TECHNICAL PAPER

9

Operational Noise and Vibration Assessment (Rail) Report

ILLABO TO STOCKINBINGAL ENVIRONMENTAL IMPACT STATEMENT

INLAND RAIL ILLABO TO STOCKINBINGAL OPERATIONAL NOISE AND VIBRATION ASSESSMENT (RAIL) REPORT

Revision date: 30/03/2022

2-0001-220-EEC-00-RP-0001_I

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 Illabo to Stockinbingal section of Inland Rail (the Proposal).

The Proposal consists of about 39 kilometres (km) of new single-track standard gauge railway with a crossing loop and the upgrade of approximately 3 km of existing rail infrastructure. 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 Albury to Illabo section of Inland Rail with the Stockinbingal to Parkes section of Inland Rail. Australian Rail Track Corporation Ltd (ARTC) ('the proponent') is seeking approval to construct and operate the Illabo to Stockinbingal section of Inland Rail.

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 has been prepared on behalf of ARTC to support the environmental impact statement (EIS) for the proposal and responds to the Secretary environmental assessment requirements (draft 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.

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 loop. The noise model covered an area 2 km either side of the alignment, which comprised a total area approximately 148 km^2 (>14,800 hectares) in size and 179 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 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 six sensitive residential receivers for railway operations at the commencement of operations (2026) and at six sensitive residential receivers (no additional 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. The highest predicted railway noise level was 4 dBA above the noise assessment criteria. The margin by which the noise levels are being triggered is one aspect considered when evaluating the reasonable and feasible mitigation options for each receiver.

There are non-residential sensitive receivers, such as schools and churches, that are located within the town of Stockinbingal. In addition to the residential noise triggers, the noise levels at the Stockinbingal Public School and St. Joseph's Catholic Church in Stockinbingal may be above the internal noise criterion assuming a conservative outside-to-inside level difference of 7 dB.

Based on the isolated location of the sensitive receivers where noise levels trigger a review of mitigation, the reasonable and feasible 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 noise and ground-borne vibration levels associated with train movements on the track were assessed to achieve the relevant vibration criteria at all identified sensitive receivers.

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 reasonable and feasible 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 reasonable and feasible 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 reasonable and feasible 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 and, as required, the consideration of suitable resilient matting for ballast retention and vibration isolation for the ballasted track on over bridges and viaducts.
- 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 additional reasonable and feasible and feasible mitigation measures where monitored noise and/or vibration levels at sensitive receivers are confirmed to be above adopted railway noise and vibration criteria.

CONTENTS

DOCUMENT REFERENCES

TABLES

FIGURES

APPENDICES

ACRONYMS

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	Department of Environment and Conservation
DECC	Department of Environment and Climate Change (now NSW EPA)
DIN	Deutches Institut für Normung (German Institute for Standardisation)
DoIP	Department of Planning, Industry and Environment
EIS	Environmental Impact Statement
EP&A Act	*Environmental Planning and Assessment Act 1979*
EPA	Environment Protection Authority
Hz	Hertz
I2S	Illabo to Stockinbingal section of Inland Rail
ISO	International Standards Organisation
Km	Kilometres
Km/h	Kilometres per hour
Km^2	Square kilometres
LAE	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.
LAeq(15hour)	The equivalent continuous noise level for the 15-hour daytime period of 7.00 am to 10.00 pm
LAeq(9hour)	The equivalent continuous noise for the 9-hour daytime period of 10.00 pm to 7.00 am
LAeq(1hour)	The equivalent continuous noise for the busiest 1-hour period.
LAmax	The maximum noise level during the measurement or assessment period. The LAFmax or Fast is averaged over 0.125 of a second and the LASmax or Slow is averaged over 1-second.
m	Metres
mm	Millimetres
mm/s	Millimetres per second
m/s	Metres per second
NSW	New South Wales
OEH	(former) Office of Environment and Heritage
PPV	Peak Particle Velocity
QLD	Queensland
RING	Rail Infrastructure Noise Guideline

Term	Definition
SEL	Sound Exposure Level (see LAE)
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 OF PROPOSAL TERMINOLOGY

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 and 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 place on a single line railway where trains travelling in the opposite direction can pass each other.
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	Relates to engineering considerations, what can practically be built (e.g. safety, access, site constraints).
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 typically only occurs when not masked by 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.
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.

Term	Definition
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.
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 which are sensitive to potential noise and vibration impacts, such as residential dwellings, schools and hospitals.
Study area	The assessment of noise and vibration from railway operations adopted a study area comprising approximately 150 km^2 (square kilometres) based on a 2 km (kilometre) distance surrounding either side of the proposed rail alignment.
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.
Vibration	The movement of particles in a medium, such as the ground soil or a building, which can result from the energy associated with train passbys on the tracks.

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. 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 approximately 1,700 kilometres (km) long, involves:

- Utilising the existing interstate rail line through Victoria and southern NSW.
- Upgrading approximately 400 km of existing track, mainly in western NSW.
- Providing approximately 600 km of new track in NSW and south-east Queensland.

Inland Rail has been divided into 13 sections, seven of which are located in NSW. Australian Rail Track Corporation Ltd (ARTC) (the proponent) is seeking approval to construct and operate the Illabo to Stockinbingal 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 has been 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.

1.2 The Proposal

The proposal consists of about 39 km of new single-track standard gauge railway, approximately 3 km of upgrades to existing rail and one crossing loop. The proposal would be constructed to accommodate double-stacked freight trains up to 1,800 metres (m) long and 7.1 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 requirement for the proposal varies in width between about 40 and 90 m to cater for large embankments and cuttings to respond to local topography and incorporate infrastructure. Clearing of the proposal site would occur to allow for construction and to maintain the safe operation of the railway.

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. 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.

1.2.1 Location

The proposal would be located between the towns of Illabo and Stockinbingal in NSW. The proposal would link the Albury to Illabo section of Inland Rail located in southern NSW, with the Stockinbingal to Parkes section of Inland Rail located in central NSW. The location of the proposal is shown in **Figure 1**.

1.2.2 Key features

The key features of the Proposal are outlined below and the proposal features and activities relating to the operation of the railway are discussed further in **Section 2**.

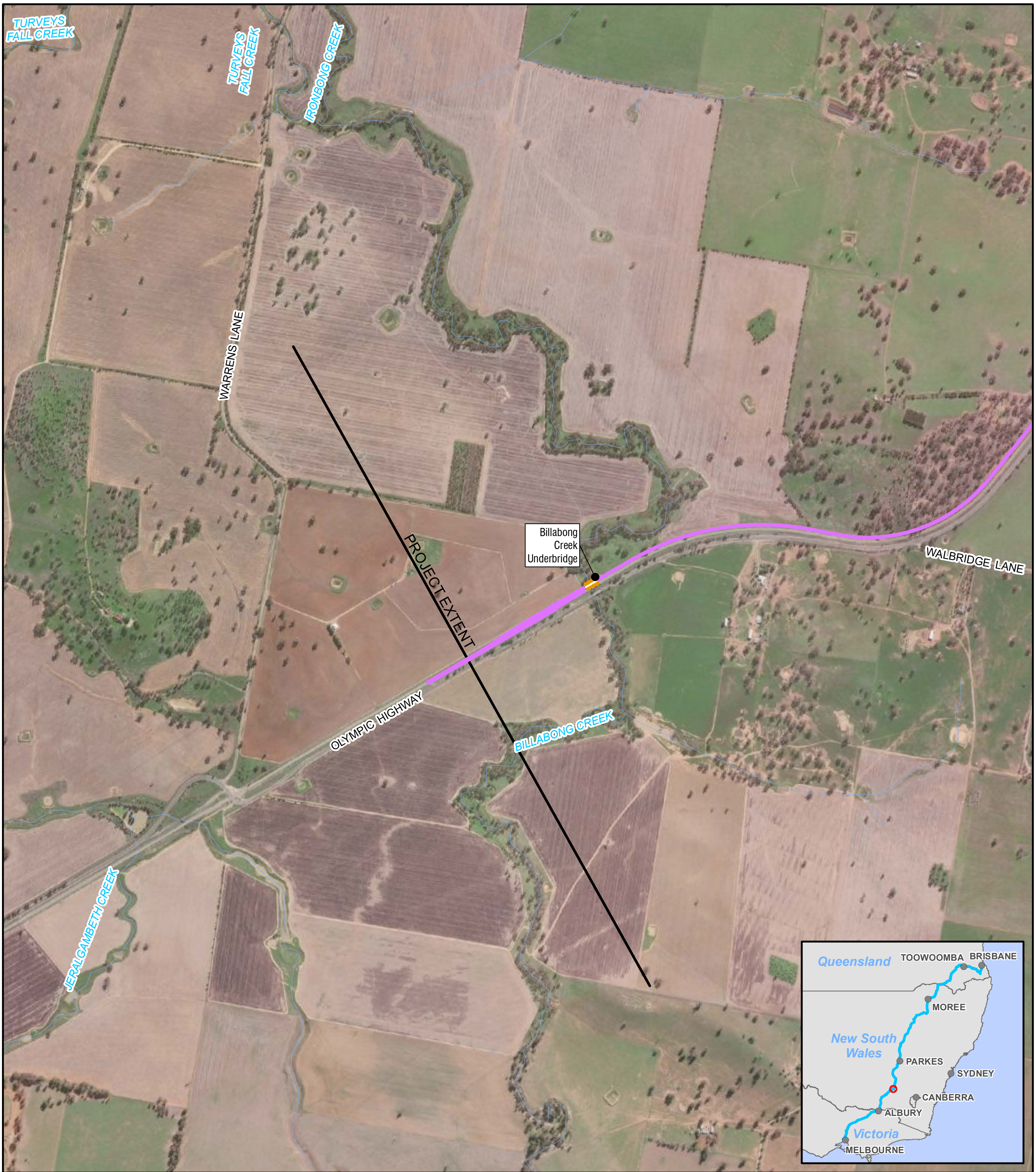
- A total of 42.5 km, including about 39 km of new, single track standard gauge railway between Illabo and Stockinbingal, including:
  - 11 new bridges, including the road over rail bridge for Burley Griffin Way.
  - One crossing loop and associated maintenance siding.
  - Construction of new and upgrades to existing level crossings (including public roads and private accesses).
  - Stock crossings to allow for the movement of livestock and vehicles across the rail line.
  - One major drainage diversion to collect and transport stormwater away from the rail line.
  - Installation and upgrade of about 93 new and existing cross drainage culverts below the rail formation and 27 longitudinal drainage culverts below level crossings.
  - Removal of redundant sections of track along the Stockinbingal to Parkes line and Lake Cargelligo line at Stockinbingal.
- Upgrades of about 3 km of existing track for the tie-in works to the existing Main South rail line at Illabo and the Stockinbingal to Parkes rail line at Stockinbingal.
- Construction of about 1.7 km of new track to maintain the existing connection of the Lake Cargelligo rail line either side of the proposal.
- Realignment of a 1.4 km section of the Burley Griffin Way to provide a road over rail bridge at Stockinbingal.
- Realignment of Ironbong Road to allow for safe sight line at the new active level crossing.
- A range of infrastructure associated with the operation of the rail corridor would be installed, including permanent access roads, signalling and communications, signage, fencing and services and utilities.

The Main South line, Lake Cargelligo line and the Stockinbingal to Parkes line, are existing operational rail lines that join the proposal. These lines would continue to operate following construction of the proposal and only the relevant direct impacts on these existing lines, as described above and in **Section 2**, form part of the proposal.

1.2.3 Railway operations

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 would involve operation of a single rail track with a crossing loop, to accommodate double stacked freight trains up to 1,800 metres (m) long and 7.1 m high. Train speeds would vary according to axle loads and range from 80 to 115 kilometres per hour (km/h).

The Inland Rail trains would be a mix of grain, bulk freight, and other general transport trains. The bulk freight traffic would include new Express and Super-freighter services that would enable the use of double stacked trains along the entire length of Inland Rail. Based on current demand forecasting, it is estimated I2S would be trafficked by an average of 6 trains per day (both directions) in 2026, increasing to about 11 trains per day (both directions) in 2040. Note that the train numbers used for noise modelling differ from this as the numbers have been derived based on weekly average forecast numbers and have been rounded up to the next integer. The modelled train numbers for I2S, and the sections north and south of the this are provided in Section **6.2**.



ILLABO TO STOCKINBINGAL

Overview I2S Section Alignment

FIGURE 1 - Map 1 of 14

500 m

Coordinate System: GDA 1994 MGA Zone 55

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Author: JG

- Level Crossings
- Watercourses
- Design Loops
- I2S Design Centreline
- Bridges and Tunnels
- Project Extent

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ILLABO TO STOCKINBINGAL

Overview I2S Section Alignment

FIGURE 1 - Map 2 of 14

500 m

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ILLABO TO STOCKINBINGAL

Overview I2S Section Alignment

FIGURE 1 - Map 3 of 14

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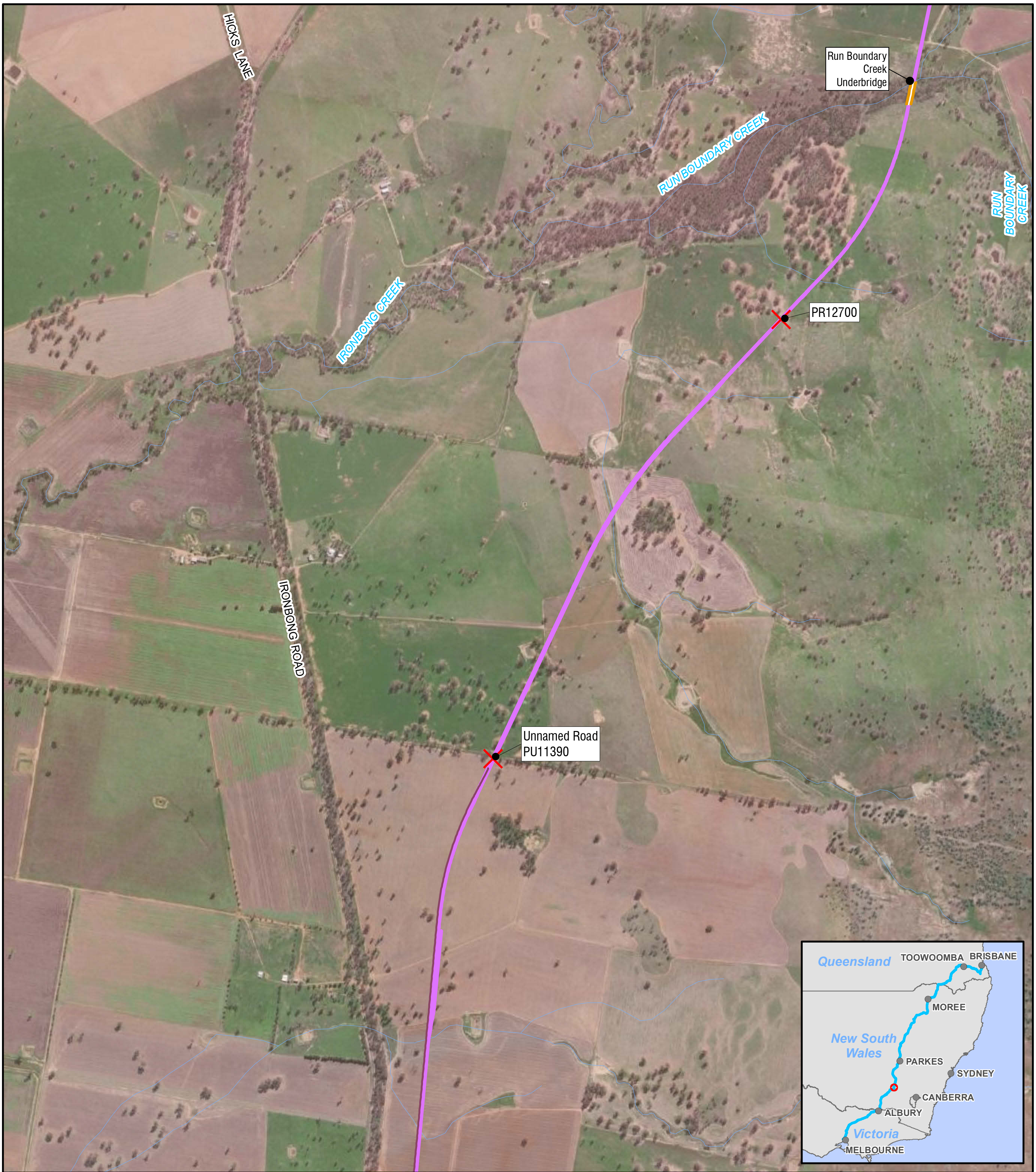

ILLABO TO STOCKINBINGAL

Overview I2S Section Alignment

FIGURE 1 - Map 4 of 14

500 m

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ILLABO TO STOCKINBINGAL

Overview I2S Section Alignment

FIGURE 1 - Map 5 of 14

500 m

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Level Crossings
Watercourses
Design Loops
I2S Design Centreline
Bridges and Tunnels
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ILLABO TO STOCKINBINGAL

Overview I2S Section Alignment

FIGURE 1 - Map 6 of 14

500 m

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ILLABO TO STOCKINBINGAL

Overview I2S Section Alignment

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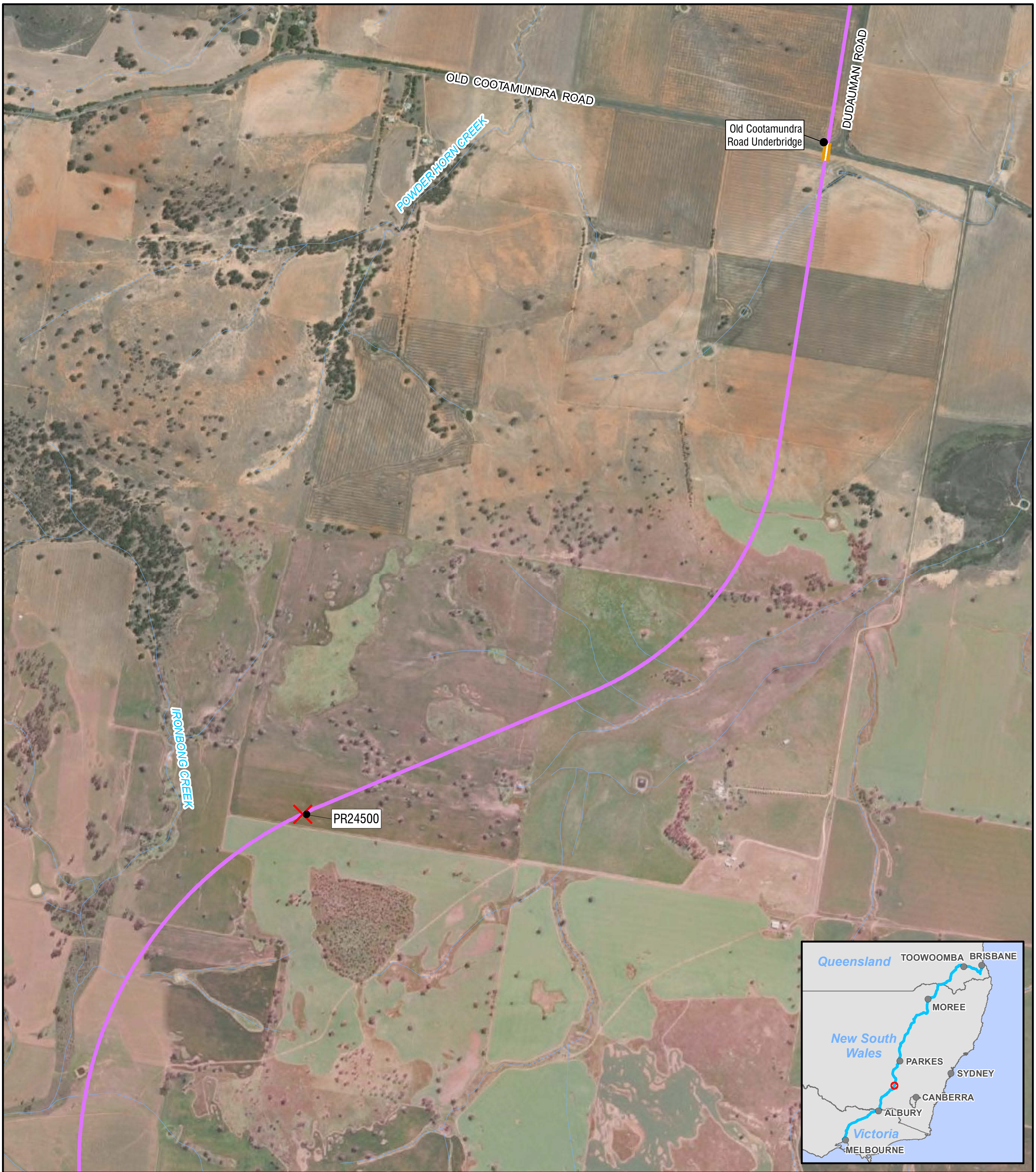

ILLABO TO STOCKINBINGAL Overview I2S Section Alignment

FIGURE 1 - Map 8 of 14

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ILLABO TO STOCKINBINGAL

Overview I2S Section Alignment

FIGURE 1 - Map 9 of 14

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ILLABO TO STOCKINBINGAL

Overview I2S Section Alignment

FIGURE 1 - Map 10 of 14

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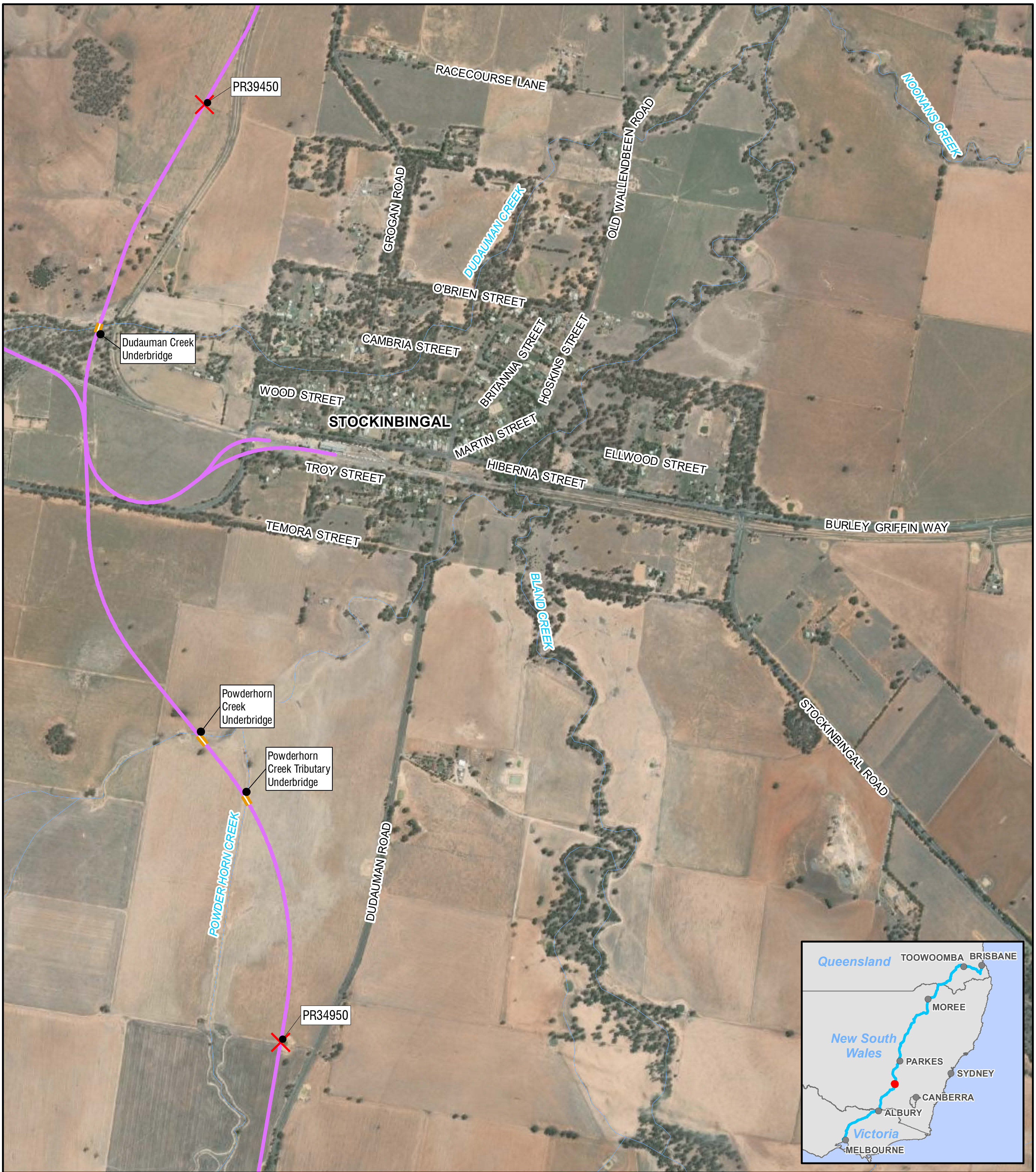

ILLABO TO STOCKINBINGAL

Overview I2S Section Alignment

FIGURE 1 - Map 11 of 14

500 m

Coordinate System: GDA 1994 MGA Zone 55

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- Level Crossings
- Watercourses
- Design Loops
- I2S Design Centreline
- Bridges and Tunnels
- Project Extent

Paper: A4 Scale: 1:20,000
Date: 01-Nov-2021
Author: JG

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ILLABO TO STOCKINBINGAL

Overview I2S Section Alignment

FIGURE 1 - Map 12 of 14

500 m

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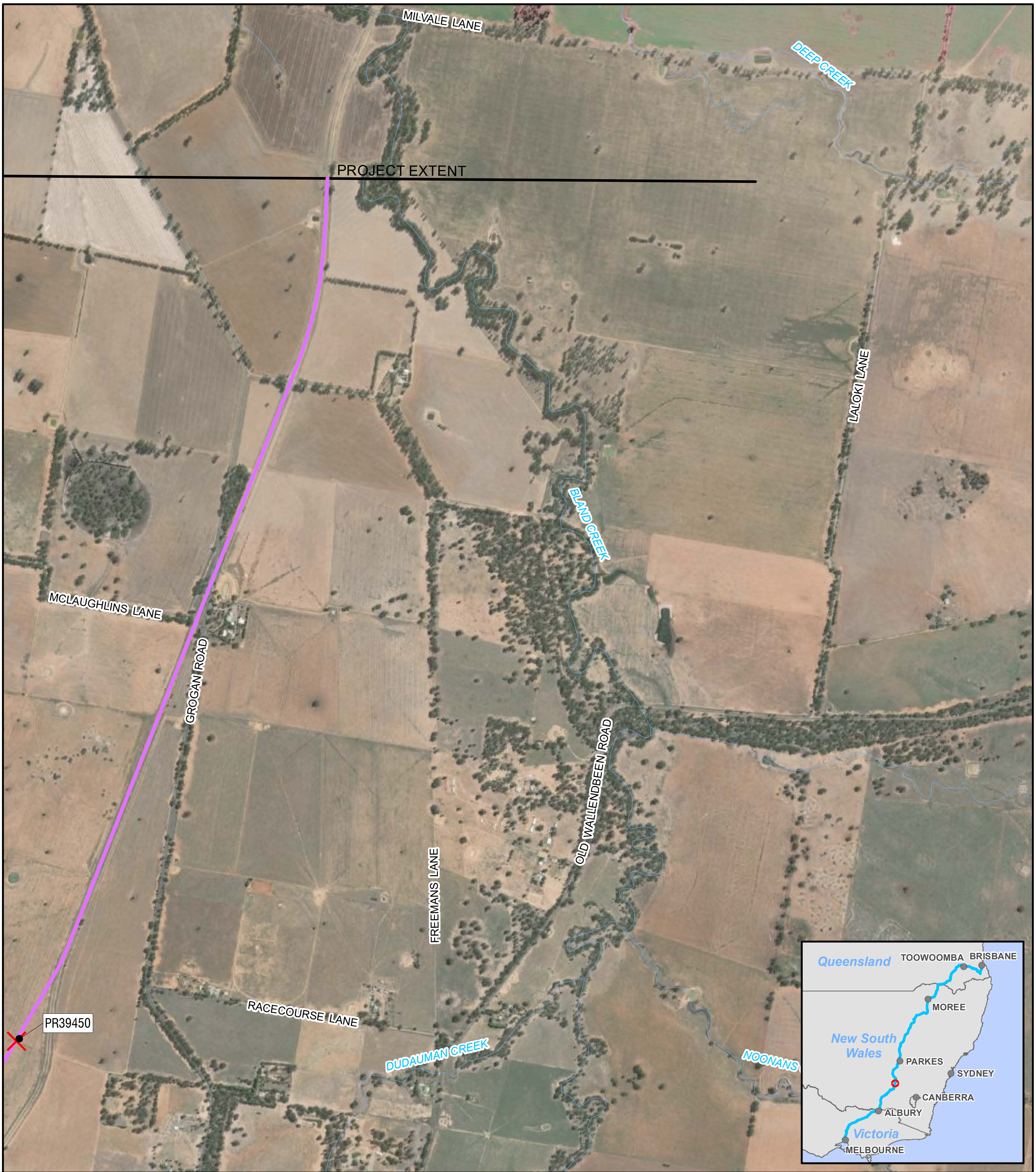

ILLABO TO STOCKINBINGAL

Overview I2S Section Alignment

FIGURE 1 - Map 13 of 14

500 m

Coordinate System: GDA 1994 MGA Zone 55

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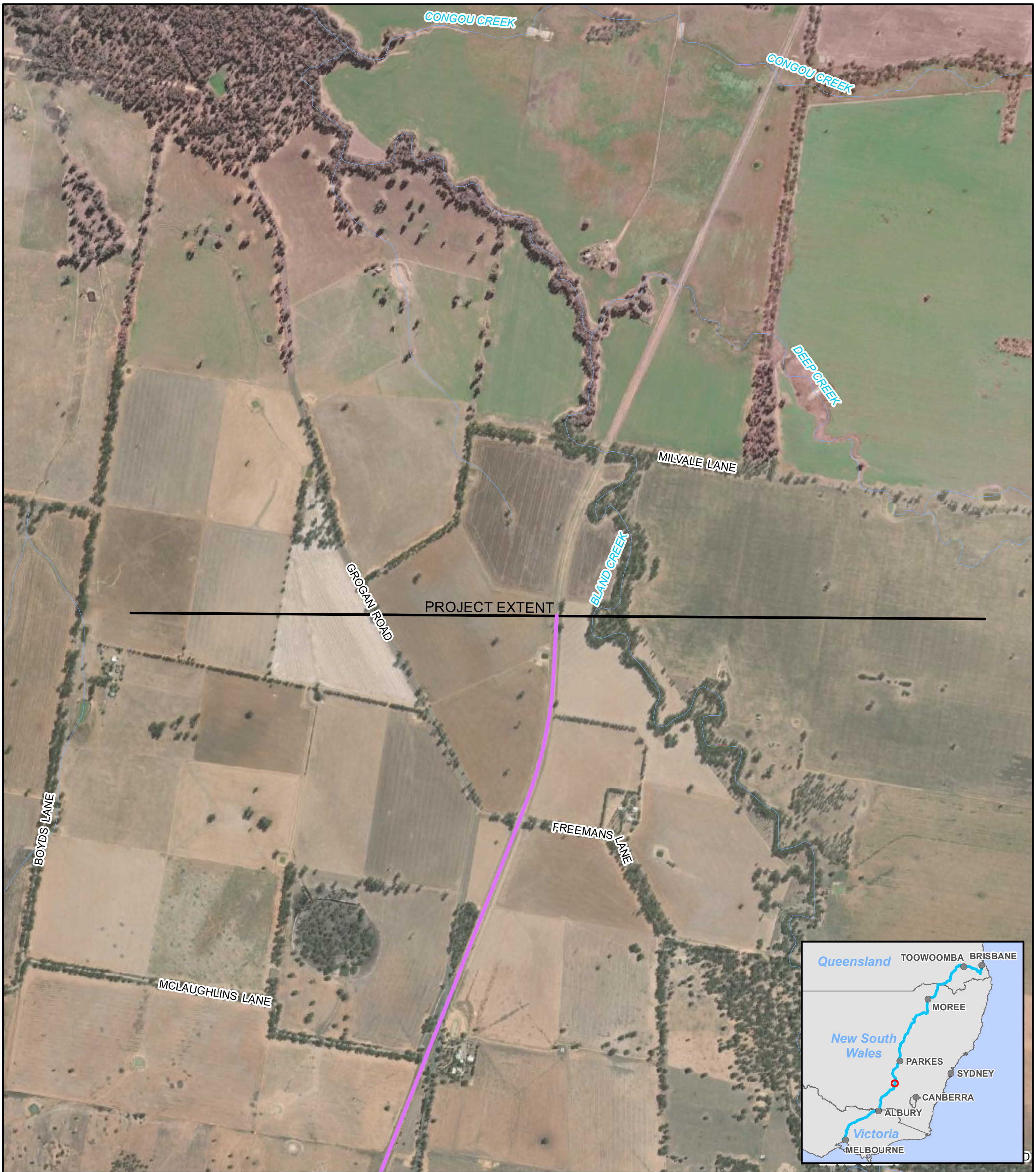

ILLABO TO STOCKINBINGAL

Overview I2S Section Alignment

FIGURE 1 - Map 14 of 14

500 m

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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 and:

- Address the relevant Secretary's Environmental Assessment Requirements (SEARs) listed in **Table 1**.
- Describe the existing environment with respect to railway noise and vibration sensitive receivers and the existing ambient and background noise levels.
- Assess the potential noise and vibration impacts from the railway operations of the Proposal at sensitive receivers, including the daily rail traffic and the operation of rail infrastructure.
- Recommend reasonable and feasible measures to mitigate and manage the impacts identified.

This report is specific to railway operations on the Proposal. The noise and vibration impact assessment for the construction works, road transport and stationary (fixed) infrastructure is detailed in *Technical Paper 8 – Construction Noise and Vibration Impact Assessment Report* and *Technical Paper 10 – Operational Noise and Vibration Impact Assessment (Non-Rail) Report*.

Table 1 SEARs relevant to this assessment

Key issue and desired performance outcome	Assessment requirements relevant to noise and vibration	Where addressed in this report
9. Noise and Vibration Amenity Construction noise and vibration (including airborne noise, ground-borne noise and blasting) are effectively managed to minimise adverse impacts on acoustic amenity. Increases in noise emissions and vibration affecting nearby properties and other sensitive receivers during operation of the project are effectively managed to protect the amenity and well-being of the community. Increase in noise emissions and vibration affecting environmental heritage as defined in the Heritage Act 1977 during operation of the project are effectively managed.	1. Construction and operational noise and vibration impacts in accordance with relevant NSW noise and vibration guidelines. 2. The assessment of construction noise and vibration must address: (a) the nature of construction activities and related noise characteristics; (b) the intensity and duration of noise (both air and ground-borne) and vibration. This must include consideration of extended construction impacts associated with ancillary facilities (and the like) and construction fatigue; (c) the identification and nature of receivers, existing and proposed during the construction period; (d) the structural integrity and heritage significance of items (including Aboriginal places and items of environmental heritage); (e) the nature of the impact and the sensitivity of receivers, including but not limited to residential (permanent and short term), tourist and commercial uses, both existing and proposed, and level of impact including for out of hours works; (f) the need to balance timely conclusion of noise and vibration-generating works with period of receiver respite, and other factors that may influence the timing and duration of construction activities (such as traffic management);	Sections 7, 8 and 9 (airborne noise) Sections 10 and 11 (ground-borne noise and vibration). *Technical Paper 8 – Construction Noise and Vibration Impact Assessment Report*. *Technical Paper 10 – Operational Noise and Vibration Impact Assessment (Non-Rail)*.

Key issue and desired performance outcome	Assessment requirements relevant to noise and vibration	Where addressed in this report
9. Noise and Vibration Amenity Construction noise and vibration (including airborne noise, ground-borne noise and blasting) are effectively managed to minimise adverse impacts on acoustic amenity. Increases in noise emissions and vibration affecting nearby properties and other sensitive receivers during operation of the project are effectively managed to protect the amenity and well-being of the community. Increase in noise emissions and vibration affecting environmental heritage as defined in the Heritage Act 1977 during operation of the project are effectively managed.	(g) noise impacts of out-of-hours works (including utility works and works associated with the SSI including those undertaken under another assessment pathway), possible locations where out-of-hours works would be undertaken, the activities that would be undertaken, the estimated duration of those activities and justification for these activities in terms of the *Interim Construction Noise Guidelines* (DECC, 2009); (h) sleep disturbance (including the number of noise-awakening events); (i) details and analysis of the predicted effectiveness of mitigation measures to adequately manage identified impacts, including impacts identified in (h); (j) any potential residual noise and vibration impacts following application of mitigation measures; and (k) a description of how receiver feedback received during the preparation of the EIS has been taken into account (and would be taken into account post exhibition of the EIS) in the design of mitigation measures, including any tailored mitigation, management and communication strategies for sensitive receivers. If blasting is required, demonstration that blast impacts can comply with current guidelines.	Sections 7, 8 and 9 (airborne noise) Sections 10 and 11 (ground-borne noise and vibration). *Technical Paper 8 – Construction Noise and Vibration Impact Assessment Report*. *Technical Paper 10 – Operational Noise and Vibration Impact Assessment (Non-Rail)*.
14. Climate Change and Sustainability The project reduces the NSW Government's operating costs and ensures the effective and efficient use of resources. Conservation of natural resources is maximised. The project is designed, constructed and operated to be resilient to the future impacts of climate change.	1. Sustainability of the project in accordance with the Infrastructure Sustainability Council of Australia (ISCA) Infrastructure Sustainability Rating Tool and recommend an appropriate target rating for the project.	See **Section 1.3.1**

Source NSW Department of Planning, industry and Environment SEARs – Inland Rail Project Illabo to Stockinbingal (SSI 9406) 30 April 2021.

1.3.1 ISCA targets

It is understood that the proposal is targeting Level 2 credits for noise and vibration. Level 2 requirements cover noise (within Dis-2) and vibration (within Dis-3) for design, construction, and operational phases of the proposal. This report highlights the sections that act as preliminary evidence to support the credit requirements for the design phase and highlights the requirements for the operational phase of the proposal. The specific requirements relating to the construction phases are not addressed in this report.

The relevant requirements are highlighted in **Table 2**and **Table 3**.

Table 2 ISCA Level 2 credits for Dis-2 Noise

Credit		Dis-2 Noise	Where addressed in this Report
Aim		To reward the management of noise impacts.	-
Summary of Requirements Target: Level 2	1	Measures to mitigate noise during construction and operation have been identified and implemented.	Potential target exceedances are identified in **Section 9**. Noise mitigation measures are discussed in **Section 13**.
	1	Monitoring of noise is undertaken at appropriate intervals and in response to complaints during construction and operation.	Monitoring requirements are discussed in **Section 13.6**.
	2	For construction, modelling and monitoring demonstrates no recurring or major divergences from the noise management process in ISCA approved noise guidelines.	Not addressed in this report
	2	For operation, modelling demonstrates no recurring or major exceedances of noise goals.	Modelling results are provided in **Section 8.**
Additional Guidance (Must Statements)	1	Noise goals are limits that must not be exceeded or noise levels that projects aim to keep within.	Noise investigation thresholds are discussed in **Section 3.**
	2	The assessor must provide evidence to show that the requirements of the guideline have been met	As above. The final evidence shall be provided during the detailed design of this proposal.

Table 3 ISCA Level 2 credits for Dis-2 Vibration

Credit		Dis-3 Vibration	Where addressed in this Report
Aim		To reward the management of vibration impacts.	-
Summary of Requirements Target: Level 2	1	Measures to mitigate vibration during construction and operation have been identified and implemented.	Assessment details are provided in **Section 10**. Mitigation measures are discussed in **Section 13**.
	1	Monitoring of vibration is undertaken at appropriate intervals and in response to complaints during construction.	Not addressed in this Report
	2	For construction, modelling and monitoring demonstrates no exceedances of vibration goals for structural damage to buildings and structures.	Not addressed in this Report
	2	For operation, modelling demonstrates no recurring or major exceedances of vibration goals for human comfort criteria.	Assessment details are provided in **Section 10**.

Credit		Dis-3 Vibration	Where addressed in this Report
	2	No physical damage has been caused to any buildings or structures by vibration caused by construction	Not addressed in this Report
Additional Guidance (Must Statements)	1	When vibration has low materiality, monitoring is only required in response to complaints. In this case only Level 1 applies, and this receives the full points for the credits.	This is anticipated to be the case for operational vibration effects, subject to detailed design.
	1	Vibration goals are limits that must not be exceeded or vibration levels which the project aims to keep within.	Investigation thresholds are discussed in **Section 3.**

1.4 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 reported findings.

Concept mitigation measures for railway noise and vibration have been presented in this assessment based on the adopted assessment criteria, identified sensitive receivers and the predicted 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 has been developed in response to environmental, engineering and social constraints. The design objective is to minimise environmental and social impacts, minimise disturbance to existing infrastructure and utilities, meet the engineering design criteria and realise the benefits of Inland Rail.

The key components of the Proposal are summarised in **Table 4**.

Table 4 Key infrastructure for the Proposal

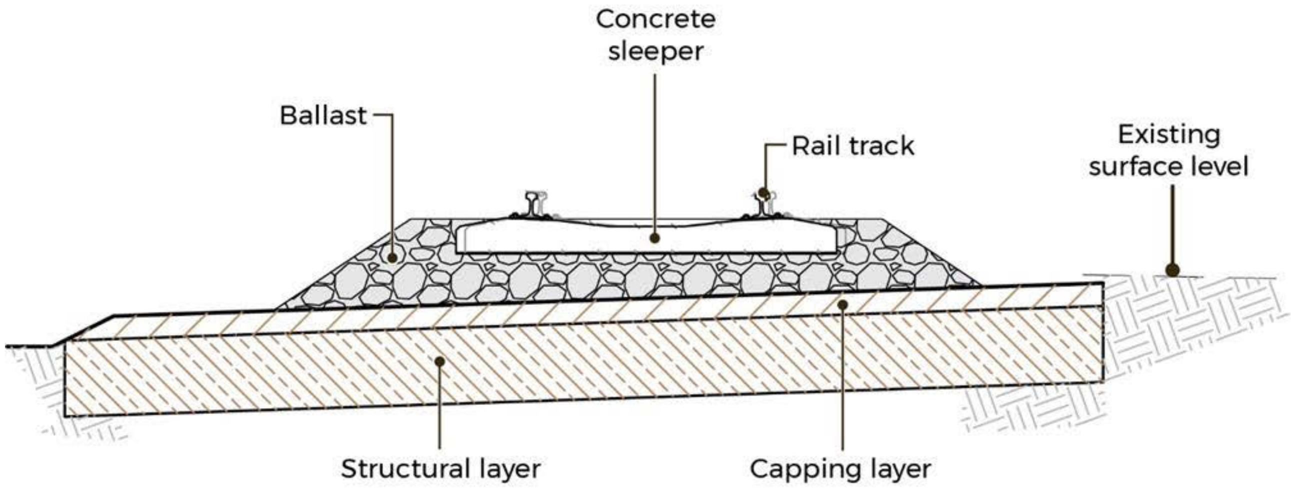
Key component	
Start and finish point	Illabo and Stockinbingal, NSW
Local government areas	Junee Shire Council and Cootamundra-Gundagai Regional Council
Length of alignment	Approximately 42.5 km, with 39 km of new rail alignment
Track dimensions	Rail corridor with a typical width ranging from approximately 40 m to 90 m wide, consisting of a single-track dual gauge railway line to facilitate rail traffic in both directions. The corridor extends wider where earthworks, structures and other associated infrastructure are required.
Level crossings	Construction of new level crossings and upgrades to existing level crosings
New rail bridges and viaducts	11, of which 10 are rail bridges for crossing roads and waterways

Connection with existing rail lines	Tie-ins to the Main South rail line at Illabo and the Stockinbingal to Parkes rail line at Stockinbingal are provided.
Crossing loops	One loop initially up to 2,200 m in length adjacent to Ironbong Road.

2.2 Rail design

A single-track dual gauge railway line is proposed to facilitate the travel of trains in both directions. The track structure is typically a ballasted track system consisting of continuously welded rail, resilient track fasteners, rail pads and concrete dual gauge full-depth sleepers. An indicative design of the new track is provided in **Figure 2**.

Figure 2 Proposed track design



2.3 Tie-in and track upgrades

Within the existing rail corridor at Illabo and Stockinbingal the existing track and formation would need to be upgraded for the new tie-ins. In addition, crossovers would be required at the tie-in points along the Main South line. Track upgrades would be required at the following locations:

- Connection to the Main South line at Illabo and connection to the Stockinbingal to Parkes line at Stockinbingal. This would require about 3 km of track to be upgraded to suit the new tie-ins.
- Construction and upgrades of about 1.6 km of track to maintain the existing connection of the Lake Cargelligo line.

2.4 Crossing loop and maintenance siding

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

In operation, one train enters the crossing loop through one of the turnouts and idles at the other end, while the opposing train continues along the mainline track to pass the now stationary train. The time required to complete the crossing typically ranges from 10–15 minutes to up to an hour.

The Proposal incorporates one new crossing loop adjacent to Ironbong Road and is designed 2,200 m in length to accommodate a maximum train length of up to 1,800 m. The crossing loop will be connected to the main line track at both ends so the crossing loop can be accessed by trains travelling in either direction. The loop will be a new section of track parallel to the existing track at approximately 4.5 m from the mainline track.

2.5 Turnouts

A turnout is a point where a train can leave a given track for a branching or parallel track. The turnouts on the Proposal are expected at the locations detailed in **Table 5**.

Table 5 Location of turnouts on the Proposal

Railway infrastructure	Connection
Main South line	Connection between the Main South Line and the new rail track and crossovers on the Main South Line.
Crossing loop	Northern and southern ends of the crossing loop to access the main line of the Proposal.
Maintenance siding	Connection between the maintenance siding and the main line of the Proposal.
Lake Cargelligo line	Connections to the eastern and western branches of the Lake Cargelligo Line.

2.6 Bridges and viaducts

The Proposal requires new bridge structures, as detailed in **Table 6**. There are eight bridges for rail to cross over waterways and two are to enable the rail line to cross over roads and one road over rail bridge.

The bridge and viaduct superstructures include the track system, walkways, guard rails and barriers as appropriate, and are typically founded on piles supporting in-situ reinforced concrete columns or blade piers. The sub-formation and ballast height will be approximately the same as the deck edge.

Table 6 Proposed new bridges

Bridge name	Crossing type	Approximate bridge length, m
Billabong Creek Bridge	Rail over waterway	60
Ulandra Creek Bridge	Rail over waterway	60
Run Boundary Creek Bridge	Stock movements beneath the rail line	90
Dirnaseer Road Bridge	Rail over road	70
Isobel Creek Bridge	Rail over waterway	70
Isobel Creek Tributary Bridge	Rail over waterway	70
Old Cootamundra Road Bridge	Stock movements beneath the rail line	60
Powder Horn Creek Bridge	Rail over waterway	40
Powder Horn Creek Tributary Bridge	Rail over waterway	40
Burley Griffin Way Bridge	Road over rail	20
Dudauman Creek Bridge	Rail over waterway	30

2.7 Level crossings

Level crossings shall be constructed where the railway line and a public and private roads cross at the same level. For safety purposes, some level crossings may require alarm bells and a requirement for all trains to sound the horns as they approach each level crossing. There are two types of level crossing on the Proposal:

- 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 levels crossing.

The Proposal includes the passive and active level crossings as detailed in **Table 7**.

Table 7 Level crossings on the Proposal

Road interface	Location of level crossings
Private road crossings	Crossings for local private access roads adjacent to the Proposal
Public road crossings	Unnamed Road (active level crossing)
	Old Sydney Road (passive level crossing)
	Ironbong Road (active level crossing)
	Unnamed Road (active level crossing)
	Unnamed Road (passive level crossing)
	Diraseer Road (grade separated rail over road)
	Old Cootamundra Road (grade separated rail over road)
	Corbys Lane (passive level crossing)
	Burley Griffin Way (road over rail)

3 Environmental impact assessment requirements

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.

Document	Publisher	Application in the assessment
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.
Infrastructure Sustainability Technical Manual – v 1.2, 2016	Infrastructure Sustainability council of Australia (ISCA)	• Referenced for relevant rating tool targets relating to noise and vibration that are inherently addressed in this report.
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 Illabo to Stockinbingal (SSI 9406) 30 April 2021.

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) 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.
- The influence of specific track features such as bridges, tight-radius curves, turnouts and crossings.
- Level crossing bells/alarms at road intersections and the use of train horns as safety and warning devices.

The RING provides non-mandatory railway noise assessment criteria for sensitive residential receivers, as detailed in **Table 9**.

Table 9 Airborne railway noise criteria for residential receivers

Type of development	Noise assessment criteria at residential receivers (External)	
	Day (7.00 am to 10.00 pm)	**Night-time (10.00 pm to 7.00 am)**
New rail line development[1]	Predicted rail noise levels exceed:	
	$L_{Aeq(15hour)}$ 60 dBA	$L_{Aeq(9 hour)}$ 55 dBA
	L_{AFmax} 80 dBA	L_{AFmax} 80 dBA
Upgrade of existing rail line[2]	Development increases existing $L_{Aeq(period)}$ rail noise levels by 2 dB or more, or existing L_{Amax} rail noise levels by 3 dB or more and predicted rail noise levels exceed:	
	$L_{Aeq(15hour)}$ 65 dBA	$L_{Aeq(9 hour)}$ 60 dBA
	L_{AFmax} 85 dBA	L_{AFmax} 85 dBA

Note 1 A new rail line development is a rail infrastructure project on land that is not currently an operational rail corridor.

Note 2 An upgraded line is a development on land that is within an existing operational rail corridor, where a line is or has been operational or is immediately adjacent to an existing operational rail line which may result in the widening of an existing rail corridor.

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.

There are different assessment criteria for new railways and for upgrading existing railway infrastructure. The criteria for new railways are 5 dBA lower (more stringent) based on the assumption that noise mitigation can be more readily implemented on newly constructed sections of railway infrastructure.

The RING includes rail noise criteria for sensitive receivers other than residential land uses. The noise criteria for these receiver 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 reasonable and feasible noise mitigation has been applied.

Where the rail noise levels are above the assessment criteria, ARTC will investigate reasonable and feasible mitigation measures, as guided by RING, with the aim of reducing noise levels to meet the criteria and minimising potential noise impacts at sensitive receivers.

Whilst the Proposal includes discrete locations where the Inland Rail alignment interacts with existing rail corridors, the existing railway operations at these rail connections is expected to be infrequent, for example one to two trains per day. The trains on the rail connections would also operate at speeds slower than the proposed train movements on Inland Rail. Accordingly, the daily railway activities on Inland Rail are likely to be the dominant noise source of railway noise within the environment surrounding the Proposal.

On this basis, the Proposal has been assessed as a new rail line development for the purpose of managing railway noise. This is a conservative approach that applies the most stringent noise trigger levels from the RING.

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 the 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 ground-borne vibration events 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 reasonable and feasible 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. 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.

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**.

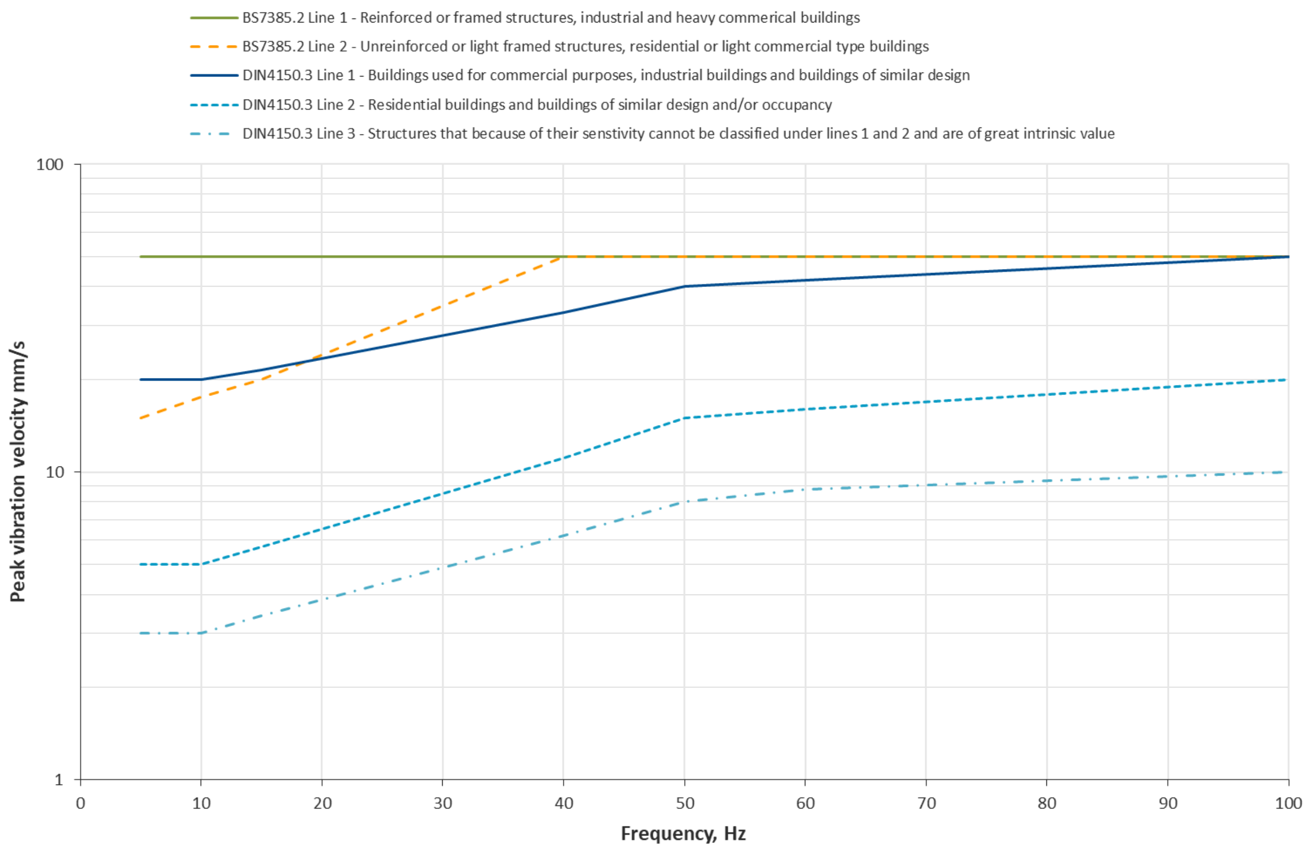
Table 12 Referenced standards associated with cosmetic building damage risk

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.

Based on **Table 12**, the relevant PPV guidance values for assessment of ground-borne vibration at heritage sites are presented in **Figure 3**.

[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.

Figure 3 Guidance values for short term vibration



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. 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.

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 Proposal alignment. An area greater than 148 km^2 (>14,800 hectares) was applied as the study area for railway noise and vibration.
- The 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 Albury to Illabo and Stockinbingal to Parkes projects on Inland Rail.
- 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 reasonable and feasible 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

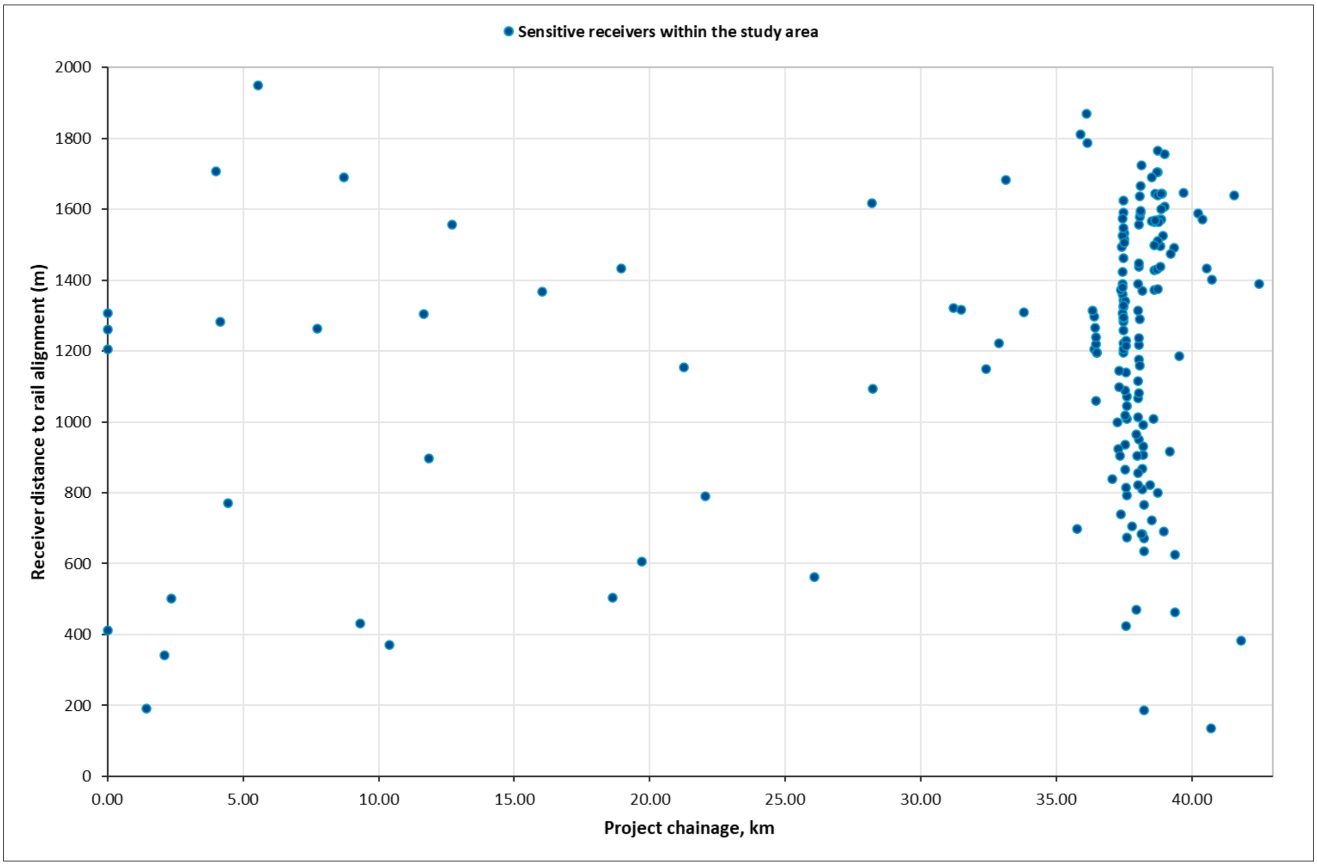
Receivers potentially sensitive to noise and vibration have been categorised as residential dwellings, commercial/industrial buildings, or ‘other sensitive’ land uses which can include educational institutions, childcare centres, medical facilities, places of worship, as described in the RING.

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 901 buildings were identified within the 2 km study area for the main line of the proposal and 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. Any property identified by ARTC are likely to be resumed by the Proposal was excluded. Railway noise and vibration levels were not assessed at the non-sensitive buildings. Of the buildings identified, a total of 179 receivers were identified as being potential noise and vibration sensitive receivers within the study area.

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

5.2 Sensitive receivers other than residential

Land use information from the EIS and geospatial surveys was referenced to identify the following buildings within the study area that could be sensitive receivers other than individual residential properties.

- Stockinbingal Public School, Stockinbingal
- St. James' Anglican Church, Stockinbingal.
- St. Joseph's Catholic Church, Stockinbingal.

5.3 Heritage sites

The cultural heritage assessment for the Proposal identified the 19 non-Indigenous sites in **Table 15** as sites of potential heritage significance. All listed items identified were located within the township of Stockinbingal. There are no heritage listed items within the disturbance footprint of the Proposal.

Table 15 Non-Indigenous heritage sites

Site ID	Site name	Proximity to the Proposal
Cootamundra LEP (i75)	Baker, William Fallon	Within 500 m of the proposal site
Cootamundra LEP (i73)	Bank of NSW and Residence, Former	Within 500 m of the proposal site

Site ID	Site name	Proximity to the Proposal
Cootamundra LEP (i71)	Cohen's Trade Palace, CWA Rooms	Within 500 m of the proposal site
Cootamundra LEP (i82)	Ellwood's Hall	Within 500 m of the proposal site
Cootamundra LEP (i72)	Federation Period Shop	Within 500 m of the proposal site
Cootamundra LEP (i65)	Public School - Original Buildings	Greater than 1 km from the proposal site
Cootamundra LEP (i83)	Soldiers War Memorial Hospital	Greater than 1 km from the proposal site
Cootamundra LEP (i68)	St. Ita's Convent	Greater than 1 km from the proposal site
Cootamundra LEP (i69)	St. Ita's Convent School	Greater than 1 km from the proposal site
Cootamundra LEP (i76)	Stock and Station Agent (Powder Horn Museum)	Within 1 km of the proposal site
Cootamundra LEP (i70)	Stockinbingal Cemetery	Greater than 1 km from the proposal site
Cootamundra LEP (C3)	Stockinbingal Conservation Area	Adjacent to the proposal site
Cootamundra LEP (i80)	Stockinbingal Court House	Greater than 1 km from the proposal site
Cootamundra LEP (i81)	Stockinbingal Hotel (Former)	Within 500 m of the proposal site
Cootamundra LEP (i79)	Stockinbingal Police Residence	Greater than 1 km from the proposal site
Cootamundra LEP (i66)	Stockinbingal Post Office and Residence	Within 1 km of the proposal site
Cootamundra LEP (i78)	Stockinbingal Railway Station	Within 1 km of the proposal site
Cootamundra LEP (i77)	Kurrajong Trees	Within 500 m of the proposal site
-	Billabong Creek Rail Underbridge	Within the rail corridor

Note 1 Site identification from the Non-Indigenous Cultural Heritage Technical Report.

5.4 Existing noise environment

A baseline environmental noise survey was undertaken in February 2019, to quantify and characterise the existing noise environment. The existing environmental noise levels were monitored at six locations surrounding the Proposal. Details of the noise monitoring survey are provided in the non-operational noise and vibration report (*Technical Paper 8 Construction Noise and Vibration Impact Assessment Report* of the EIS).

The Rating Background Levels (RBL) determined from the monitoring survey are summarised in **Table 16** and confirm that the existing noise levels are generally low, typically below 30 dBA during the daytime and evening and below 30 dBA during the night-time.

Table 16 Existing environmental noise levels

Monitoring location	Rating background levels, dBA		
	Daytime	Evening	Night-time
NM01	27	30	28
NM02	28	28	29
NM03	29	28	29
NM04	30	26	22
NM05	27	27	22
NM06	27	22	19

Note 1 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 Inland Rail: Illabo to Stockinbingal, Appendix B: Environmental Impact Statement.

The RBLs are characteristic of rural environments where the main sources of noise are local road traffic, residential activities and natural sources, such as windblown vegetation and bird song. The noise levels highlight the potential sensitivity of the environment to the introduction of additional sources of noise and this was considered by ARTC when proposing the noise management criteria for the Proposal.

6 Rail noise assessment

6.1 Prediction of railway noise

Noise emissions from the railway operations on the Proposal were calculated through detailed noise predictions using the SoundPLAN (version 7.4) noise modelling software. The noise prediction model included a detailed terrain model to develop a 3-dimensional (3D) representation of the Proposal and the 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 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 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.

In lieu of the known building construction for the 199 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 rural regions can be elevated on stumps or similar structures. In such circumstances, the ground floor of the properties is likely to be above the conventional 1.5 m or 1.8 m ground floor receiver heights.

Furthermore, rail tracks on the Proposal are elevated above the surrounding ground level, either on constructed earthworks or the bridges. The 2.4 m receiver calculation height allowed calculation of railway noise with a more direct line of sight between the rails and the receiver facades and represents a conservative approach to modelled noise levels.

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 environments further from 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].

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

The SoundPLAN modelling software and the Nordic prediction methodology are widely applied in Australia for the prediction of railway noise levels and are endorsed as acceptable methodologies under the rail guidelines.

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 railway 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 included the following principles:

- Daily train numbers include the existing services that will be accommodated on the Proposal or operate on the Main South rail line where Inland Rail shall be collocated within the rail corridor.
- 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.
- The proposed weekly rail operations (train movements) with the Proposal were referenced to determine the daily train movements for the daytime and night-time periods.
- 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 higher than the actual daily train movements forecast for the Proposal.

The daily train movements on the Proposal vary due to the rail connections with the existing Main South rail line at Illabo and the Stockinbingal to Parkes rail line at Stockinbingal. The majority of the route would service the Inland Rail Express and Inland Rail Superfreighter services with other services either collected within the existing rail corridor or utilising discrete sections of the Proposal infrastructure.

The daily train movements for the year 2026 that were applied in the noise modelling are detailed in **Table 17**.

Table 17 Daily train movements on the Proposal (year 2026)

Train service	Train movements		
	Daytime	**Night-time**	**Total 24-hour period**
Year 2026 Proposal commencement			
Rail corridor at the connection with the existing Main South line at Illabo			
Inland Rail Express	3	1	4
Inland Rail Superfreighter	4	2	6
Intermodal freight	1	0	1
Melbourne to Sydney XPT passenger	3	0	3
Griffith Export container freight	1	1	2
Central NSW grain, Junee to Illabo	2	2	4
Daily totals year 2026	**14**	**6**	**20**

Train service	Train movements		
	Daytime	**Night-time**	**Total 24-hour period**
Rail corridor between Main South line at Illabo and Stockinbingal			
Inland Rail Express	2	2	4
Inland Rail Superfreighter	3	3	6
Daily totals year 2026	**5**	**5**	**10**
Rail corridor Stockinbingal to northern extent of the Proposal			
Inland Rail Express	2	2	4
Inland Rail Superfreighter	4	4	8
Central NSW grain, Stockinbingal to Parkes	1	1	2
Daily totals year 2026	**7**	**7**	**14**

Note The daily train movements are derived from the weekly train movements and rounded to whole numbers (integers).

The forecast train movements in year 2040 represent the capacity railway operations for the Proposal. The future operations allow for an increase in the number of Inland Rail freight services and a relatively minor increase in the Melbourne to Sydney XPT passenger services.

Compared to the proposed railway operations at the commencement of the Proposal, the railway operations in year 2040 are not more than three additional train services per daytime or night-time period. On this basis, there is potential for the majority of the proposed railway operations, and potential noise and vibration emissions, to occur from the commencement of the Proposal.

The train movements for the year 2040, which represents the capacity usage of the Proposal, are detailed in **Table 18**.

Table 18 Daily train movements on the Proposal (year 2040)

Train service	Train movements		
	Daytime	**Night-time**	**Total 24-hour period**
Year 2040 future operations on the Proposal			
Rail corridor at the connection with the existing Main South line at Illabo			
Inland Rail Express	3	1	4
Inland Rail Superfreighter	5	2	7
Intermodal freight	2	0	2
Melbourne to Sydney XPT passenger	4	0	4
Griffith Export container freight	1	1	2
Central NSW grain, Junee to Illabo	2	2	4
Daily totals year 2040	**17**	**6**	**23**
Rail corridor between Main South line at Illabo and Stockinbingal			
Inland Rail Express	2	2	4
Inland Rail Superfreighter	3	4	7
Daily totals year 2040	**5**	**6**	**11**

Train service	Train movements		
	Daytime	**Night-time**	**Total 24-hour period**
Rail corridor Stockinbingal to northern extent of the Proposal			
Inland Rail Express	2	2	4
Inland Rail Superfreighter	5	5	10
Central NSW grain, Stockinbingal to Parkes	2	2	4
Daily totals year 2040	**9**	**9**	**18**

Note The daily train movements are derived from the weekly train movements and rounded to whole numbers (integers).

6.3 Operational railway noise model inputs

6.3.1 Track gradient and locomotive notch setting

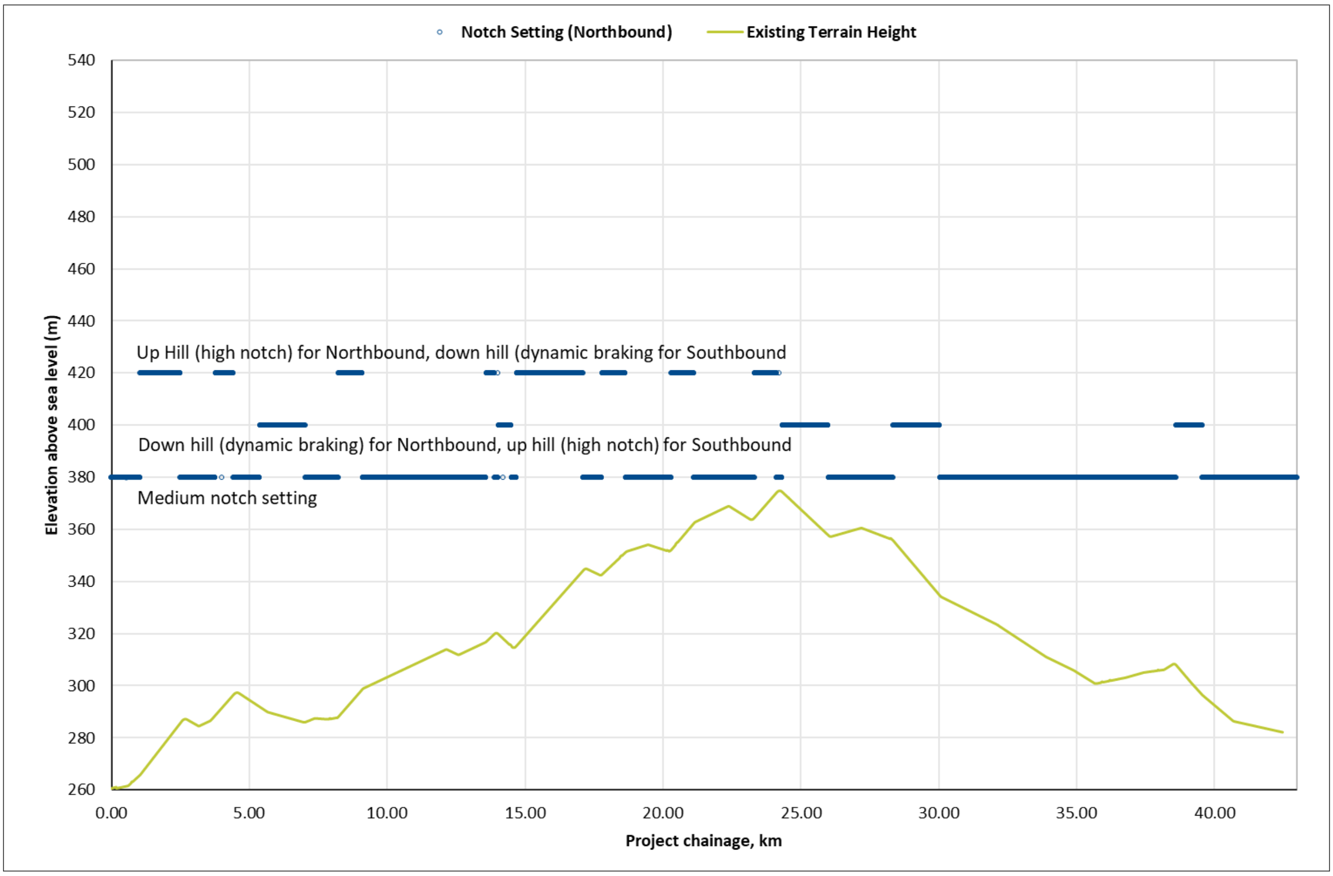
To control the speed of the trains, the locomotives have a series of throttle controls, known as notches. Most locomotives have up to eight notches. The notch setting is related to the noise emission, with higher notch settings generally causing higher noise levels. The noise prediction modelling applied the following principles for the assessment of locomotive 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. 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 5**.

Figure 5 Track elevation and locomotive notch setting



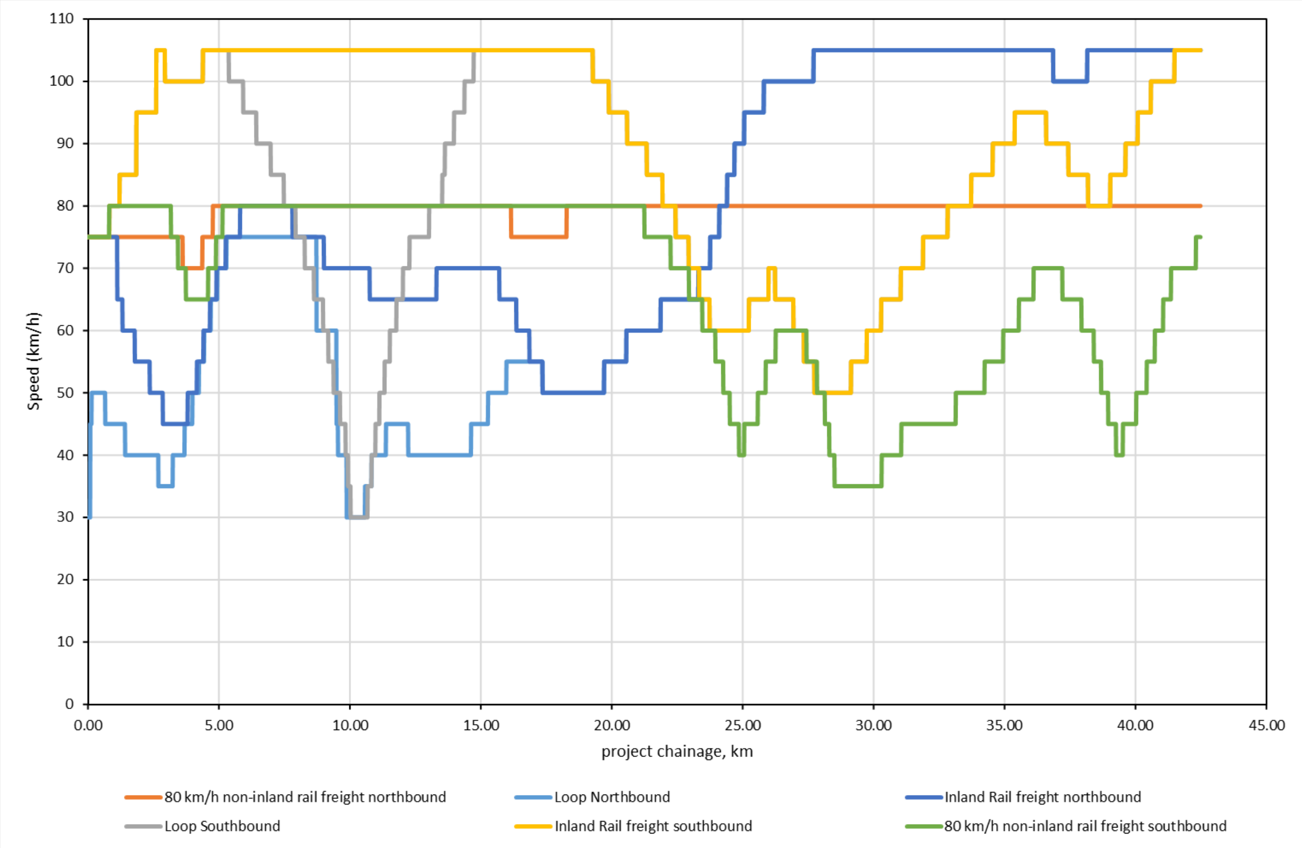
6.3.2 Train speeds

The trains on the Proposal are required to operate at their designated line speed of up to 115 km/h for the Inland Rail Express and Inland Rail Superfreighter services. The other rail services will operate at up to 80 km/h.

The train speeds supplied by ARTC 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.

To manage the railway operations, some trains will be required to slow down to access the crossing loop and then, on departure from the crossing loop, accelerate back up to the line speed. The train speed profiles adopted in the noise modelling are presented in **Figure 6**. The acute changes in train speed are associated with entry to and exit from the crossing loop.

Figure 6 Train speed profile



6.3.3 Train lengths and locomotive classes

The length of each train type and the number of locomotives, for the future railway operations with the Proposal, is shown in **Table 19**. The train data was derived from ARTC's forecast daily train movements for Inland Rail.

Table 19 Train lengths 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
Intermodal freight (NR class)	3	66 m	1,720 m	1,786 m
Melbourne to Sydney XPT passenger	2	34 m	120 m	154 m
Griffith Export container freight (SCT class)	2	44 m	540 m	584 m
Central NSW grain, Junee to Illabo (SCT class)	2	44 m	940 m	984 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.
- 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).
- 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.
- 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 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.

[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*.

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 20**. 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 20 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 provided 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 reduce noise levels 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 rolling noise and vibration emission levels, such as 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 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 20**.

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 proposed to be ballasted concrete bridges. Consistent with guidelines for noise prediction modelling, the rail noise emissions for the ballast track on the concrete bridges were assumed to have noise emission levels and characteristics as the ballasted track at ground level.

At Stockinbingal, new track spurs are included in the Proposal to connect Inland Rail alignment with the existing Stockinbingal to Park rail line. The track radius of these spurs is less than 500 m (greater than 300 m) and the noise modelling applied emission correction factors for potential curving noise emissions. The correction factors were 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 21** 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 21 Noise model rail infrastructure corrections

Track feature and infrastructure	Modelling correction for wheel-rail contribution, dBA	
	SEL	**L_{Amax}**
Ballasted concrete rail bridges	0	0
Turnouts	+6	+6
At-grade active level crossings with the road network	+3	+3
Tight radius curves (≥300 and <500 m radius)	+3	+3
Tight radius curves (<300 m)	+3	+8

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 level crossings included noise sources of approaching train horns during each train passby. Two train horn source emissions were considered, one train horn source located 100 m either side of the crossing to account for trains approaching from either direction. In addition, at each active level crossing the noise sources included a single alarm bell. 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 receivers, 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 22**. The noise levels were referenced from SLR's measurement of representative events on existing freight corridors.

Table 22 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.

6.3.8 Train movements within the crossing loop

For the purpose of assessment, it has been assumed that approximately one in four trains per daytime or night-time period would access the 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 23**.

Table 23 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	5	5	5	5
Year 2040	5	6	5	6

Note The number of trains accessing the crossing loop is based on the daily rail operations for the main line track adjacent to the loop.

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

At the 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 can result 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 noise emission height of 4 m above the residual ground level. The idling of locomotive engines is a steady-state continuous noise emission and 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 the crossing loop.

The source noise emission levels for rolling noise, including potential wagon bunching, were referenced from the measurement of the train movements on existing rail networks. 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 noise emission height of 1.0 m above residual ground level was adopted for the bunching noise sources.

The noise prediction modelling applied the ISO 9613-2 prediction methodology and each idling locomotive and bunching noise event was modelled as individual point noise sources. The bunching sources were modelled at approximately 300 m intervals to anticipate the potential for such events along the length of the train. The source noise emissions for the idling trains and wagons bunching are detailed in **Table 24**.

Table 24 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 railway noise levels – Proposal opening 2026

7.1 Overview

The predicted daytime and night-time railway noise levels for the commencement of railway operations on the Proposal 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 loop and the alarm bells and train horn events at the level crossings.

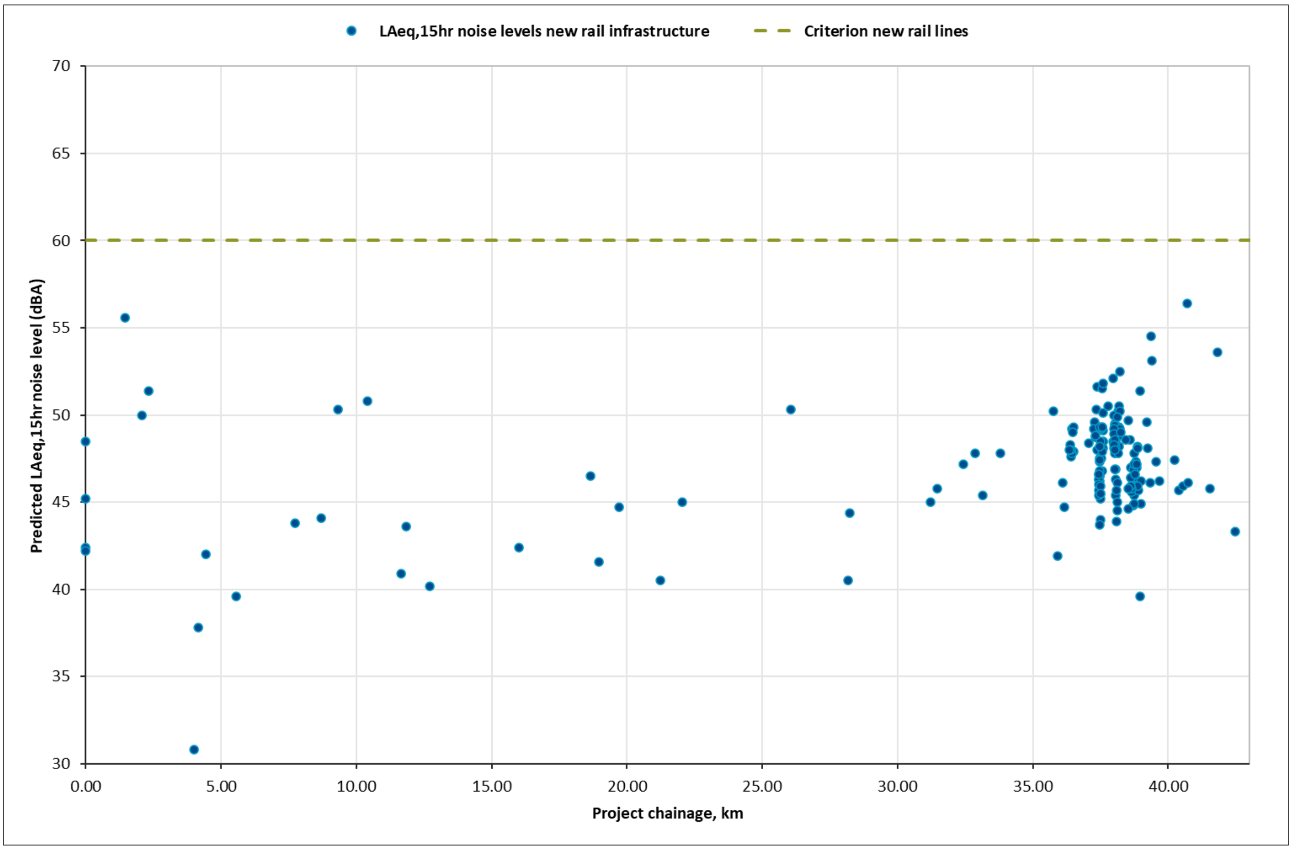
The assessment of daytime, night-time and maximum railway noise levels is discussed in the following sections. The predicted noise levels have been assessed against the adopted railway noise criteria to evaluate the potential noise impact of the Proposal and identify where noise mitigation options are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

7.2 Railway noise levels at residential receivers

7.2.1 Daytime railway noise levels

The predicted daytime $L_{Aeq(15hour)}$ railway noise levels are detailed in **Figure 7**. At all identified residential sensitive receivers the noise levels meet the $L_{Aeq(15hour)}$ 60 dBA noise criterion. Analysis of the modelling railway noise levels determined the train movements on the main track were the primary source of the railway noise.

Figure 7 Predicted daytime $L_{Aeq(15hour)}$ railway noise levels (year 2026)



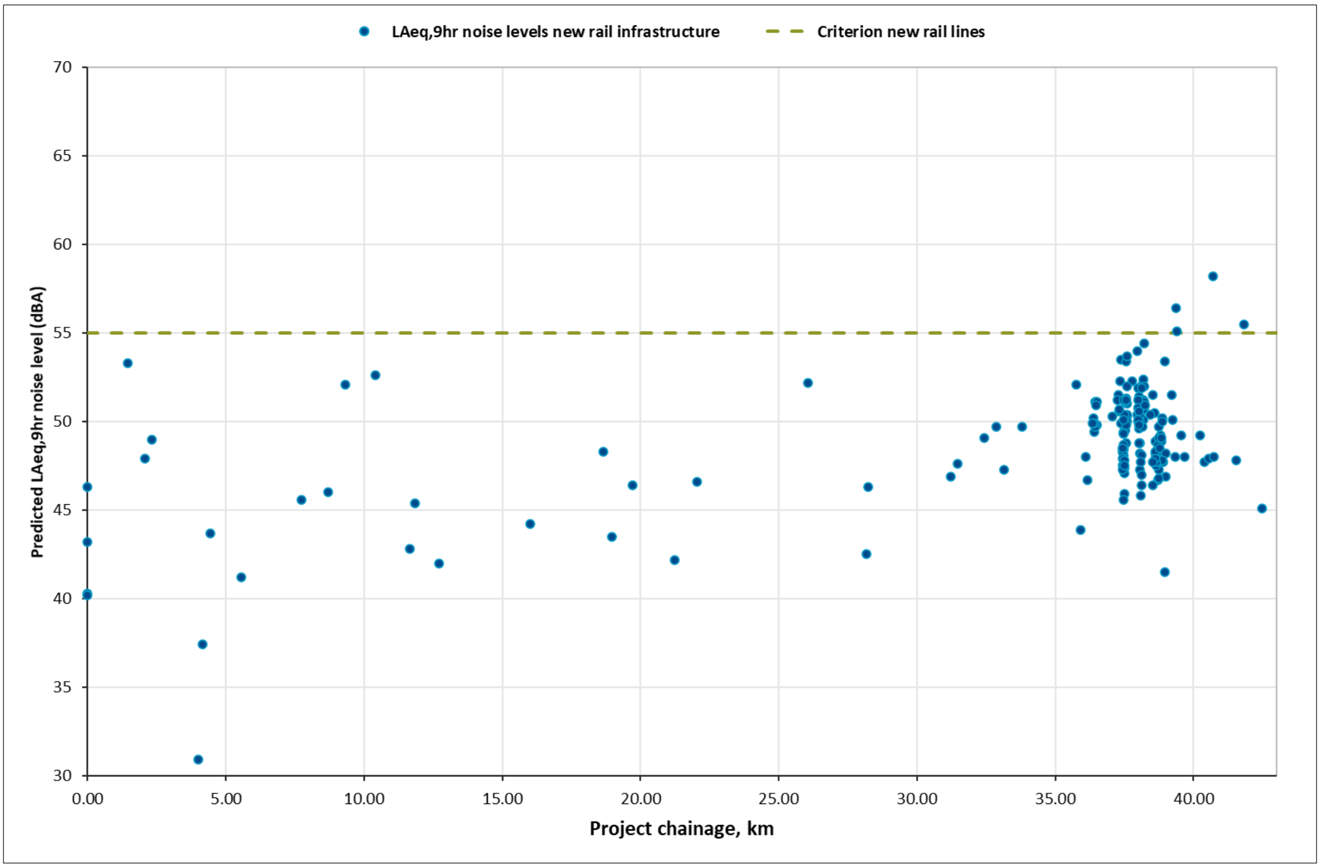
Note Some receivers are in the same location and the markers in the above scatter plot represent more than one receiver.

7.2.2 Night-time railway noise levels

The predicted $L_{Aeq(9hour)}$ night-time railway noise levels are detailed in **Figure 8**.

At all but three residential sensitive receivers the noise levels meet the $L_{Aeq(9hour)}$ 55 dBA noise criterion. The predicted noise levels at the three residential receivers are up to 3 dBA above the $L_{Aeq(9hour)}$ 55 dBA noise criterion. The train movements on the main track were the primary source of the railway noise.

Figure 8 Predicted night-time $L_{Aeq(9hour)}$ railway noise levels (year 2026)



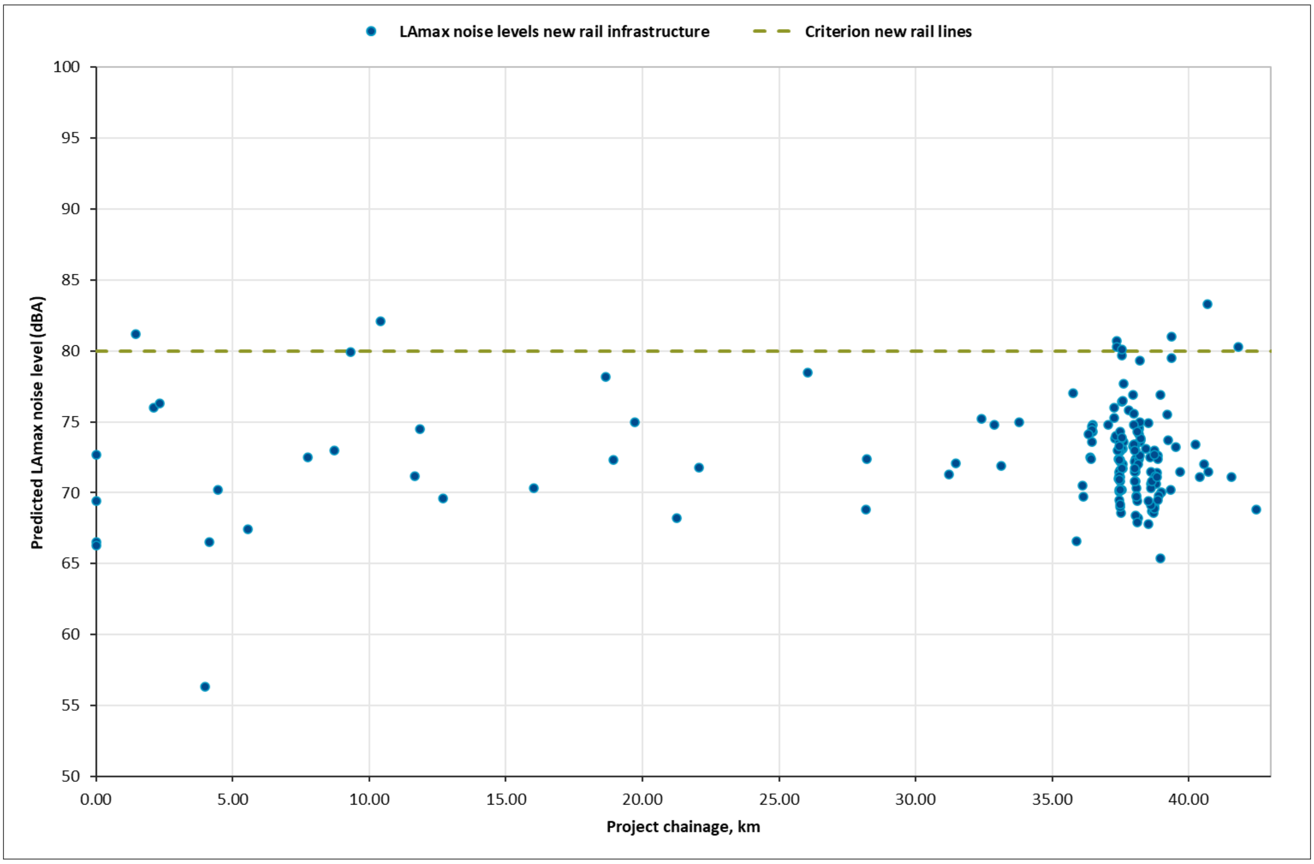
Note Some receivers are in the same location and the markers in the above scatter plot represent more than one receiver.

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 the crossing loop. 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 9**.

Figure 9 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 LAmax 80 dBA noise criterion is met at the majority of the residential receivers. The predicted noise levels are above the noise criterion at five residential receivers. At the five receivers the noise levels are above the criterion by not more than 3 dBA.

At the five receivers where the predicted noise levels are above the LAmax criterion, the railway noise levels are primarily influenced by the rail traffic on the main track.

7.3 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. 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 25**.

Table 25 Predicted noise levels at non-residential receivers (year 2026)

Sensitive receiver	LAeq(1hr) noise levels Year 2026, dBA			
	Daytime		Night-time	
	Outside	Inside	Outside	Inside
Sensitive receivers (other than individual residences)				
Stockinbingal Public School	48	41	50	43
St. James' Anglican Church	47	40	49	42
St. Joseph's Catholic Church	49	42	51	44

The assessment has assumed that the three premises would not be in use during the night-time period 10.00 pm to 7.00 am. On this basis, the $L_{Aeq(1hour)}$ 40 dBA noise criterion is predicted to be achieved at St. James' Anglican Church.

Potential internal noise levels are a marginal 1 and 2 dBA above the internal noise criterion at Stockinbingal Public School and St. Joseph's Catholic Church respectively. This is contingent on the difference between the outdoor and indoor noise levels being 7 dBA. Where the building structure can reduce the intrusion of outdoor railway noise by 9 dBA or more, the estimated internal noise level would achieve the noise criterion. Detailed investigations in accordance with the RING is recommended during the detailed design to determine compliance at these locations.

Outdoor active and passive recreational spaces associated with these identified receivers are predicted to be below the investigation thresholds, and hence do not require any further considerations for mitigation.

Based on the separation distance between these receivers and the Proposal, and the conservatism applied to estimate the indoor noise, it is expected that railway noise mitigation measures may not be required for these properties.

8 Airborne railway noise levels – Design year 2040

8.1 Overview

The predicted daytime and night-time railway noise levels for the railway operations on the Proposal in year 2040 are detailed in **Appendix E**. The railway noise levels include the combined effect of the train passbys, train operations on the crossing loop and the alarm bells and train horn events at the level crossings.

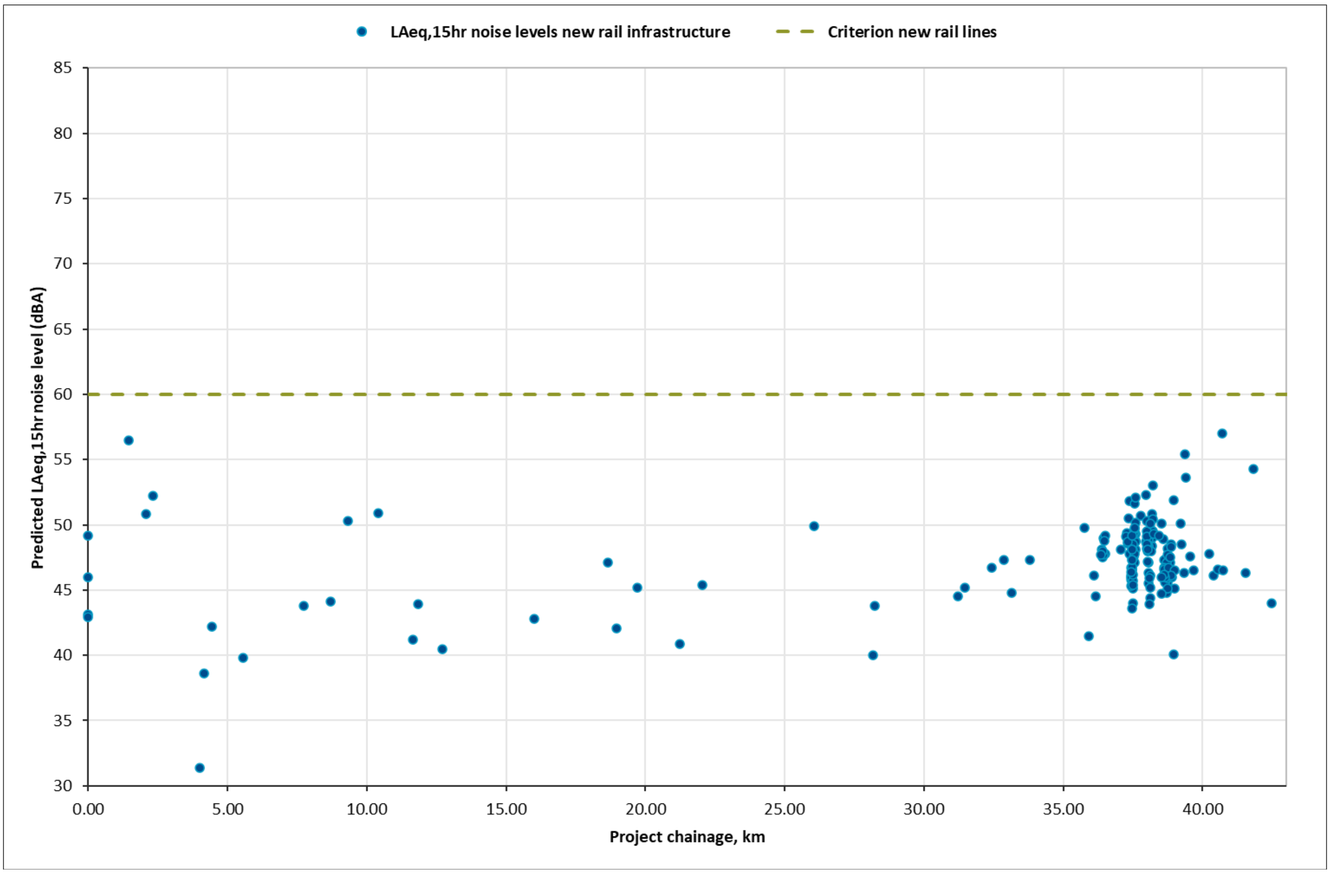
The assessment of daytime, night-time and maximum railway noise levels is discussed in the following sections. The predicted noise levels have been assessed against the adopted railway noise criteria to evaluate the potential noise impact of the Proposal and identify where noise mitigation options are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

8.2 Railway noise levels at residential receivers

8.2.1 Daytime railway noise levels

The predicted daytime $L_{Aeq(15hour)}$ railway noise levels are detailed in **Figure 10**. The noise levels at all identified residential sensitive receivers the noise levels meet the $L_{Aeq(15hour)}$ 60 dBA noise criterion.

Figure 10 Predicted daytime $L_{Aeq(15hour)}$ railway noise levels (year 2040)



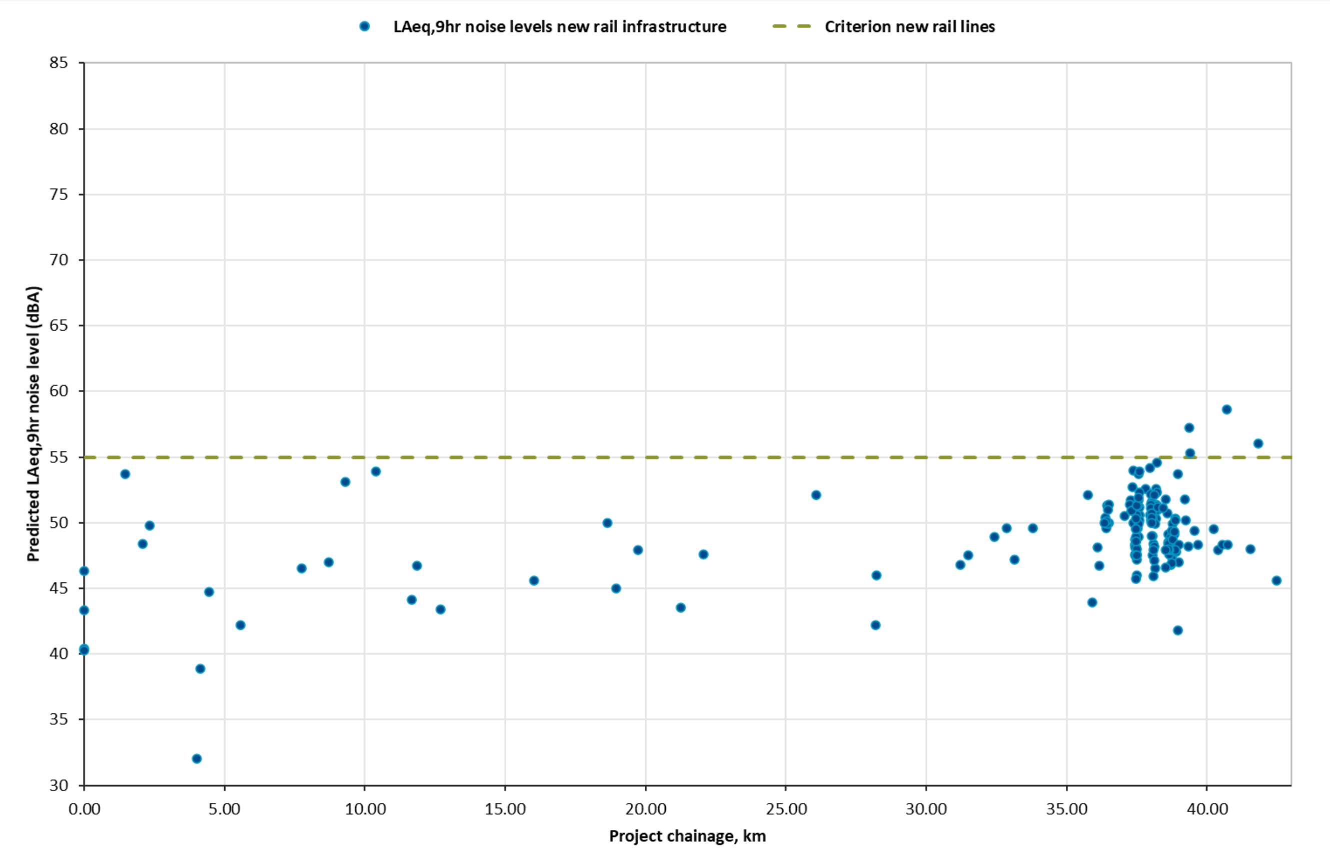
Note Some receivers are in the same location and the markers in the above scatter plot represent more than one receiver.

8.2.2 Night-time railway noise levels

The predicted $L_{Aeq(9hour)}$ night-time railway noise levels are detailed in **Figure 11**. The noise levels meet the $L_{Aeq(9hour)}$ 55 dBA noise criterion at the major of residential receivers, with noise levels above the criterion at three identified residences.

The predicted noise levels at three residential receivers are up to 4 dBA above the $L_{Aeq(9hour)}$ 55 dBA noise criterion.

Figure 11 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.

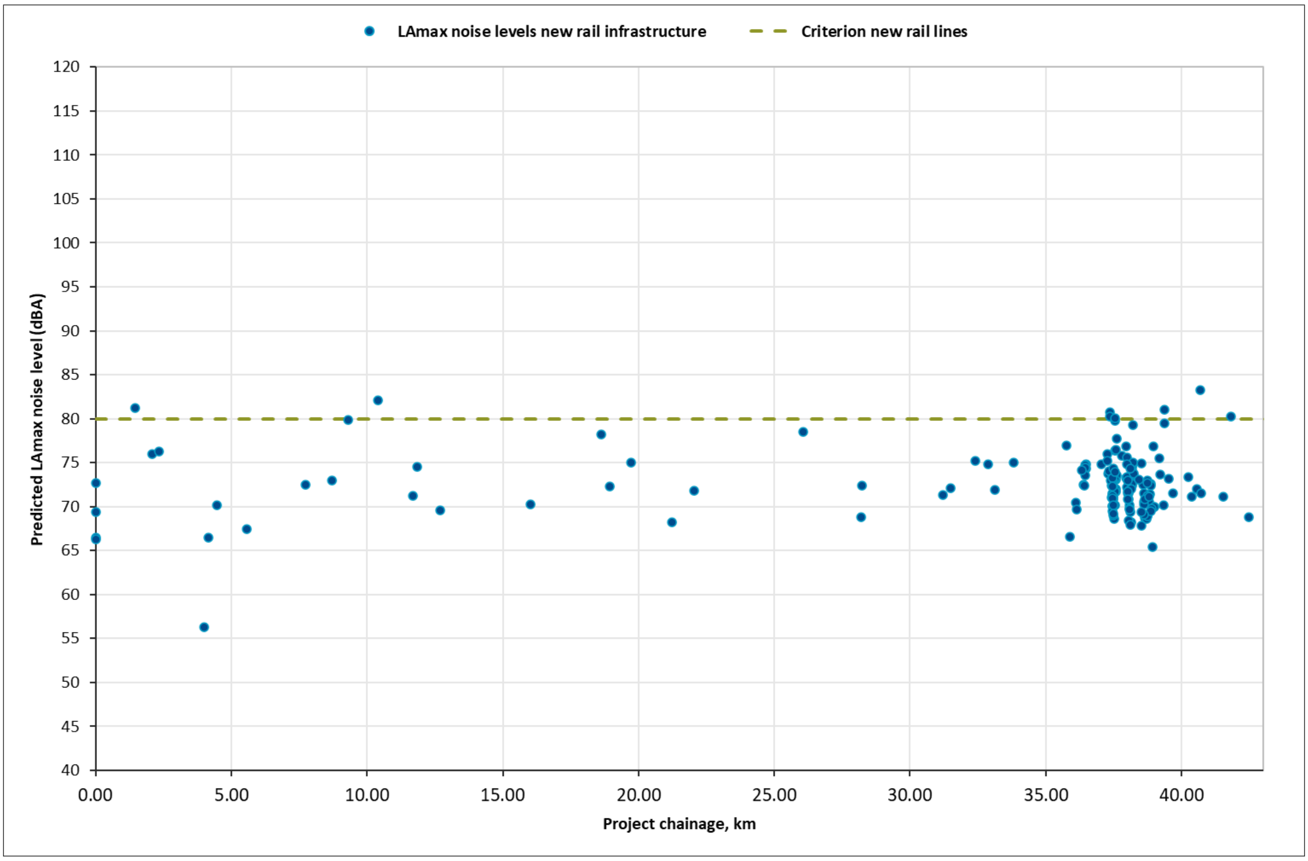
8.2.3 Daytime and night-time maximum railway noise levels

The 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 12**.

The L_{Amax} 80 dBA noise criterion is met at the majority of the residential receivers. The predicted noise levels are above the noise criterion at five residential receivers by not more than 3 dBA.

Figure 12 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.

8.3 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. 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 railway noise levels at the non-residential sensitive receivers is detailed in **Table 26**.

Table 26 Predicted noise levels at non-residential receivers (year 2040)

Sensitive receiver	$L_{Aeq(1hr)}$ noise levels Year 2040, dBA			
	Daytime		**Night-time**	
	Outside	**Inside**	**Outside**	**Inside**
Sensitive receivers (other than individual residences)				
Stockinbingal Public School	48	41	50	43
St. James' Anglican Church	47	40	49	42
St. Joseph's Catholic Church	49	42	51	44

The assessment has assumed that the three premises would not be in use during the night-time period 10.00 pm to 7.00 am. On this basis, the $L_{Aeq(1hour)}$ 40 dBA noise criterion is predicted to be achieved at St. James' Anglican Church.

Potential internal noise levels are a marginal 1 and 2 dBA above the internal noise criterion at Stockinbingal Public School and St. Joseph's Catholic Church respectively. This is contingent on the difference between the outdoor and indoor noise levels being 7 dBA. Where the building structure can reduce the intrusion of outdoor railway noise by 9 dBA or more, the estimated internal noise level would achieve the noise criterion. Detailed investigations in accordance with the RING is recommended during the detailed design to determine compliance at these locations.

Outdoor active and passive recreational spaces associated with these identified receivers are predicted to be below the investigation thresholds, and hence do not require any further considerations for mitigation.

As discussed in **Section 7.3**, railway line railway noise mitigation is not expected to be required for these properties.

9 Summary of the railway noise assessment

9.1 Receivers triggering the investigation of noise mitigation

The review of noise mitigation is triggered at six individual residential receivers for the commencement of railway operations in 2026, and the same residential receivers for the design year 2040. The noise levels at the Stockinbingal Public School and St. Joseph's Catholic Church may marginally trigger the noise criterion for schools and places of worship respectively.

The predicted railway noise levels in year 2040 for the eight sensitive receivers triggering the assessment criteria are detailed in **Table 27** and **Figure 13** . Noise levels above the criteria are highlighted in bold. The investigation of mitigation was most frequently triggered by the night-time $L_{Aeq(9hour)}$ 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.

Table 27 Summary of triggers for the review of noise mitigation (year 2040)

SLR ID	Railway noise levels, dBA			Level crossing noise levels, dBA			Overall railway noise levels, dBA		
	LAeq(15hr)	LAeq(9hr)	LAmax	LAeq(15hr)	LAeq(9hr)	LAmax	LAeq(15hr)	LAeq(9hr)	LAmax
226614	57	54	**81**	37	30	63	57	54	**81**
226702	51	54	**82**	34	34	70	51	54	**82**
226994	57	**59**	**83**	41	43	72	57	**59**	**83**
227003	54	**56**	80	27	29	58	54	**56**	80
318977	51	53	**81**	33	35	64	51	53	**81**
321487	54	**56**	**81**	49	51	80	55	**57**	**81**
School[1]	**48**	50	71	30	32	60	**48**	50	71
Church[2]	**49**	51	72	31	33	61	**49**	51	72

Note 1 Stockinbingal Public School has daytime only use – The internal noise levels trigger the LAeq rail noise assessment criterion.

Note 2 St. Joseph's Catholic Church in Stockinbingal, has daytime only use – The internal noise levels trigger the LAeq rail noise assessment criterion.

9.2 Operation of level crossings

Whilst the level crossings and train horns are a potential source of noise in the local environment, the daytime and night-time noise emissions from the level crossings met the noise criteria at all sensitive receivers. The railway noise levels at most sensitive receivers were determined by the train movements on the main line track.

The noise from the level crossings, particularly the train horns, have the potential to be audible at sensitive receivers and recommendations have been provided in this report to assist the management of noise associated with the level crossings.

ILLABO TO STOCKINBINGAL

Sensitive Receivers Triggering the Investigation of Noise Mitigation

Figure 13 - Map 1 of 6

100 m

Coordinate System: GDA 1994 MGA Zone 55

Rail Alignment/Centreline

Sensitive Receivers

Paper: A4 Scale: 1:5,000
Date: 01-Nov-2021
Author: JG

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ILLABO TO STOCKINBINGAL

Sensitive Receivers Triggering the Investigation of Noise Mitigation

Figure 13 - Map 2 of 6

100 m

Coordinate System: GDA 1994 MGA Zone 55

Crossing Loops

Rail

Sensitive Receivers

Paper: A4 Scale: 1:5,000
Date: 01-Nov-2021
Author: JG

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ILLABO TO STOCKINBINGAL

Sensitive Receivers Triggering the Investigation of Noise Mitigation

Figure 13 - Map 3 of 6

100 m

Coordinate System: GDA 1994 MGA Zone 55

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Rail

Sensitive Receivers

Non-residential Sensitive Receivers

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ILLABO TO STOCKINBINGAL

Sensitive Receivers Triggering the Investigation of Noise Mitigation

Figure 13 - Map 4 of 6

100 m

Coordinate System: GDA 1994 MGA Zone 55

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Level Crossings
Rail Alignment/Centreline
Sensitive Receivers

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ILLABO TO STOCKINBINGAL

Sensitive Receivers Triggering the Investigation of Noise Mitigation

Figure 13 - Map 5 of 6

100 m

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Rail

Sensitive Receivers

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ILLABO TO STOCKINBINGAL

Sensitive Receivers Triggering the Investigation of Noise Mitigation

Figure 13 - Map 6 of 6

100 m

Coordinate System: GDA 1994 MGA Zone 55

Rail

Sensitive Receivers

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9.3 Trains accessing the crossing loop

The assessment of L_{Aeq} and L_{Amax} railway noise levels in the previous sections included the contribution of railway operations at the crossing loop. A review of the predicted noise levels at the nearest sensitive receivers determined the noise level contribution from the crossing loop was up to $L_{Aeq(15hour)}$ 40 dBA daytime, $L_{Aeq(9hour)}$ 40 dBA night-time and L_{Amax} 41 dBA for both the daytime and night-time periods.

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

9.4 Potential for sleep disturbance

The night-time L_{Amax} (maximum) rail noise assessment criteria have been adopted by ARTC across Inland Rail to 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 assessment criteria account for the highest level of noise during train passbys and the number of passby events in the night-time.

The assessment of railway noise determined the conservative L_{Amax} noise assessment criteria for new railways were met at the majority of sensitive receivers. There were up to five sensitive receivers where the predicted noise levels were above the L_{Amax} noise assessment criteria by up to 3 dBA within the night-time period. The noise predictions identified the L_{Amax} noise management criteria was generally met where receivers were further than 500 m from the rail alignment.

Railway noise has the potential to be audible at sensitive receivers, 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 (2009)[8] recommends that internal (indoor) noise levels are not above L_{Amax} 42 dBA to preserve sleep quality. The WHO guideline 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.

Further advice from the WHO also acknowledges the establishment of relationships between single event noise indicators, such as L_{Amax}, and long-term health outcomes remains tentative. In this regard, the new Environmental Noise Guidelines for European Region (2018) do not recommend specific L_{Amax} levels for rail noise emissions.

Note that individuals will respond to noise differently, and just because railway noise can be audible does not mean it will cause disturbance or annoyance impacts. Where sensitive residential land uses are proposed to be developed within the study area, it would also 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.

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

9.5 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 effect 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 over large distances.

The potential for railway noise at individual sensitive receivers to be influenced by the 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 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. The ISO methodology applied for the calculation of noise levels from the crossing loop and level crossings included an allowance for downwind noise enhancing weather conditions and/or moderate temperature inversions.

9.6 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 14**.

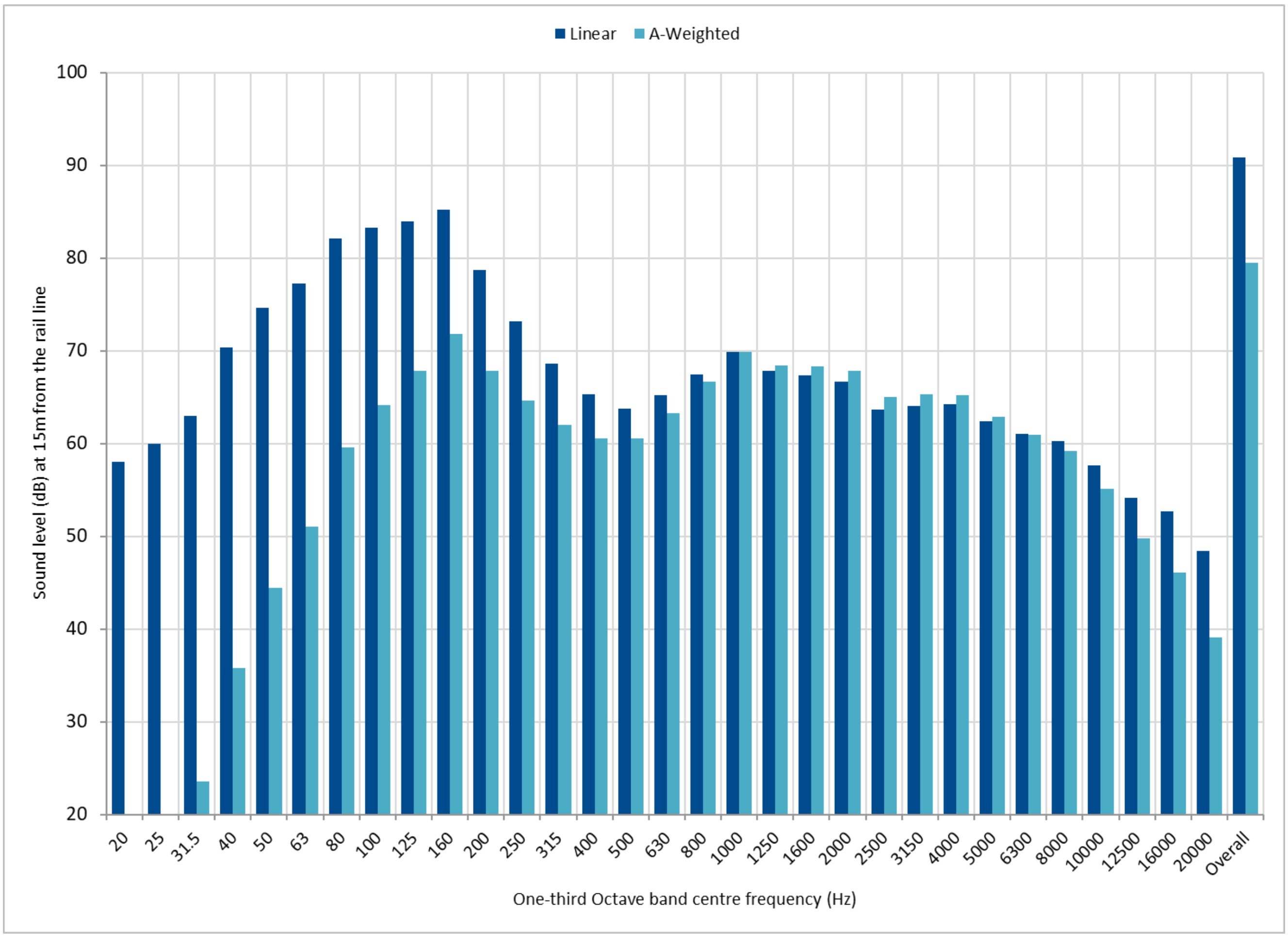
The noise spectrum was derived from measurement of noise levels of 149 rail freight movements from existing rail lines on Inland Rail. The noise levels were measured at 15 m from the single rail line where trains were operating at approximately 60 km/h.

The typical train passby spectra identifies there is a prominent contribution of noise in the low frequency range between 80 Hertz (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.

Where locomotives noise emissions have a low frequency noise content in proximity to the rail line (200 m for example) 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 14 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 (Kilde 130) 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 is reasonable to assume that where railway noise would be clearly audible above the ambient noise environment there may 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 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 EIS stage.
- 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 of such events adjacent to the main track, the event would not be expected to influence the railway 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 Proposal includes a relatively short section of a tight-radius curve where the Proposal ties into the existing rail corridors. Corrections for potential curving noise were included in the noise prediction modelling at these locations. The noise modelling identified the noise criteria were not triggered as a result of curving noise.
- 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 designed for freight rail 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.

10 Assessment of ground-borne vibration

10.1 Approach

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

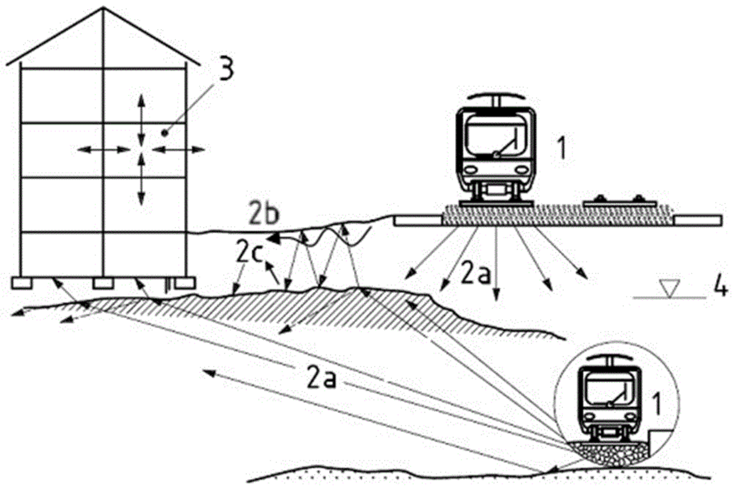
- **Scoping Model** at the very earliest stages.
- **Environmental Assessment Model** during planning process and preliminary design.
- **Detailed Design Model** to finalise extent and form of mitigation for construction.

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 15**. 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.

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

Figure 15 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.

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.

The assessment referenced measured rail vibration levels from existing freight services on rail corridors that will form part of Inland Rail in NSW and Victoria. The source vibration data referenced in this assessment is provided in **Appendix B**.

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.

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

The bridge 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. On this basis, further assessment of rail induced vibration at the bridges is not considered to be required.

10.2 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').

10.2.1 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 28**.

Table 28 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	10 m (14 trains)	12 m (7 trains)	None
2040 design year	10 m (17 trains)	13 m (9 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).

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.

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.

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

- The Proposal will require condition surveys of buildings and structures in the vicinity of the alignment and that any excavations would be carried out prior to final 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 out to confirm vibration levels remain below appropriate limits for that structure.
- For heritage items, any detailed assessment would determine any specific sensitivities in consultation with relevant specialists to ensure risks are adequately managed.
- If a heritage building or structure is found to be structurally unsound (following inspection), a more conservative cosmetic damage objective (for example 2.5 mm/s peak component particle velocity for long term vibration from DIN 4150.3) would be considered.

Based on the reference ground-borne vibration velocity for a freight train passby (**Appendix B**), 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 co-locating within an existing corridor that is primarily used by coal and freight trains; and,
- ground-borne vibration levels may still be within guideline values at closer distances, depending on local factors and the spectral nature of criteria used to estimate cosmetic damage risk.

The screening assessment of vibration impacts at the sites of potential non-indigenous heritage significance (areas of interest) is provided in **Table 29**. On this basis, structural impacts due to railway induced vibration are not expected with the proposal.

The Billabong Creek Rail Underbridge is located within the rail corridor, it is recommended a review of the structures sensitivity to rail induced vibration is undertaken during detailed design if this structure is confirmed to be within 15 m of the nearest outer rail.

Table 29 Assessment of vibration impacts on listed and potential heritage items

Site ID[1]	Site name	Approximate distance to the Proposal	Assessment outcome
Cootamundra LEP (i75)	Baker, William Fallon	380 m	No impact
Cootamundra LEP (i73)	Bank of NSW and Residence, Former	490 m	No impact
Cootamundra LEP (i71)	Cohen's Trade Palace, CWA Rooms	400 m	No impact
Cootamundra LEP (i82)	Ellwood's Hall	475 m	No impact
Cootamundra LEP (i72)	Federation Period Shop	430 m	No impact
Cootamundra LEP (i65)	Public School - Original Buildings	>1 km	No impact
Cootamundra LEP (i83)	Soldiers War Memorial Hospital	>1 km	No impact
Cootamundra LEP (i68)	St. Ita's Convent	>1 km	No impact

Site ID[1]	Site name	Approximate distance to the Proposal	Assessment outcome
Cootamundra LEP (i69)	St. Ita's Convent School	>1 km	No impact
Cootamundra LEP (i76)	Stock and Station Agent (Powder Horn Museum)	235 m	No impact
Cootamundra LEP (i70)	Stockinbingal Cemetery	>1 km	No impact
Cootamundra LEP (C3)	Stockinbingal Conservation Area	25 m	No impact
Cootamundra LEP (i80)	Stockinbingal Court House	>1 km	No impact
Cootamundra LEP (i81)	Stockinbingal Hotel (Former)	>500 m	No impact
Cootamundra LEP (i79)	Stockinbingal Police Residence	>500 m	No impact
Cootamundra LEP (i66)	Stockinbingal Post Office and Residence	490 m	No impact
Cootamundra LEP (i78)	Stockinbingal Railway Station	270 m	No impact
Cootamundra LEP (i77)	Kurrajong Trees	80 m	No impact
-	Billabong Creek Rail Underbridge	Within the rail corridor	Review during design

11 Assessment of ground-borne noise

11.1 Overview

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, referred to here as ground borne noise or regenerated noise. The potential for ground-borne noise is highly dependent on the arrangement, construction, and condition of a property.

The specific building types and construction details of the sensitive receivers are not known and could have substantial variations in rural areas. To conservatively estimate the ground-borne noise levels at sensitive receivers, the assessment 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 10**.

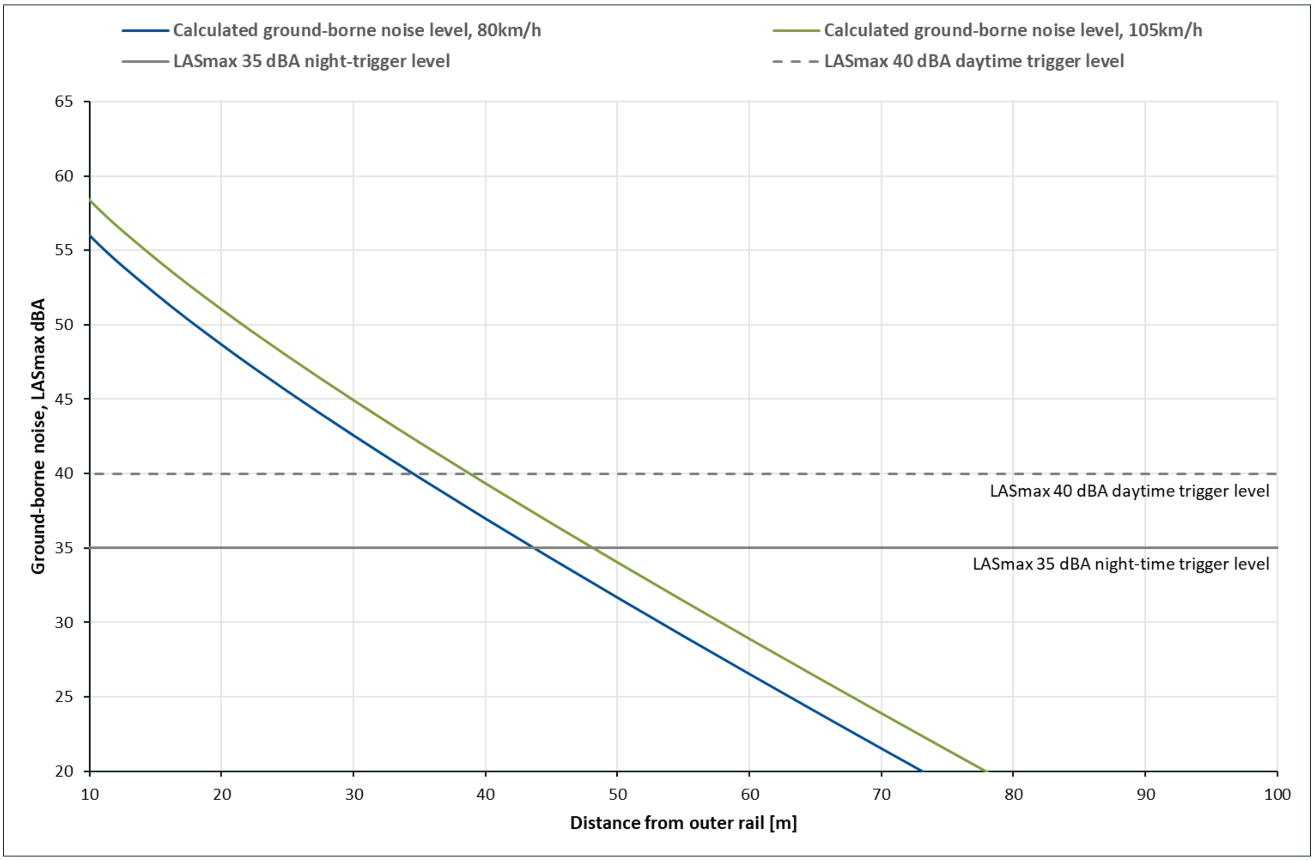
[11] Acoustics and Noise Consultants, Guideline "Measurement & Assessment of Groundborne Noise & Vibration", 2nd Edition 2012.

11.2 Ground-borne noise from train passbys

11.2.1 Assessment approach

The calculated ground-borne noise levels in decibels, at increasing distance from the outer rail, are detailed in **Figure 16**. The ground-borne noise levels are presented for a train speed of up to 105 km/h. Calculated ground-borne noise levels at a distance of greater than 50 m from the outer rail are less than or equal to the L_{ASmax} 40 dBA daytime and L_{ASmax} 35 dBA night-time ground-borne noise assessment criteria.

Figure 16 Calculated ground-borne noise levels from train passbys



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

All identified sensitive receivers are further than 50 m from the track and the ground-borne noise criteria are likely to be met at these receivers.

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 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.

12 Cumulative impacts

On Inland Rail the Proposal directly links to the Albury to Illabo project section to the south and the Stockinbingal to Parkes project section to the north. At the sensitive receivers within the study 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 sections of Inland Rail 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.

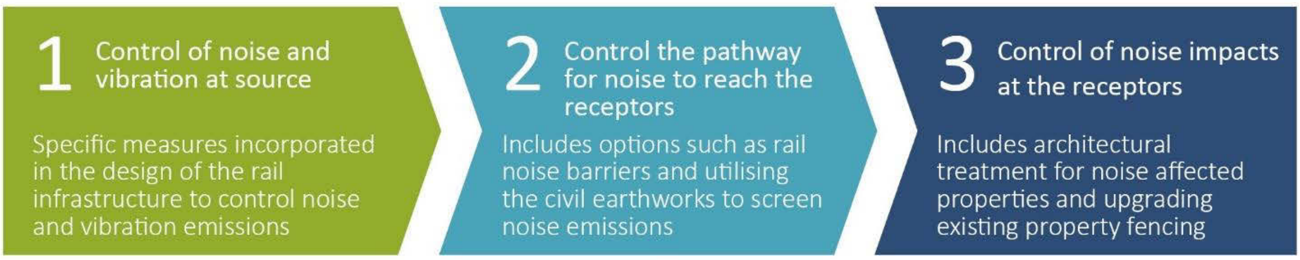
The proposal shall connect or intersect with existing rail lines and given the relatively low utilisation and seasonal rail traffic on the other rail lines the Inland Rail operations are expected to the be the primary (dominant) source of railway noise.

13 Recommendations

13.1 Reasonable and feasible 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 17**.

Figure 17 Hierarchy of noise and vibration mitigation measures



Determination of reasonable and feasible measures are guided by the RING. In addition to it, on Inland Rail, ARTC is applying the following strategy as the basis for selecting reasonable and feasible noise mitigation:

- Noise barriers are generally only considered where groups of triggered sensitive receivers are apparent. For isolated sensitive receivers, such as single dwellings in rural areas, 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 'reasonable' and 'feasible', with respect to noise mitigation, are outlined below in **Table 30**.

Table 30 Evaluation of reasonable and feasible for noise mitigation

<table>
<tr><th>Term</th><th colspan="2">Description</th></tr>
<tr><td>Feasible</td><td colspan="2">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.</td></tr>
<tr><td rowspan="7">Reasonable</td><td colspan="2">When determining if mitigation is reasonable, the following factors should be considered:</td></tr>
<tr><td>Safety</td><td>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.</td></tr>
<tr><td>Noise impacts</td><td>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.</td></tr>
<tr><td>Noise mitigation benefits</td><td>The noise reduction performance achieved by the mitigation is reviewed, along with the perceptible change in noise level that could be experienced.</td></tr>
<tr><td>Community views</td><td>The views of landowners and the community should be consulted and options that have support from the affected community should be considered.</td></tr>
<tr><td>State government requirements</td><td>Consider any State specific requirements for what constitutes reasonable or feasible.</td></tr>
<tr><td>Cost</td><td>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.</td></tr>
</table>

13.2 Noise and vibration mitigation options

A review of potential reasonable and feasible mitigation options to reduce and control noise and/ or vibration levels, and related impacts at sensitive receivers is provided in **Table 31**.

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 studies to verify the outcomes of this assessment.

The mitigation measures are specific to the sources of noise and vibration and the detailed design may determine a combination of options would be implemented to provide the reasonable and feasible control of the noise and vibration, targeted to achieving the assessment criteria and minimising potential impacts.

Table 31 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 considers noise walls or barriers where the mitigation can effectively control noise at groups of sensitive land uses and receiver buildings and where noise level reductions are clearly noticeable.
		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 feasible 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 sound 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, 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 ≤ 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 the compliance to the 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 at the rail corridor boundary 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 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 mounds 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 that 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 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 the movement of surface water.
	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 provide modest capability for 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 highly susceptible to prominent or regular wear, would be most suited for the consideration of rail dampers.

Noise source	Aspect	Commentary
	Top of Rail Friction Modifiers (TORFM)	The TORFM and gauge face lubricators would assist in reducing wheel-rail squeal and rolling noise within the curved sections. The track conditions have to be regularly monitored at curved sections and the TORFM can be adequately implemented on a regular basis, or as needed. Note that these friction modifiers are not found to be effective on straight sections of track.
Locomotives and engine shrouds	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, and necessary management and funding to implement these measures.
Maintenance	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 of noise for the 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. This measure is not readily implementable by ARTC without appropriate commitments, management and funding from rail operators. 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.
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 noise impacts.
	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 sound 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 two train horn events every hour with the Proposal.

Noise source	Aspect	Commentary
	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 are to 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 feasible, 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.
	Turning off audible alarms at night	Subject to appropriate review of safety and operational requirements, the audible alarms on level crossings could potentially be turned off during the night-time period, for example between 10.00 pm to 7.00 am.
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	The age and construction of residential properties can influence the practical implementation of modern architectural treatments. The review of architectural treatments will require further review of eligible properties and advice from suitably qualified professionals.
	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 and 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 be reduced by approximately 3 dB to 6 dB .

Noise source	Aspect	Commentary
	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 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 identified.
Property controls	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.
	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.

13.3 Summary of noise mitigation

The noise assessment identified railway noise levels triggered the review of noise mitigation at up to six residential receivers at Proposal opening (2026), with no additional residential receivers triggering the criteria at the design year 2040.

The residential receivers where noise levels trigger a review of noise mitigation are isolated and individual properties. It is likely that at-property treatment shall be the approach to mitigate potential railway noise impacts rather than other physical measures to control railway noise, such as noise barriers. A review of the noise mitigation triggers is provided in **Table 32**.

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

Table 32 Summary of residential noise mitigation triggers

Assessment criteria margin	Sensitive receivers triggering the assessment criteria
Year 2026 – Proposal opening	
1 dBA to 2 dBA	4
>2 dBA to 5 dBA	2
>5 dBA to 10 dBA	0
>10 dBA	0
Total receivers triggering noise mitigation - Proposal opening	**6**
Year 2040 – design year	
1 dBA to 2 dBA	4
>2 dBA to 5 dBA	2
>5 dBA to 10 dBA	0
>10 dBA	0
Total receivers triggering noise mitigation - design year	**6 (same receivers triggering in 2026)**

The noise levels at the majority of sensitive receivers are within 3 dBA of the criteria. A 2 dBA 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 margin by which the noise levels are being triggered is considered when evaluating the reasonable and feasible mitigation options for each receiver.

In addition to the residential noise triggers, the noise levels at the St. Joseph's Catholic Church and Stockinbingal Public School in Stockinbingal may be above the internal noise criterion. The assessment has currently assumed a conservative 7 dBA difference between outdoor and indoor railway noise, allowing for windows to be open for ventilation. Where the level difference (outside to inside) is greater than 8 dBA, or where windows are closed, the noise criterion may be achieved. Based on the relatively large separation distance (approximately 250 m for school and 500 m for church), and the conservative assessment of indoor noise, railway noise mitigation may not be required for these non-residential receivers.

Nevertheless, the reasonable and feasible noise mitigation options for these receivers, 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.

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.

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

The assessment identified the potential ground-borne noise and vibration levels would achieve the assessment criteria at the sensitive receivers. Nonetheless, there may still be potential for perceptible ground-borne noise and vibration even where the respective criteria are met. Accordingly, the following recommendations are provided to inform the detailed design of the Proposal.

- The prediction of ground-borne noise and vibration levels from the train movements will need to be assessed during detailed design phase once additional 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. The implementation of such measures to control ground-borne noise from rail freight will need to be investigated further.
- The effectiveness of alternative or supplementary measures, such as under sleeper pads and under ballast matting, may be significantly limited by the stiffness of the track and concrete sleepers, the forces exerted by the heavy rail freight and the long-term durability and maintenance of such measures.

It is recommended that further assessment is undertaken during detailed design to verify the screening assessment outcomes. Where feasible this should include the measurement of existing ground-borne noise and vibration levels from railway operations on the Proposal and the measurement of local ground borne vibration attenuation characteristics.

13.5 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 and can be inherently conservative, it is considered suitable for the assessment of future noise impacts for an EIS.

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 for the detailed designs. 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.

13.6 Validation of noise and vibration levels during operation

A program 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 the Proposal's 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 assessment criteria and relevant conditions of approval.

The recommendations below are provided to assist the development 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.
  - Monitoring locations being 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 and climate 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, reference the monitored noise levels to update and reassess 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 reasonable and feasible mitigation measures.

The results of the monitoring surveys are to be applied, as-required, to revise and update the rail noise and vibration predictions. In this regard, the validated noise and vibration levels can be applied to continually refine the conservatism and uncertainty in the predictions and support the selection of reasonable and feasible mitigation measures.

14 Residual noise and vibration impacts

The rail noise and vibration assessment criteria implemented by ARTC are designed to manage aspects such as environmental harm and nuisance. The intent of the criteria is to identify where reasonable and feasible noise mitigations should be implemented to manage the potential for impacts.

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 reasonable and feasible noise mitigation for the Proposal is expected to 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. The at-property treatments do not address the source emission of rollingstock noise or the 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 this, the at-property treatments would be implemented to reduce the internal railway noise levels to achieve targeted improvements to the indoor acoustic environment of habitable rooms.

In lieu of the known building construction of the sensitive receivers and the acoustic performance specifications of individual at-property treatments, the noise reduction performance is not able to be quantified at this stage. 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 has identified the ground-borne noise and vibration assessment criteria would be met at the majority of sensitive receivers. There is potential for ground-borne noise and vibration to be perceptible even where the assessment criteria are achieved within sensitive receivers. However, disturbance or annoyance impacts would not necessarily be experienced based on the relatively low levels of ground-borne noise and vibration predicted at the sensitive receivers.

15 Conclusions

The operation of the Illabo to Stockinbingal section of Inland Rail has 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 meet the adopted criteria and where the noise and vibration levels trigger an investigation of reasonable and feasible mitigation options.

Based on the assessment of potential noise levels from the daily train movements on the Proposal, the noise criteria for the daytime and night-time periods are met at the majority of the identified sensitive receivers. There are up to six residential receivers where predicted noise levels trigger a review of mitigation.

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

At-property mitigations may 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 and vibration assessments, analysis of engineering and environmental constraints and the verification of noise levels once railway operations commence on the Proposal.

The assessment of vibration from railway operations determined that predicted levels would meet the ground-borne noise and ground-borne vibration criteria at the sensitive receivers.

Where the Proposal meets the noise and vibration criteria there may still be potential for noise and vibration from railway operations to be audible within the environment. It is not uncommon 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 detailed design and construction of the Proposal. It is recommended that the predicted noise and vibration levels and assessment outcomes presented in this report are validated 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 noise and vibration from railway operations.

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TECHNICAL PAPER 9

Operational Noise and Vibration Assessment (Rail) Report

Appendix A Sensitive receivers

ILLABO TO STOCKINBINGAL ENVIRONMENTAL IMPACT STATEMENT

ILLABO TO STOCKINBINGAL

Sensitive Receivers

APPENDIX A - Map 1 of 16

500 m

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- Crossing Loop
- Rail Alignment/Centreline
- Bridges and Viaducts
- Noise Assessment Area
- Sensitive Receivers
- Non-residential Sensitive Receivers

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ILLABO TO STOCKINBINGAL

Sensitive Receivers

APPENDIX A - Map 2 of 16

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ILLABO TO STOCKINBINGAL

Sensitive Receivers

APPENDIX A - Map 3 of 16

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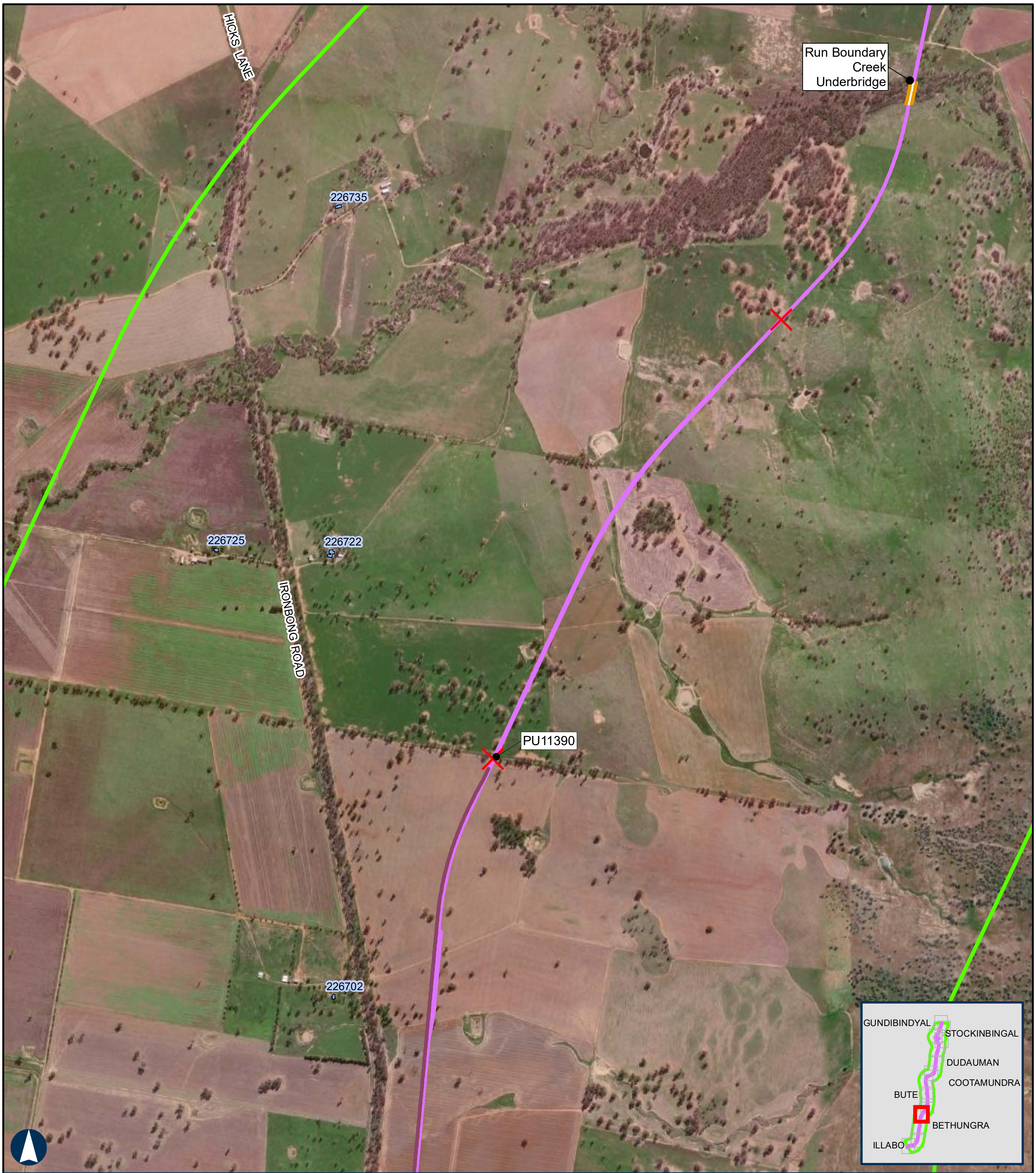

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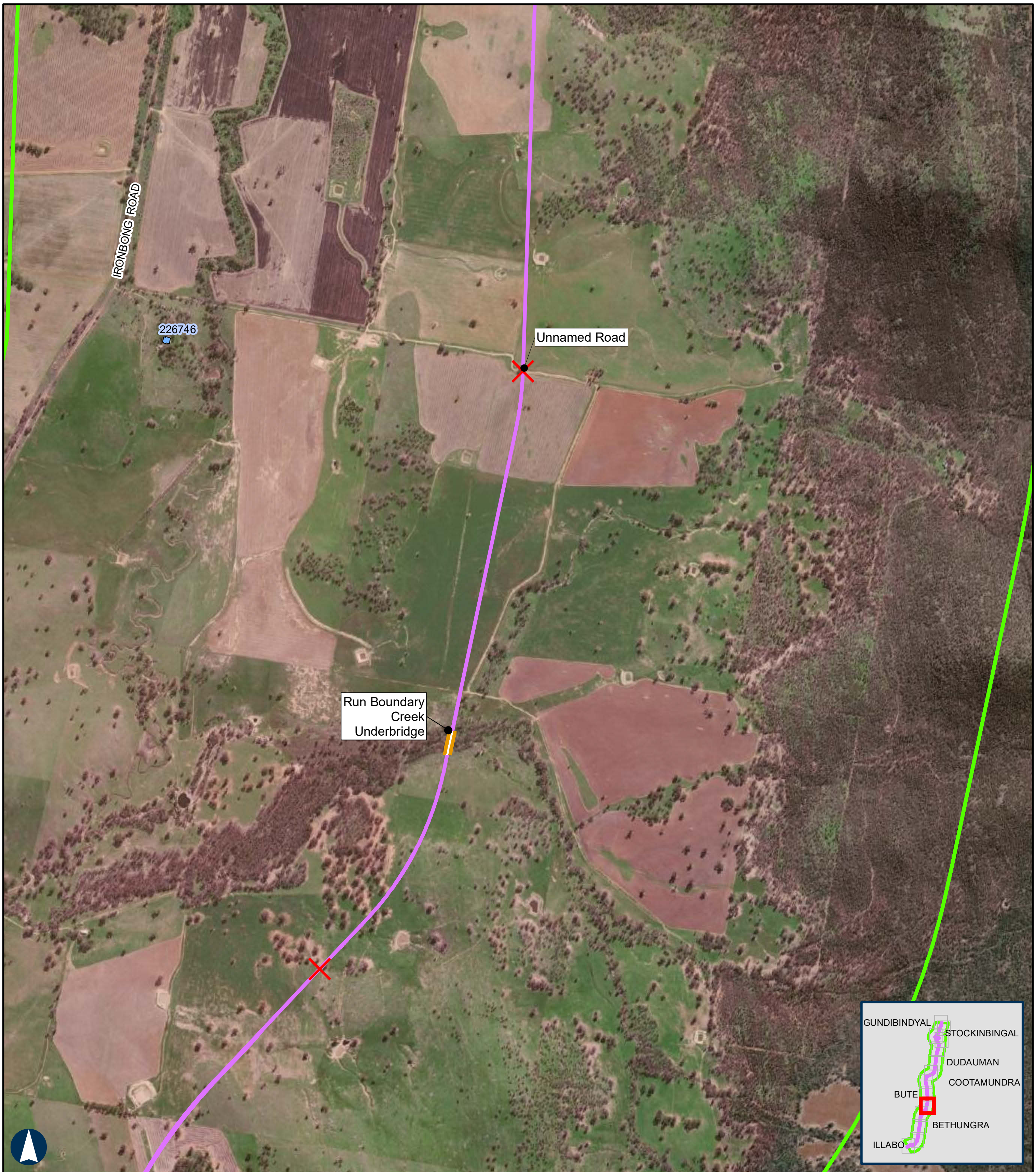

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Sensitive Receivers

APPENDIX A - Map 5 of 16

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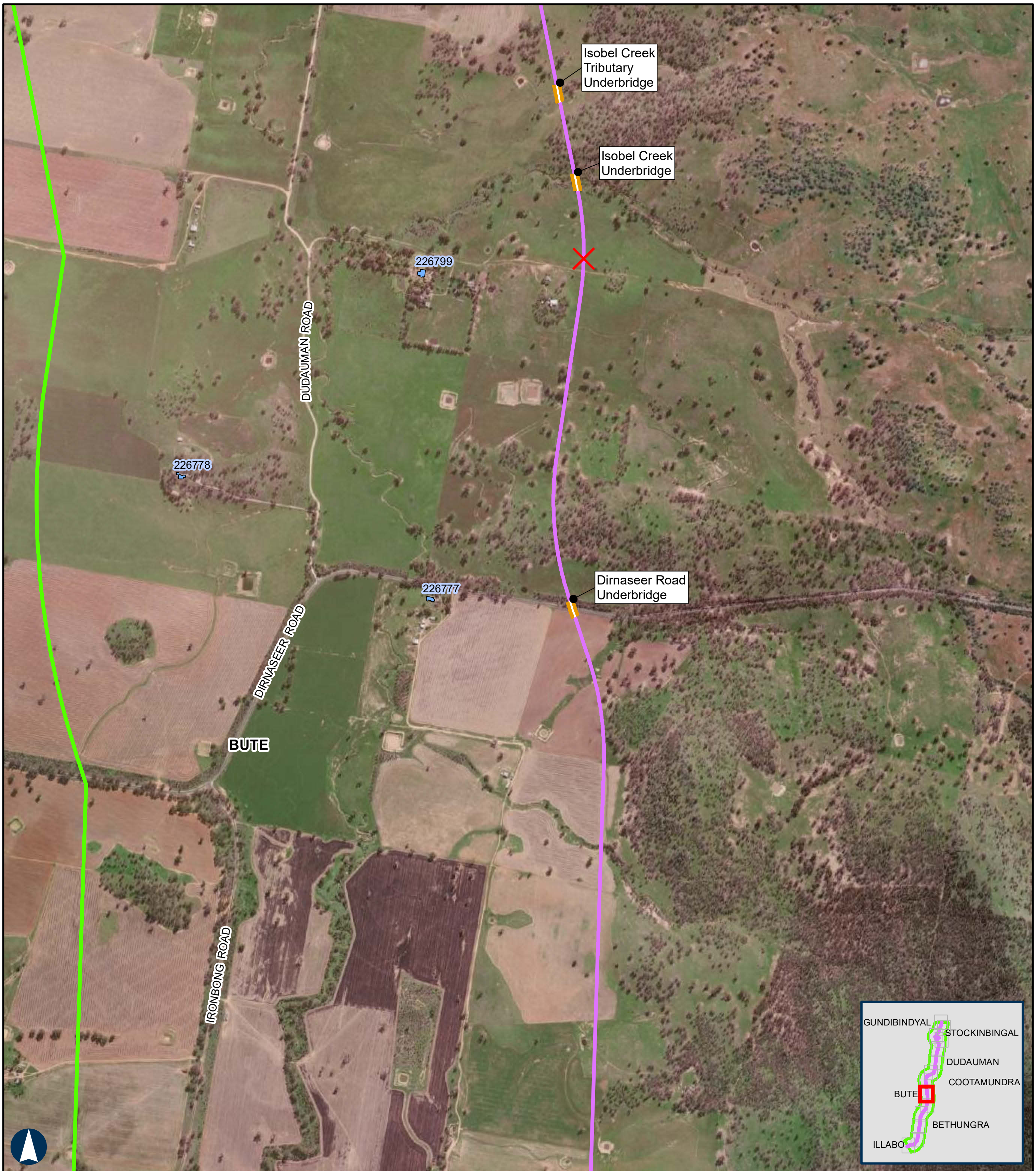

ILLABO TO STOCKINBINGAL

Sensitive Receivers

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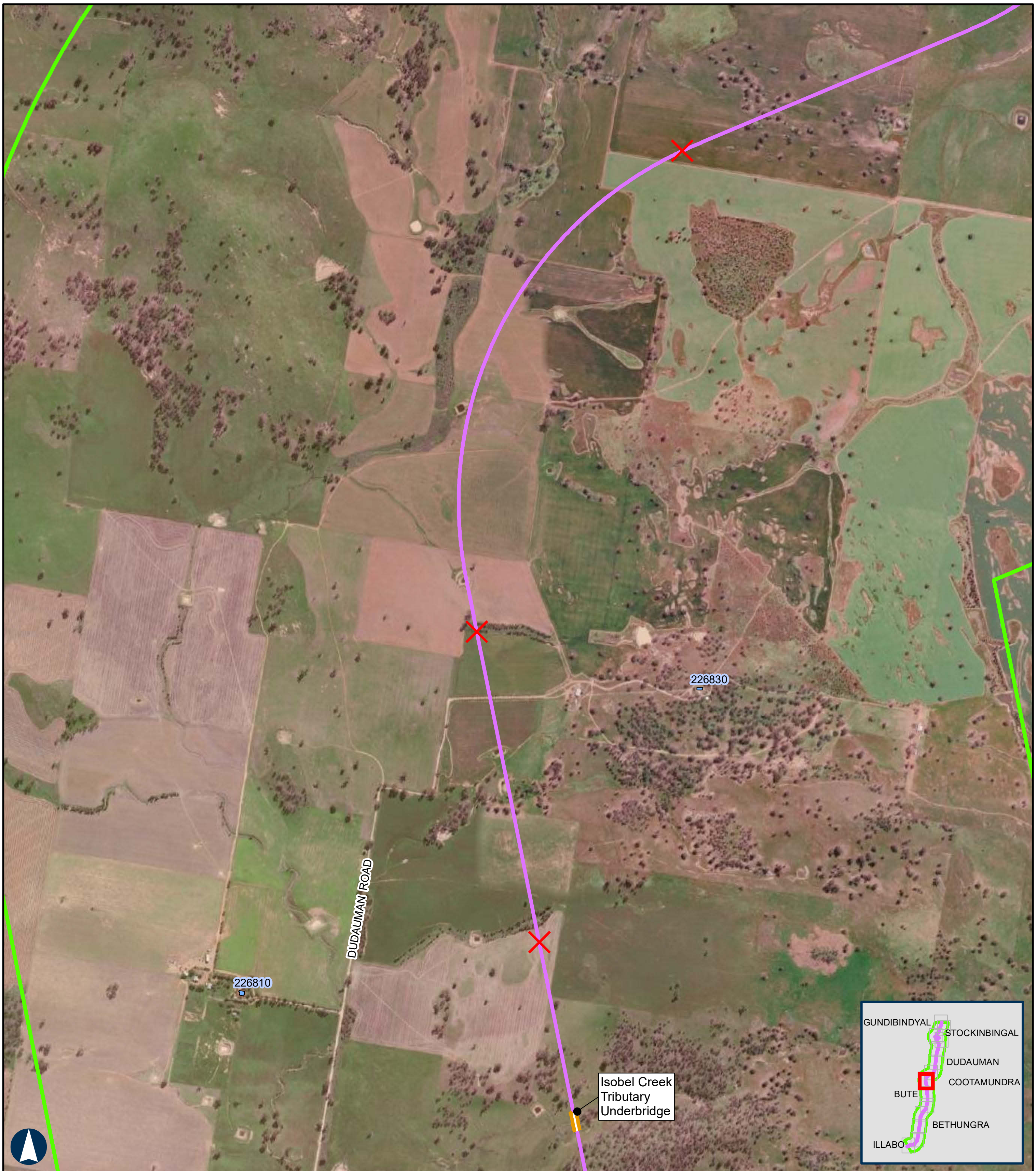

ILLABO TO STOCKINBINGAL Sensitive Receivers

APPENDIX A - Map 7 of 16

500 m

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

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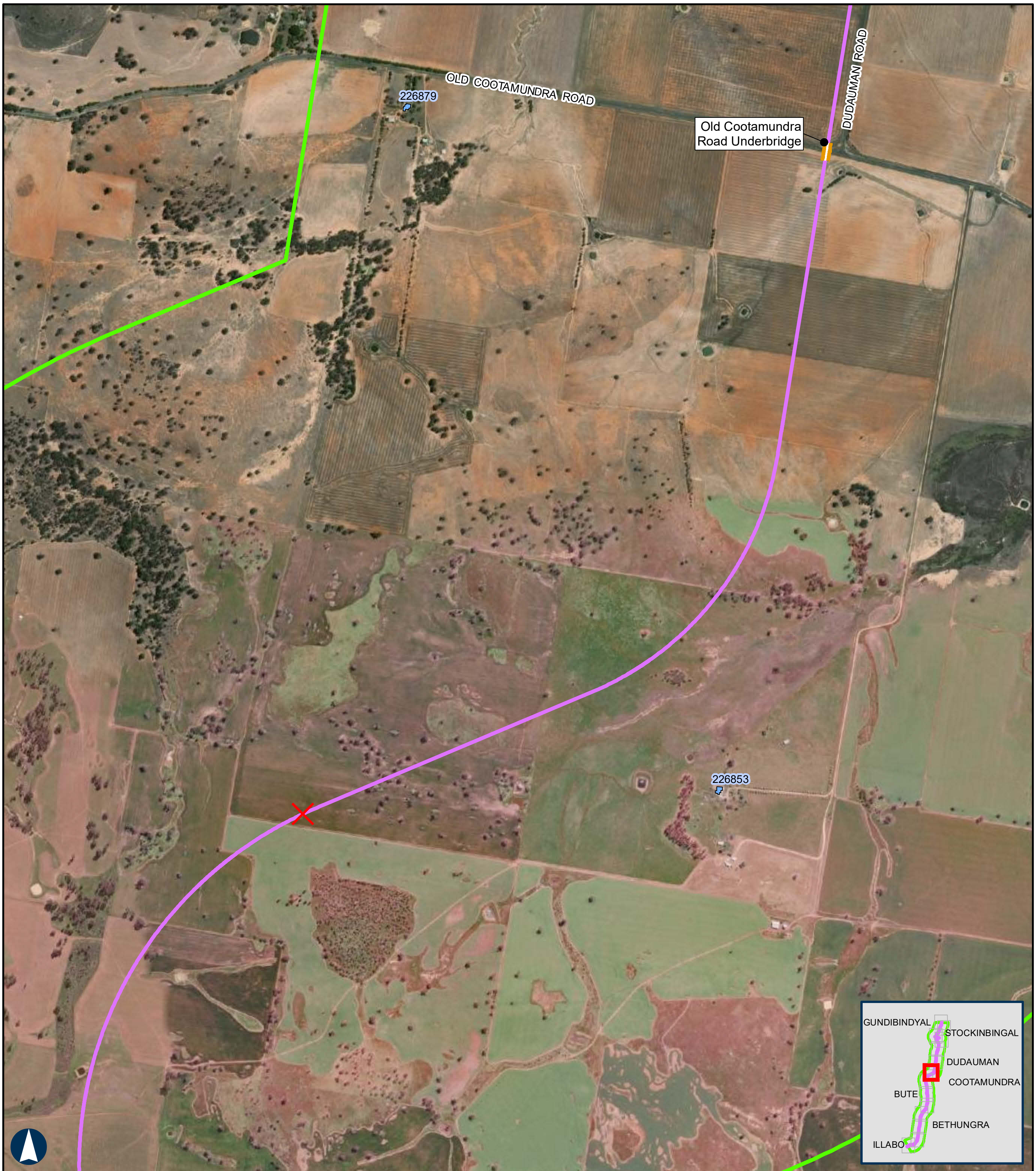

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Sensitive Receivers

APPENDIX A - Map 8 of 16

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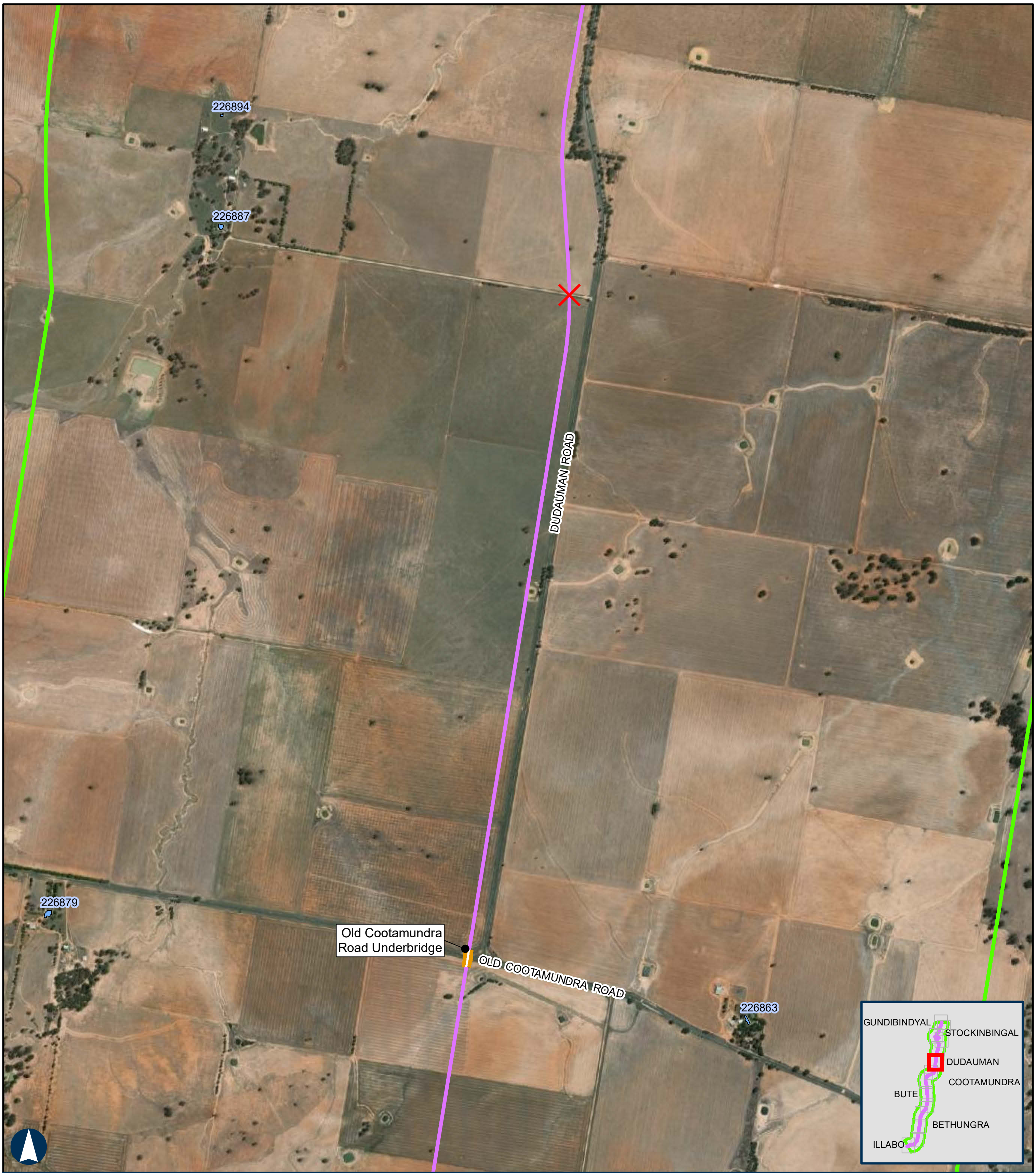

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Sensitive Receivers

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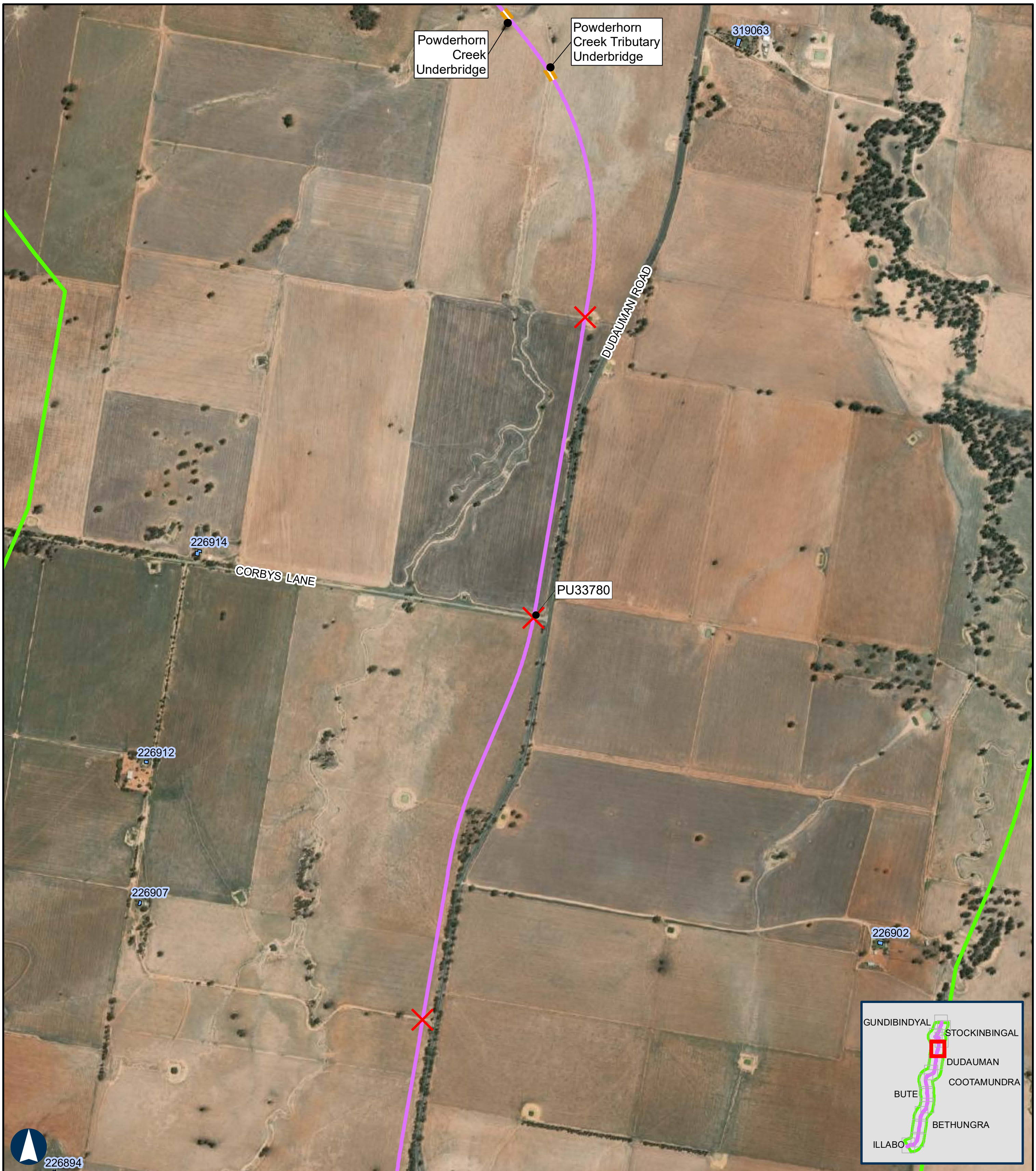

ILLABO TO STOCKINBINGAL

Sensitive Receivers

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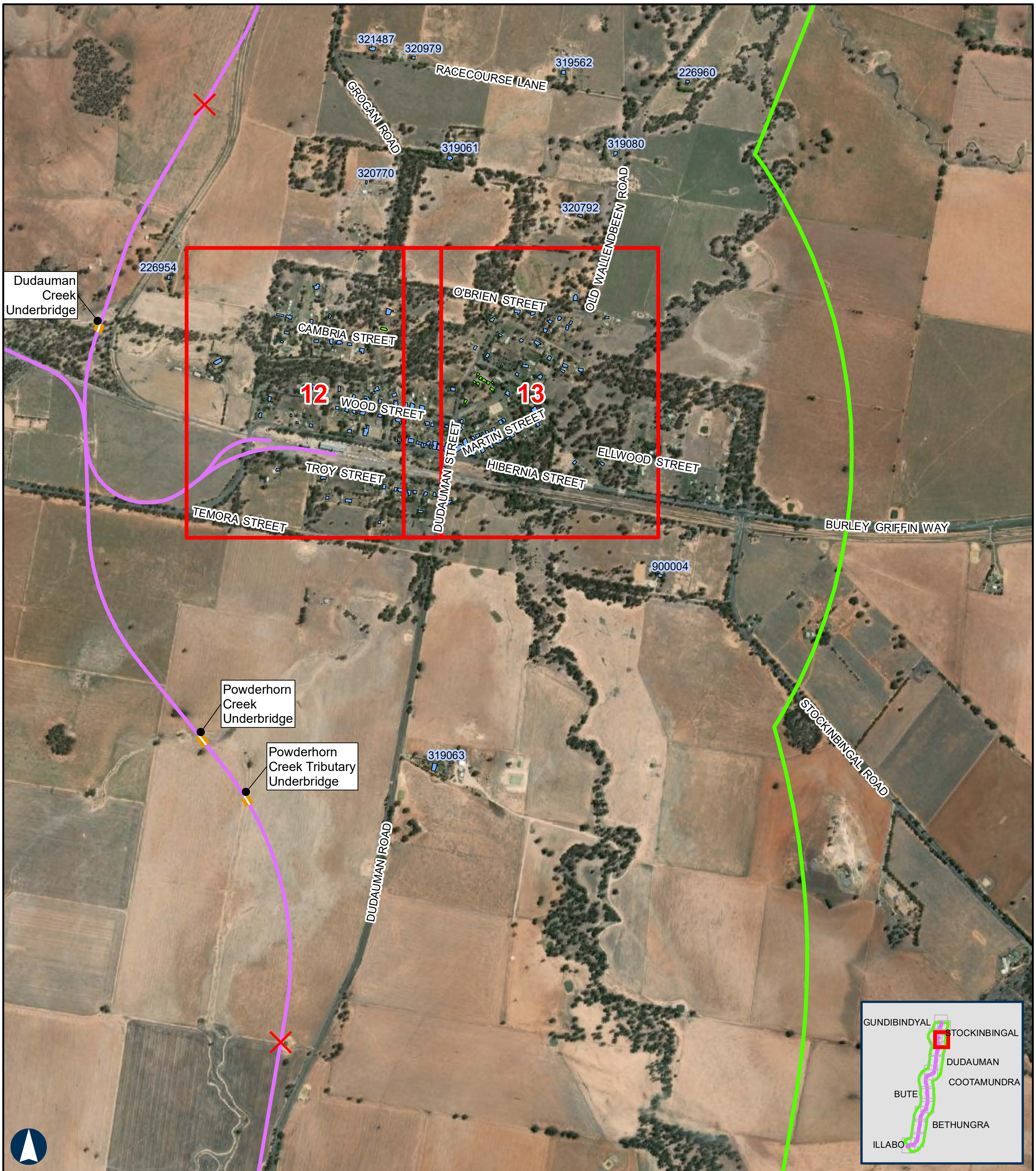

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Sensitive Receivers

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Sensitive Receivers - Detailed

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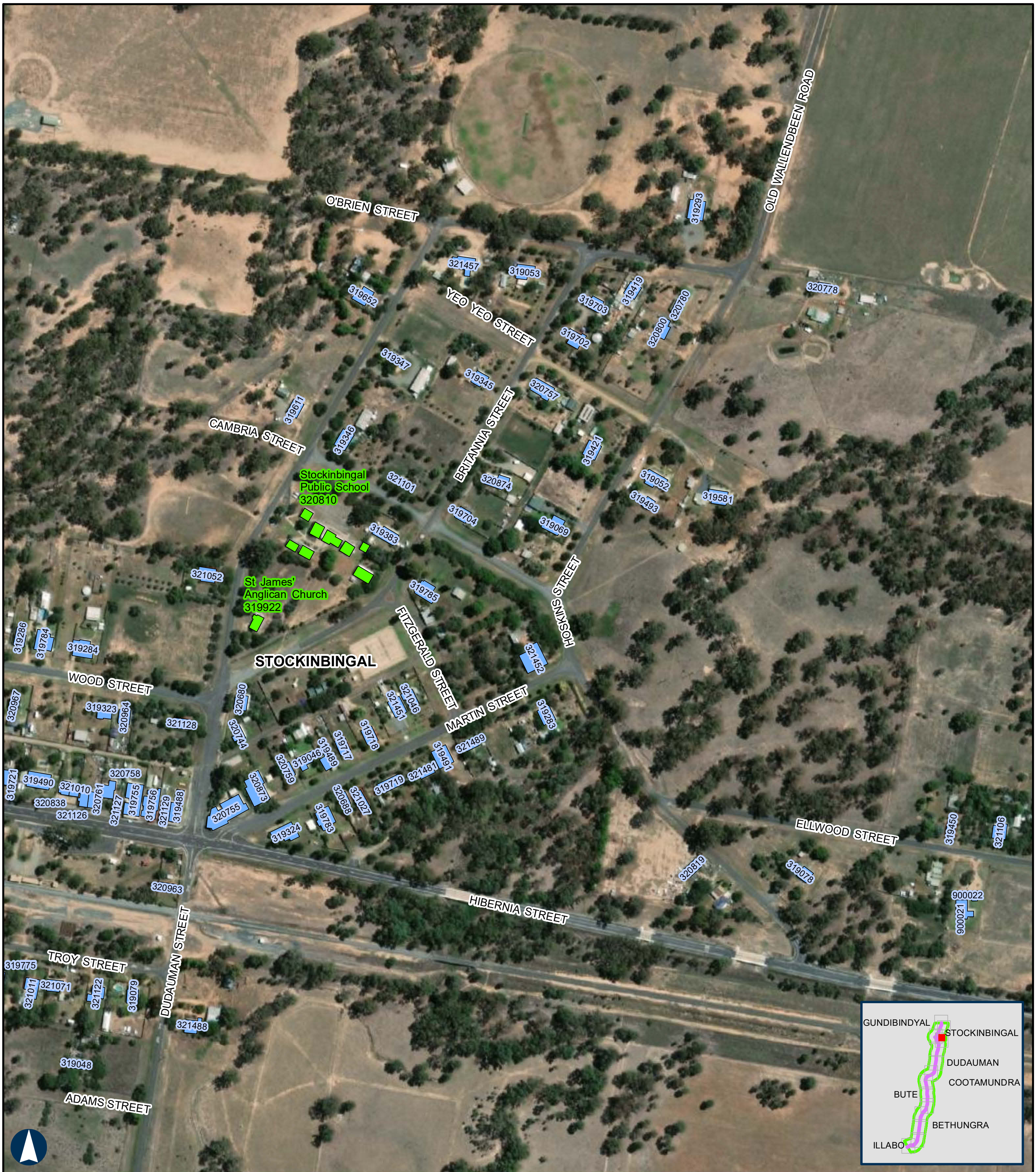

ILLABO TO STOCKINBINGAL

Sensitive Receivers - Detailed

APPENDIX A - Map 13 of 16

100 m

Coordinate System: GDA 1994 MGA Zone 55

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Author: JG

- Level Crossings
- Proposal Extent
- Crossing Loop
- Rail Alignment/Centreline
- Bridges and Viaducts
- Noise Assessment Area
- Sensitive Receivers
- Non-residential Sensitive Receivers

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ILLABO TO STOCKINBINGAL

Sensitive Receivers

APPENDIX A - Map 14 of 16

500 m

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Date: 01-Nov-2021
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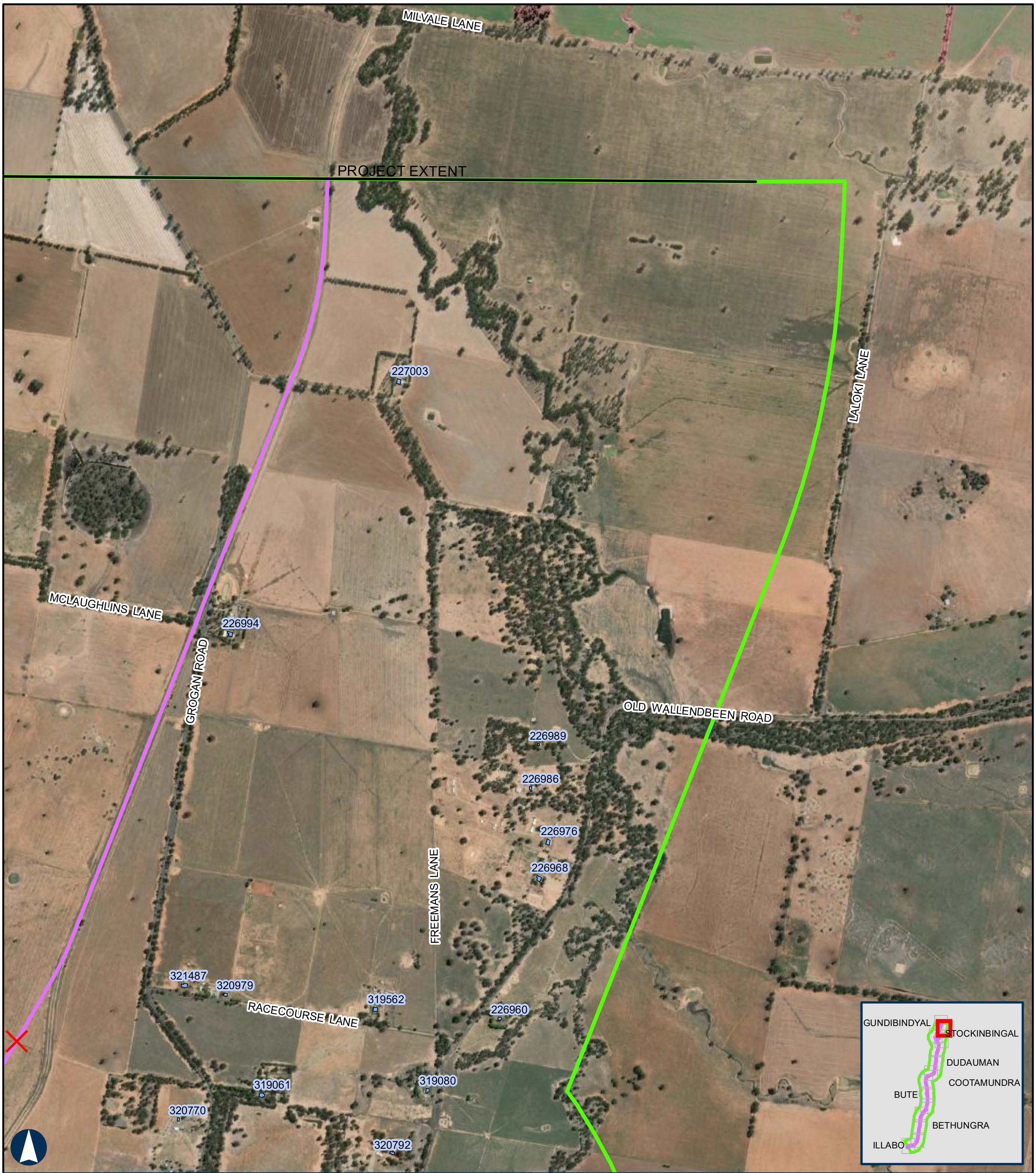

ILLABO TO STOCKINBINGAL

Sensitive Receivers

APPENDIX A - Map 15 of 16

500 m

Coordinate System: GDA 1994 MGA Zone 55

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

Noise Assessment Area
Sensitive Receivers
Non-residential Sensitive Receivers

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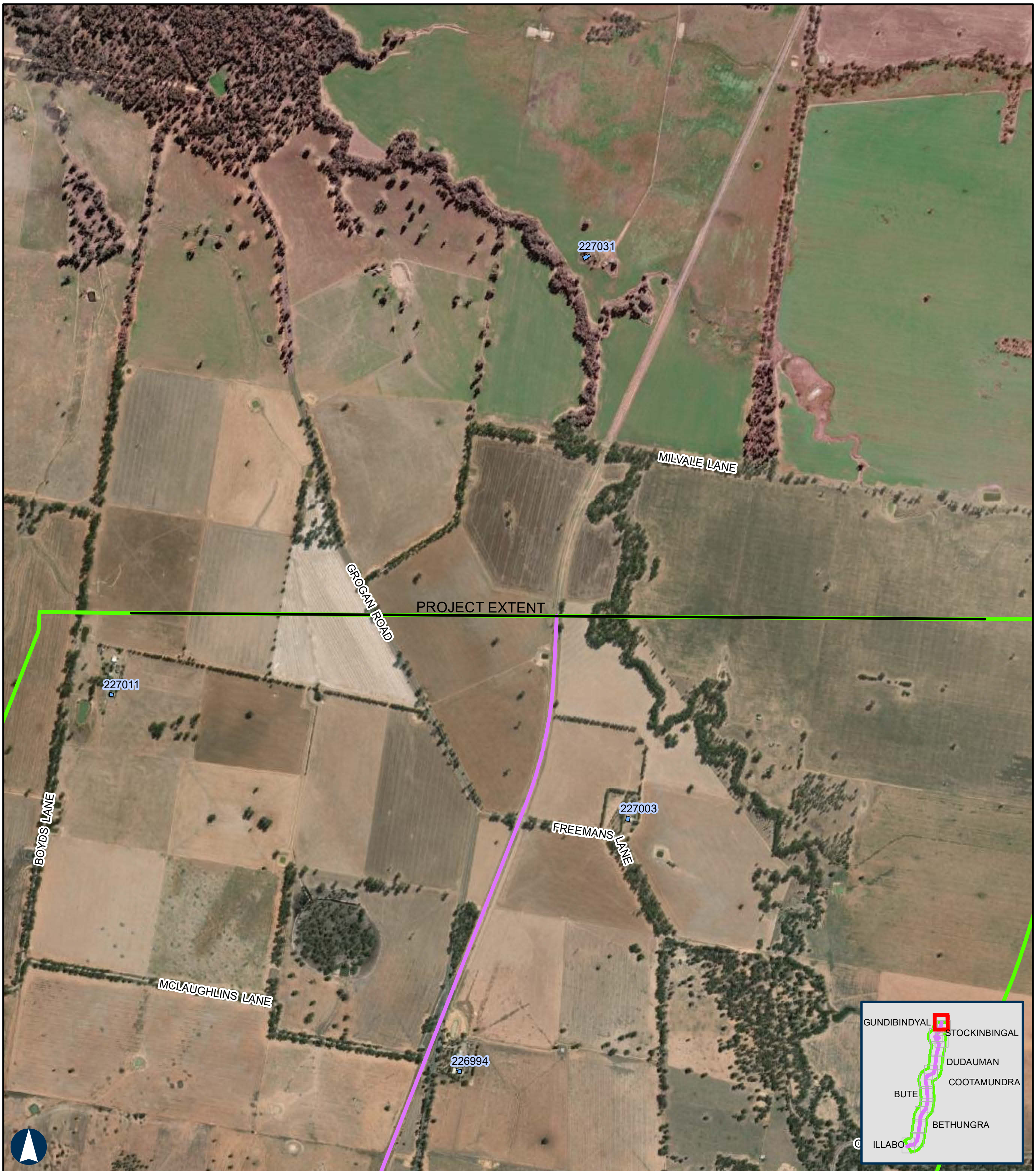

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Sensitive Receivers

500 m

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TECHNICAL PAPER

9

Operational Noise and Vibration Assessment (Rail) Report

Appendix B Noise model validation and rail vibration source data

ILLABO TO STOCKINBINGAL ENVIRONMENTAL IMPACT STATEMENT

Noise model validation

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 20** 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 20**.

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

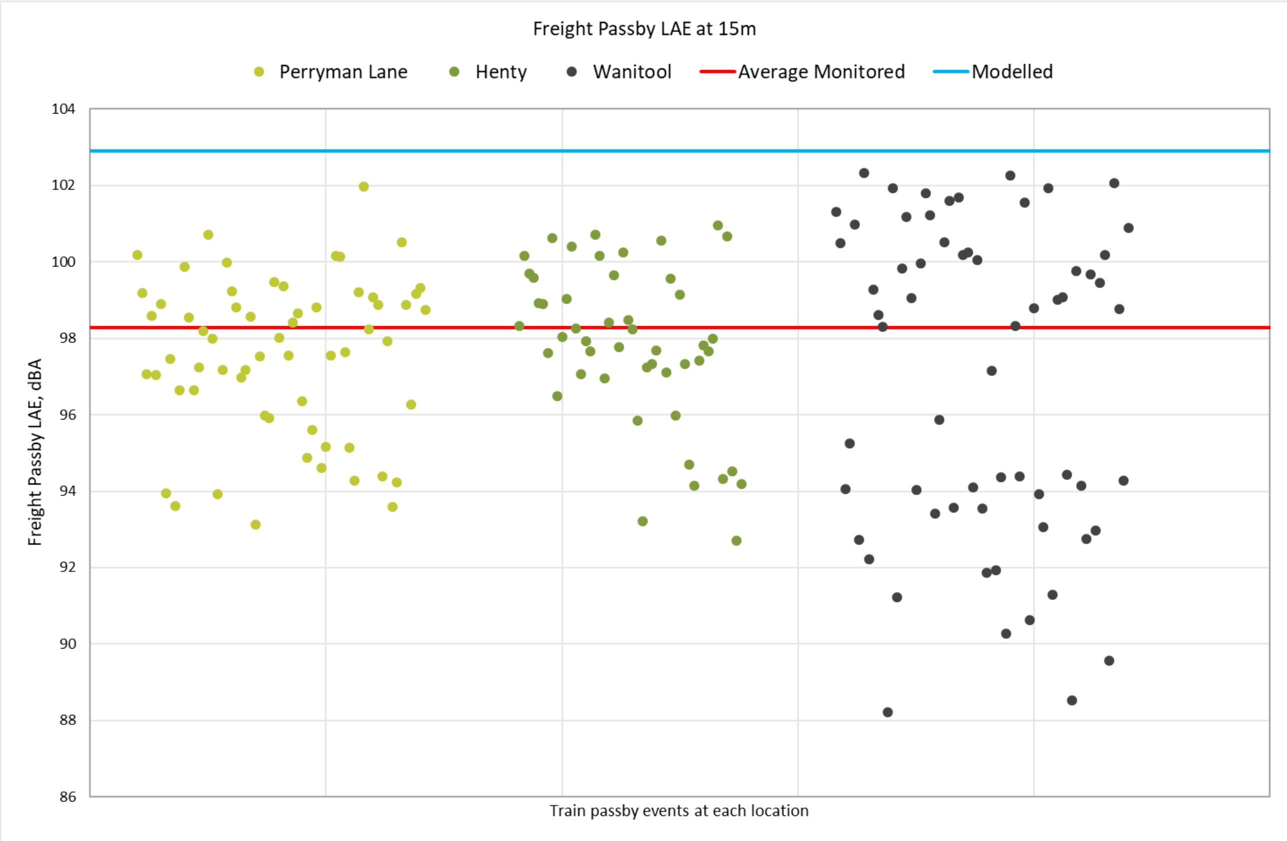
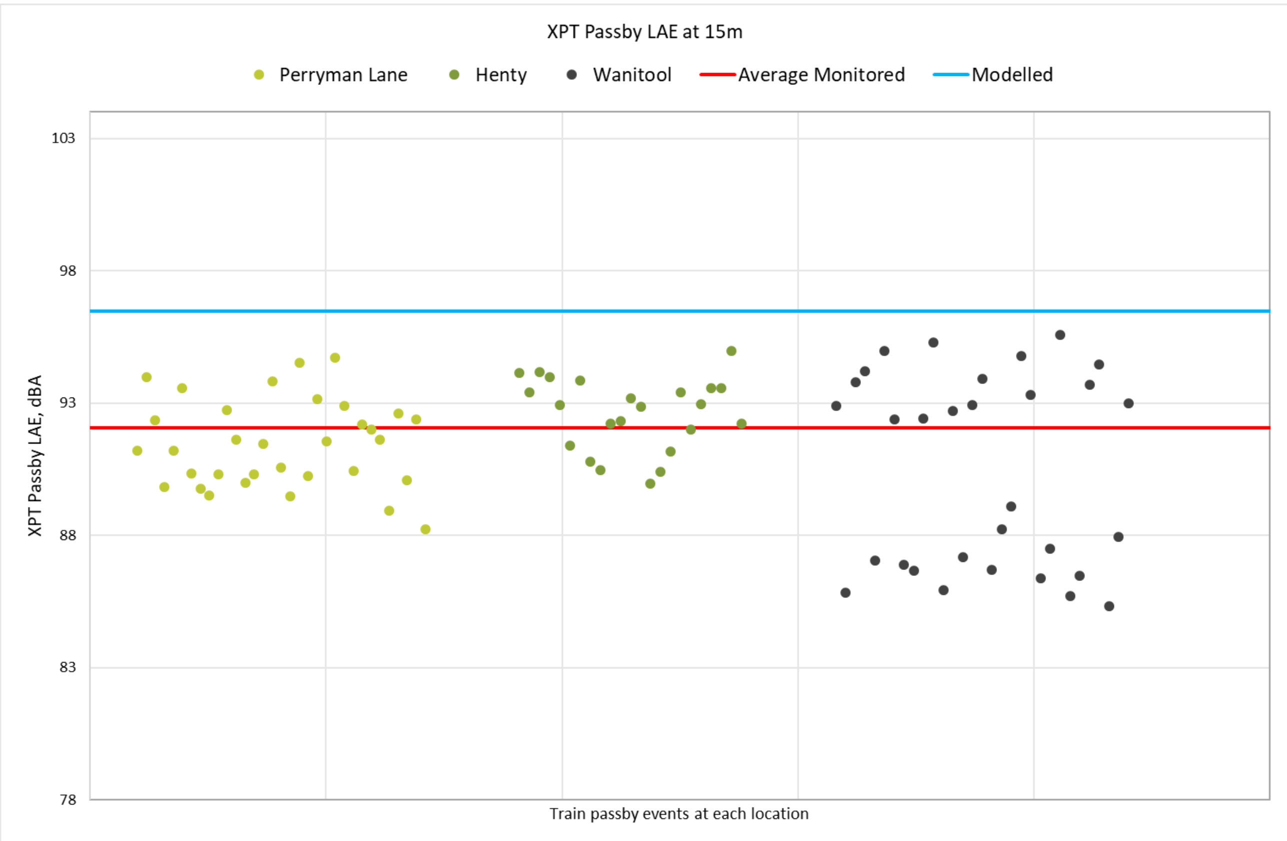


Figure B2 Monitored XPT train passby sound exposure levels



Monitored daily rail noise levels

The monitored daily L_{Aeq} railway noise levels at each monitoring location are detailed in the following table. The daily L_{Aeq} 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**
	$L_{Aeq(15hour)}$	**$L_{Aeq(9hour)}$**
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 6.1** 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.

Noise model attribute	Source data/ modelling approach
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	Monitored railway noise levels, 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

Source railway vibration data

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.

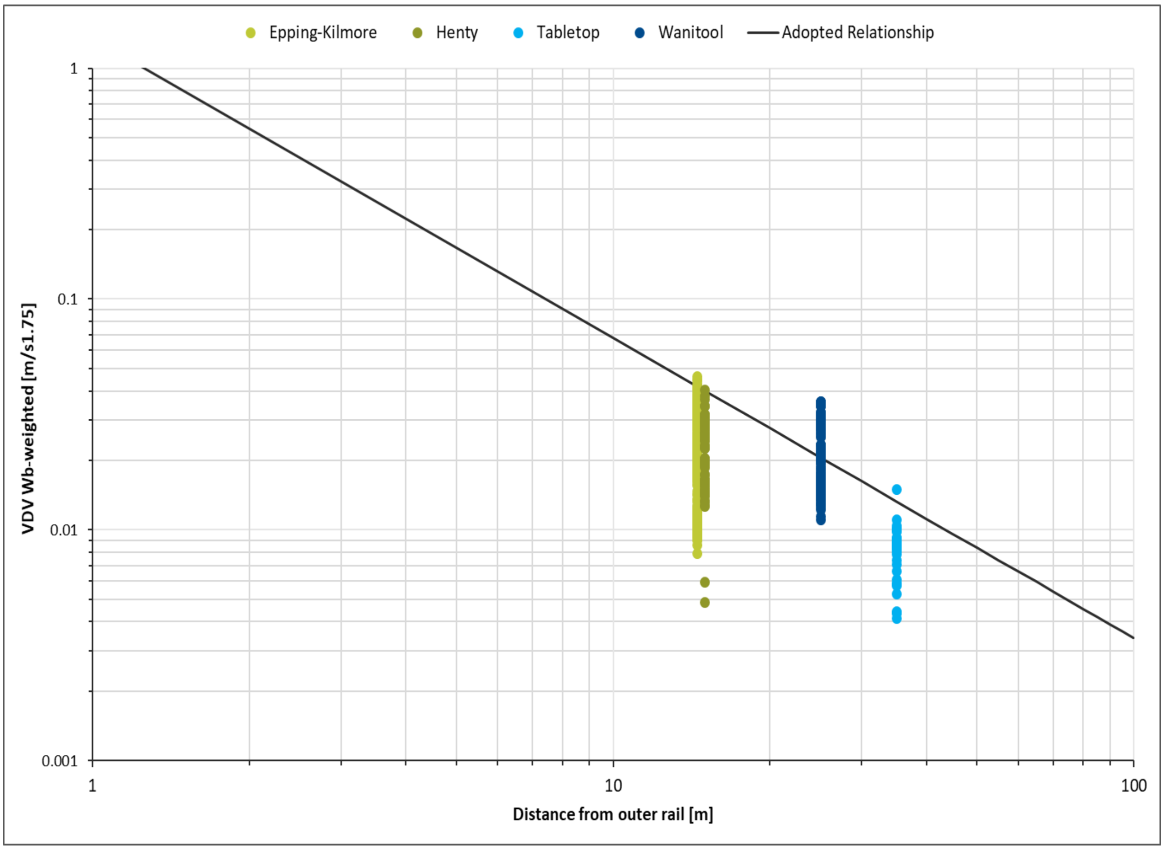
The train vibration measurements were referenced to calculate the W_b-weighted VDVs at 15 m from the outer rail. The calculated VDV (W_b weighted) varied at all sites from 0.01 $m/s^{1.75}$ to 0.04 $m/s^{1.75}$ for a single train passby event. The variation is representative of typical differences in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

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 B6**. 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.

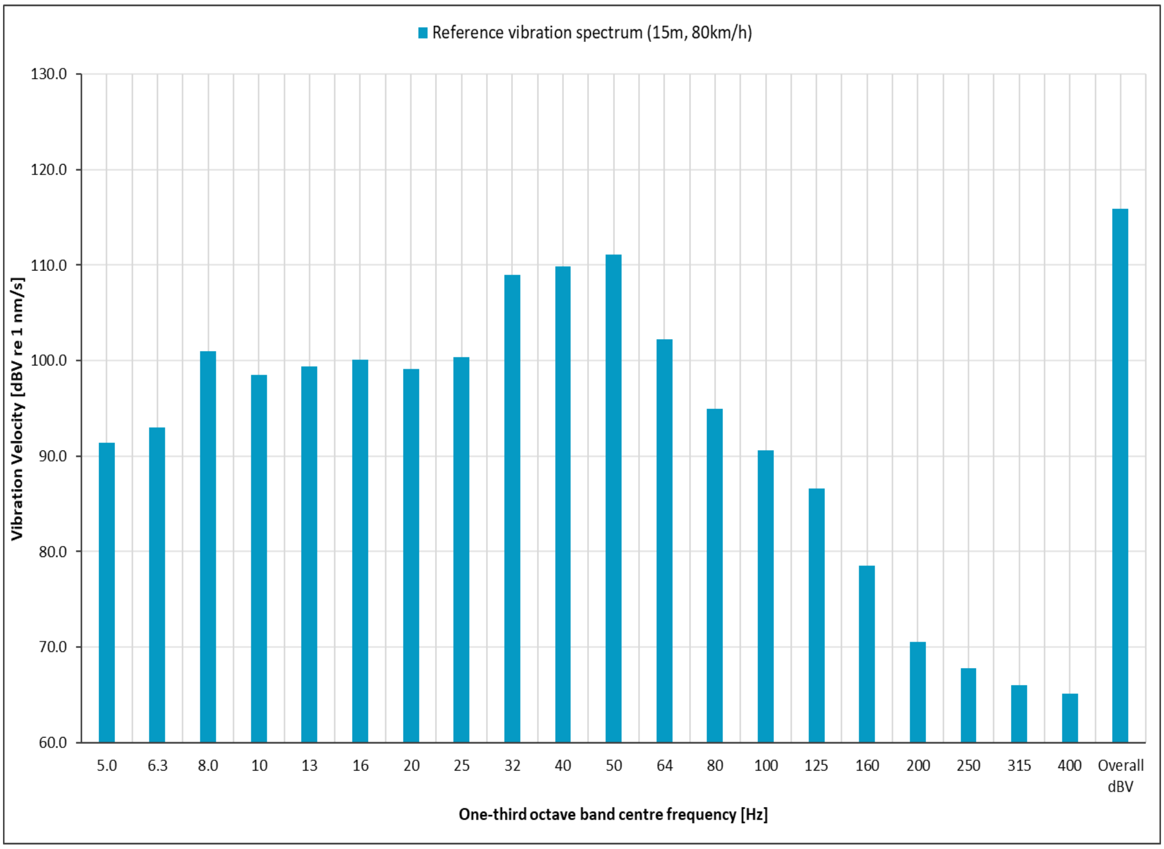
The modelled vibration spectrum in **Figure B7** is provided as one-third octave bands based on the logarithmic averages of the measurement data set. The approach has a bias for measurement sites with the highest ground-borne vibration levels during train passby events. As ground-borne vibration propagates 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 B6 Logarithmic relationship between VDV and distance



Note Reference VDV for a single freight train passby.

Figure B7 Vibration velocity spectrum at 15 m from the outer rail



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

TECHNICAL PAPER 9

Operational Noise and Vibration Assessment (Rail) Report

Appendix C Noise and vibration from double-stacked freight wagons

ILLABO TO STOCKINBINGAL ENVIRONMENTAL IMPACT STATEMENT

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 levels 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.

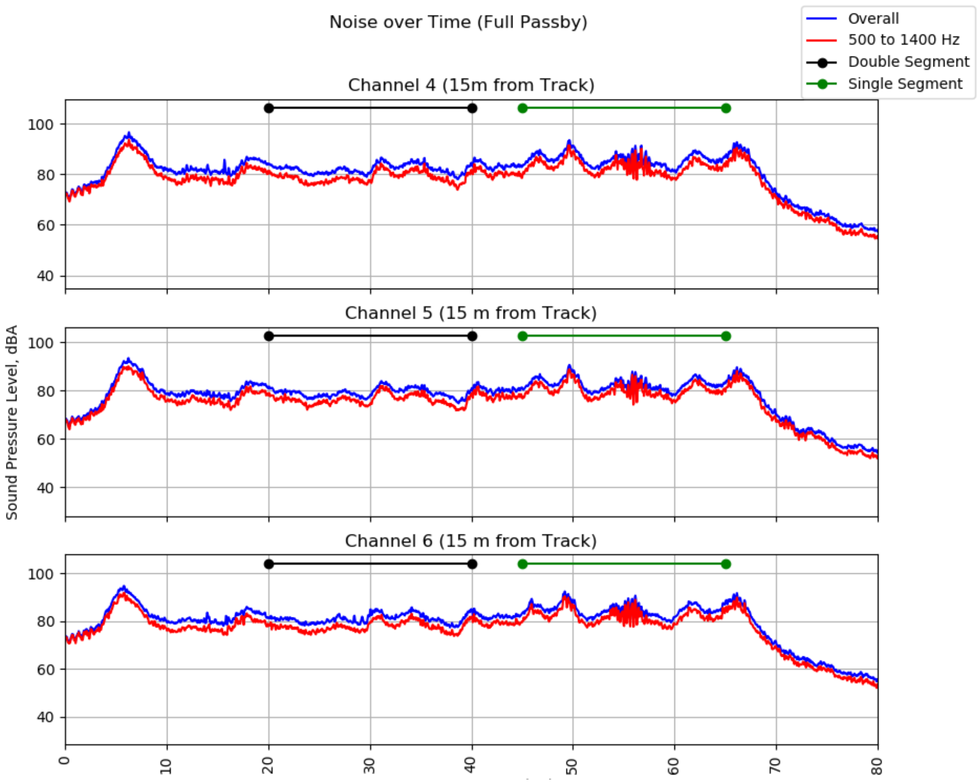
It is considered that if a noise emission correction factor were to be applied to the stacking configuration, this would be complicated by many factors in practice, particularly the:

- 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.

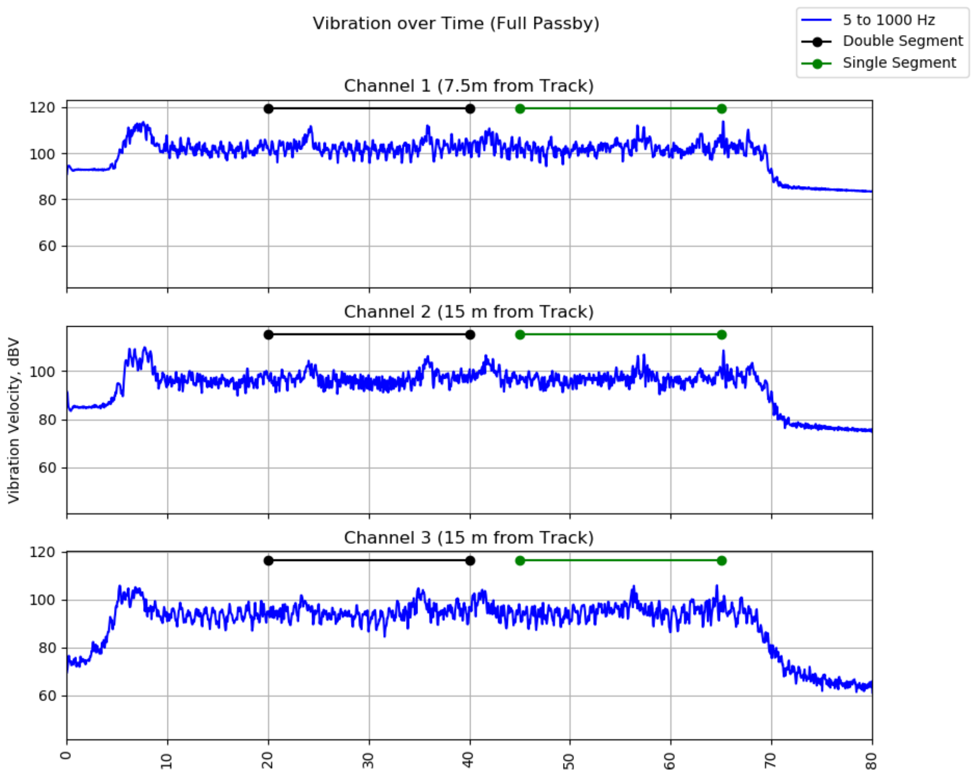
On the basis of the above analysis, correction factors to the noise and/or vibration emissions from double stacked wagons have not be considered in the Inland Rail operational rail noise and vibration assessments (at the EIS stage).

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



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Operational Noise and Vibration Assessment (Rail) Report

Appendix D Predicted airborne railway noise levels—Year 2026 project opening

ILLABO TO STOCKINBINGAL ENVIRONMENTAL IMPACT STATEMENT

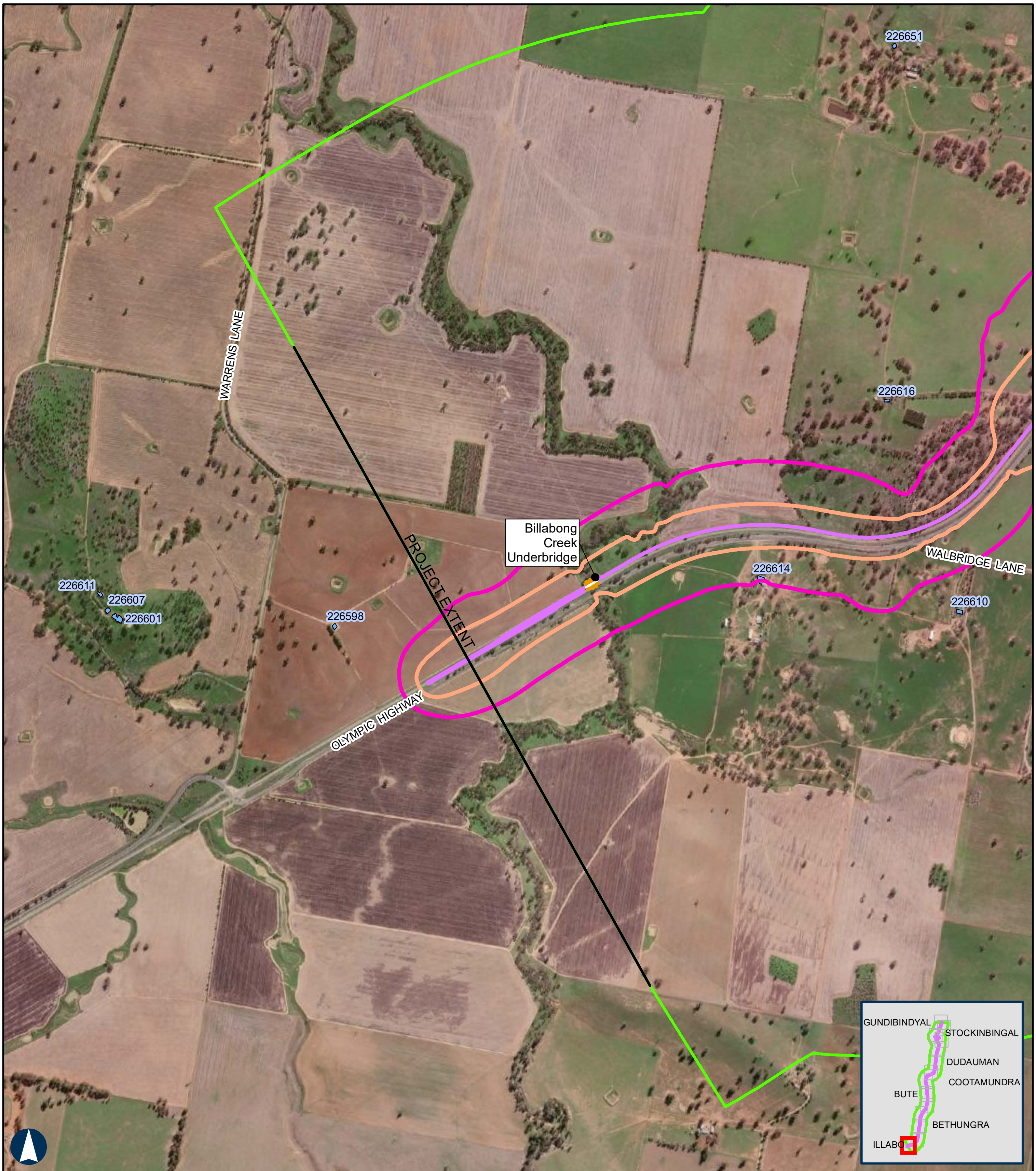
The predicted railway noise levels at the commencement of railway operations in year 2026 are detailed in the following table and noise contour maps. The predicted noise levels are provided for the identified sensitive receivers within the study area. This includes all sensitive receivers where the predicted noise levels triggered an investigation of noise mitigation.

Following the tabulated results are the predicted noise contour maps for the railway operations at the Proposal opening in year 2026. The predicted railway noise levels that trigger a review of noise mitigation are highlighted in bold.

The noise contours have been presented as the daytime and night-time assessment criteria applied by ARTC on the Proposal. All noise contours are predicted at 2.4 m above ground level.

The noise contour maps cover the entire Proposal route and provide a detailed presentation of the assessment of noise based on the daytime and night-time railway noise assessment criteria.

The noise contours are calculated from the interpolation of thousands of calculation points and provide an overview of the railway noise levels to assist the interpretation of the assessment and its outcomes. The tabulated noise levels at the individual sensitive receivers should be referenced when assessing railway noise levels against the criteria.



ILLABO TO STOCKINBINGAL

Year 2026 Daytime Rail Noise Levels

APPENDIX D - Map 1 of 16

500 m

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- Daytime noise criteria LA max 80dBA New rail corridor
- Sensitive Receivers
- Non-residential Sensitive Receivers

Noise contours are based on a set distance above the local terrain level of 2.4m.

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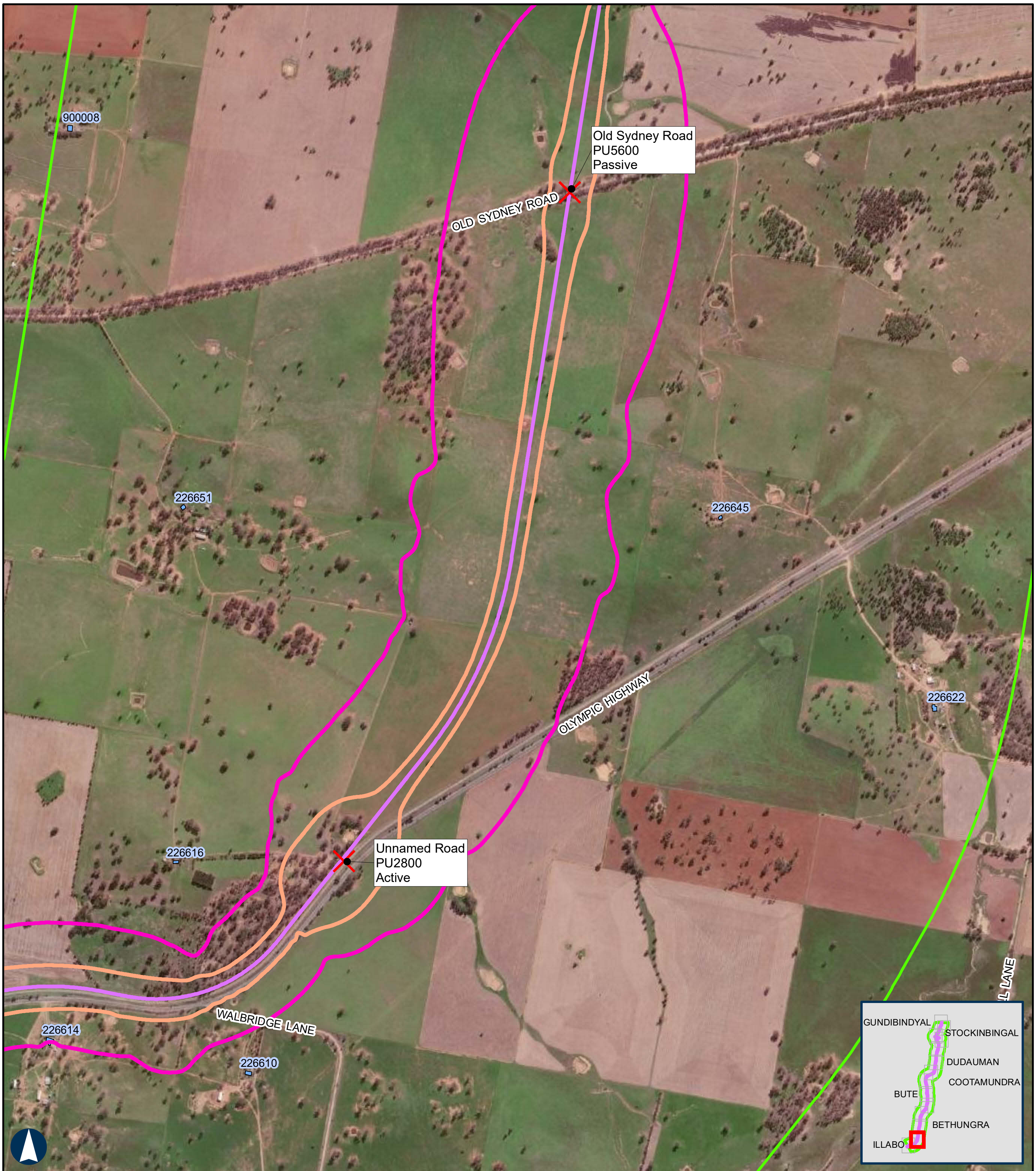

ILLABO TO STOCKINBINGAL

Year 2026 Daytime Rail Noise Levels

APPENDIX D - Map 2 of 16

500 m

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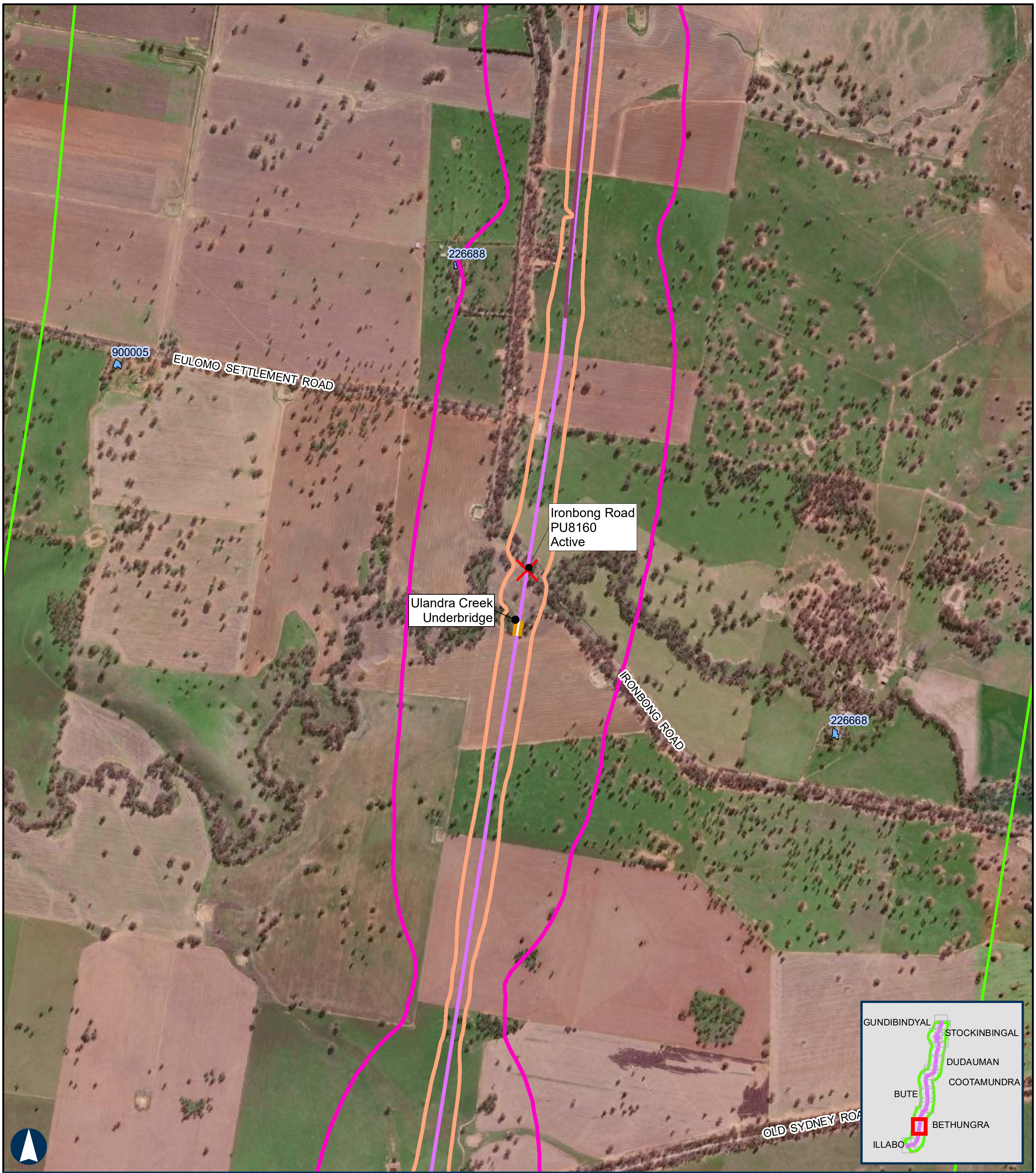

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Year 2026 Daytime Rail Noise Levels

APPENDIX D - Map 3 of 16

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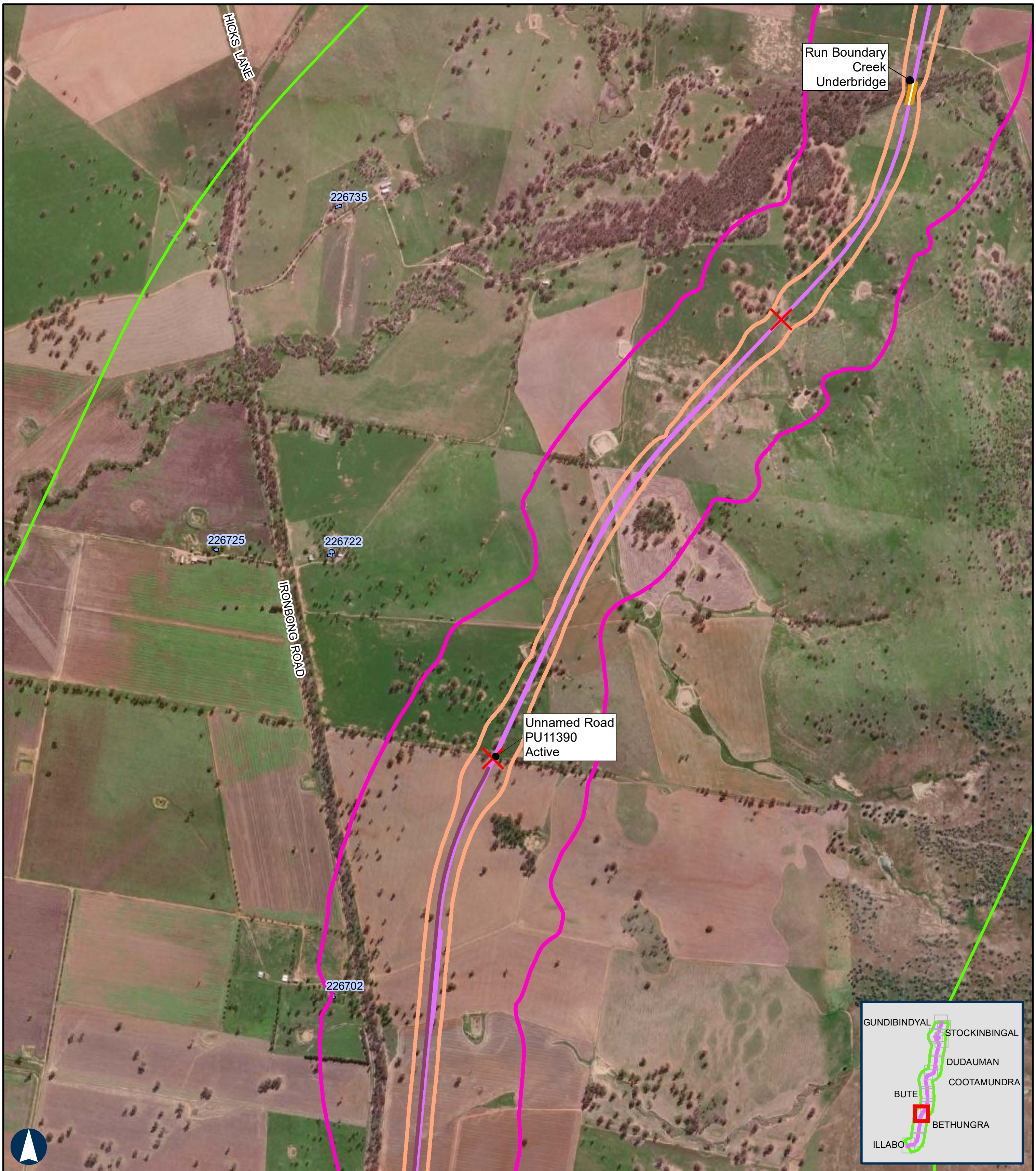

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Year 2026 Daytime Rail Noise Levels

APPENDIX D - Map 4 of 16

500 m

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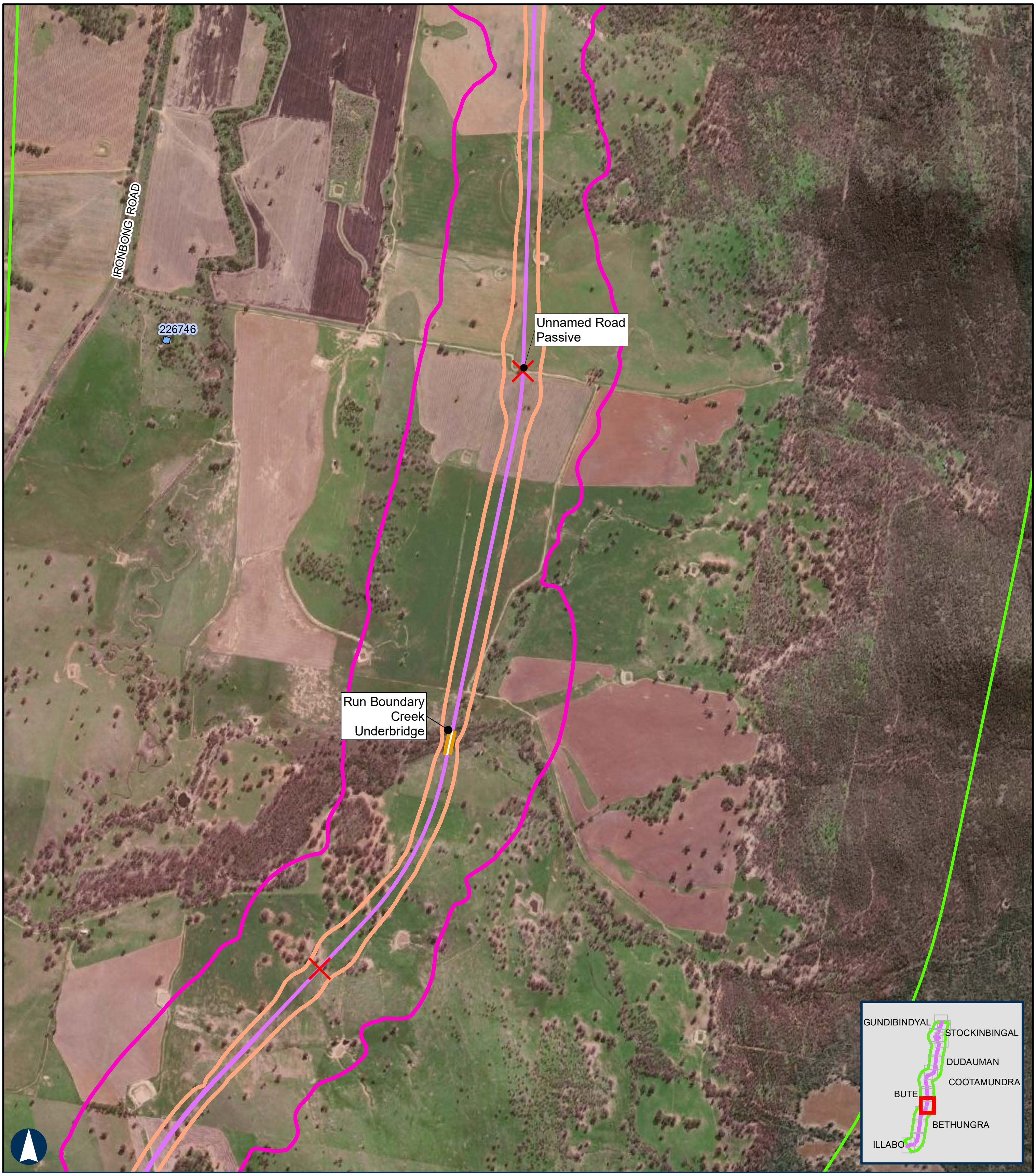

ILLABO TO STOCKINBINGAL

Year 2026 Daytime Rail Noise Levels

APPENDIX D - Map 5 of 16

500 m

Coordinate System: GDA 1994 MGA Zone 55

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Paper: A4 Scale: 1:20,000
Date: 01-Nov-2021
Author: JG

- Level Crossings
- Proposal Extent
- Crossing Loop
- Rail Alignment/Centreline
- Bridges and Viaducts
- Noise Assessment Area
- Daytime noise criteria LAeq15hr 60dBA New rail corridor
- Daytime noise criteria LA max 80dBA New rail corridor
- Sensitive Receivers
- Non-residential Sensitive Receivers

Noise contours are based on a set distance above the local terrain level of 2.4m.

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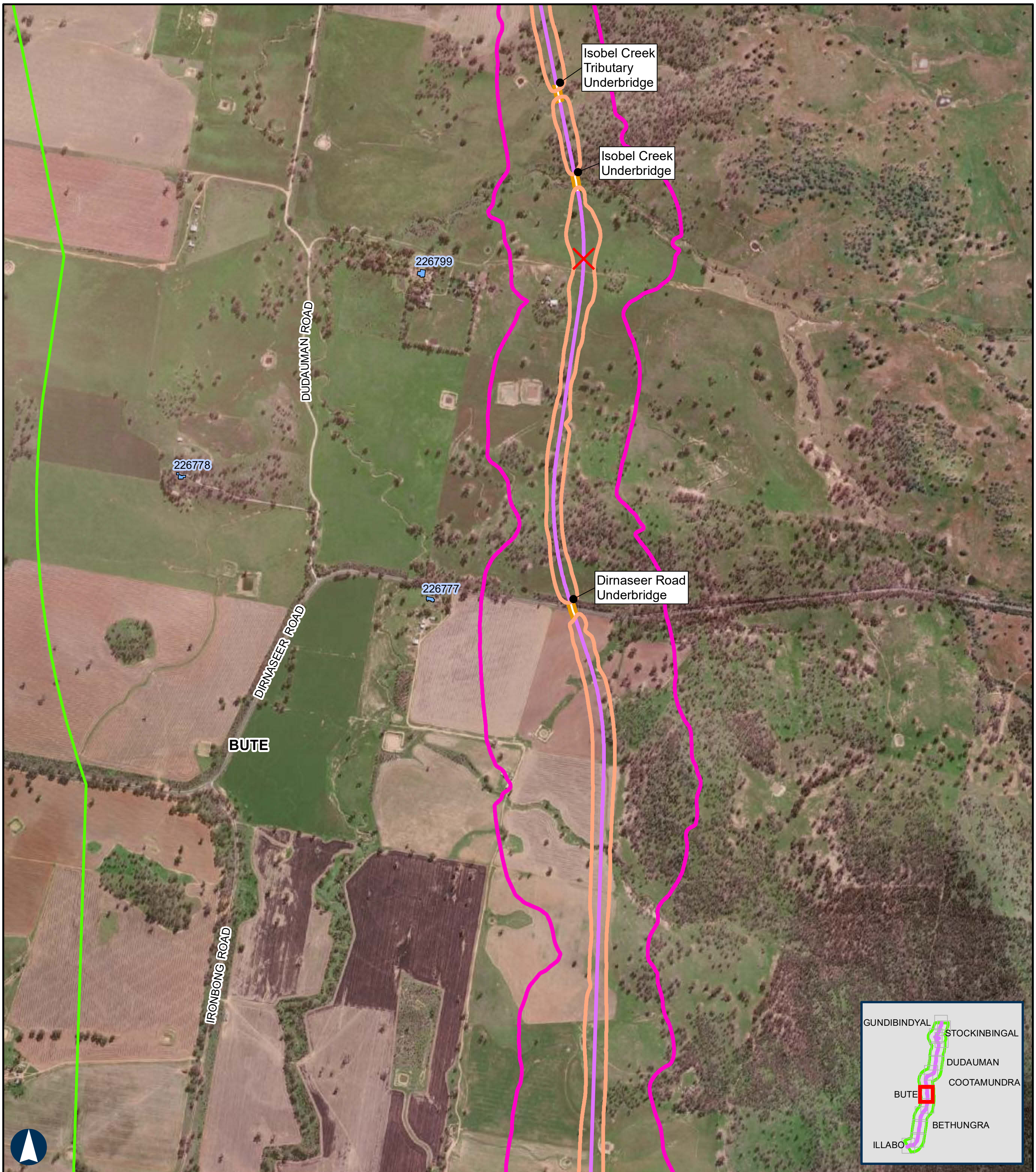

ILLABO TO STOCKINBINGAL

Year 2026 Daytime Rail Noise Levels

APPENDIX D - Map 6 of 16

500 m

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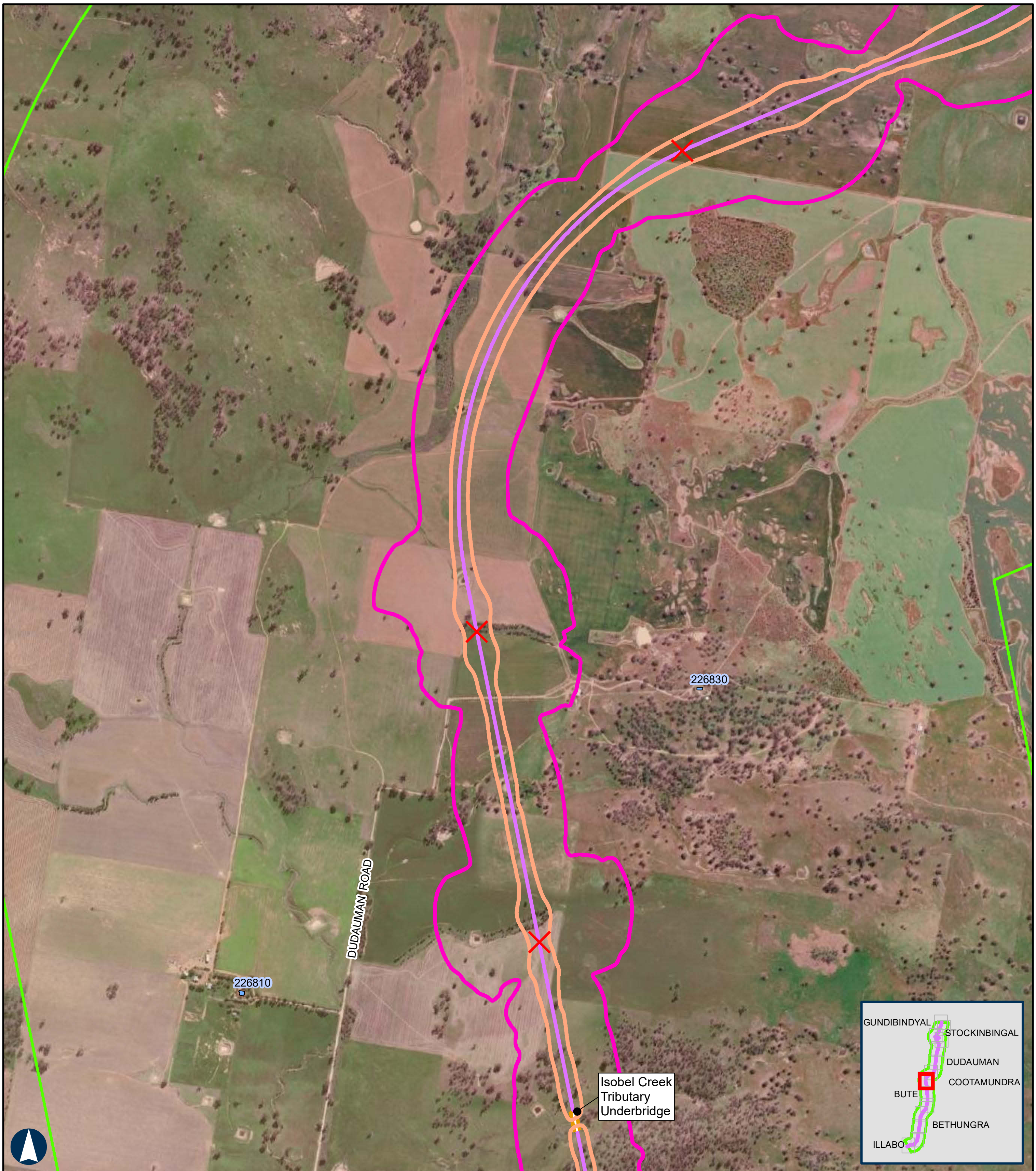

ILLABO TO STOCKINBINGAL

Year 2026 Daytime Rail Noise Levels

APPENDIX D - Map 7 of 16

500 m

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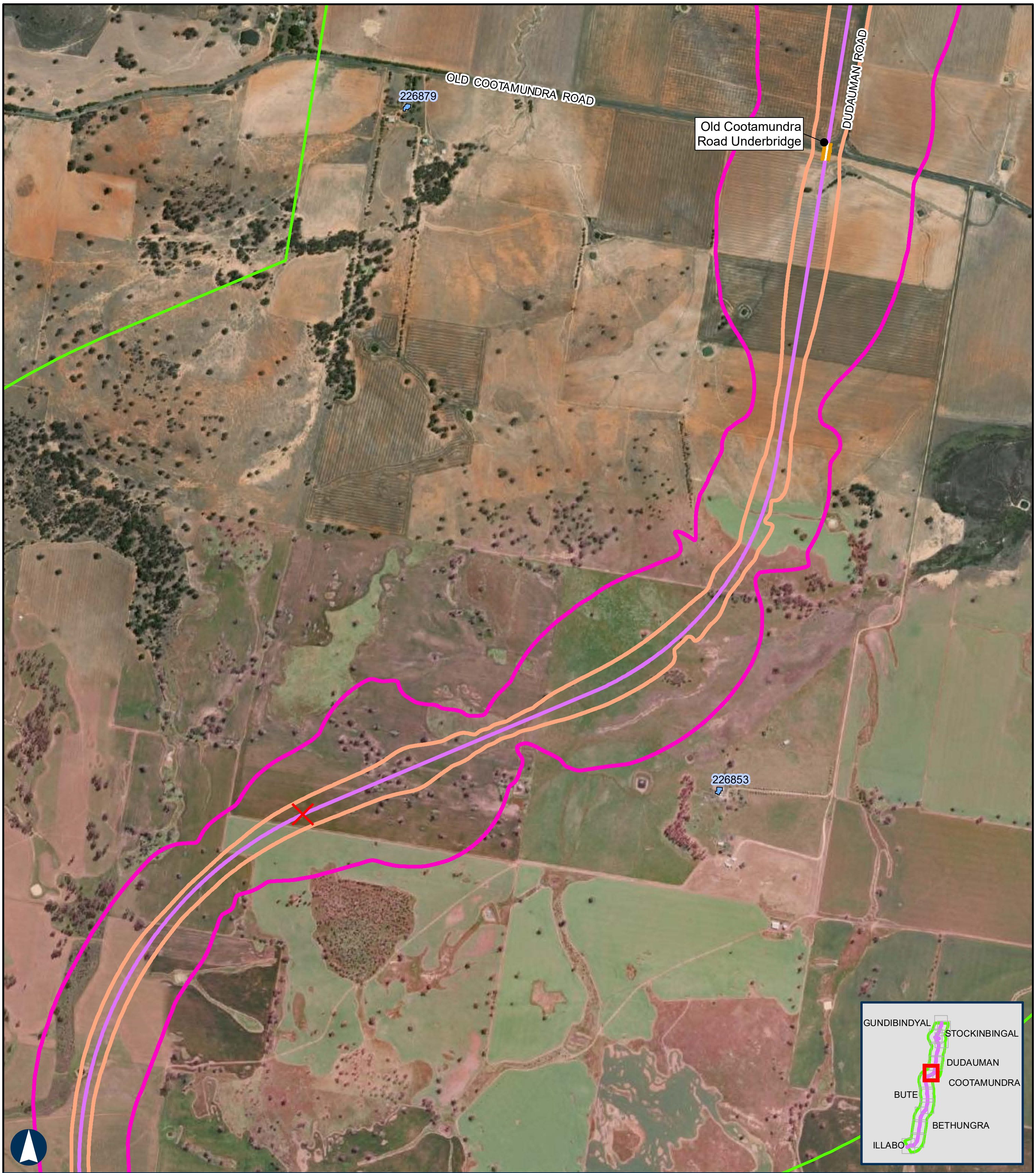

ILLABO TO STOCKINBINGAL Year 2026 Daytime Rail Noise Levels

APPENDIX D - Map 8 of 16

500 m

Coordinate System: GDA 1994 MGA Zone 55

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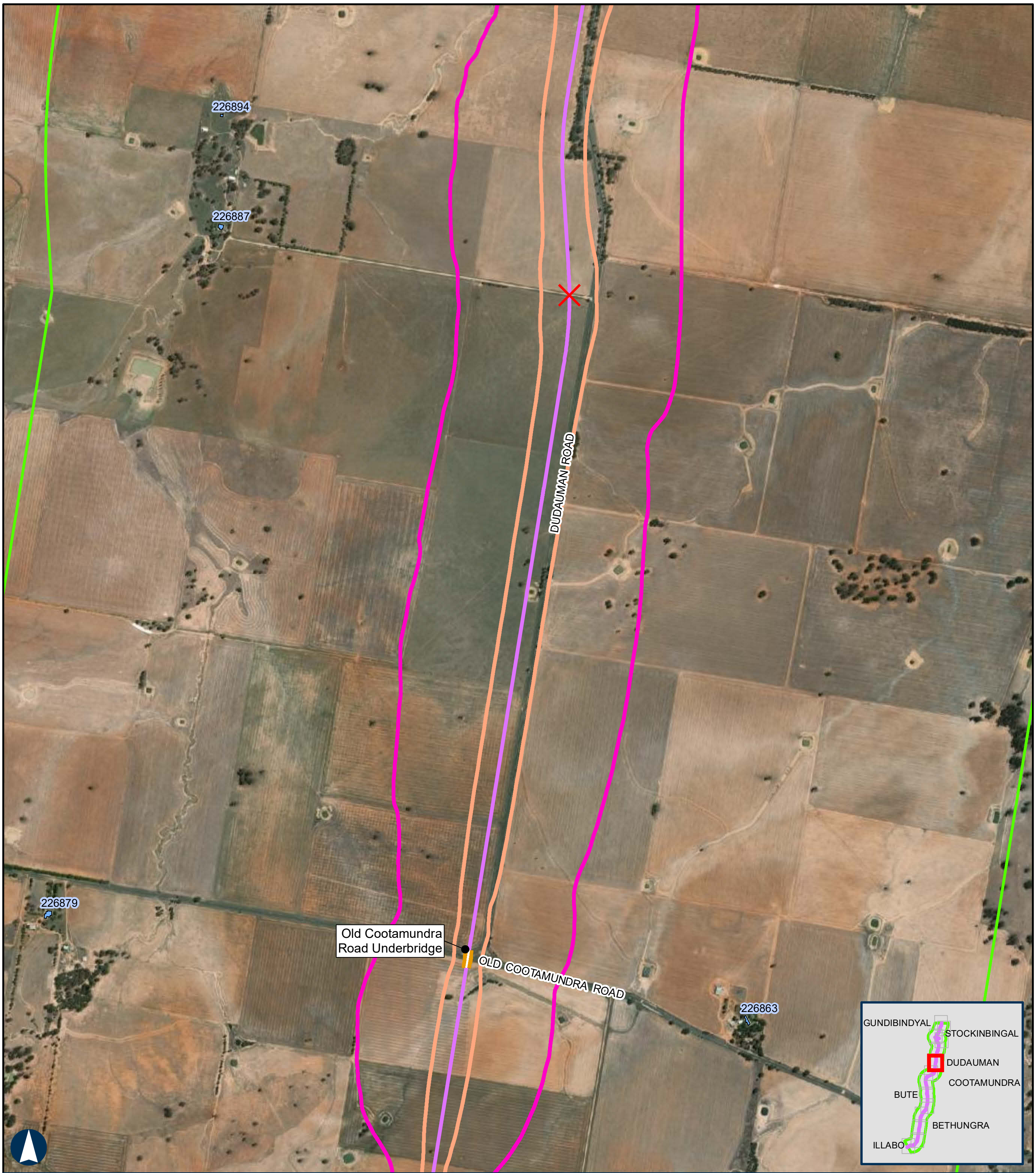

ILLABO TO STOCKINBINGAL

Year 2026 Daytime Rail Noise Levels

APPENDIX D - Map 9 of 16

500 m

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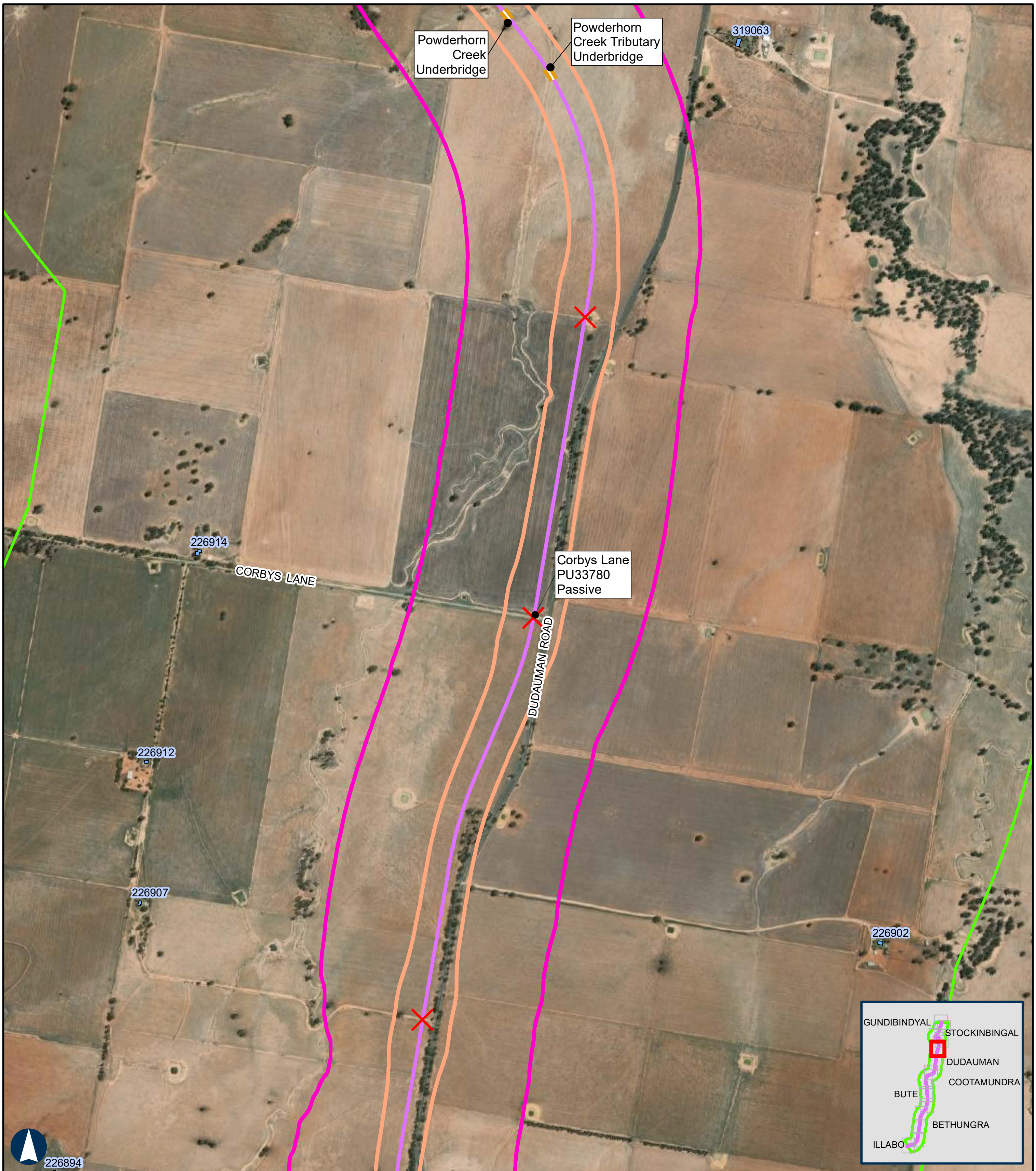

ILLABO TO STOCKINBINGAL

Year 2026 Daytime Rail Noise Levels

APPENDIX D - Map 10 of 16

500 m

Coordinate System: GDA 1994 MGA Zone 55

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Author: JG

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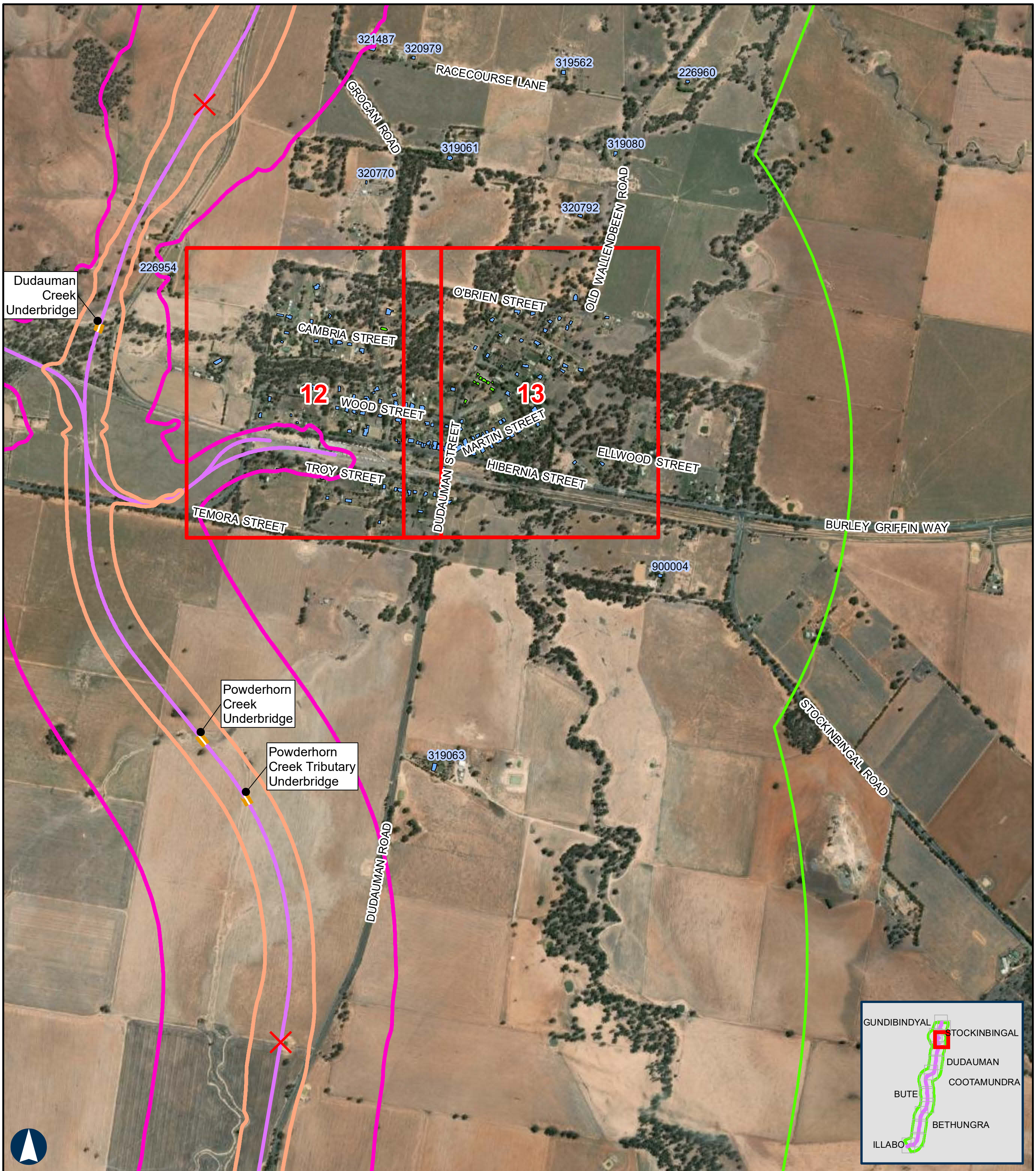

ILLABO TO STOCKINBINGAL

Year 2026 Daytime Rail Noise Levels

500 m

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Date: 01-Nov-2021
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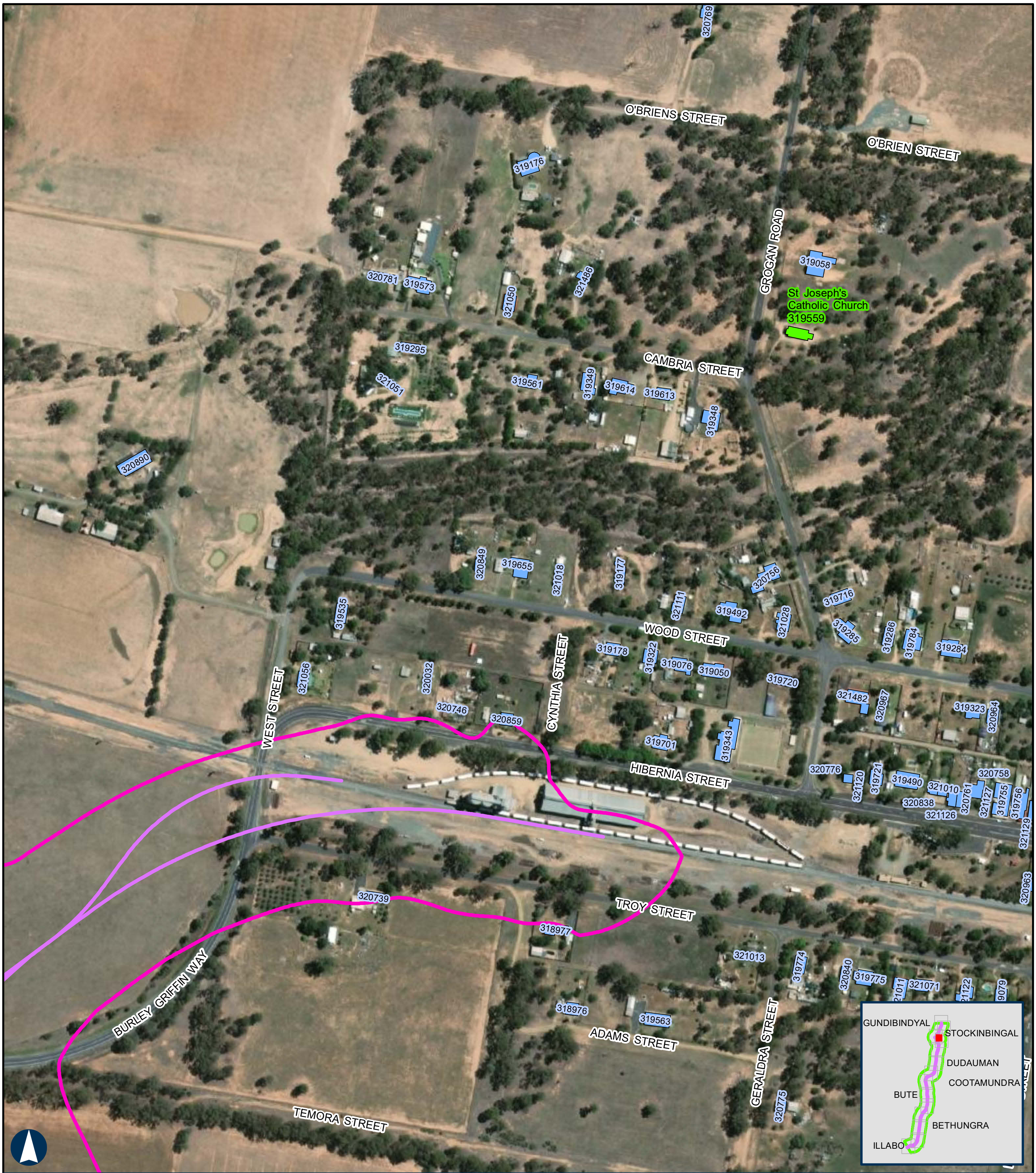

ILLABO TO STOCKINBINGAL

Year 2026 Daytime Rail Noise Levels - Detailed

APPENDIX D - Map 12 of 16

100 m

Coordinate System: GDA 1994 MGA Zone 55

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Paper: A4 Scale: 1:5,000
Date: 19-Aug-2021
Author: JG

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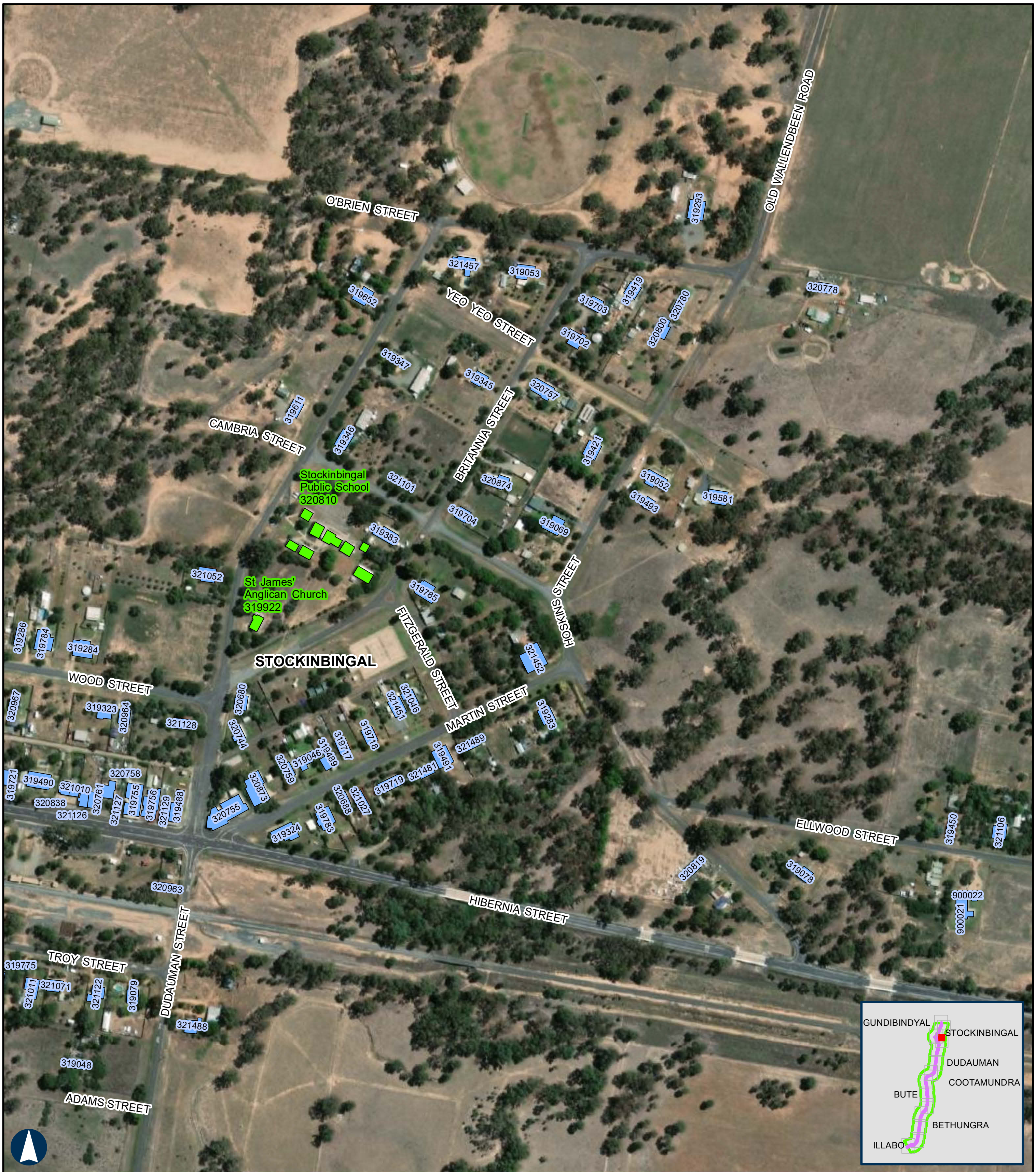

ILLABO TO STOCKINBINGAL

Year 2026 Daytime Rail Noise Levels - Detailed

APPENDIX D - Map 13 of 16

100 m

Coordinate System: GDA 1994 MGA Zone 55

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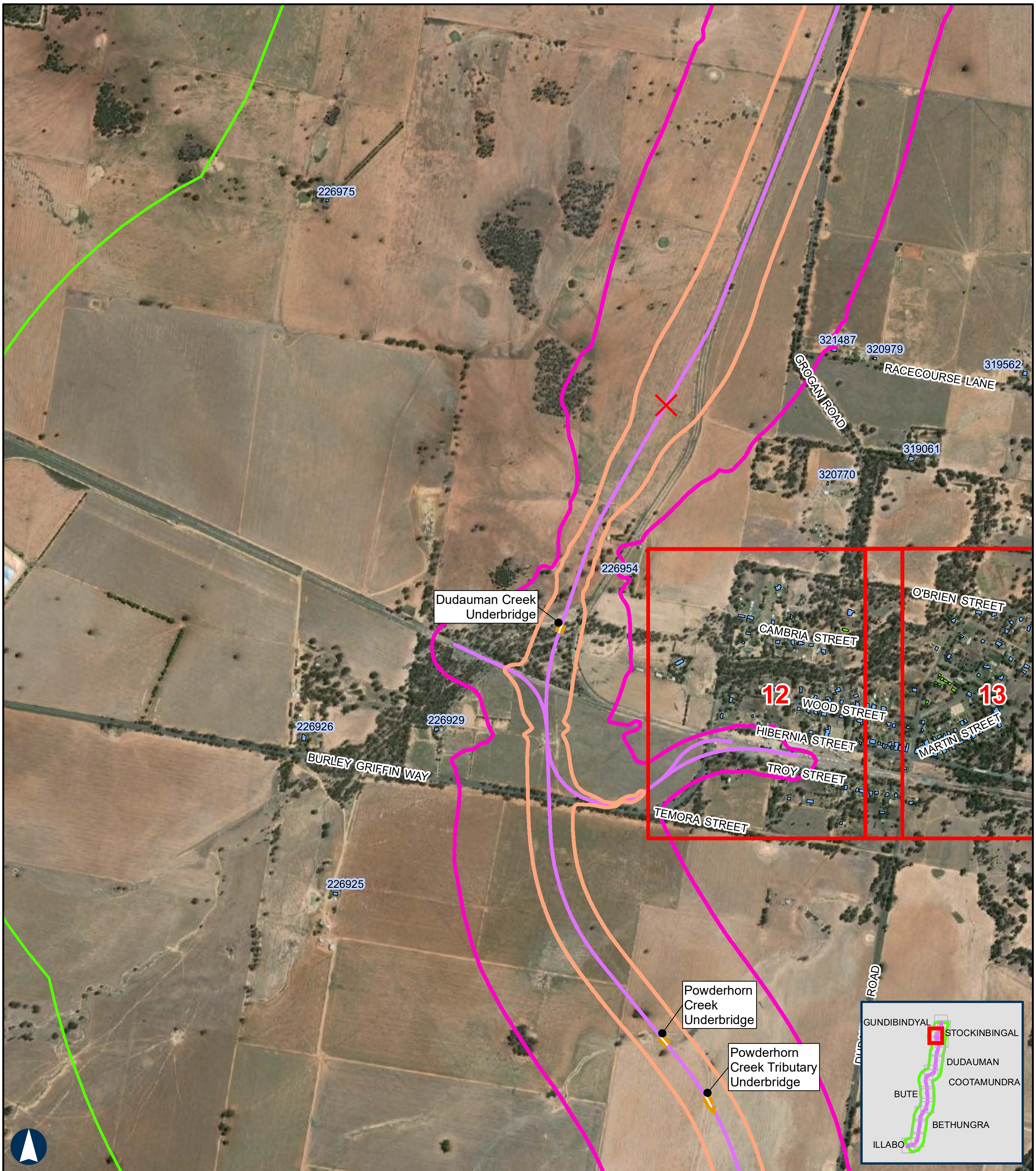

ILLABO TO STOCKINBINGAL

Year 2026 Daytime Rail Noise Levels

APPENDIX D - Map 14 of 16

500 m

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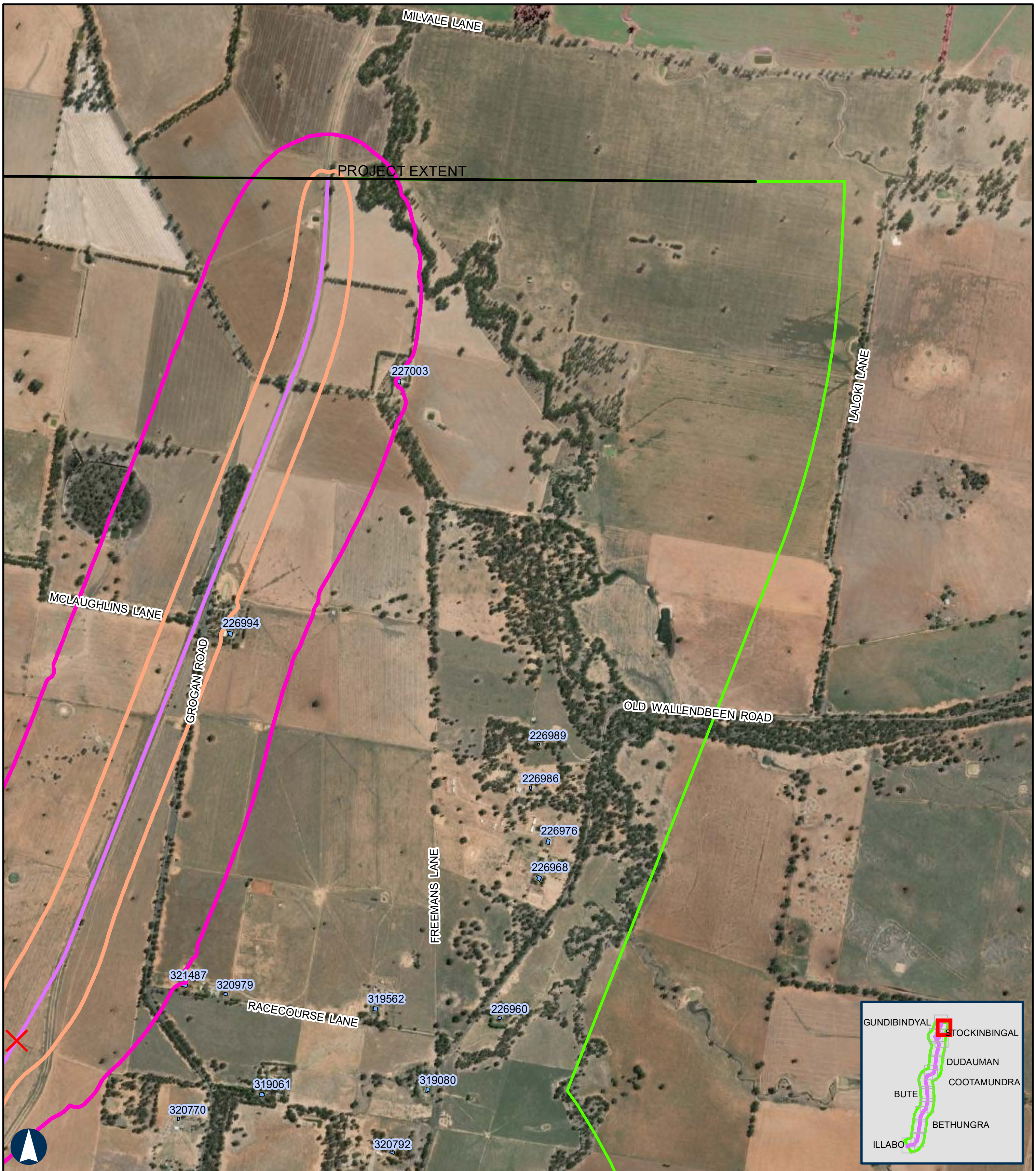

ILLABO TO STOCKINBINGAL

Year 2026 Daytime Rail Noise Levels

APPENDIX D - Map 15 of 16

500 m

Coordinate System: GDA 1994 MGA Zone 55

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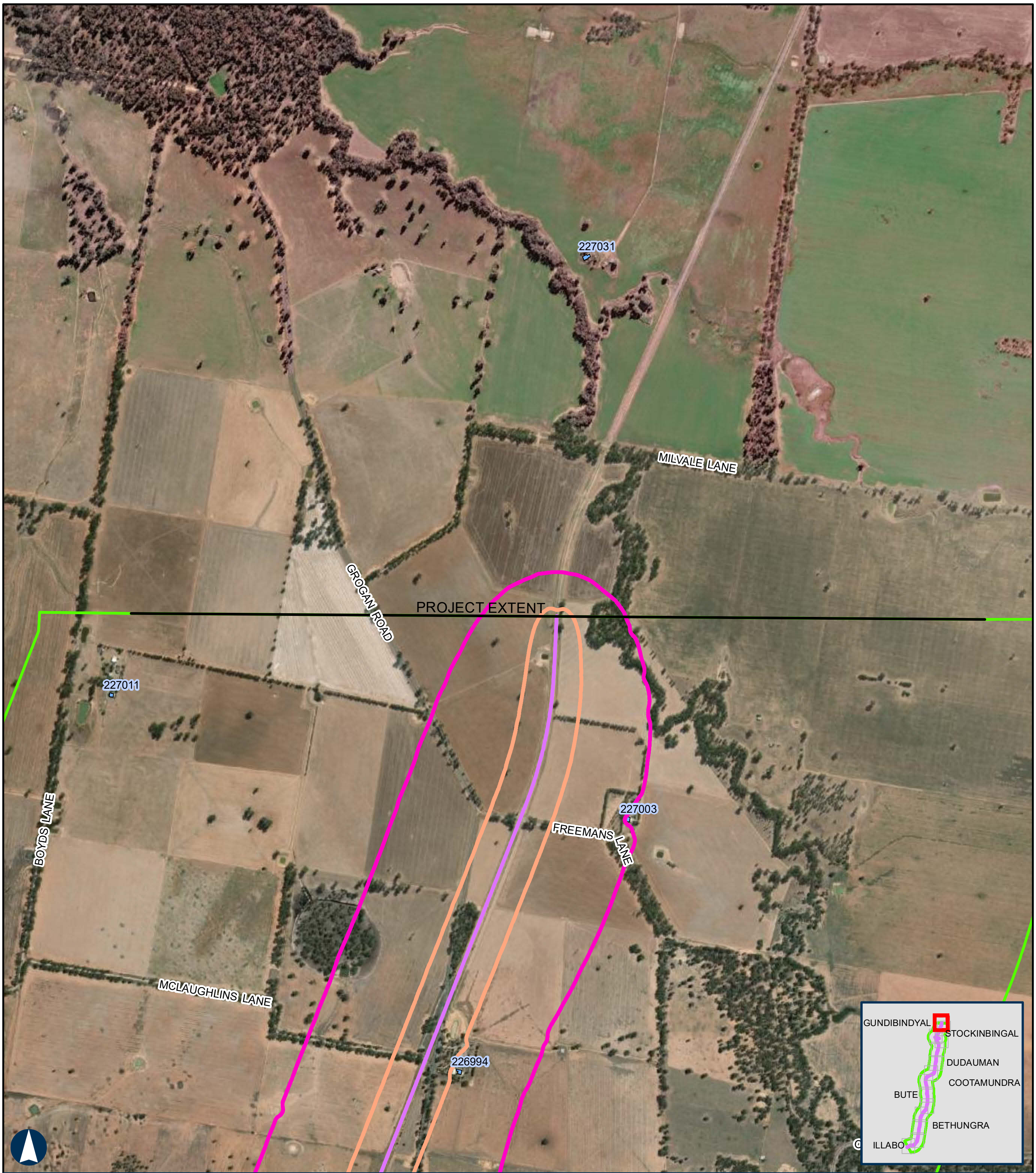

ILLABO TO STOCKINBINGAL

Year 2026 Daytime Rail Noise Levels

APPENDIX D - Map 16 of 16

500 m

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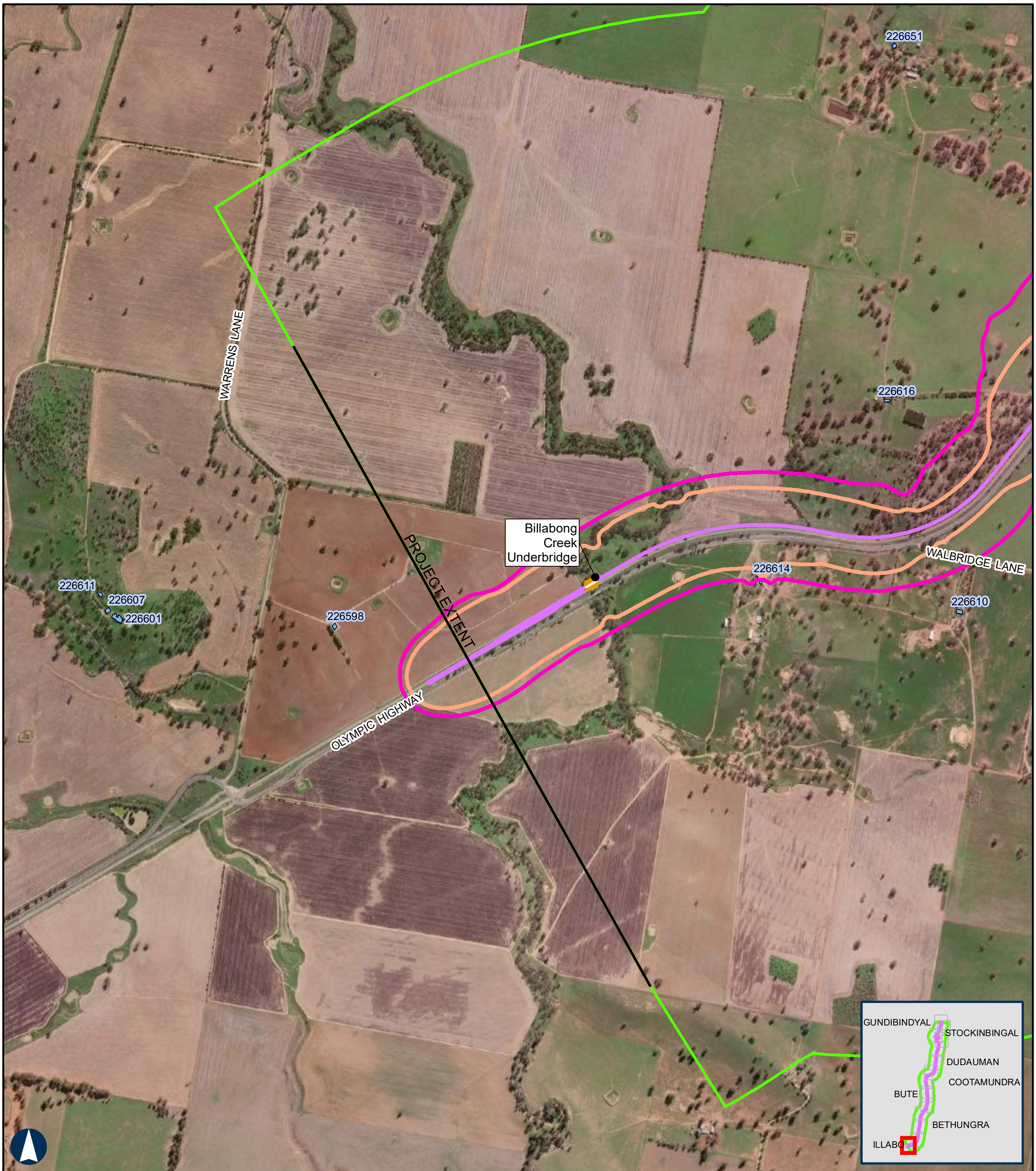

ILLABO TO STOCKINBINGAL

Year 2026 Night-time Rail Noise Levels

APPENDIX D - Map 1 of 16

500 m

Coordinate System: GDA 1994 MGA Zone 55

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Scale: 1:20,000
Date: 01-Nov-2021
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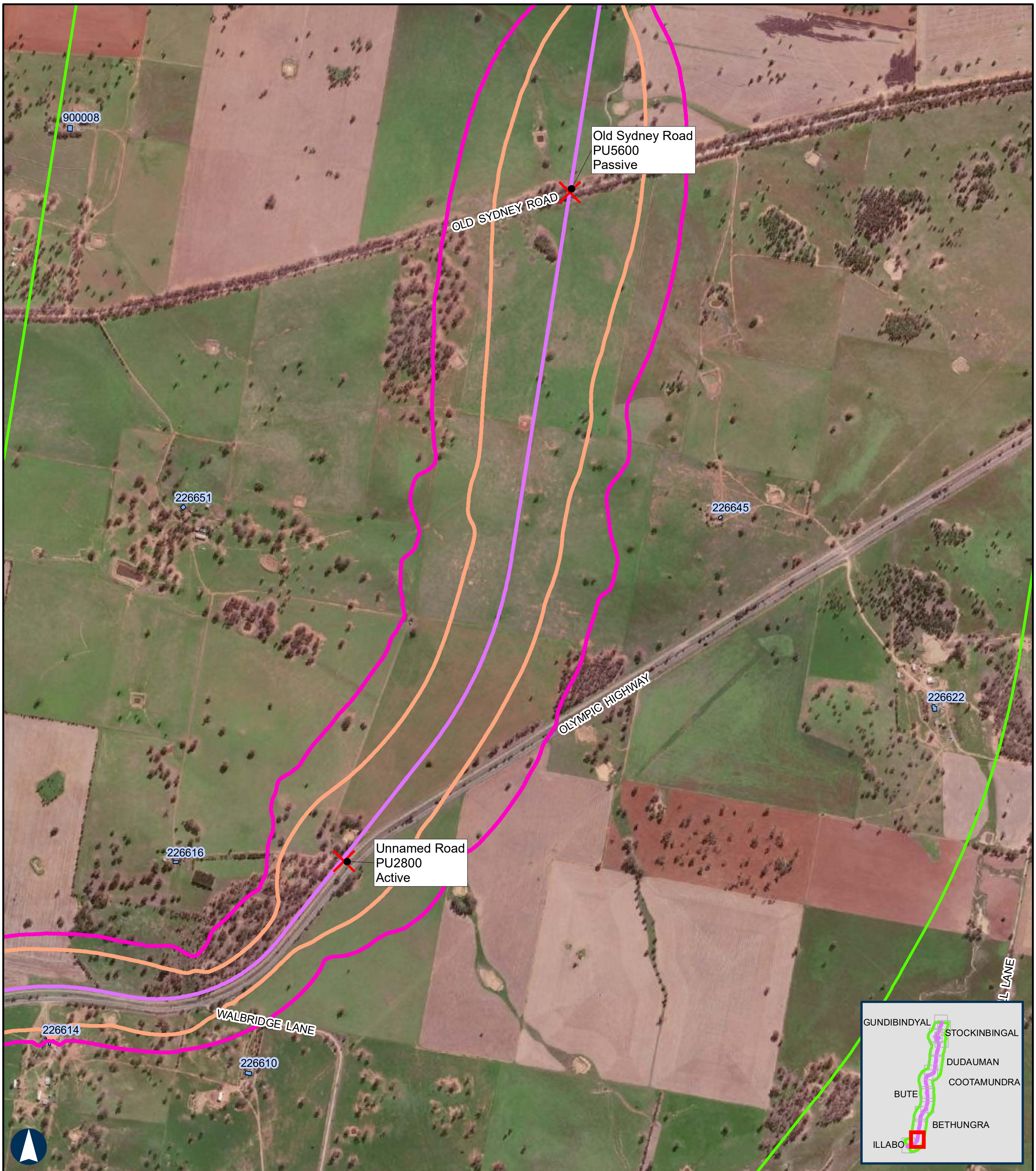

ILLABO TO STOCKINBINGAL

Year 2026 Night-time Rail Noise Levels

APPENDIX D - Map 2 of 16

500 m

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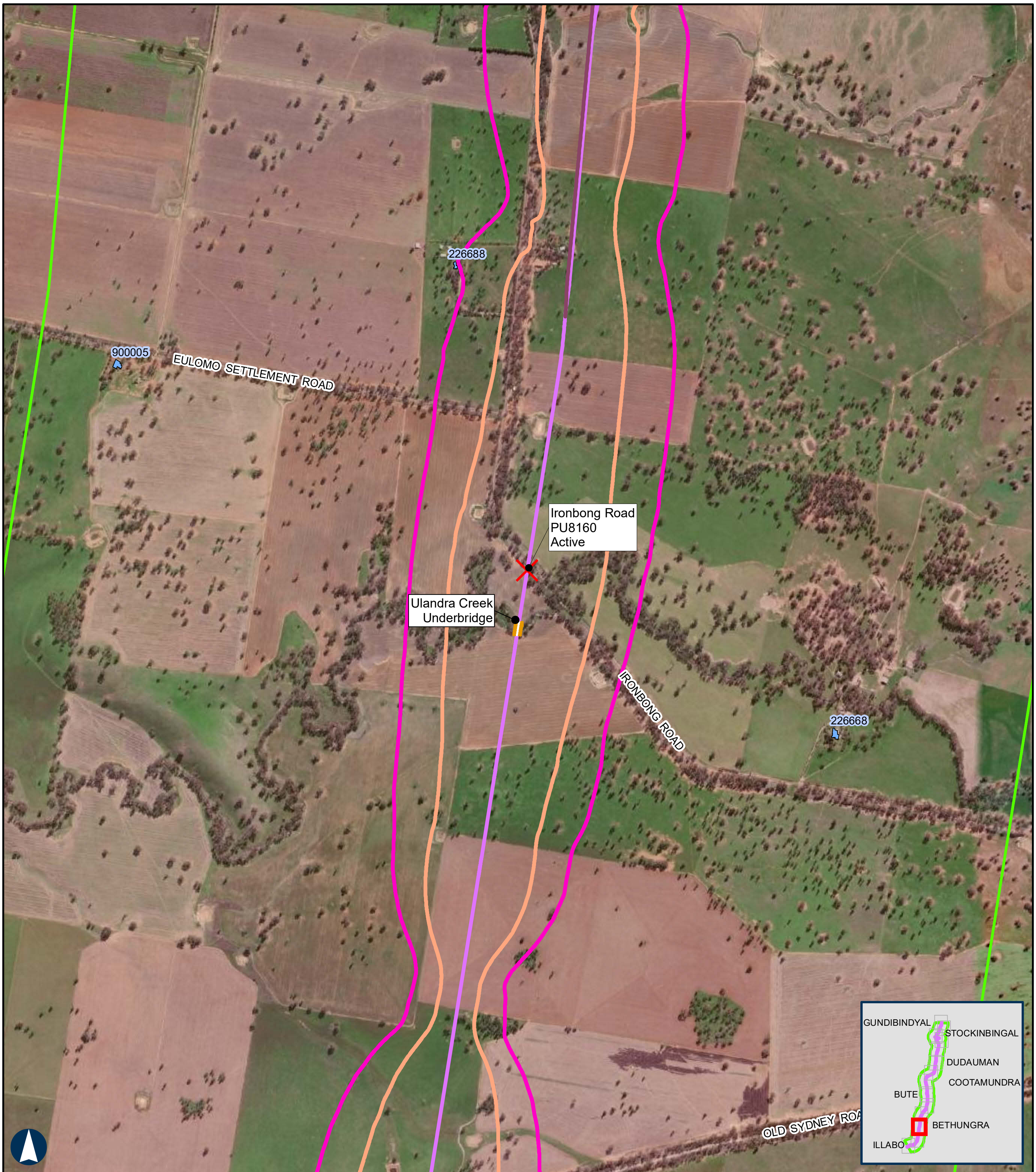

ILLABO TO STOCKINBINGAL

Year 2026 Night-time Rail Noise Levels

APPENDIX D - Map 3 of 16

500 m

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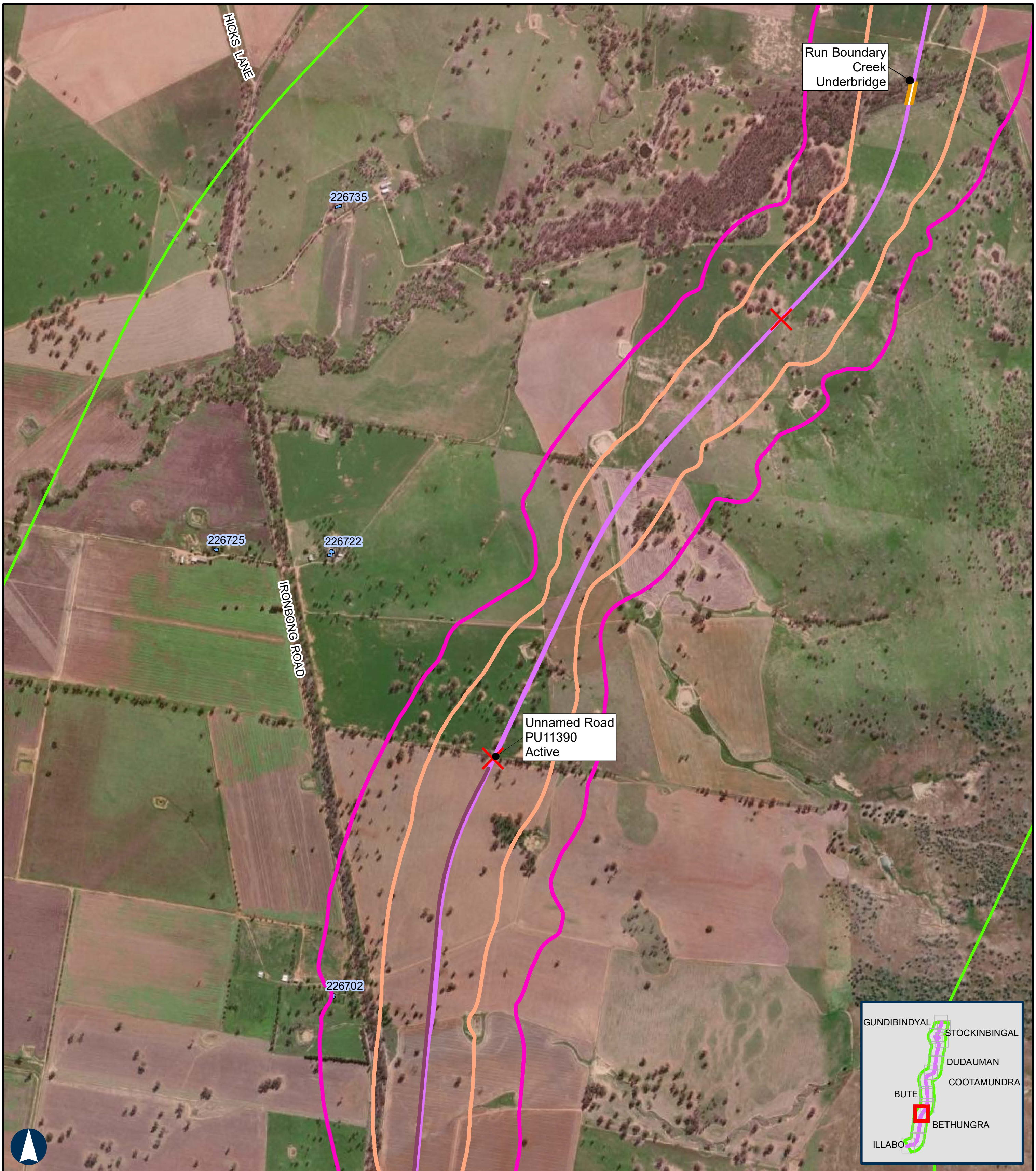

ILLABO TO STOCKINBINGAL

Year 2026 Night-time Rail Noise Levels

APPENDIX D - Map 4 of 16

500 m

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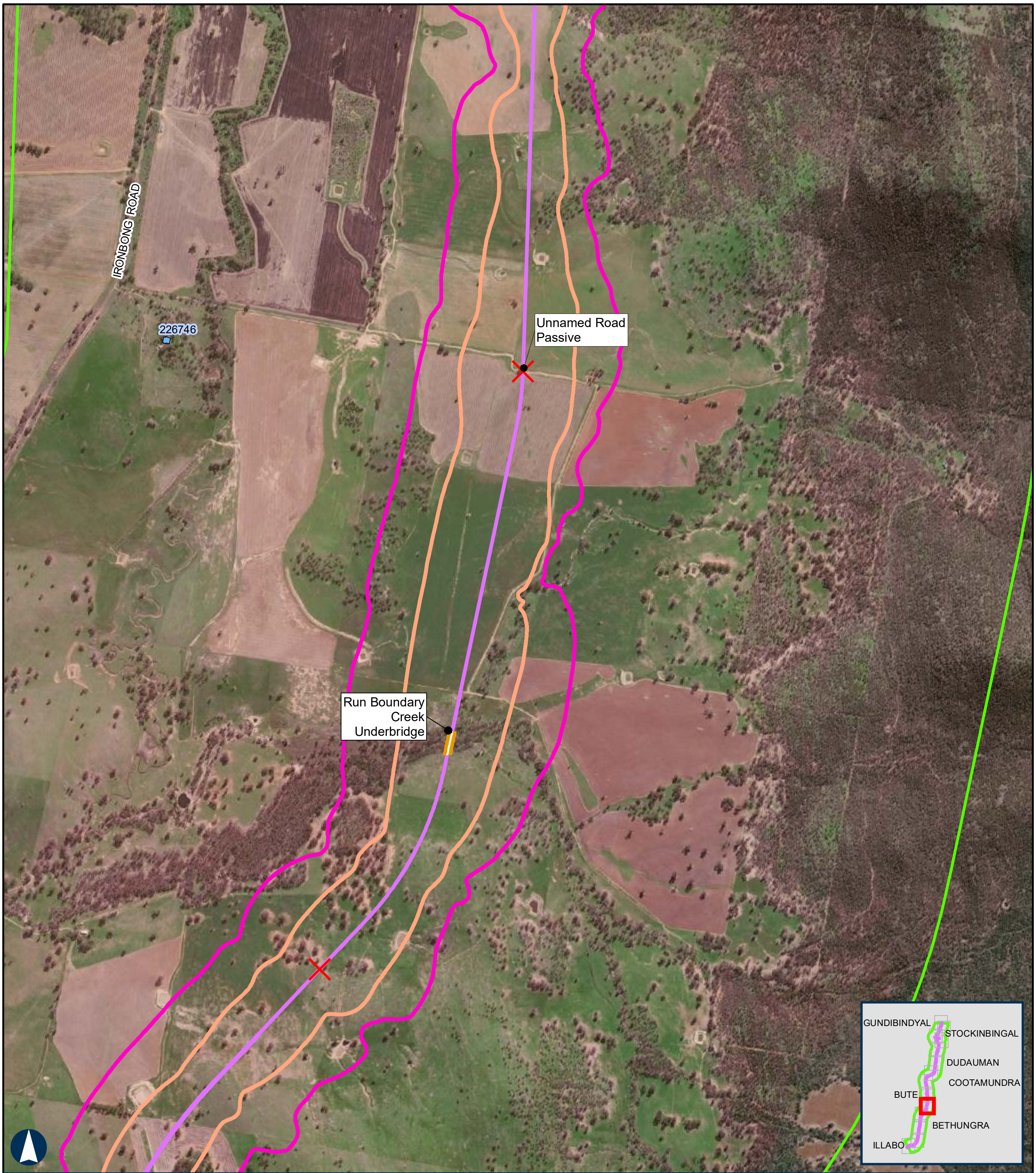

ILLABO TO STOCKINBINGAL Year 2026 Night-time Rail Noise Levels

APPENDIX D - Map 5 of 16

500 m

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Noise contours are based on a set distance above the local terrain level of 2.4m.

ARTC InlandRail

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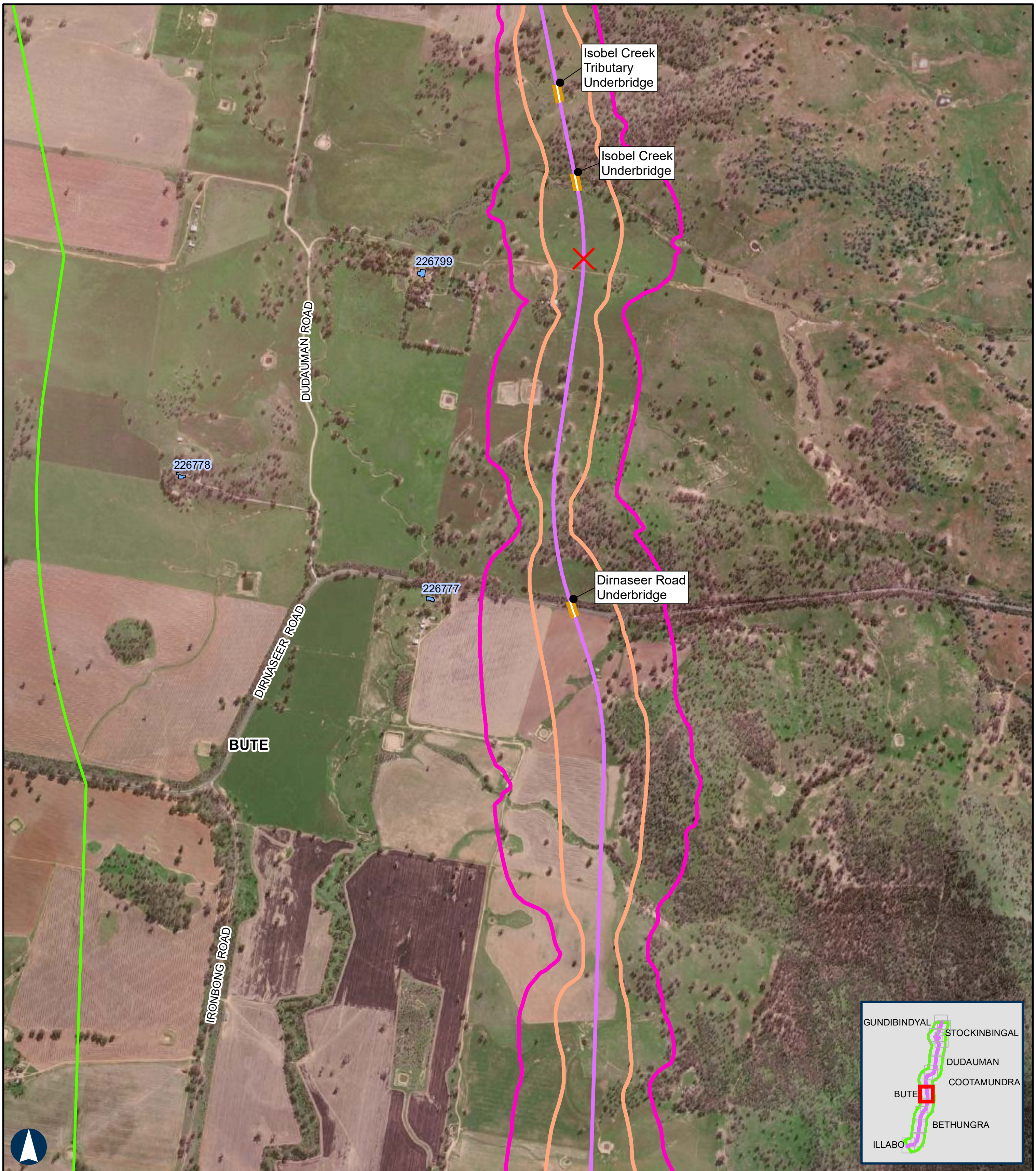
Service Layer Credits: ESRI World Imagery



ILLABO TO STOCKINBINGAL

Year 2026 Night-time Rail Noise Levels

APPENDIX D - Map 6 of 16

500 m

Coordinate System: GDA 1994 MGA Zone 55

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Paper: A4 Scale: 1:20,000
Date: 01-Nov-2021
Author: JG

- Level Crossings
- Proposal Extent
- Crossing Loop
- Rail Alignment/Centreline
- Bridges and Viaducts
- Noise Assessment Area
- Night-time noise criteria LAeq9hr 55dBA New rail corridor
- Night-time noise criteria LA max 80dBA New rail corridor
- Sensitive Receivers
- Non-residential Sensitive Receivers

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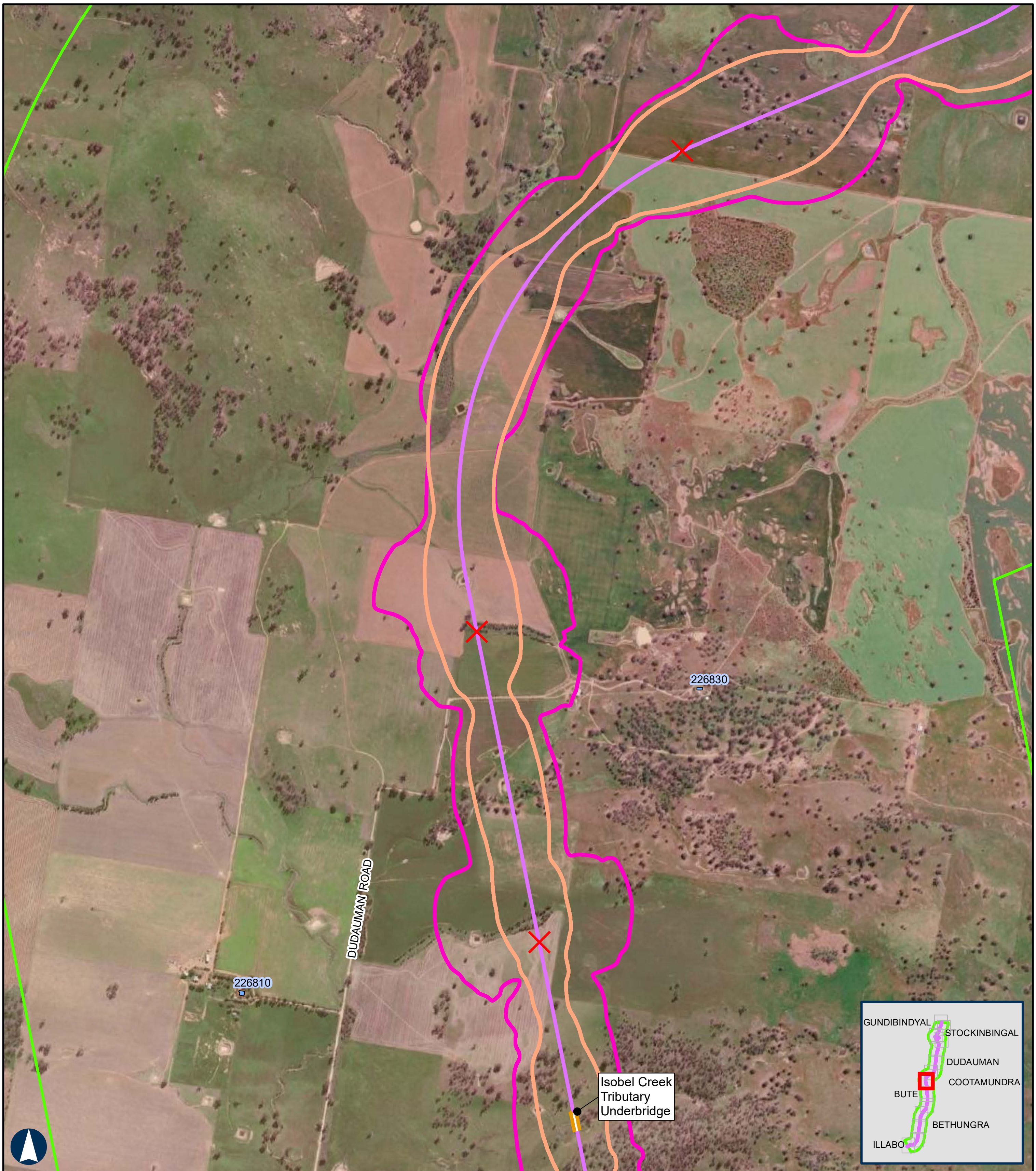
Service Layer Credits: ESRI World Imagery



ILLABO TO STOCKINBINGAL

Year 2026 Night-time Rail Noise Levels

APPENDIX D - Map 7 of 16

500 m

Coordinate System: GDA 1994 MGA Zone 55

Paper: A4 Scale: 1:20,000
Date: 01-Nov-2021
Author: JG

- Level Crossings
- Proposal Extent
- Crossing Loop
- Rail Alignment/Centreline
- Bridges and Viaducts
- Noise Assessment Area
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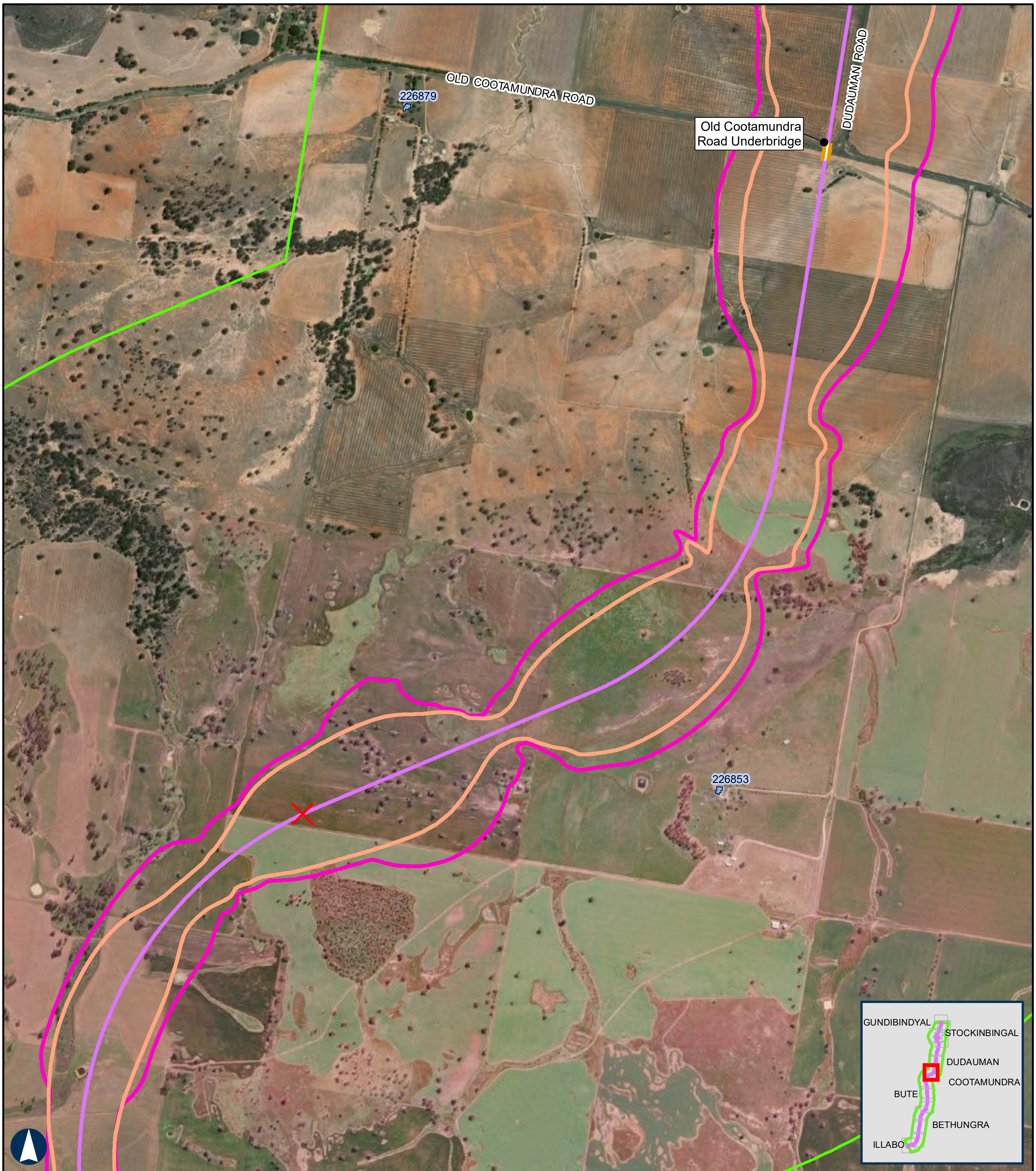

ILLABO TO STOCKINBINGAL

Year 2026 Night-time Rail Noise Levels

APPENDIX D - Map 8 of 16

500 m

Coordinate System: GDA 1994 MGA Zone 55

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Date: 01-Nov-2021
Author: JG

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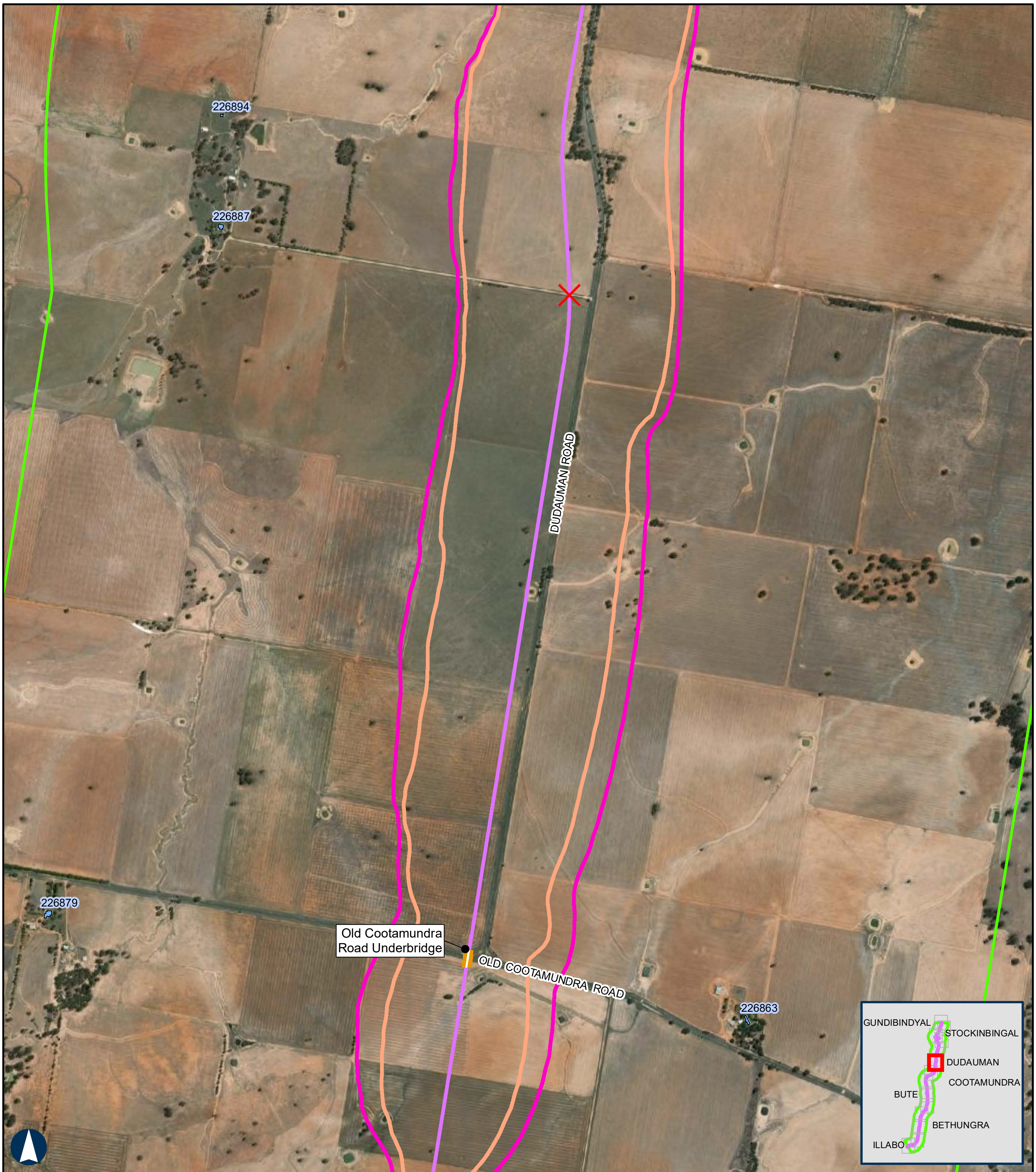
Service Layer Credits: ESRI World Imagery



ILLABO TO STOCKINBINGAL

Year 2026 Night-time Rail Noise Levels

APPENDIX D - Map 9 of 16

500 m

Coordinate System: GDA 1994 MGA Zone 55

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Paper: A4
Scale: 1:20,000
Date: 01-Nov-2021
Author: JG

- Level Crossings
- Proposal Extent
- Crossing Loop
- Rail Alignment/Centreline
- Bridges and Viaducts
- Noise Assessment Area
- Night-time noise criteria LAeq9hr 55dBA New rail corridor
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- Non-residential Sensitive Receivers

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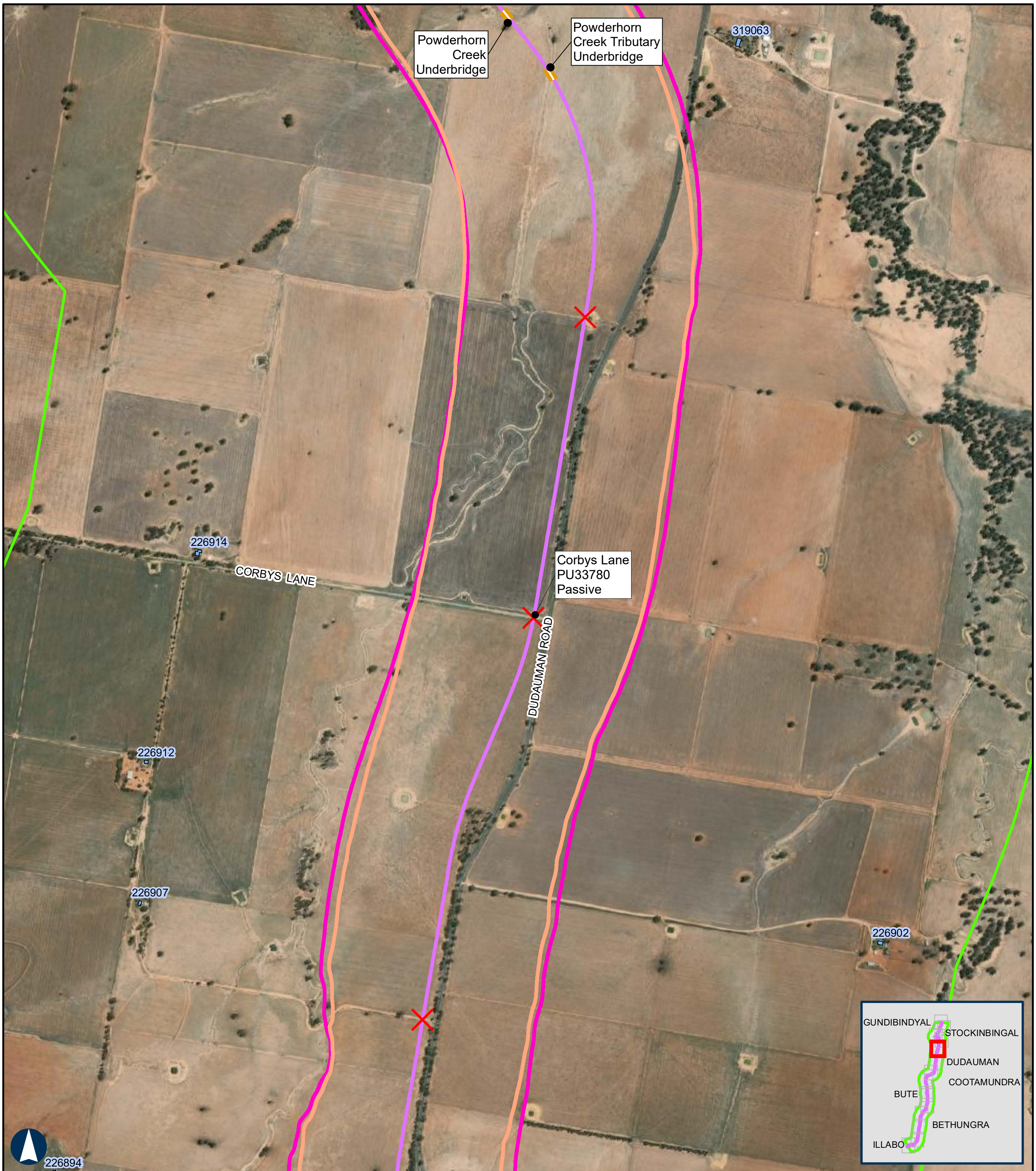
Service Layer Credits: ESRI World Imagery



ILLABO TO STOCKINBINGAL

Year 2026 Night-time Rail Noise Levels

APPENDIX D - Map 10 of 16

500 m

Coordinate System: GDA 1994 MGA Zone 55

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Paper: A4
Scale: 1:20,000
Date: 01-Nov-2021
Author: JG

- Level Crossings
- Proposal Extent
- Crossing Loop
- Rail Alignment/Centreline
- Bridges and Viaducts
- Noise Assessment Area
- Night-time noise criteria LAeq9hr 55dBA New rail corridor
- Night-time noise criteria LA max 80dBA New rail corridor
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- Non-residential Sensitive Receivers

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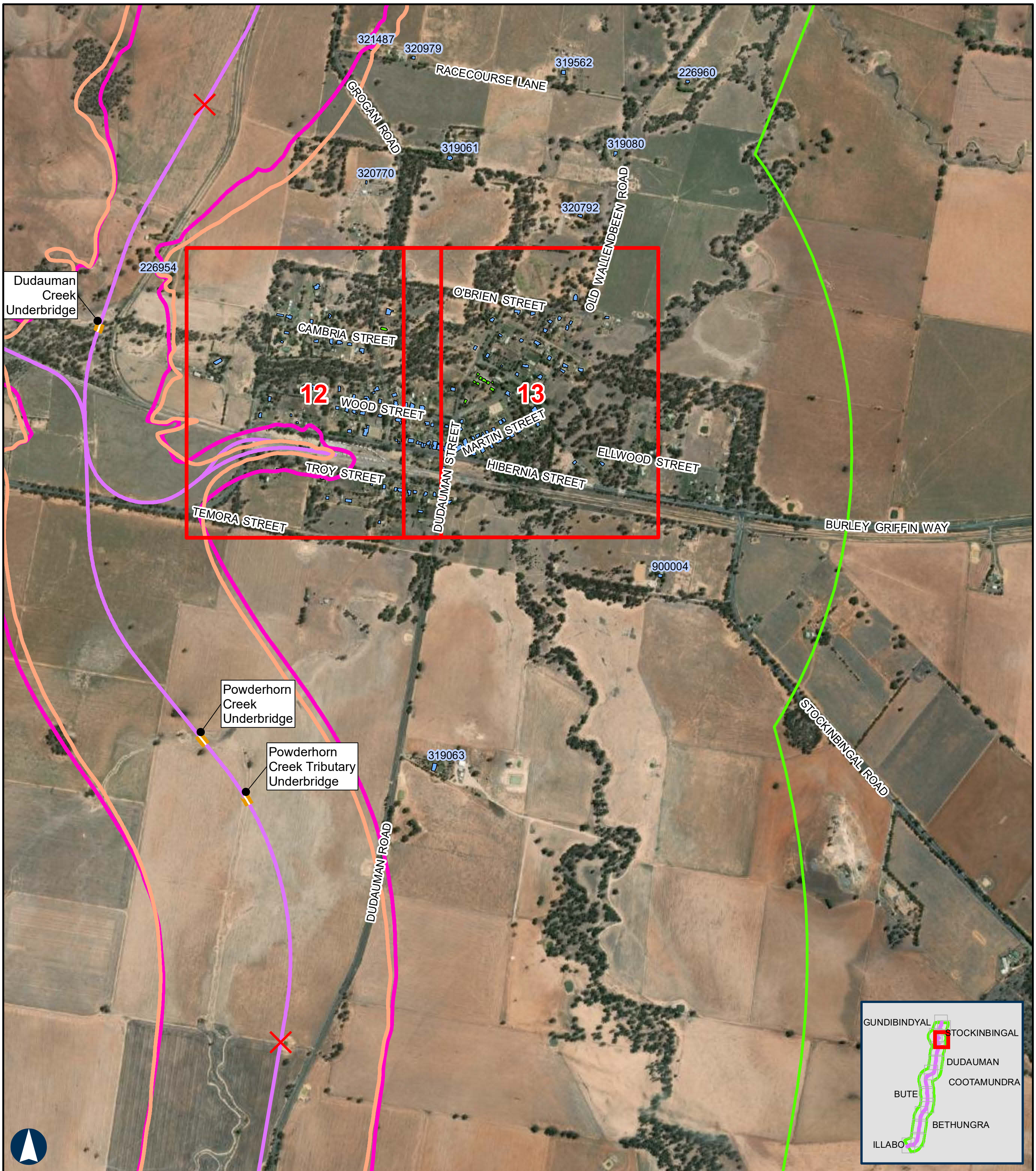
Service Layer Credits: ESRI World Imagery



ILLABO TO STOCKINBINGAL Year 2026 Night-time Rail Noise Levels

APPENDIX D - Map 11 of 16

500 m

Coordinate System: GDA 1994 MGA Zone 55

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Paper: A4 Scale: 1:20,000
Date: 01-Nov-2021
Author: JG

- Level Crossings
- Proposal Extent
- Crossing Loop
- Rail Alignment/Centreline
- Bridges and Viaducts
- Noise Assessment Area
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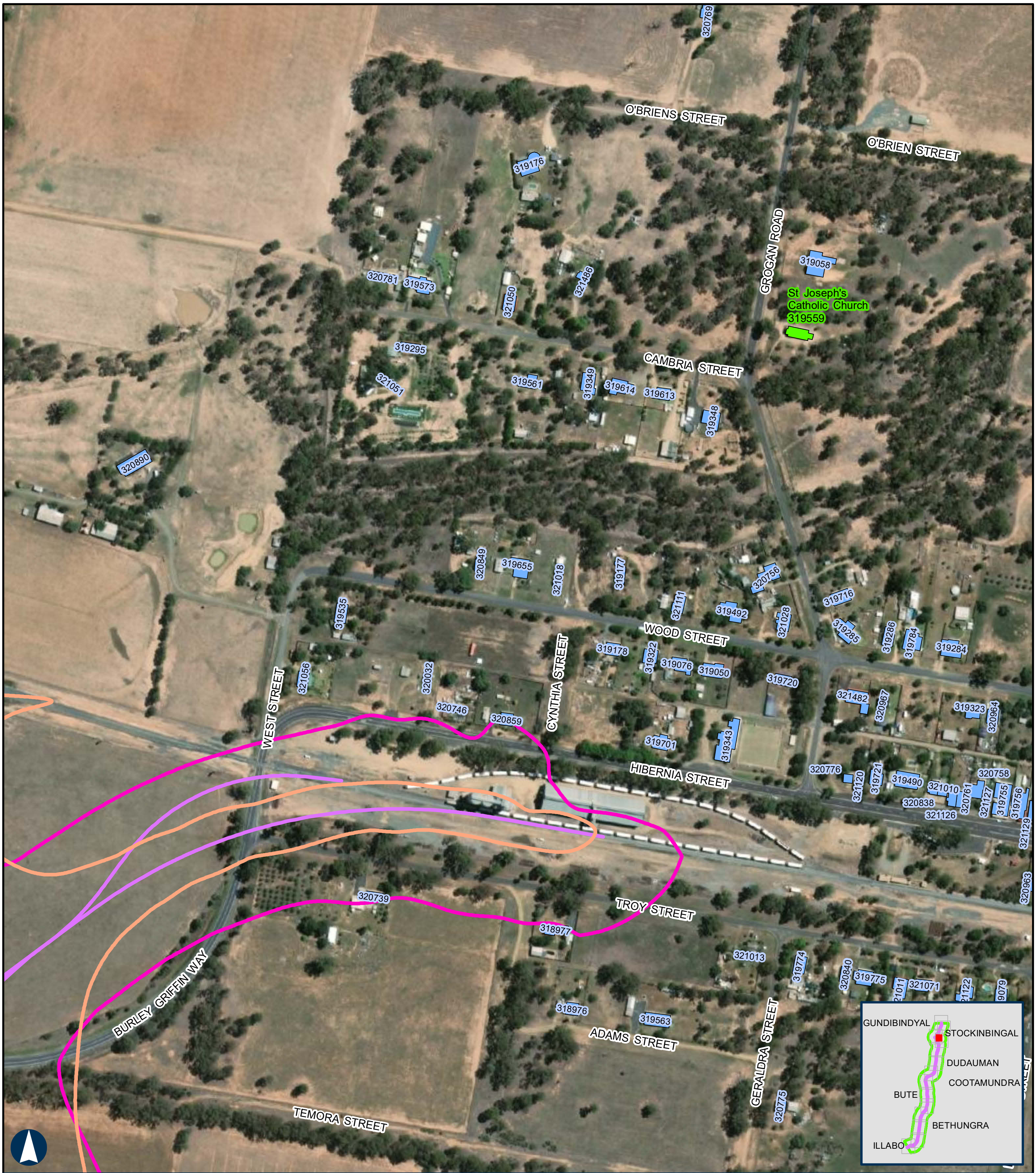
Service Layer Credits: ESRI World Imagery



ILLABO TO STOCKINBINGAL Year 2026 Night-time Rail Noise Levels - Detailed

APPENDIX D - Map 12 of 16

100 m

Coordinate System: GDA 1994 MGA Zone 55

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Paper: A4
Scale: 1:5,000
Date: 19-Aug-2021
Author: JG

- Level Crossings
- Proposal Extent
- Crossing Loop
- Rail Alignment/Centreline
- Bridges and Viaducts
- Noise Assessment Area
- Night-time noise criteria LAeq9hr 55dBA New rail corridor
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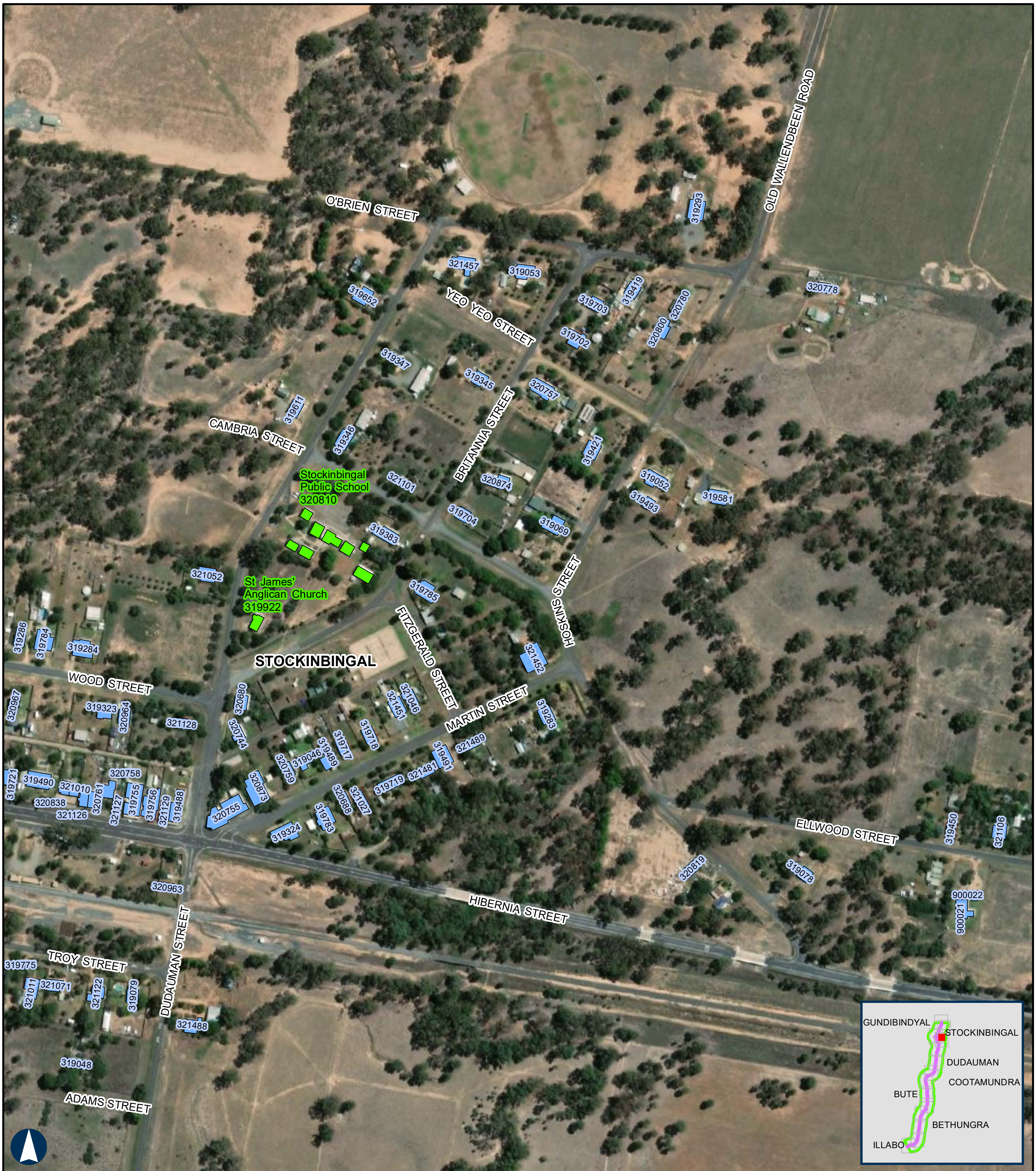
Service Layer Credits: ESRI World Imagery



ILLABO TO STOCKINBINGAL Year 2026 Night-time Rail Noise Levels - Detailed

APPENDIX D - Map 13 of 16

100 m

Coordinate System: GDA 1994 MGA Zone 55

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Date: 19-Aug-2021
Author: JG

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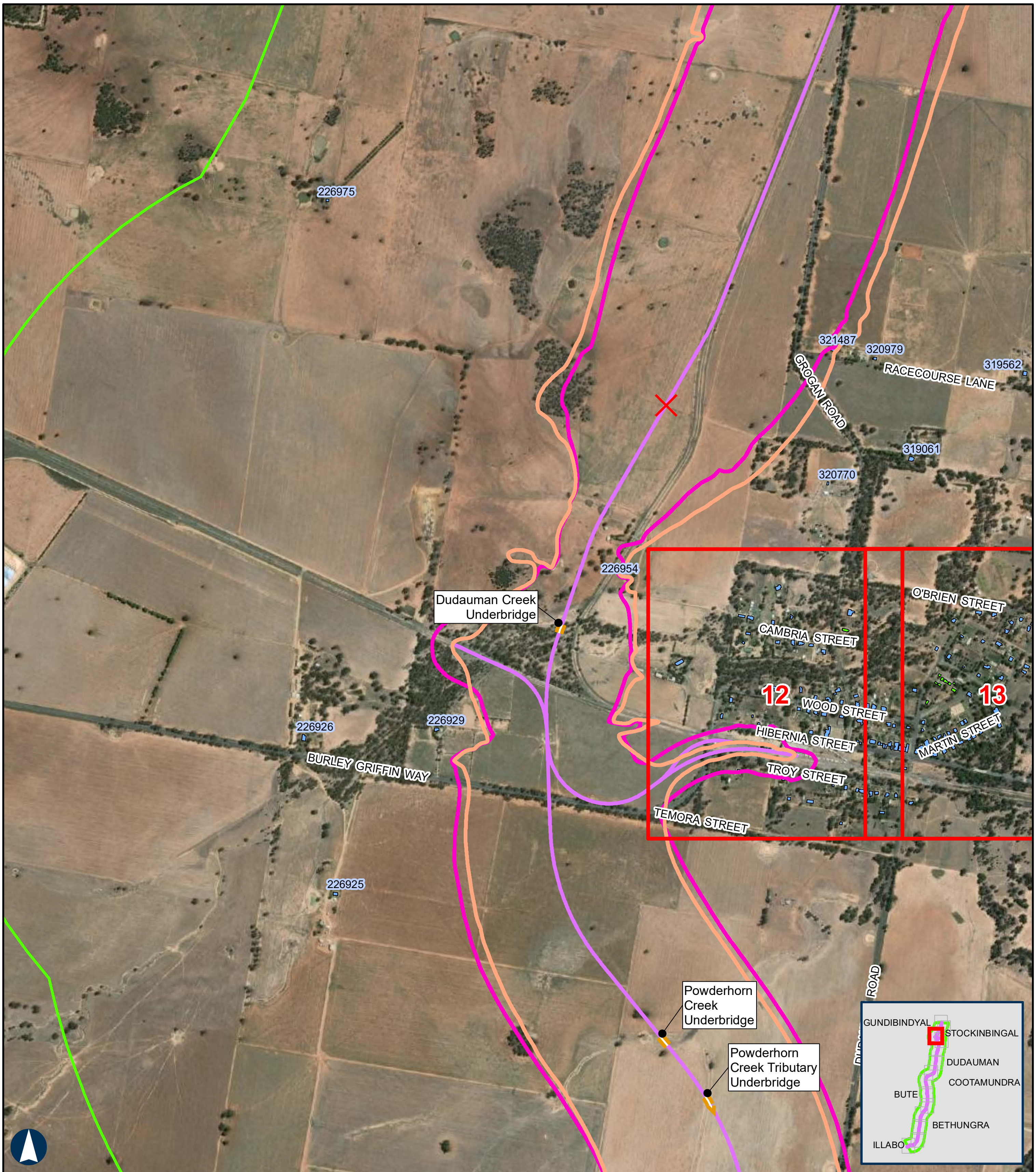
Service Layer Credits: ESRI World Imagery



ILLABO TO STOCKINBINGAL

Year 2026 Night-time Rail Noise Levels

500 m

Coordinate System: GDA 1994 MGA Zone 55

Paper: A4
Scale: 1:20,000
Date: 01-Nov-2021
Author: JG

- Level Crossings
- Proposal Extent
- Crossing Loop
- Rail Alignment/Centreline
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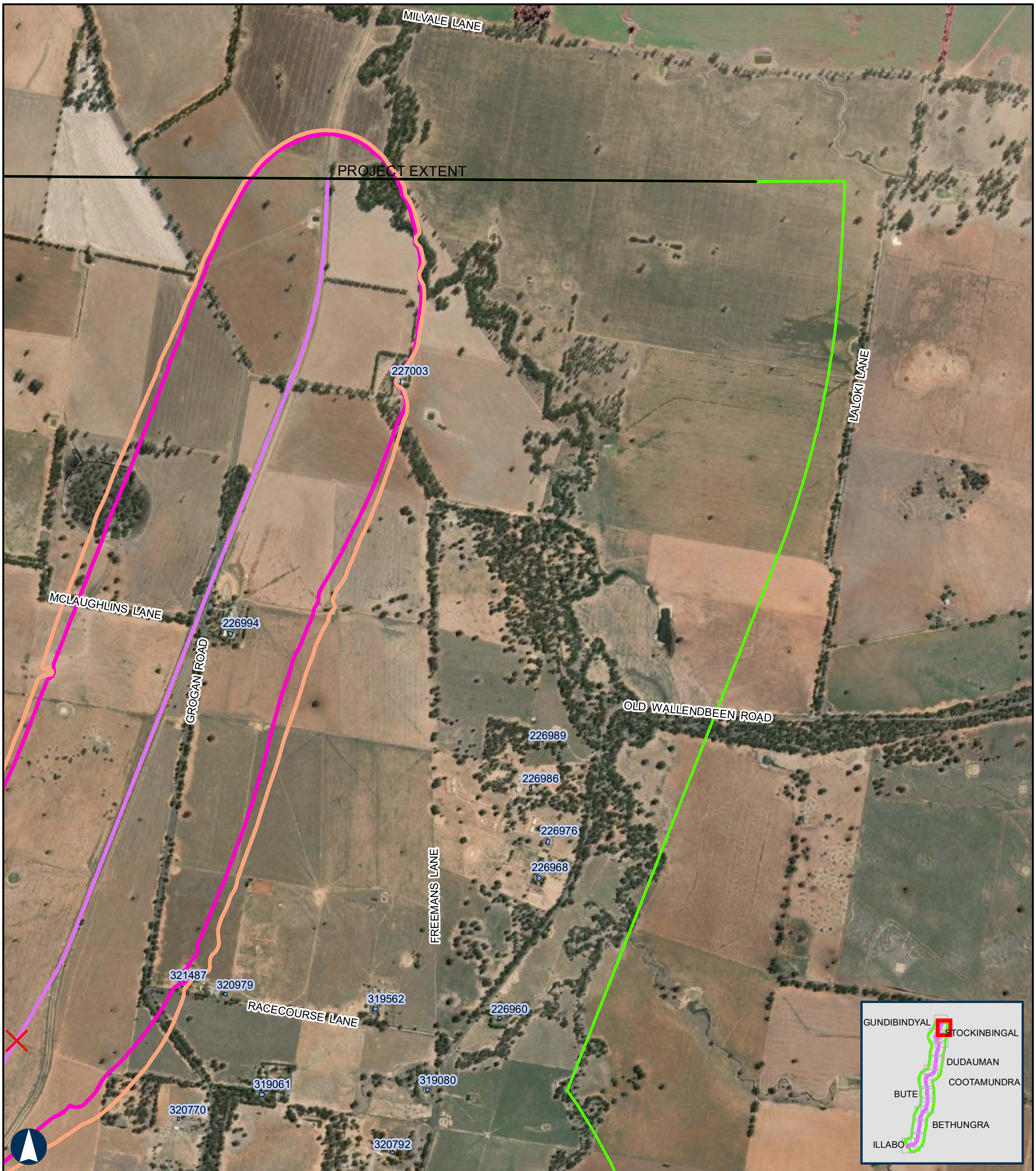

ILLABO TO STOCKINBINGAL

Year 2026 Night-time Rail Noise Levels

APPENDIX D - Map 15 of 16

500 m

Coordinate System: GDA 1994 MGA Zone 55

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Paper: A4
Scale: 1:20,000
Date: 01-Nov-2021
Author: JG

- Level Crossings
- Proposal Extent
- Crossing Loop
- Rail Alignment/Centreline
- Bridges and Viaducts
- Noise Assessment Area
- Night-time noise criteria LAeq9hr 55dBA New rail corridor
- Night-time noise criteria LA max 80dBA New rail corridor
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Noise contours are based on a set distance above the local terrain level of 2.4m.

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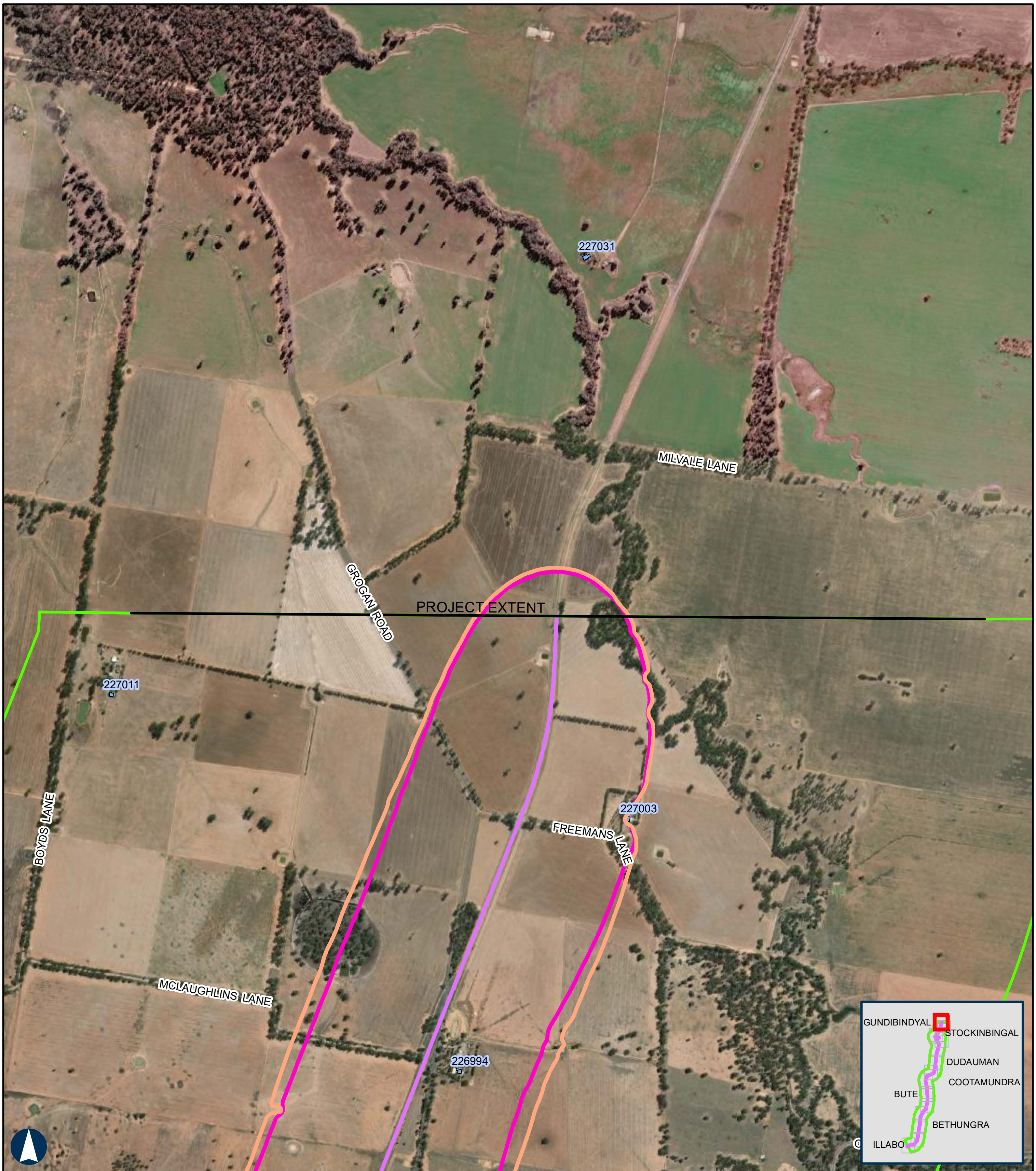
Service Layer Credits: ESRI World Imagery



ILLABO TO STOCKINBINGAL

Year 2026 Night-time Rail Noise Levels

APPENDIX D - Map 16 of 16

500 m

Coordinate System: GDA 1994 MGA Zone 55

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- Level Crossings
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- Rail Alignment/Centreline
- Bridges and Viaducts
- Noise Assessment Area
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Paper: A4
Scale: 1:20,000
Date: 01-Nov-2021
Author: JG

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Service Layer Credits: ESRI World Imagery

Receptor ID	Rail noise criteria			Project rail noise levels dBA		
	LAeq Day	LAeq Night	Lamax	LAeq,15hr	LAeq,9hr	LAmax
226598	60	55	80	49	46	73
226601	60	55	80	45	43	69
226607	60	55	80	42	40	67
226610	60	55	80	50	48	76
226611	60	55	80	42	40	66
226614	60	55	80	56	53	**81**
226616	60	55	80	51	49	76
226622	60	55	80	31	31	56
226645	60	55	80	42	44	70
226651	60	55	80	38	37	67
226668	60	55	80	44	46	73
226688	60	55	80	50	52	80
226702	60	55	80	51	53	**82**
226722	60	55	80	44	45	75
226725	60	55	80	41	43	71
226735	60	55	80	40	42	70
226746	60	55	80	42	44	70
226777	60	55	80	47	48	78
226778	60	55	80	42	44	72
226799	60	55	80	45	46	75
226810	60	55	80	41	42	68
226830	60	55	80	45	47	72
226853	60	55	80	50	52	79
226863	60	55	80	44	46	72
226879	60	55	80	41	43	69
226887	60	55	80	45	47	71
226894	60	55	80	46	48	72
226902	60	55	80	45	47	72
226907	60	55	80	47	49	75
226912	60	55	80	48	50	75
226914	60	55	80	48	50	75
226925	60	55	80	48	50	75
226926	60	55	80	47	49	74
226929	60	55	80	49	51	76
226954	60	55	80	53	54	79
226960	60	55	80	46	48	72
226968	60	55	80	47	49	73
226975	60	55	80	40	42	65
226976	60	55	80	46	48	71
226986	60	55	80	46	48	72
226989	60	55	80	46	48	72
226994	60	55	80	56	**58**	**83**
227003	60	55	80	54	**56**	80
227011	60	55	80	46	48	71
227031	60	55	80	43	45	69
318976	60	55	80	50	52	76
318977	60	55	80	50	52	**81**
319046	60	55	80	44	46	69
319048	60	55	80	48	50	74
319050	60	55	80	49	50	72
319052	60	55	80	45	47	69
319053	60	55	80	47	49	71
319058	60	55	80	49	51	73
319061	60	55	80	50	52	76
319063	60	55	80	50	52	77
319069	60	55	80	46	48	69
319076	60	55	80	49	50	73
319078	60	55	80	46	48	71
319079	60	55	80	48	49	73
319080	60	55	80	46	48	70

Receptor ID	Rail noise criteria			Project rail noise levels dBA		
	LAeq Day	LAeq Night	Lamax	LAeq,15hr	LAeq,9hr	LAmax
319176	60	55	80	50	52	75
319177	60	55	80	48	50	73
319178	60	55	80	49	50	73
319283	60	55	80	45	46	68
319284	60	55	80	48	50	72
319285	60	55	80	50	51	73
319286	60	55	80	49	51	72
319293	60	55	80	45	47	70
319295	60	55	80	50	52	75
319322	60	55	80	49	51	74
319323	60	55	80	48	50	72
319324	60	55	80	46	48	72
319343	60	55	80	49	51	73
319345	60	55	80	46	48	71
319346	60	55	80	47	49	71
319347	60	55	80	47	49	71
319348	60	55	80	48	50	72
319349	60	55	80	49	51	74
319419	60	55	80	48	50	73
319421	60	55	80	46	48	69
319488	60	55	80	46	48	70
319489	60	55	80	45	47	69
319490	60	55	80	47	49	72
319491	60	55	80	44	46	70
319492	60	55	80	49	51	73
319493	60	55	80	45	47	69
319535	60	55	80	51	52	76
319561	60	55	80	51	52	75
319562	60	55	80	47	49	73
319563	60	55	80	49	51	75
319573	60	55	80	49	51	74
319581	60	55	80	45	47	69
319611	60	55	80	46	48	72
319613	60	55	80	49	51	74
319614	60	55	80	49	51	73
319652	60	55	80	48	50	73
319655	60	55	80	50	52	76
319701	60	55	80	49	51	74
319702	60	55	80	47	49	71
319703	60	55	80	48	50	72
319704	60	55	80	46	48	70
319716	60	55	80	48	50	72
319717	60	55	80	45	47	68
319718	60	55	80	46	48	70
319719	60	55	80	46	48	70
319720	60	55	80	48	50	72
319721	60	55	80	48	50	72
319755	60	55	80	47	48	71
319756	60	55	80	47	49	71
319774	60	55	80	49	51	74
319775	60	55	80	48	50	75
319783	60	55	80	46	48	71
319784	60	55	80	49	51	72
319785	60	55	80	45	46	68
320032	60	55	80	50	52	77
320680	60	55	80	47	49	71
320688	60	55	80	44	46	70
320739	60	55	80	52	54	80
320744	60	55	80	47	49	72
320746	60	55	80	52	53	80

Receptor ID	Rail noise criteria			Project rail noise levels dBA		
	LAeq Day	LAeq Night	Lamax	LAeq,15hr	LAeq,9hr	LAmax
320755	60	55	80	46	48	71
320756	60	55	80	49	50	73
320757	60	55	80	47	49	71
320758	60	55	80	48	49	72
320759	60	55	80	46	47	69
320761	60	55	80	47	49	72
320769	60	55	80	47	49	73
320770	60	55	80	51	53	77
320775	60	55	80	49	51	75
320776	60	55	80	49	50	73
320778	60	55	80	46	48	70
320780	60	55	80	46	48	70
320781	60	55	80	50	52	75
320792	60	55	80	48	50	74
320800	60	55	80	46	48	70
320819	60	55	80	45	47	70
320838	60	55	80	48	50	73
320840	60	55	80	49	51	74
320849	60	55	80	49	51	75
320859	60	55	80	49	51	80
320873	60	55	80	46	48	71
320874	60	55	80	46	48	71
320890	60	55	80	52	54	77
320963	60	55	80	48	50	73
320964	60	55	80	48	50	70
320967	60	55	80	48	50	72
320979	60	55	80	53	55	80
321010	60	55	80	47	49	74
321011	60	55	80	49	51	74
321013	60	55	80	49	51	74
321018	60	55	80	49	51	73
321027	60	55	80	47	49	71
321028	60	55	80	49	51	73
321046	60	55	80	45	47	68
321050	60	55	80	49	51	74
321051	60	55	80	50	52	74
321052	60	55	80	48	50	72
321056	60	55	80	52	54	78
321071	60	55	80	48	50	74
321101	60	55	80	46	48	69
321111	60	55	80	48	50	72
321120	60	55	80	49	51	74
321122	60	55	80	48	50	72
321126	60	55	80	48	50	73
321127	60	55	80	47	49	72
321128	60	55	80	48	50	71
321129	60	55	80	45	47	71
321451	60	55	80	46	48	69
321452	60	55	80	46	48	69
321457	60	55	80	47	49	71
321481	60	55	80	46	48	70
321482	60	55	80	49	51	74
321486	60	55	80	49	50	73
321487	60	55	80	55	**56**	**81**
321488	60	55	80	48	50	74
321489	60	55	80	46	48	70
900004	60	55	80	42	44	67
900005	60	55	80	44	46	73
900008	60	55	80	40	41	67

TECHNICAL PAPER 9

Operational Noise and Vibration Assessment (Rail) Report

Appendix E Predicted airborne railway noise levels—Year 2040 design year

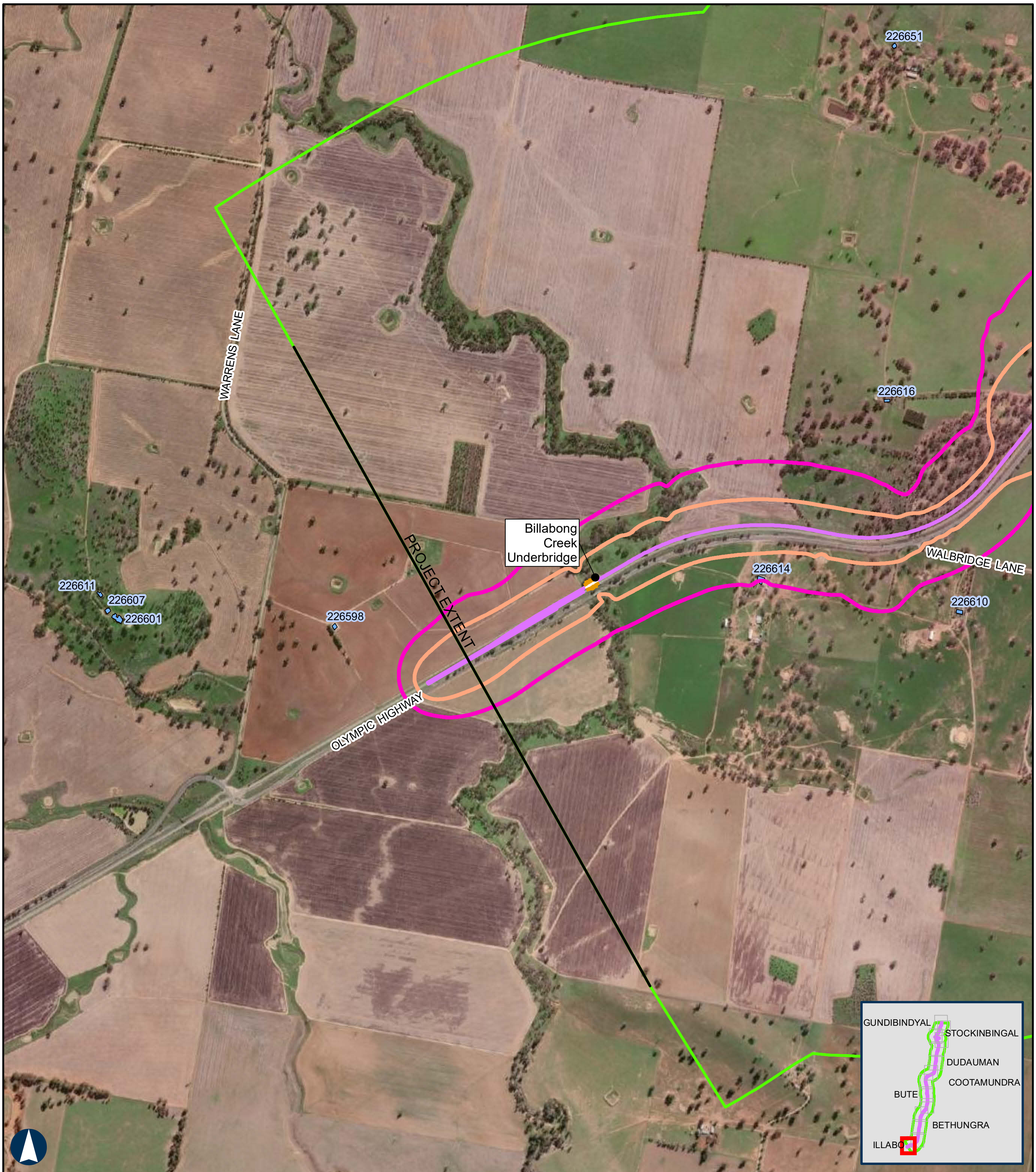
The predicted railway noise levels for railway operations in year 2040 are detailed in the following table and noise contour maps. The predicted noise levels are provided for the identified sensitive receivers within the study area. This includes all sensitive receivers where the predicted noise levels triggered an investigation of noise mitigation.

Following the tabulated results are the predicted noise contour maps for the railway operations in year 2040. The predicted railway noise levels that trigger a review of noise mitigation are highlighted in bold.

The noise contours have been presented as the daytime and night-time assessment criteria applied by ARTC on the Proposal. All noise contours are predicted at 2.4 m above ground level.

The noise contour maps cover the entire Proposal route and provide a detailed presentation of the assessment of noise based on the daytime and night-time railway noise assessment criteria.

The noise contours are calculated from the interpolation of thousands of calculation points and provide an overview of the railway noise levels to assist the interpretation of the assessment and its outcomes. The tabulated noise levels at the individual sensitive receivers should be referenced when assessing railway noise levels against the criteria.



ILLABO TO STOCKINBINGAL

Year 2040 Daytime Rail Noise Levels

APPENDIX E - Map 1 of 16

500 m

Coordinate System: GDA 1994 MGA Zone 55

Paper: A4 Scale: 1:20,000
Date: 01-Nov-2021
Author: JG

- Level Crossings
- Proposal Extent
- Crossing Loop
- Rail Alignment/Centreline
- Bridges and Viaducts
- Noise Assessment Area
- Daytime noise criteria LAeq15hr 60dBA New rail corridor
- Daytime noise criteria LA max 80dBA New rail corridor
- Sensitive Receivers
- Non-residential Sensitive Receivers

Noise contours are based on a set distance above the local terrain level of 2.4m.

ARTC InlandRail

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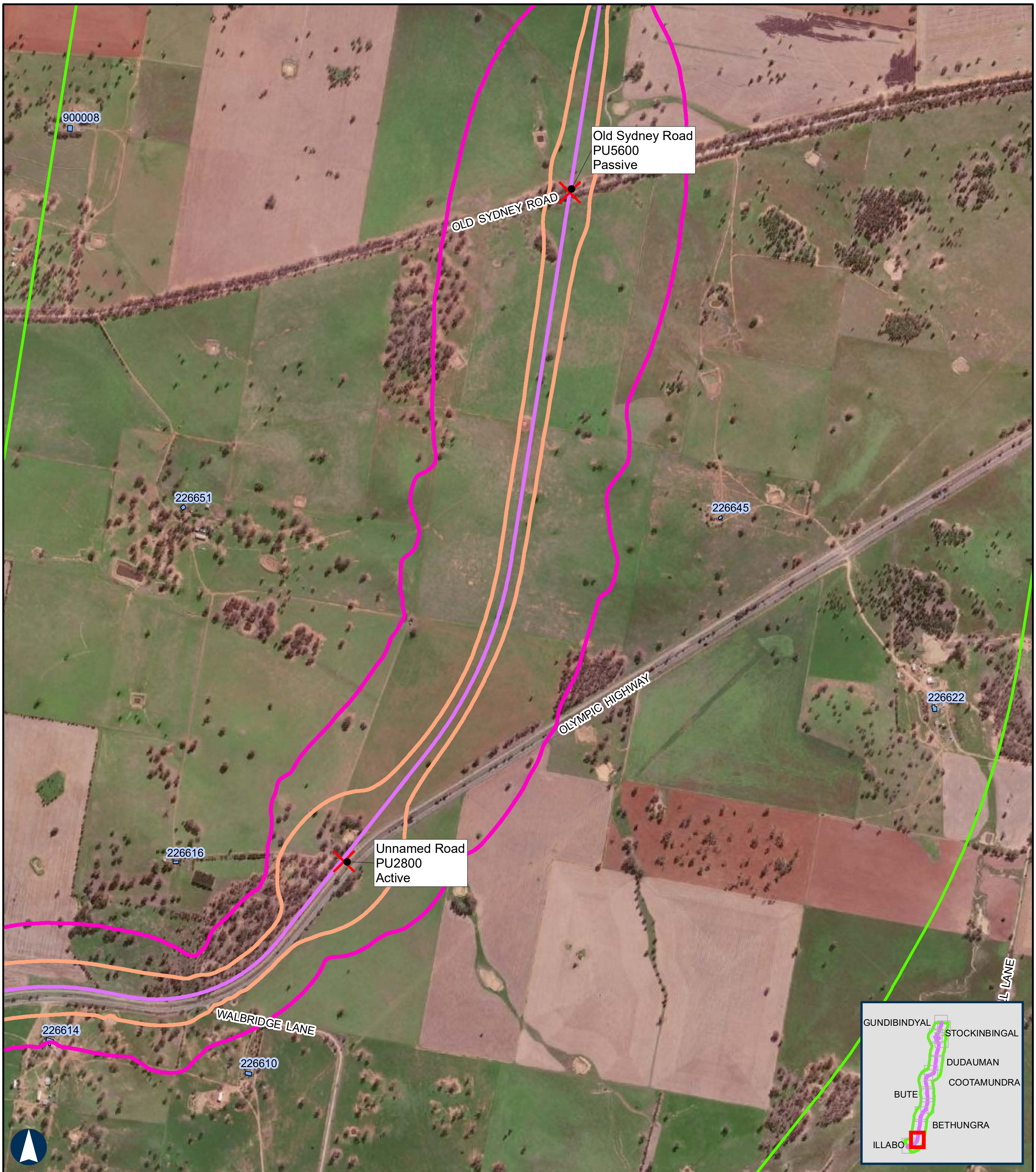

ILLABO TO STOCKINBINGAL

Year 2040 Daytime Rail Noise Levels

APPENDIX E - Map 2 of 16

500 m

Coordinate System: GDA 1994 MGA Zone 55

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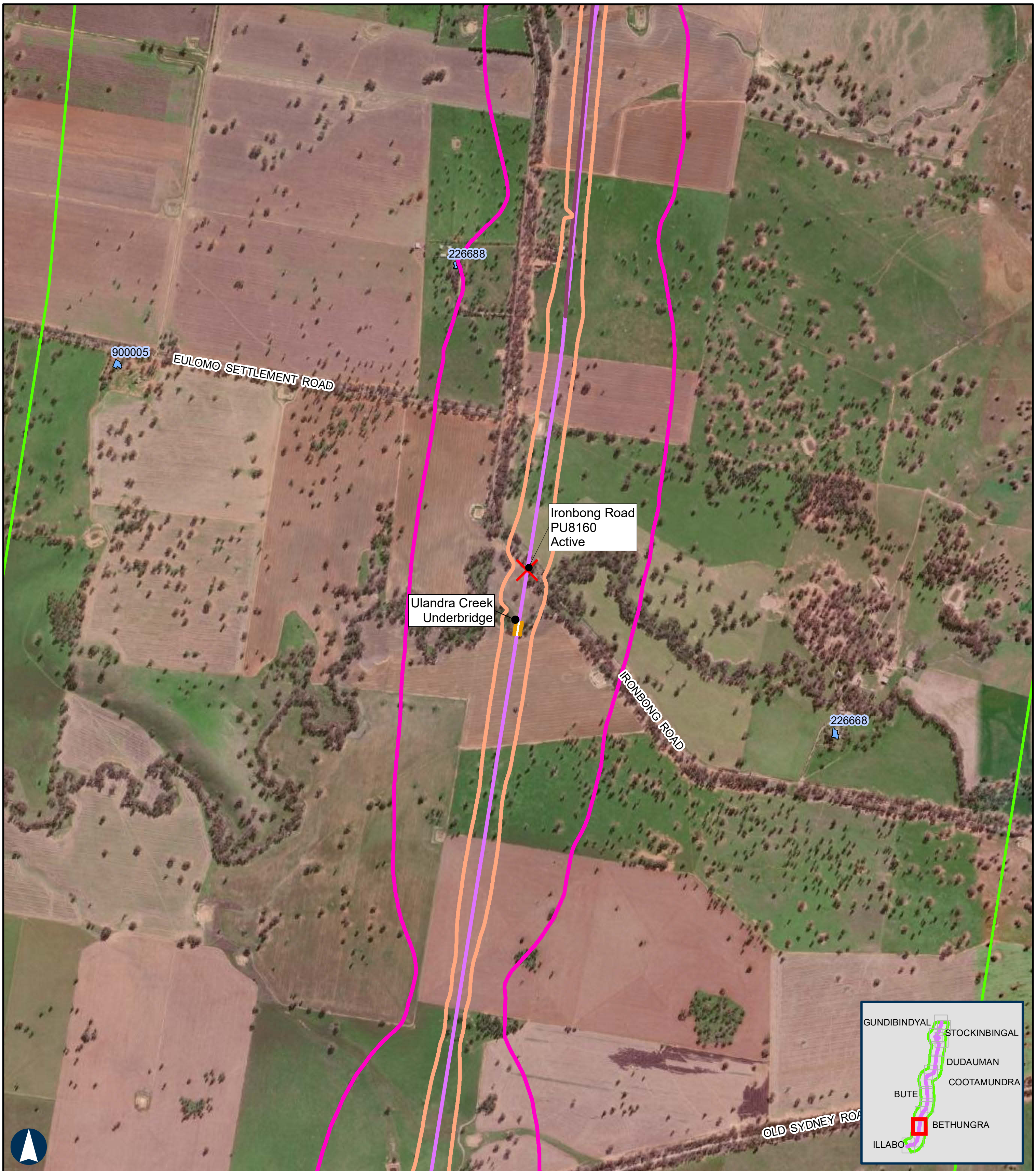

ILLABO TO STOCKINBINGAL

Year 2040 Daytime Rail Noise Levels

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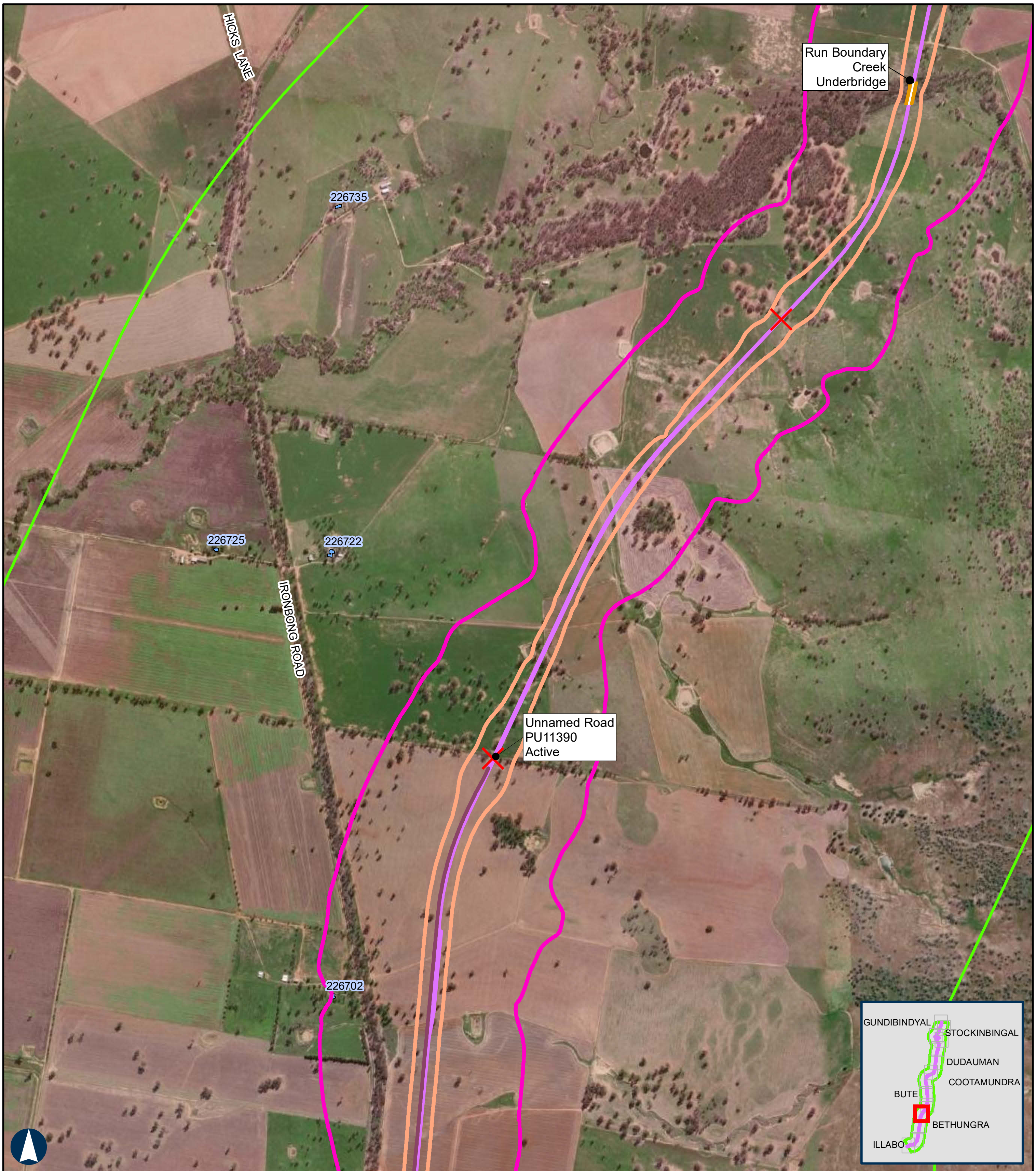

ILLABO TO STOCKINBINGAL

Year 2040 Daytime Rail Noise Levels

APPENDIX E - Map 4 of 16

500 m

Coordinate System: GDA 1994 MGA Zone 55

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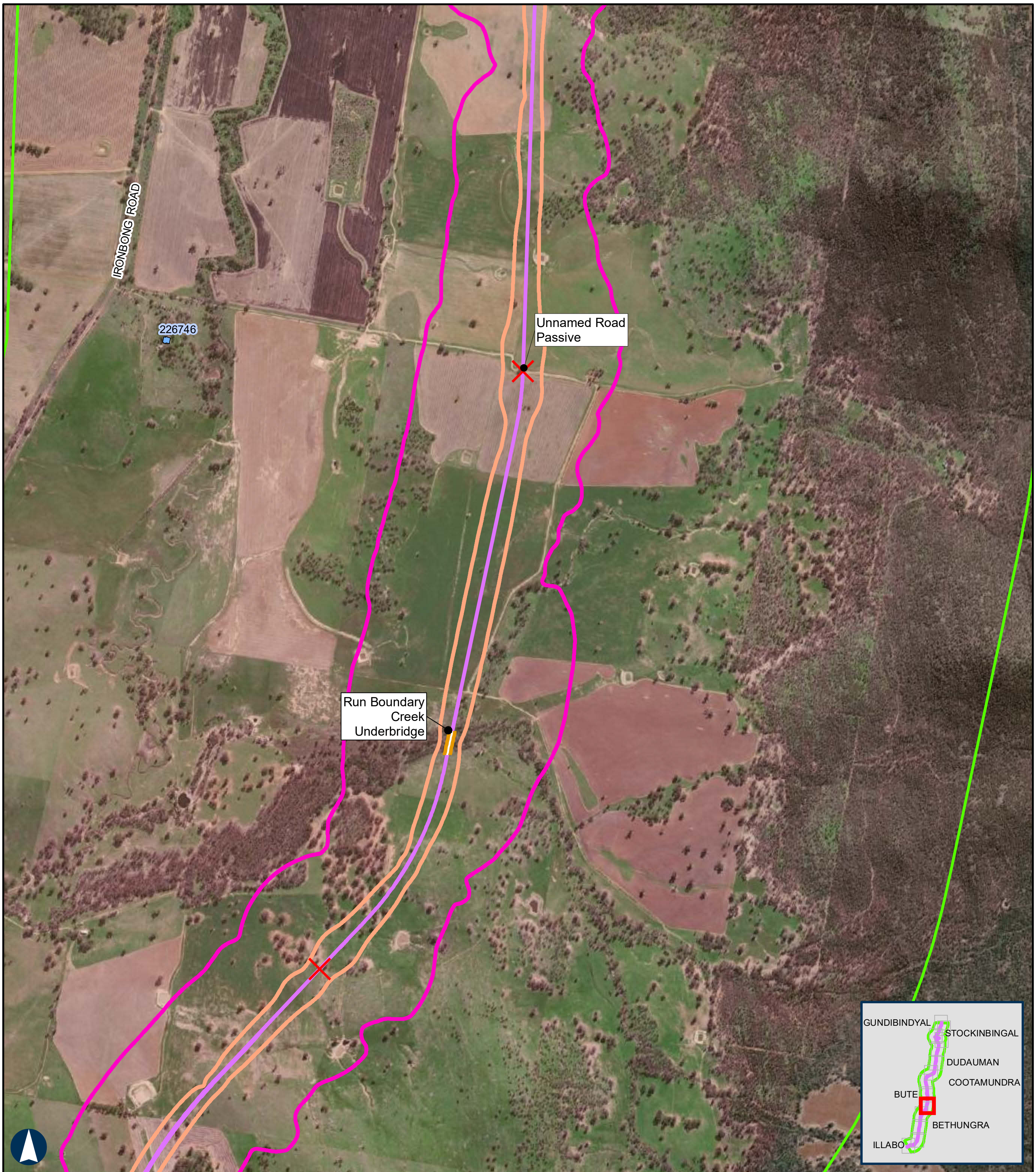

ILLABO TO STOCKINBINGAL

Year 2040 Daytime Rail Noise Levels

APPENDIX E - Map 5 of 16

500 m

Coordinate System: GDA 1994 MGA Zone 55

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Date: 01-Nov-2021
Author: JG

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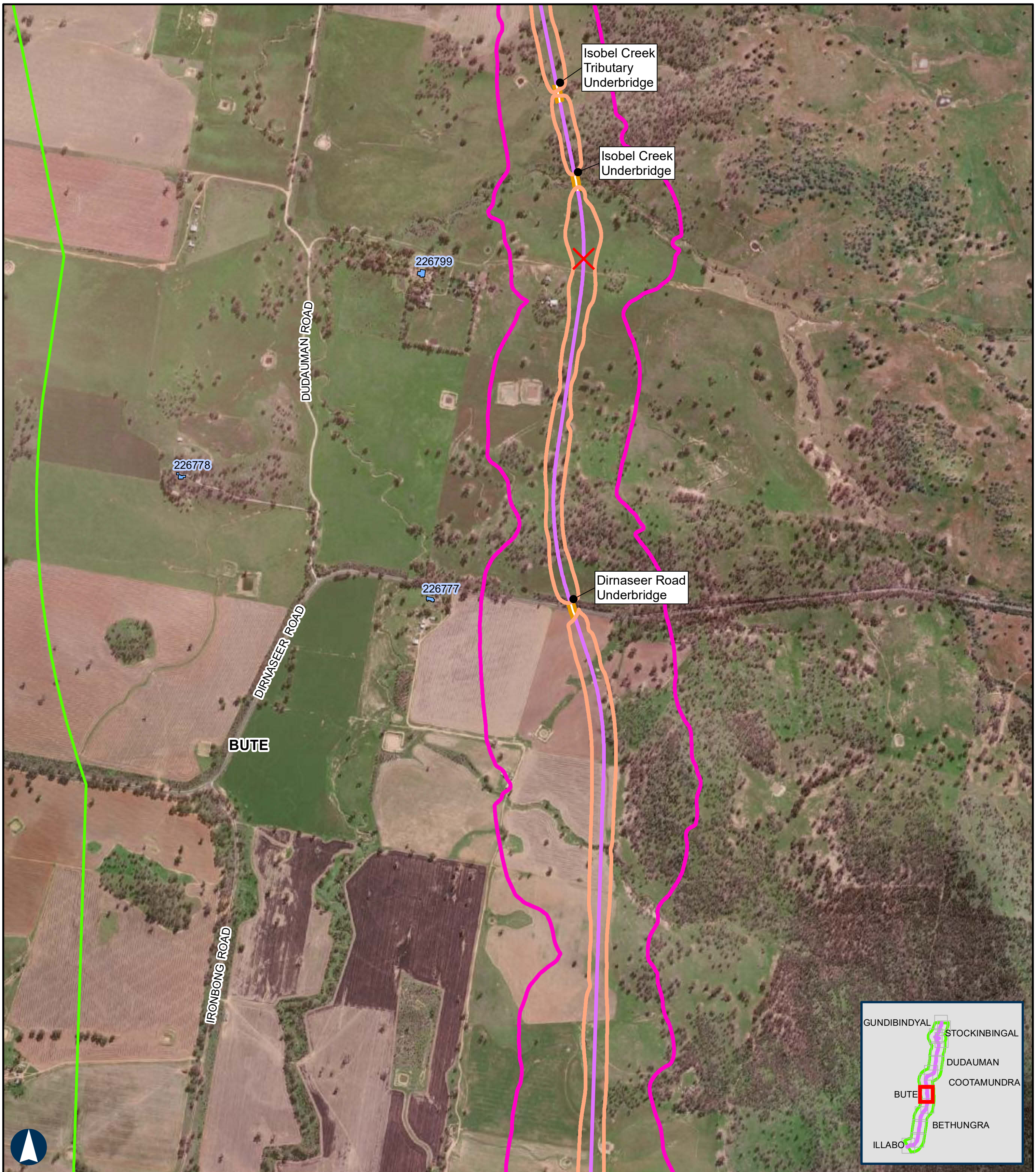

ILLABO TO STOCKINBINGAL

Year 2040 Daytime Rail Noise Levels

APPENDIX E - Map 6 of 16

500 m

Coordinate System: GDA 1994 MGA Zone 55

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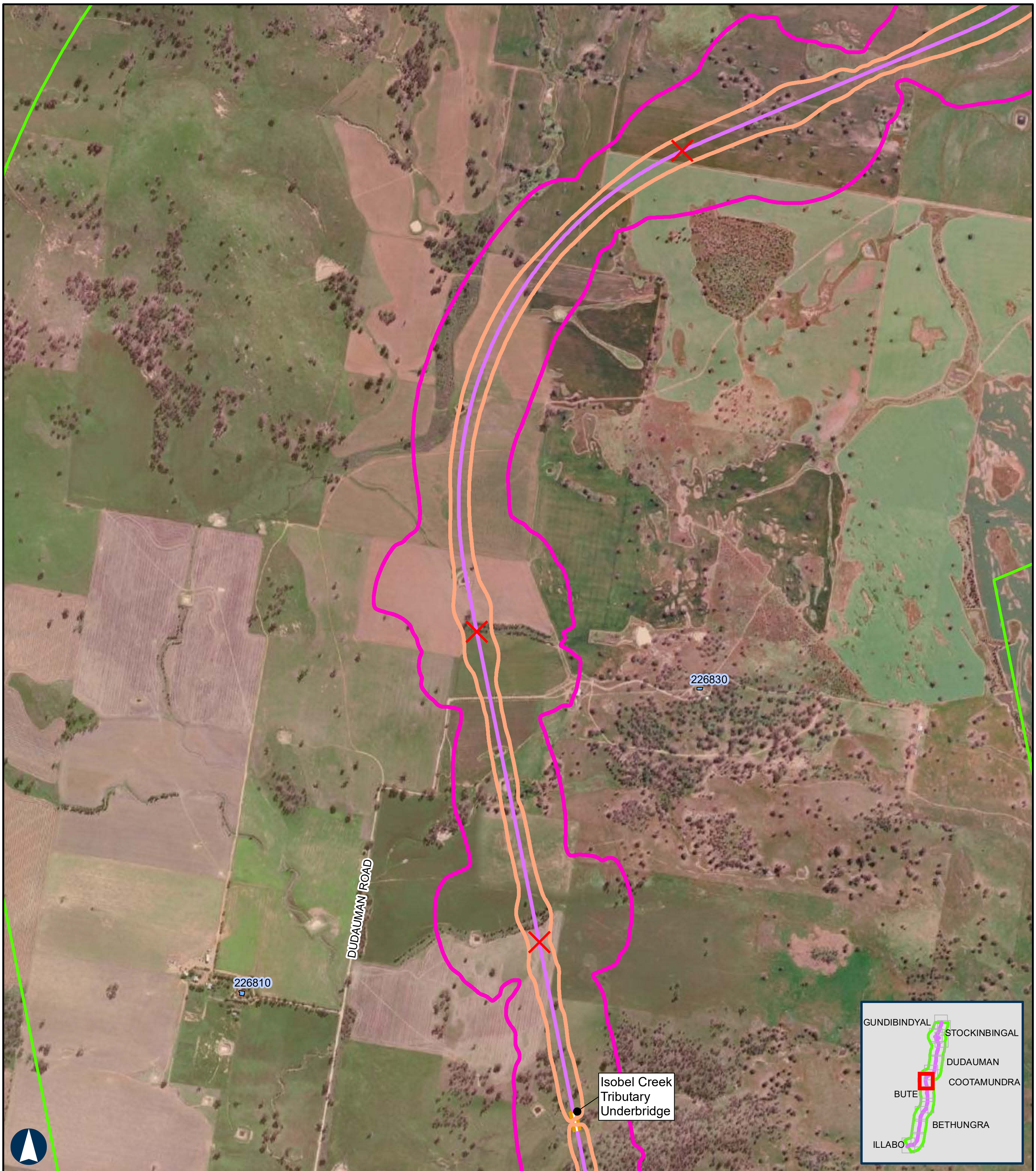

ILLABO TO STOCKINBINGAL

Year 2040 Daytime Rail Noise Levels

APPENDIX E - Map 7 of 16

500 m

Coordinate System: GDA 1994 MGA Zone 55

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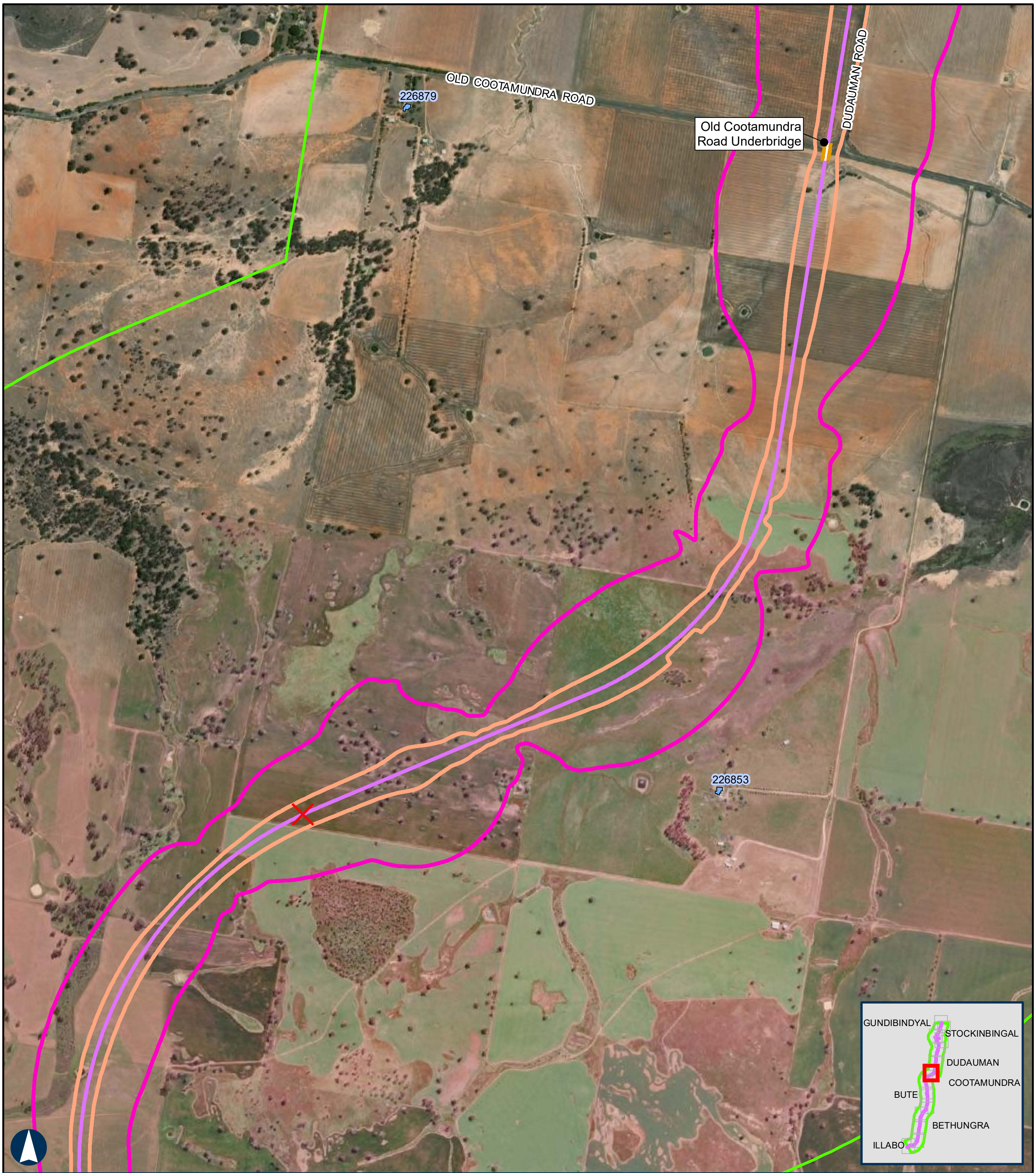

ILLABO TO STOCKINBINGAL

Year 2040 Daytime Rail Noise Levels

APPENDIX E - Map 8 of 16

500 m

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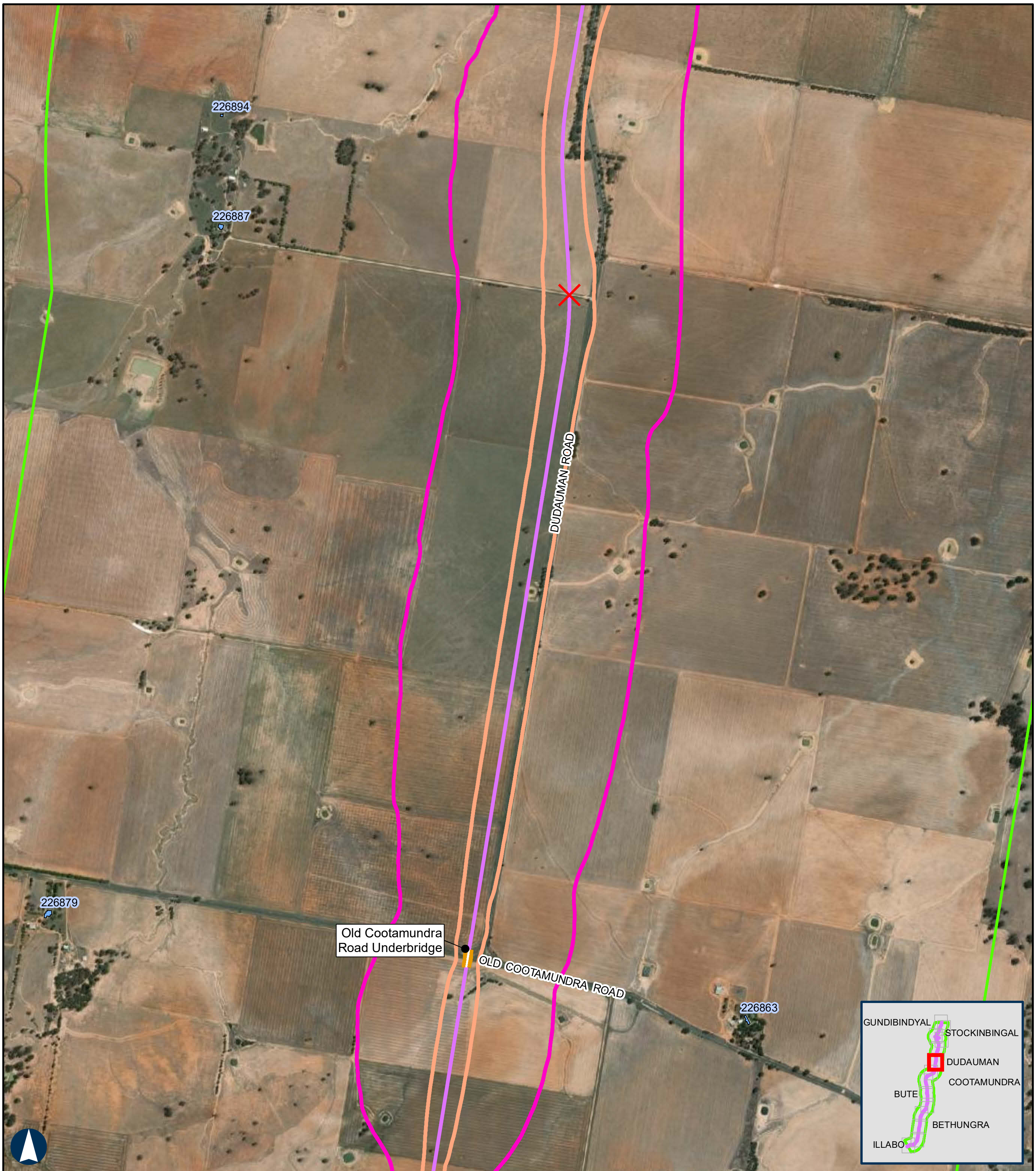

ILLABO TO STOCKINBINGAL

Year 2040 Daytime Rail Noise Levels

APPENDIX E - Map 9 of 16

500 m

Coordinate System: GDA 1994 MGA Zone 55

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Date: 01-Nov-2021
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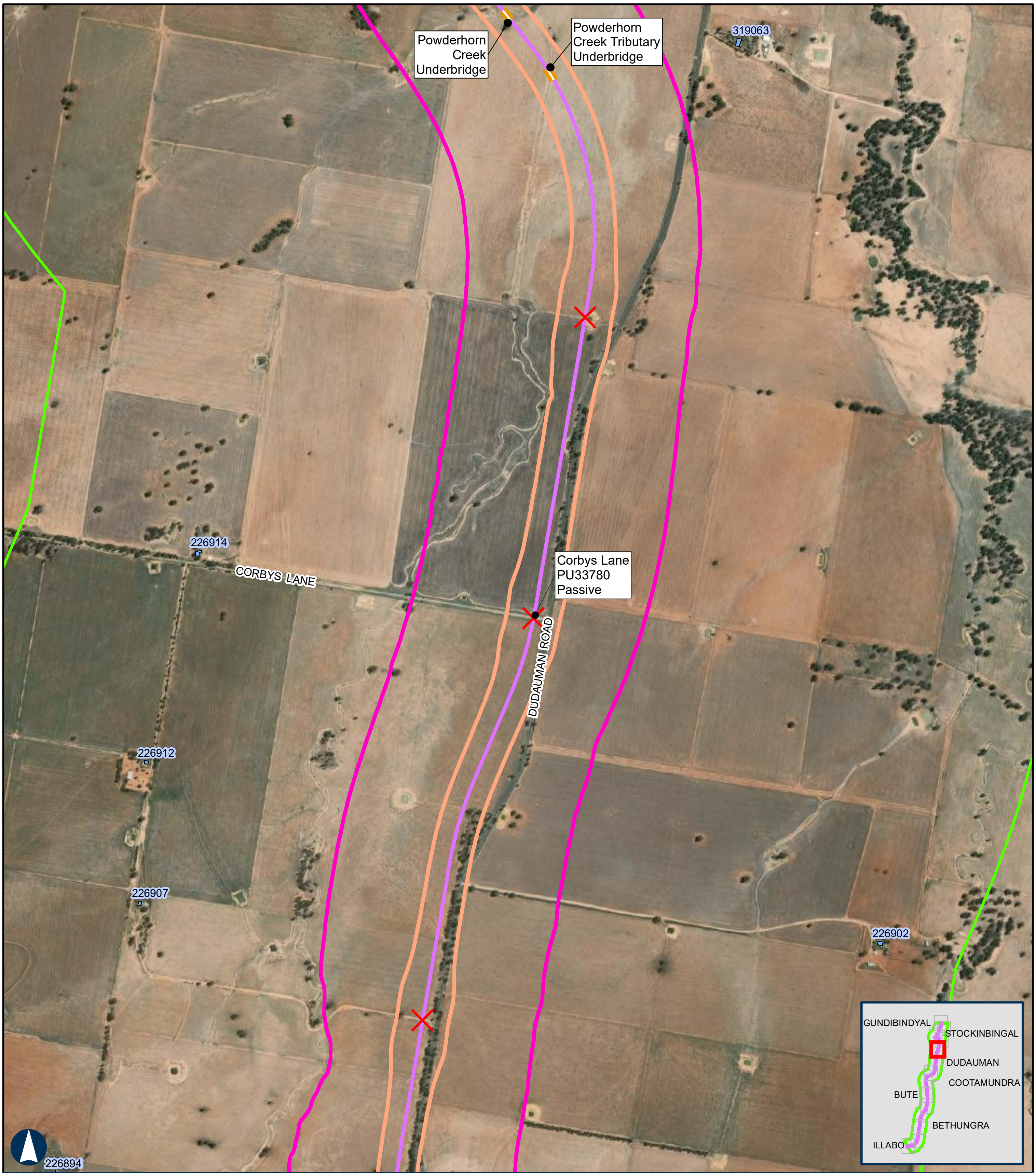

ILLABO TO STOCKINBINGAL

Year 2040 Daytime Rail Noise Levels

APPENDIX E - Map 10 of 16

500 m

Coordinate System: GDA 1994 MGA Zone 55

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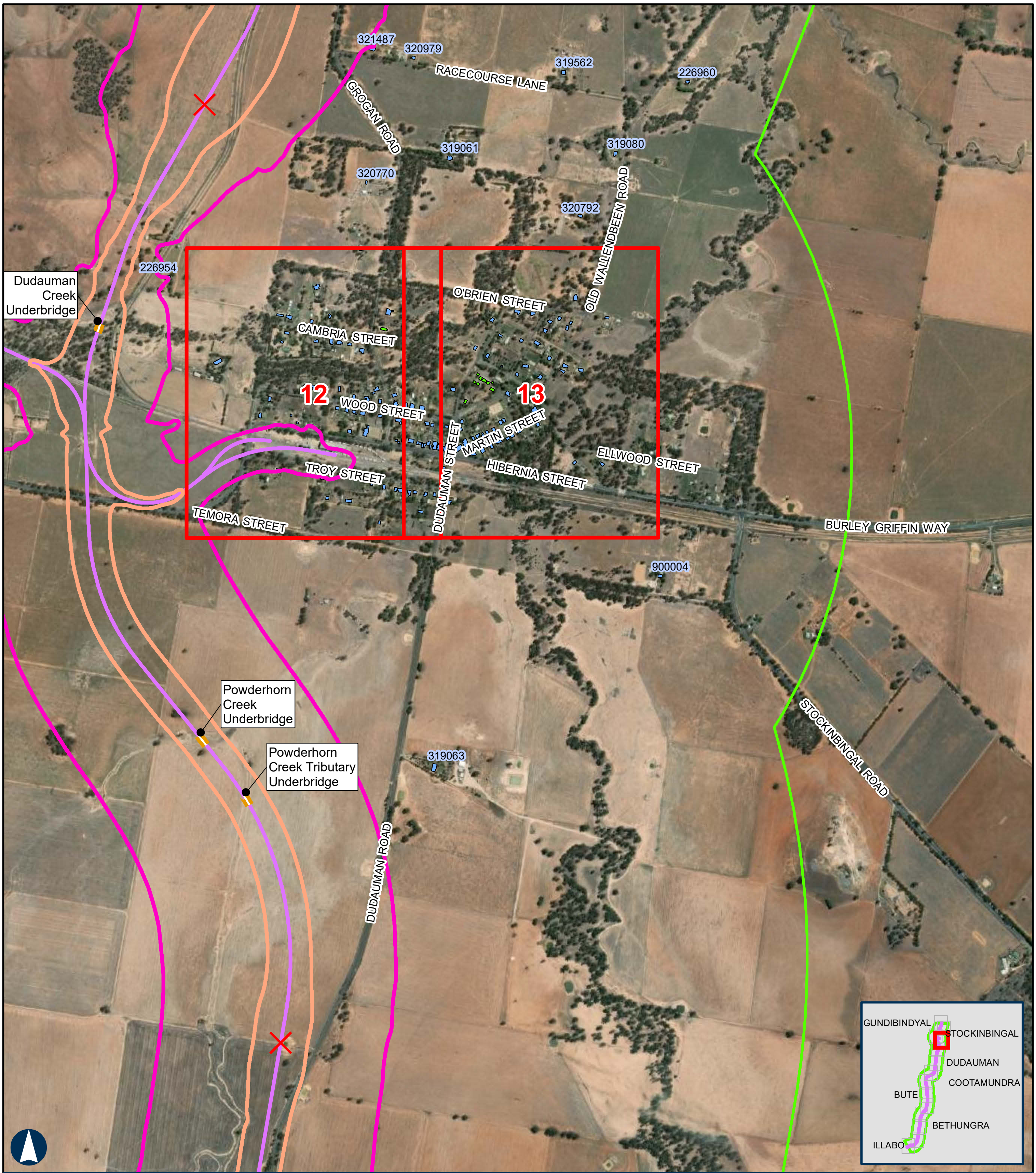

ILLABO TO STOCKINBINGAL

Year 2040 Daytime Rail Noise Levels

APPENDIX E - Map 11 of 16

500 m

Coordinate System: GDA 1994 MGA Zone 55

Paper: A4
Scale: 1:20,000
Date: 01-Nov-2021
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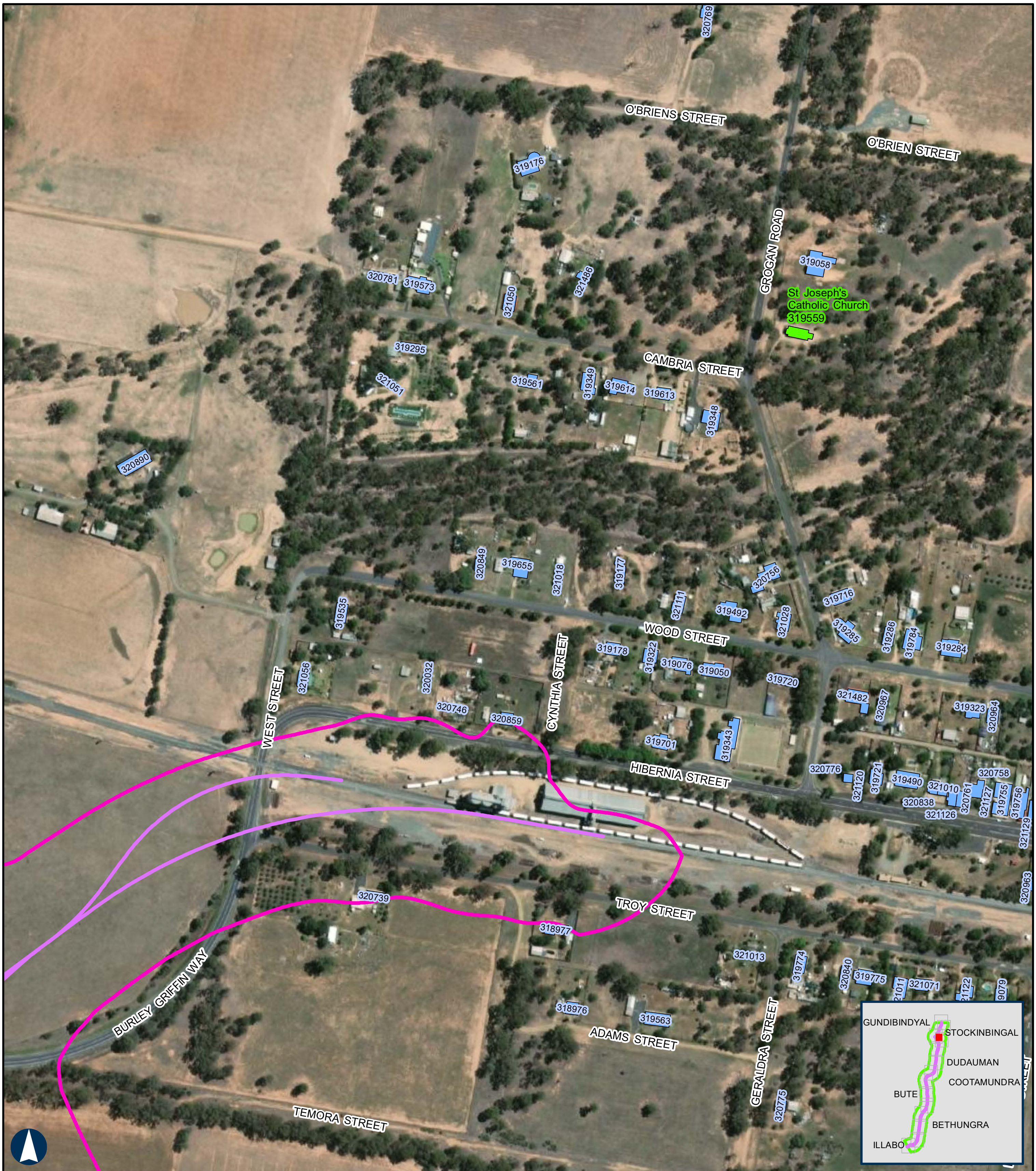

ILLABO TO STOCKINBINGAL Year 2040 Daytime Rail Noise Levels - Detailed

APPENDIX E - Map 12 of 16

100 m

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Author: JG

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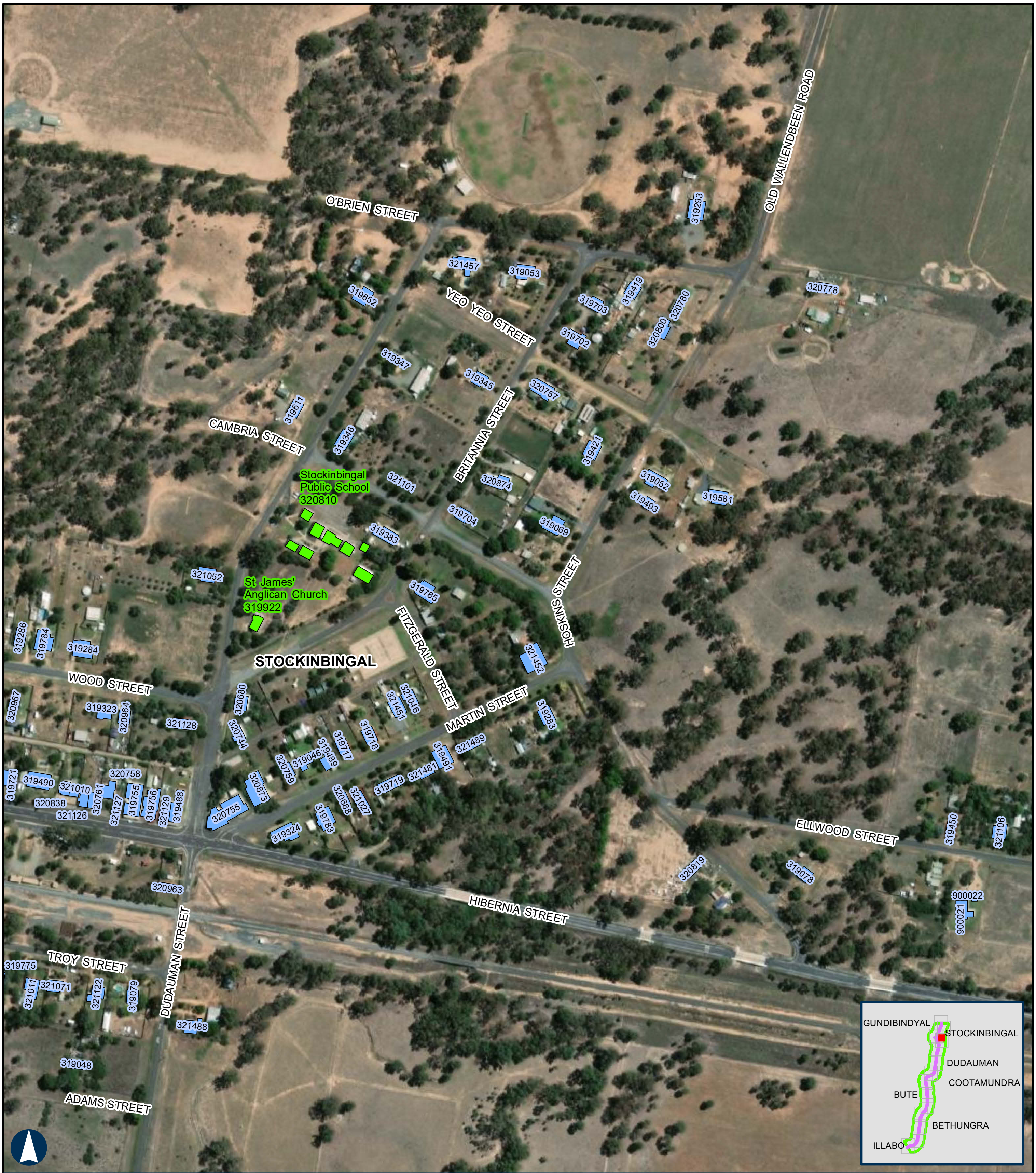

ILLABO TO STOCKINBINGAL Year 2040 Daytime Rail Noise Levels - Detailed

APPENDIX E - Map 13 of 16

100 m

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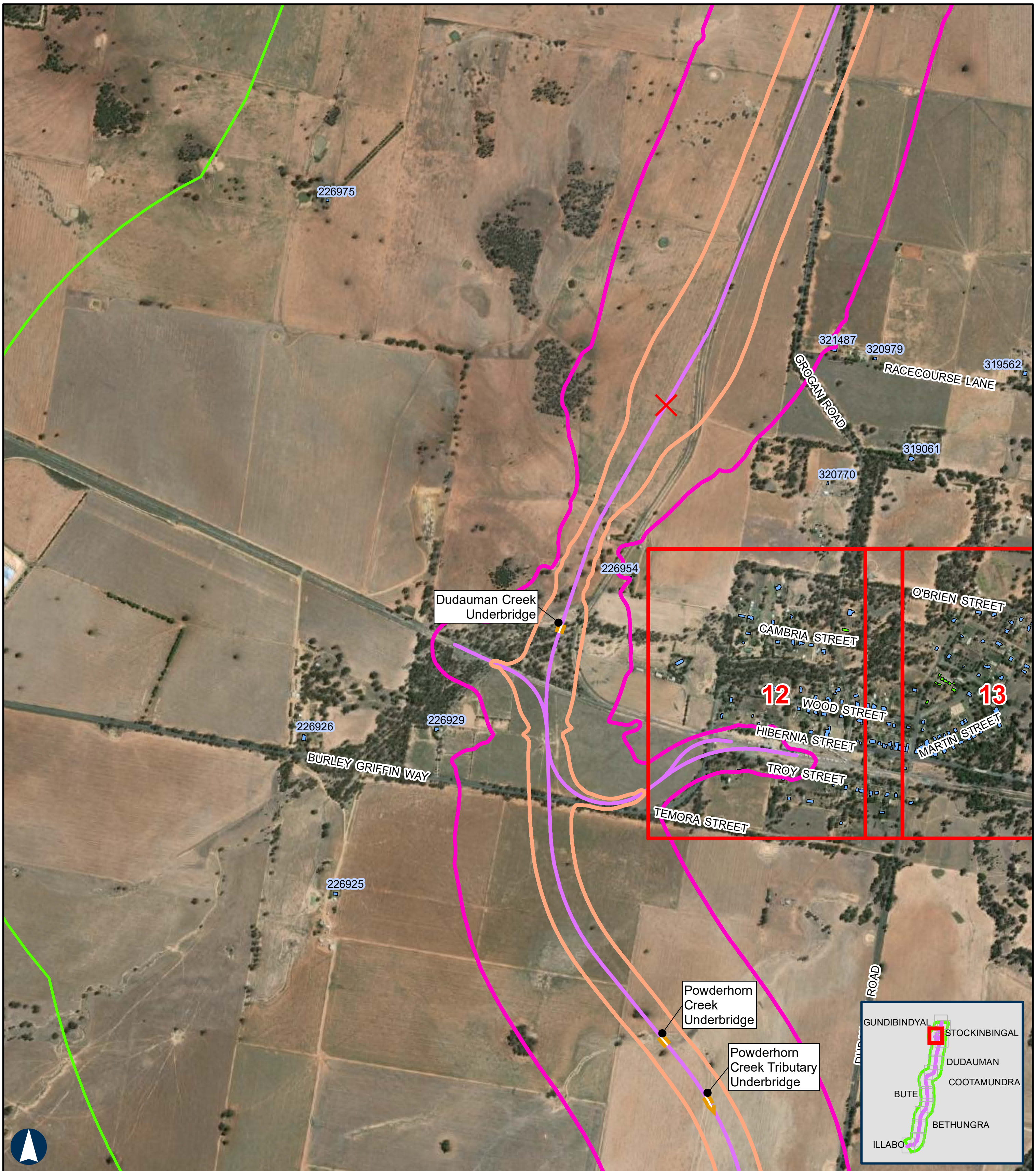

ILLABO TO STOCKINBINGAL

Year 2040 Daytime Rail Noise Levels

APPENDIX E - Map 14 of 16

500 m

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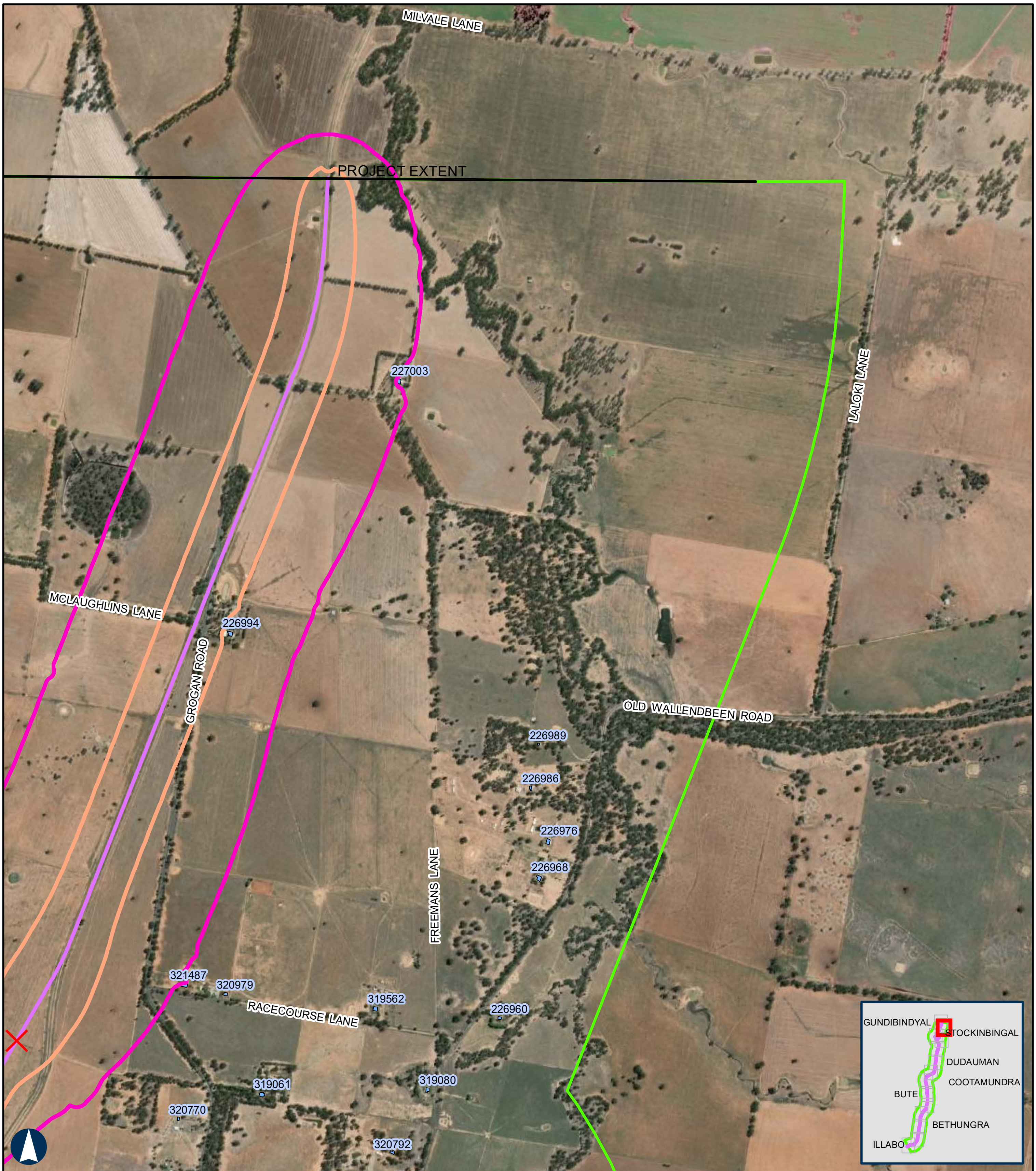

ILLABO TO STOCKINBINGAL

Year 2040 Daytime Rail Noise Levels

APPENDIX E - Map 15 of 16

500 m

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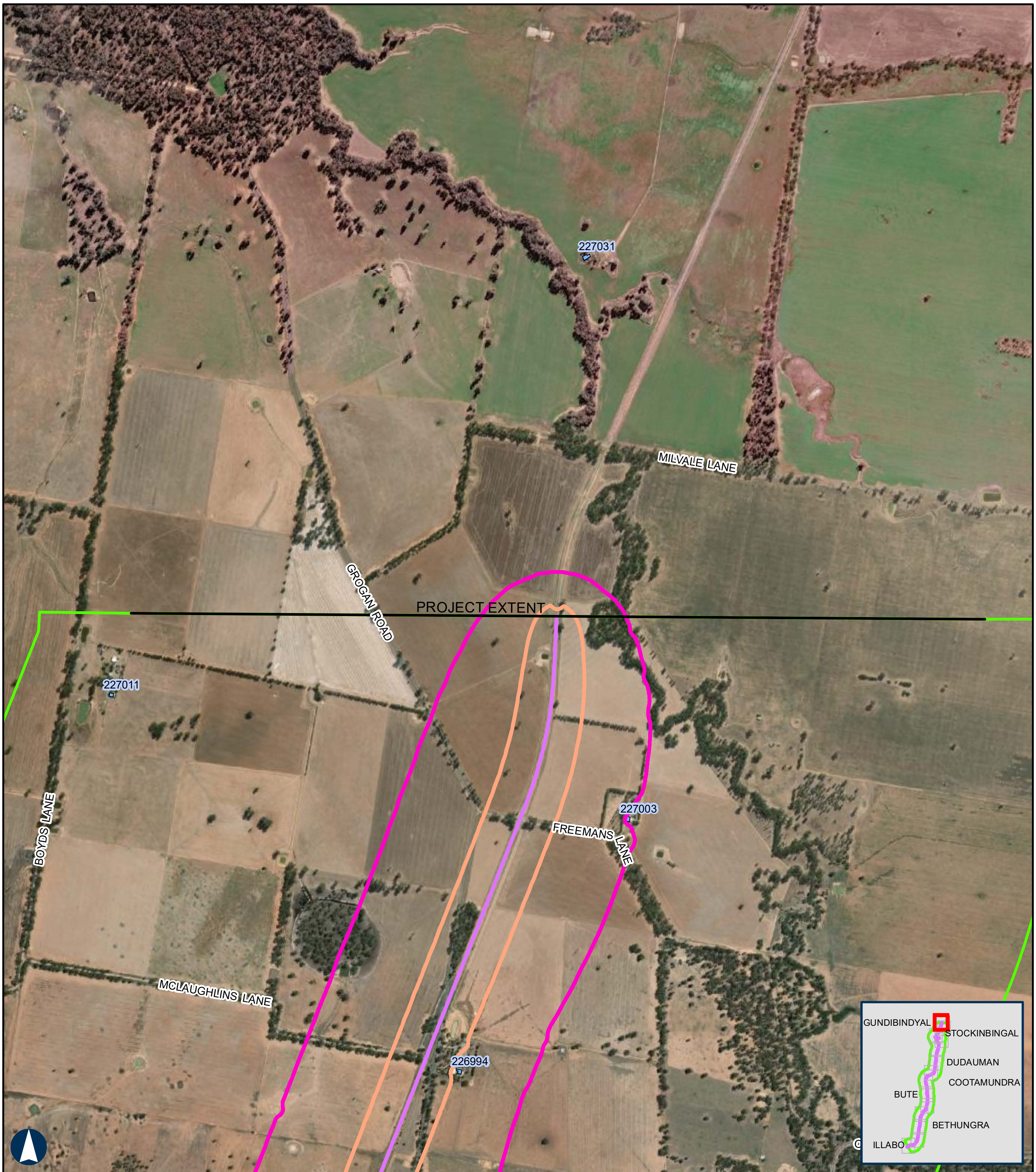

ILLABO TO STOCKINBINGAL

Year 2040 Daytime Rail Noise Levels

APPENDIX E - Map 16 of 16

500 m

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- Bridges and Viaducts
- Noise Assessment Area
- Daytime noise criteria LAeq15hr 60dBA New rail corridor
- Daytime noise criteria LA max 80dBA New rail corridor
- Sensitive Receivers
- Non-residential Sensitive Receivers

Noise contours are based on a set distance above the local terrain level of 2.4m.

ARTC InlandRail

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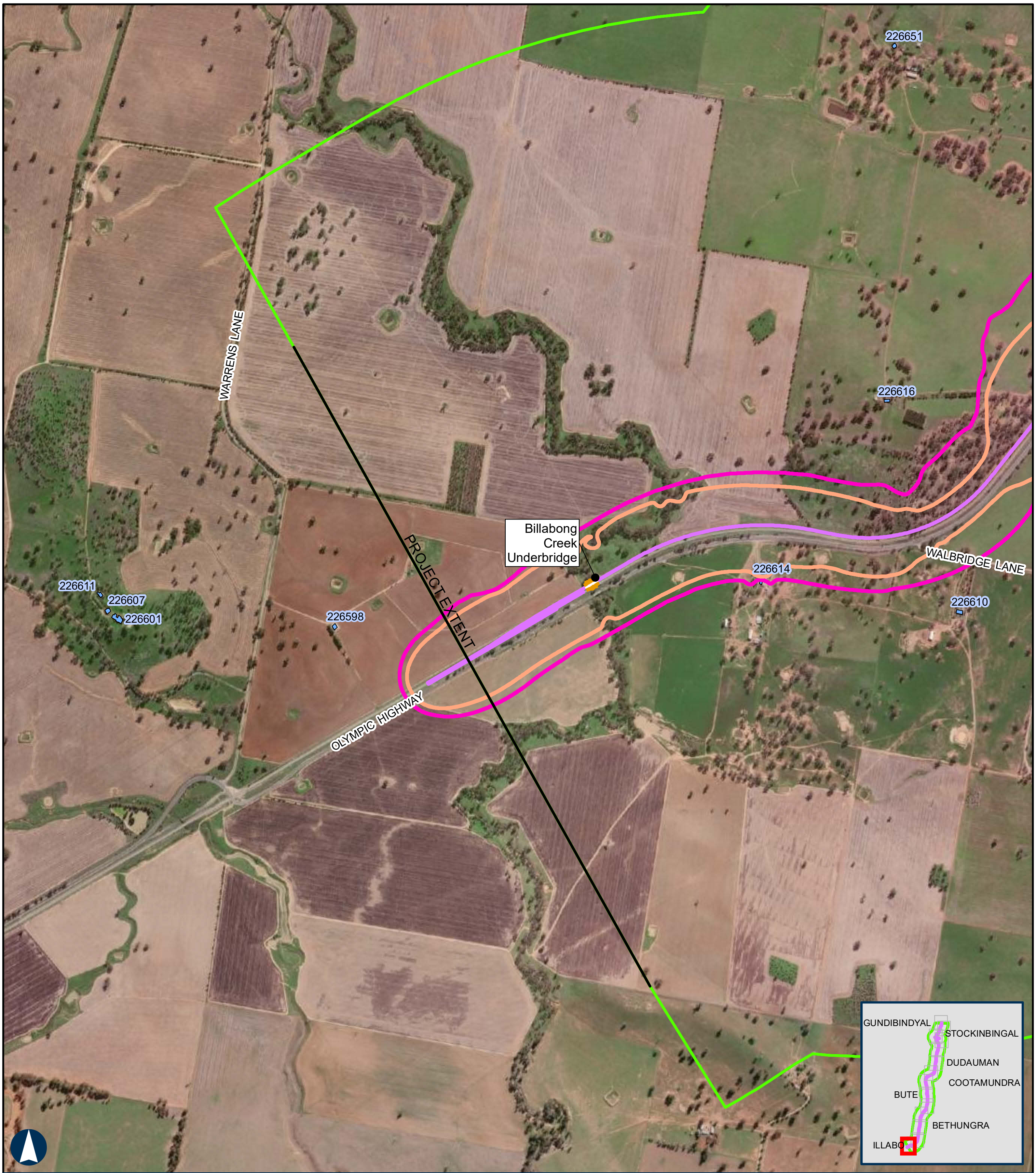

ILLABO TO STOCKINBINGAL

Year 2040 Night-time Rail Noise Levels

APPENDIX E - Map 1 of 16

500 m

Coordinate System: GDA 1994 MGA Zone 55

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Paper: A4 Scale: 1:20,000
Date: 01-Nov-2021
Author: JG

- Level Crossings
- Proposal Extent
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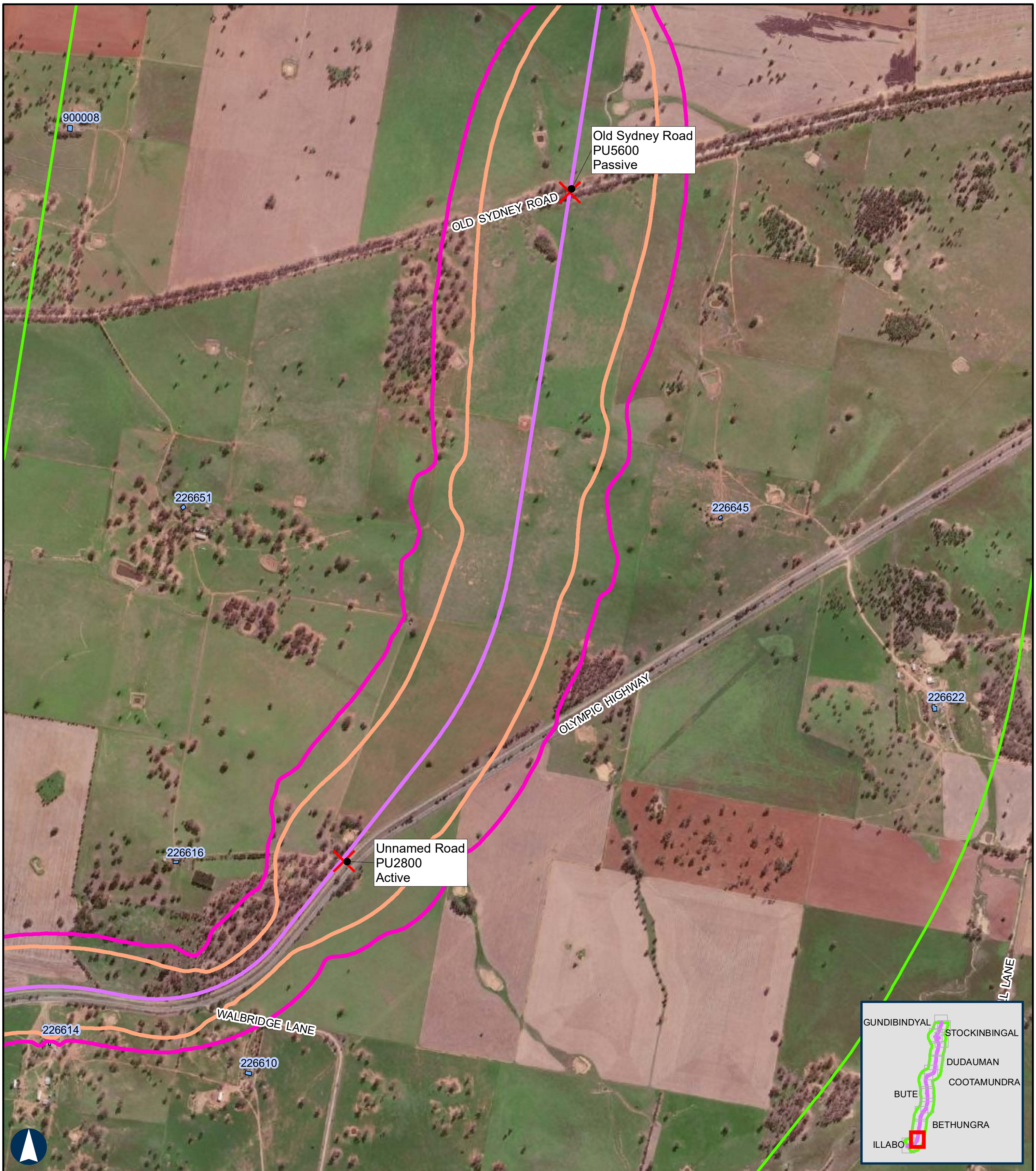

ILLABO TO STOCKINBINGAL

Year 2040 Night-time Rail Noise Levels

APPENDIX E - Map 2 of 16

500 m

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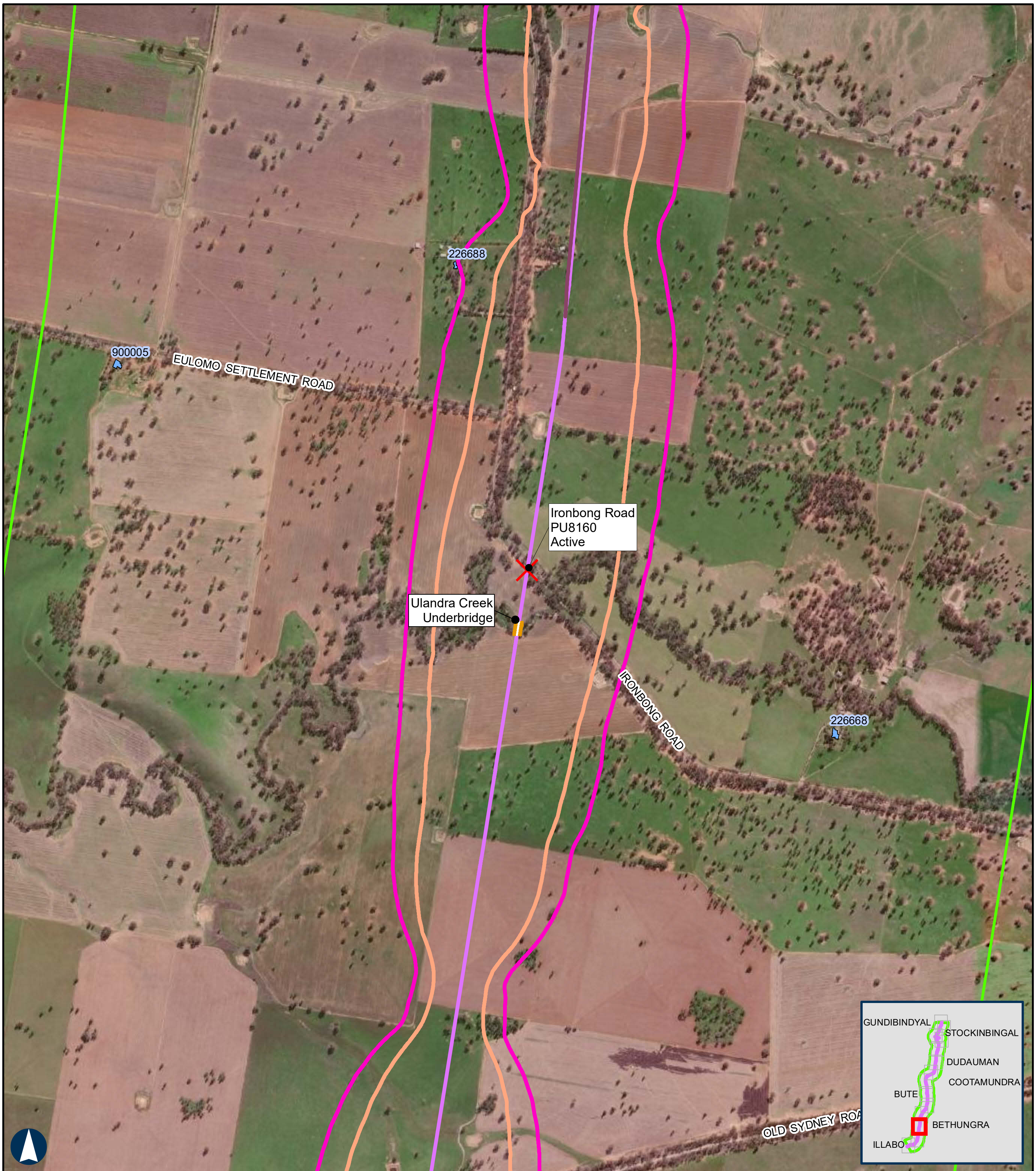

ILLABO TO STOCKINBINGAL

Year 2040 Night-time Rail Noise Levels

APPENDIX E - Map 3 of 16

500 m

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Date: 01-Nov-2021
Author: JG

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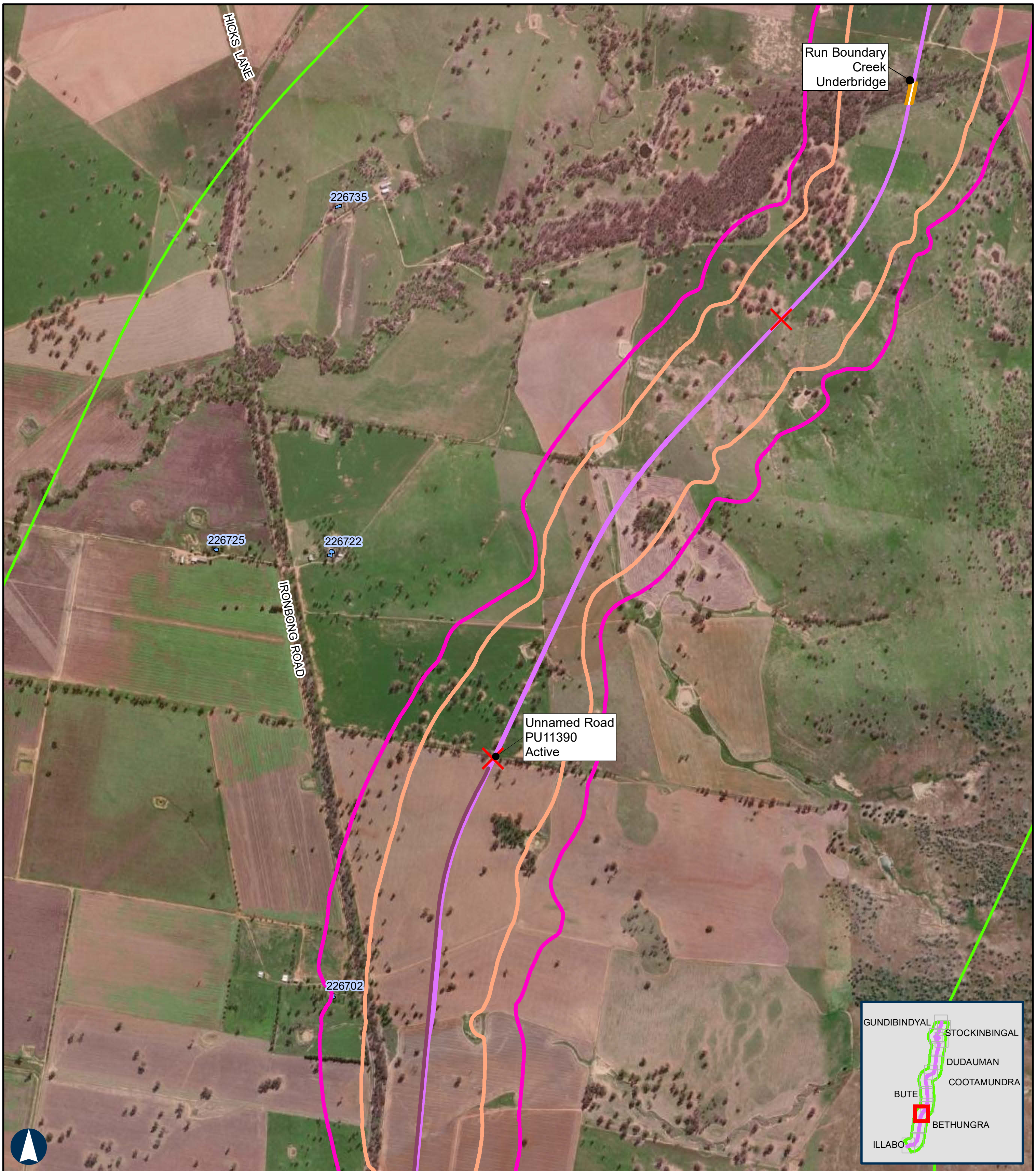

ILLABO TO STOCKINBINGAL Year 2040 Night-time Rail Noise Levels

APPENDIX E - Map 4 of 16

500 m

Coordinate System: GDA 1994 MGA Zone 55

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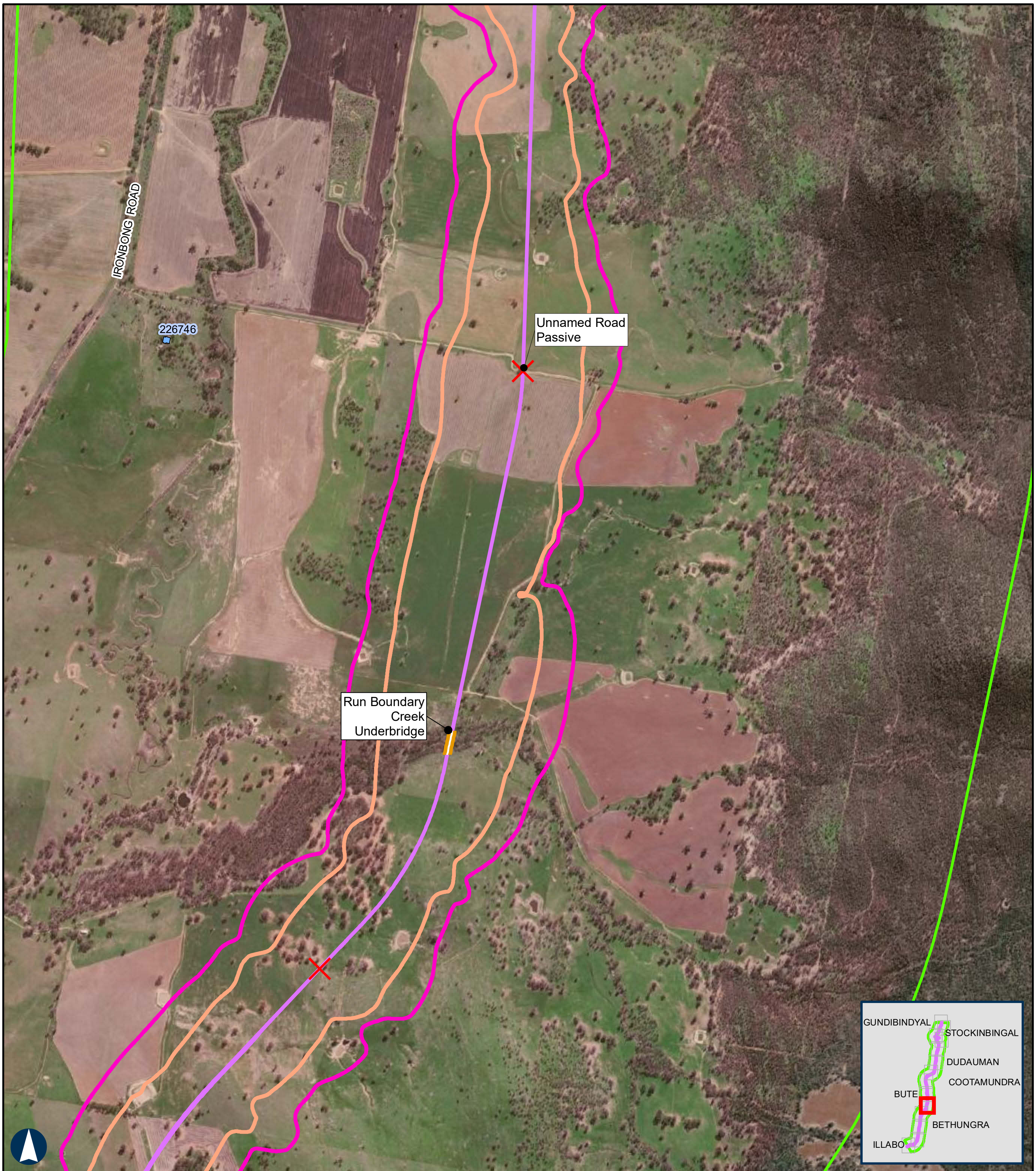

ILLABO TO STOCKINBINGAL

Year 2040 Night-time Rail Noise Levels

APPENDIX E - Map 5 of 16

500 m

Coordinate System: GDA 1994 MGA Zone 55

Paper: A4
Scale: 1:20,000
Date: 01-Nov-2021
Author: JG

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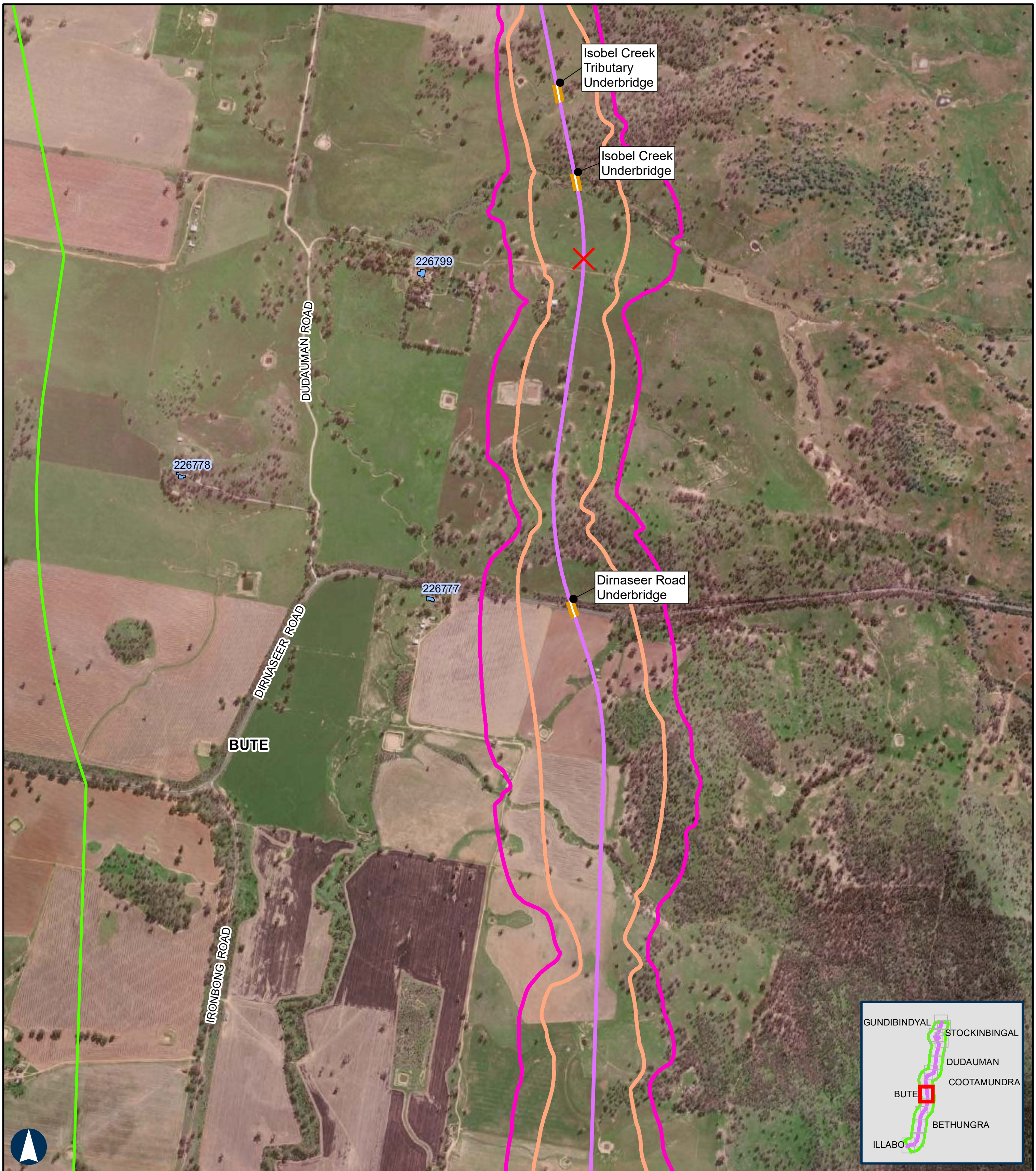

ILLABO TO STOCKINBINGAL

Year 2040 Night-time Rail Noise Levels

APPENDIX E - Map 6 of 16

500 m

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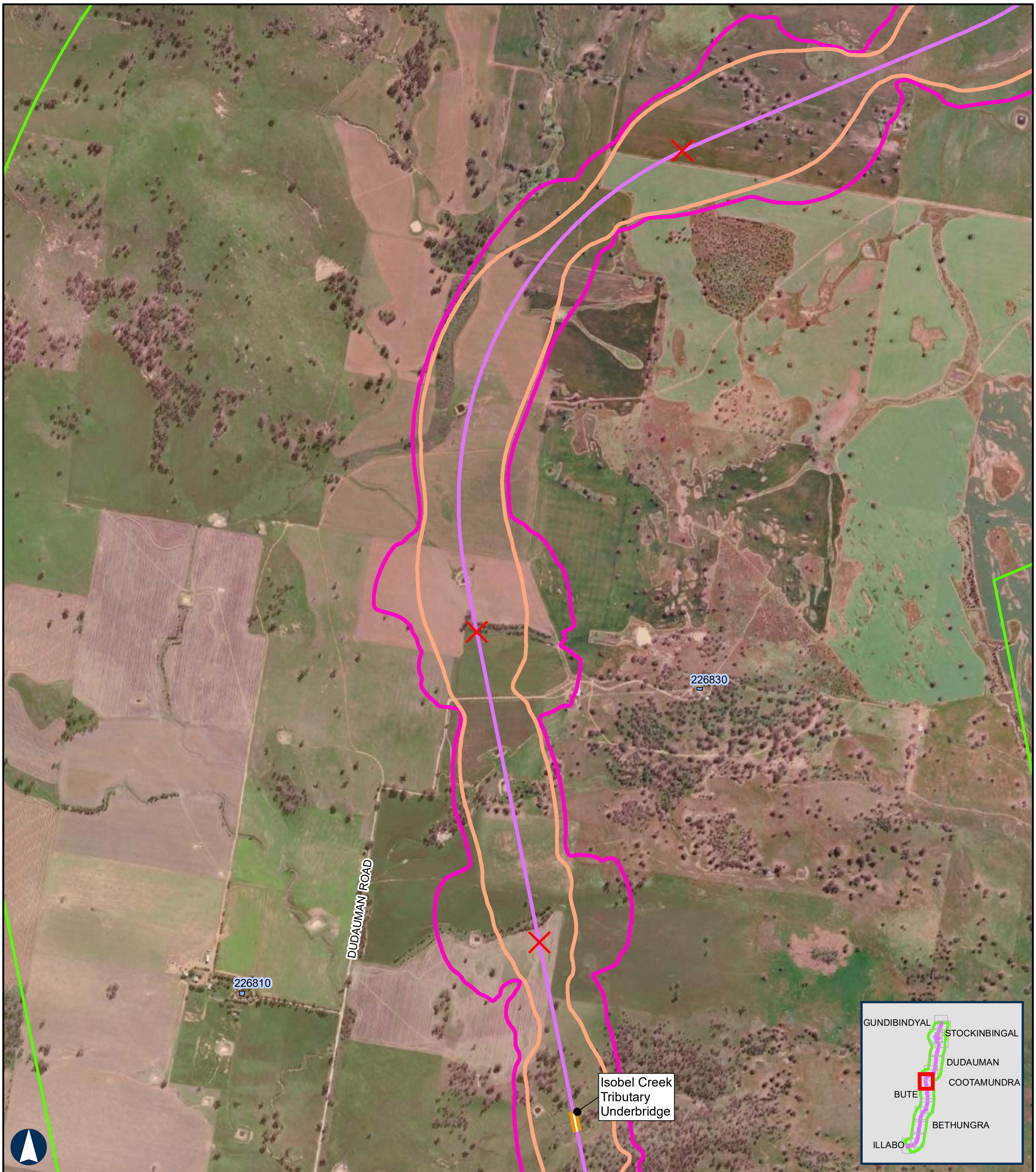

ILLABO TO STOCKINBINGAL

Year 2040 Night-time Rail Noise Levels

APPENDIX E - Map 7 of 16

500 m

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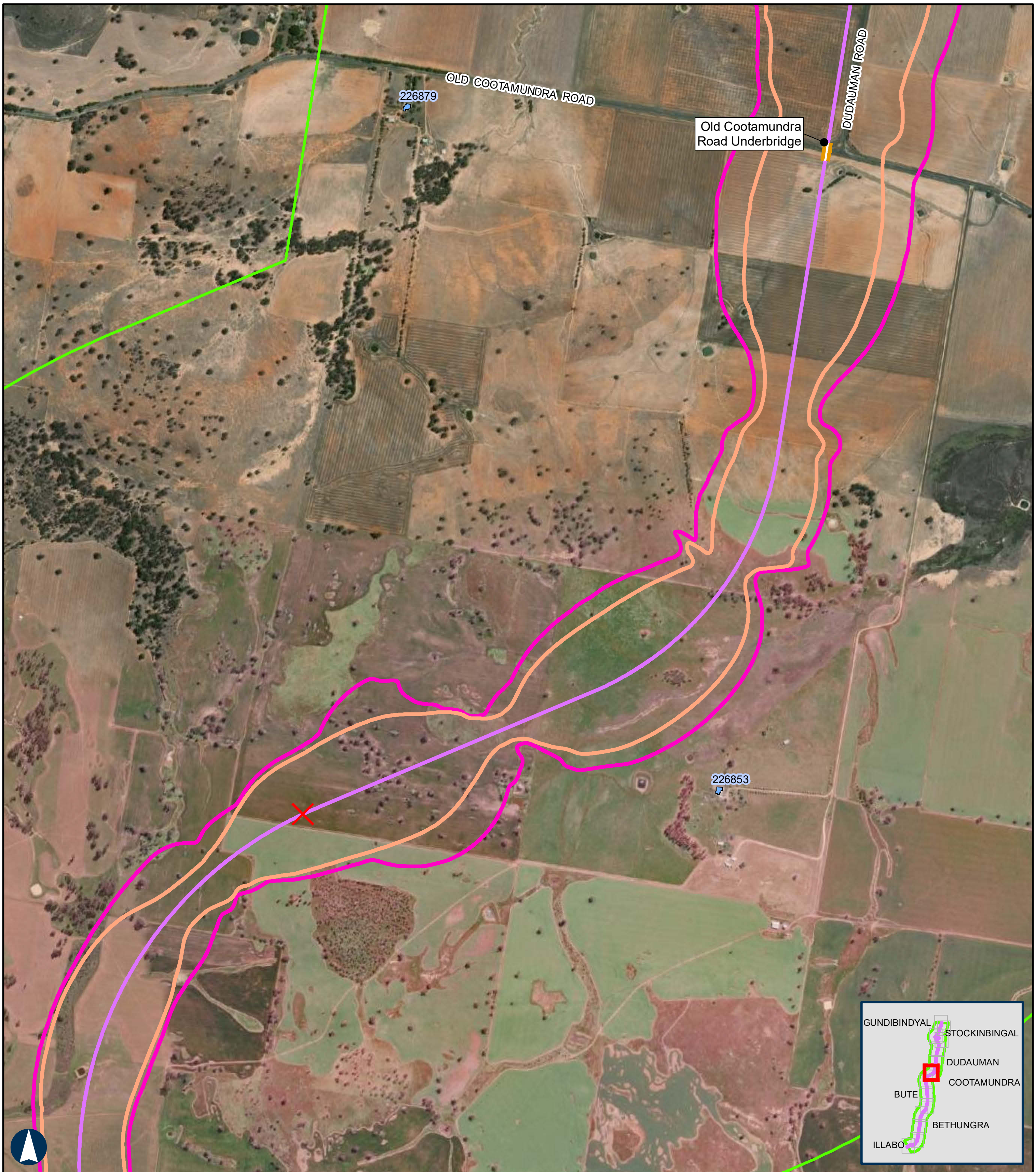

ILLABO TO STOCKINBINGAL

Year 2040 Night-time Rail Noise Levels

APPENDIX E - Map 8 of 16

500 m

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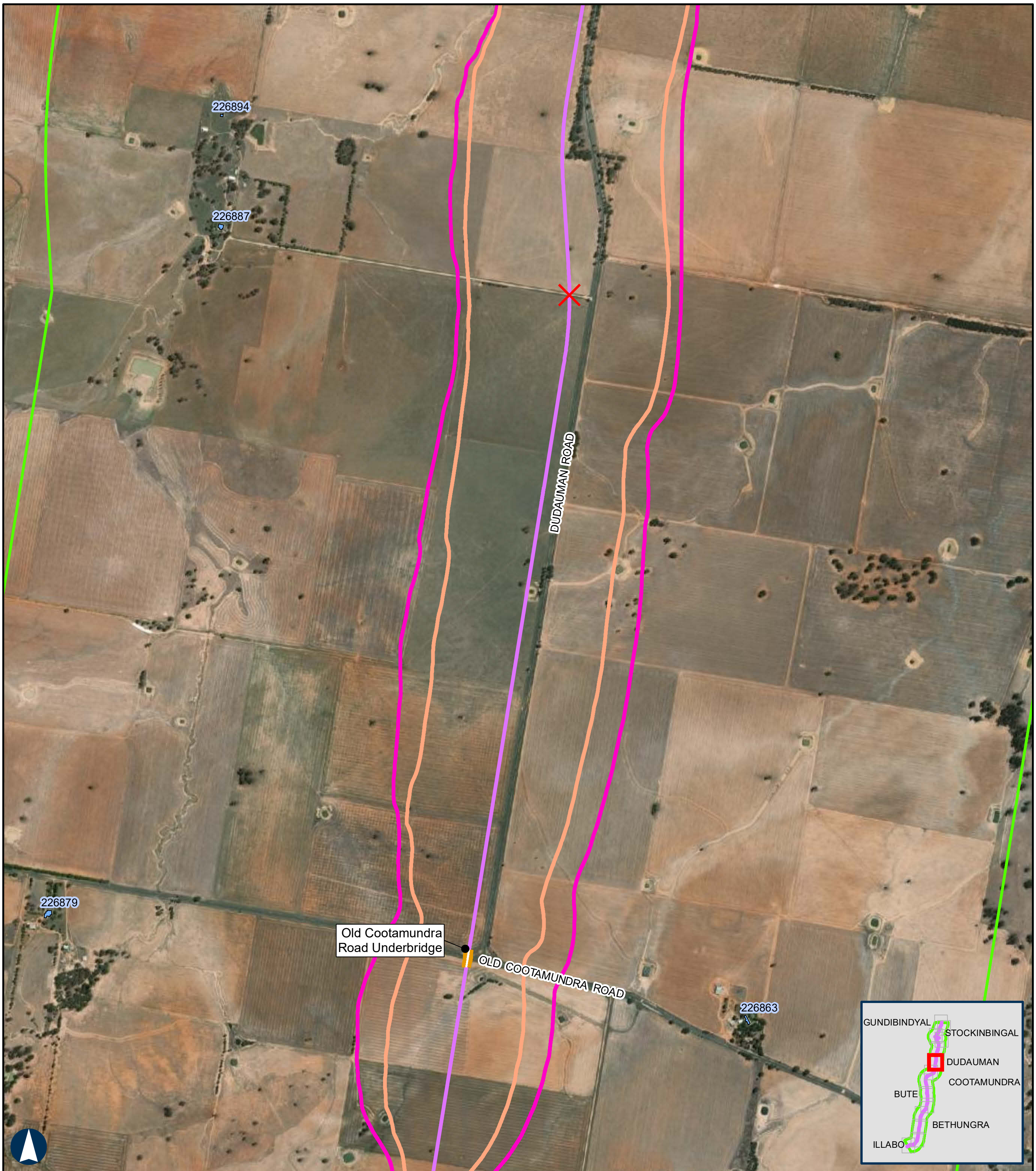

ILLABO TO STOCKINBINGAL

Year 2040 Night-time Rail Noise Levels

APPENDIX E - Map 9 of 16

500 m

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Author: JG

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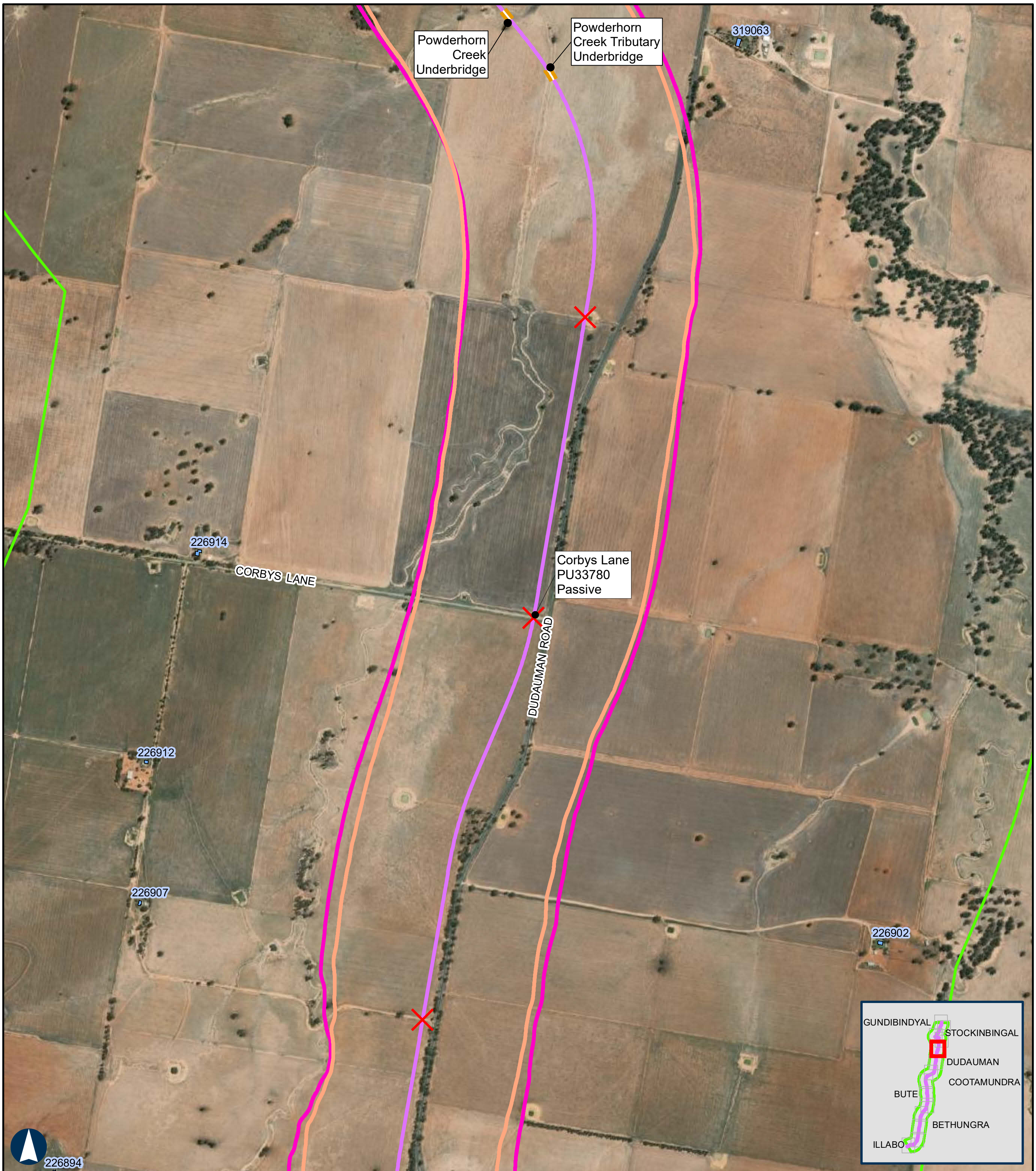

ILLABO TO STOCKINBINGAL

Year 2040 Night-time Rail Noise Levels

APPENDIX E - Map 10 of 16

500 m

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Date: 01-Nov-2021
Author: JG

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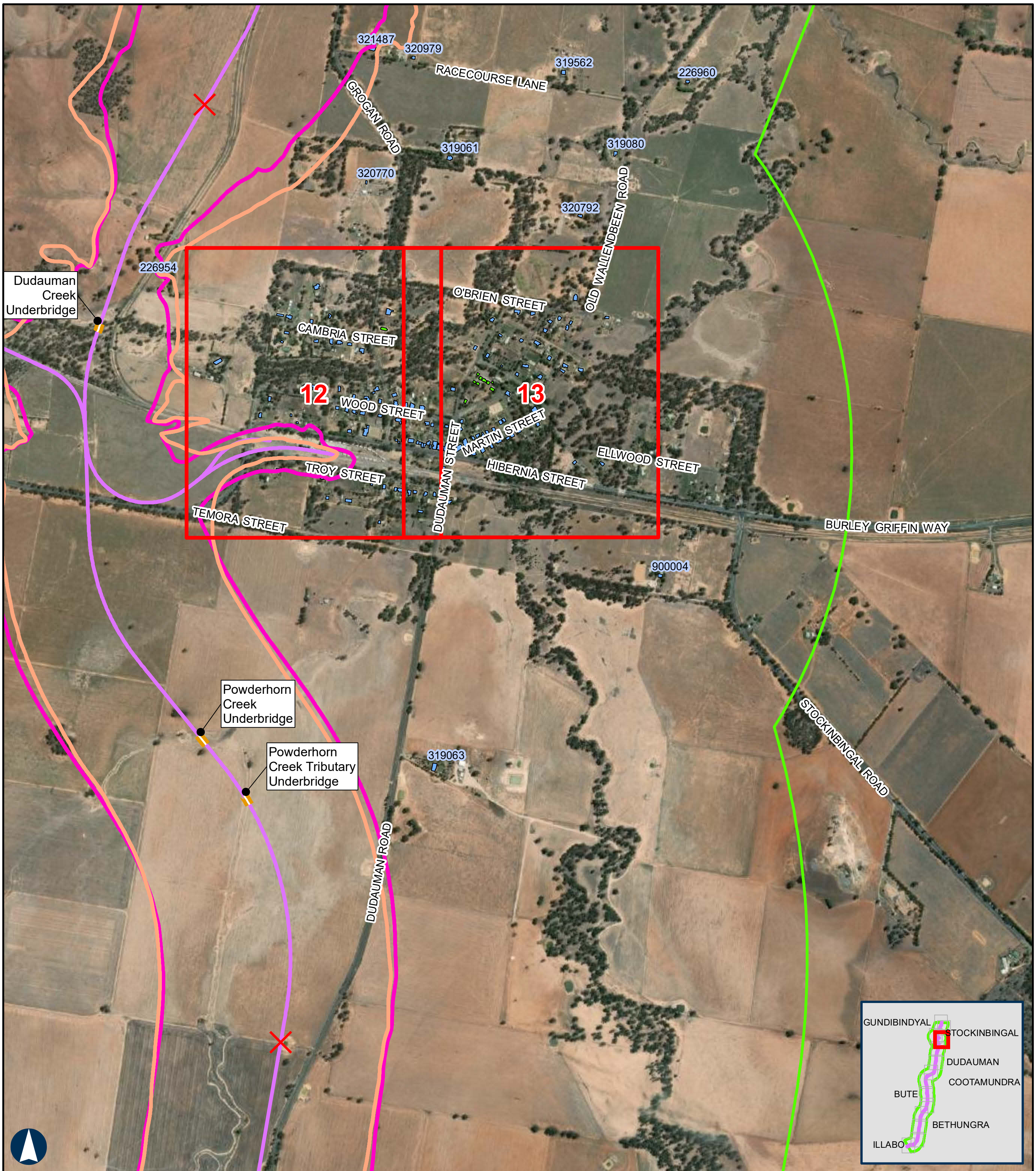

ILLABO TO STOCKINBINGAL

Year 2040 Night-time Rail Noise Levels

APPENDIX E - Map 11 of 16

500 m

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Date: 01-Nov-2021
Author: JG

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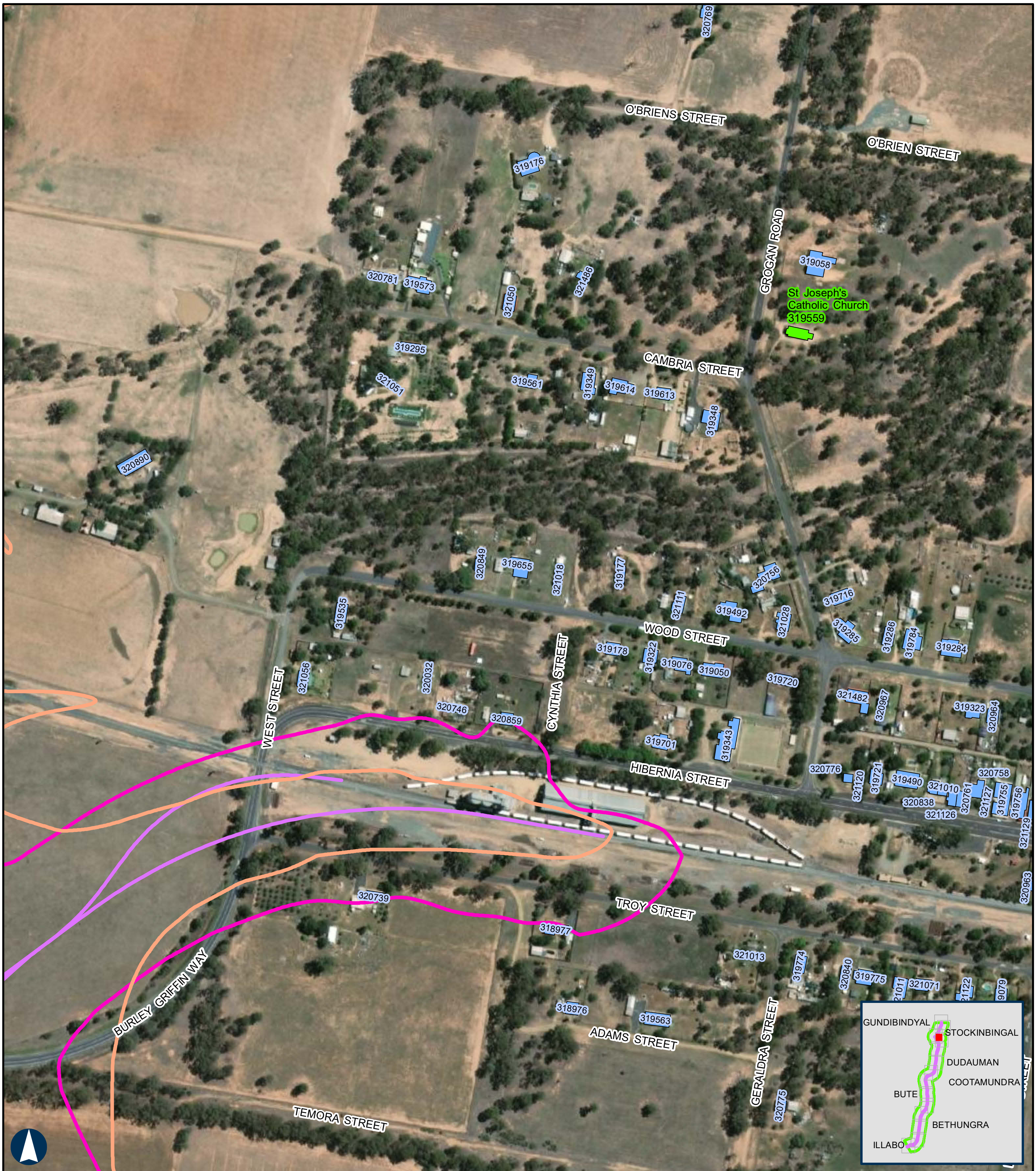

ILLABO TO STOCKINBINGAL Year 2040 Night-time Rail Noise Levels - Detailed

APPENDIX E - Map 12 of 16

100 m

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Paper: A4
Scale: 1:5,000
Date: 19-Aug-2021
Author: JG

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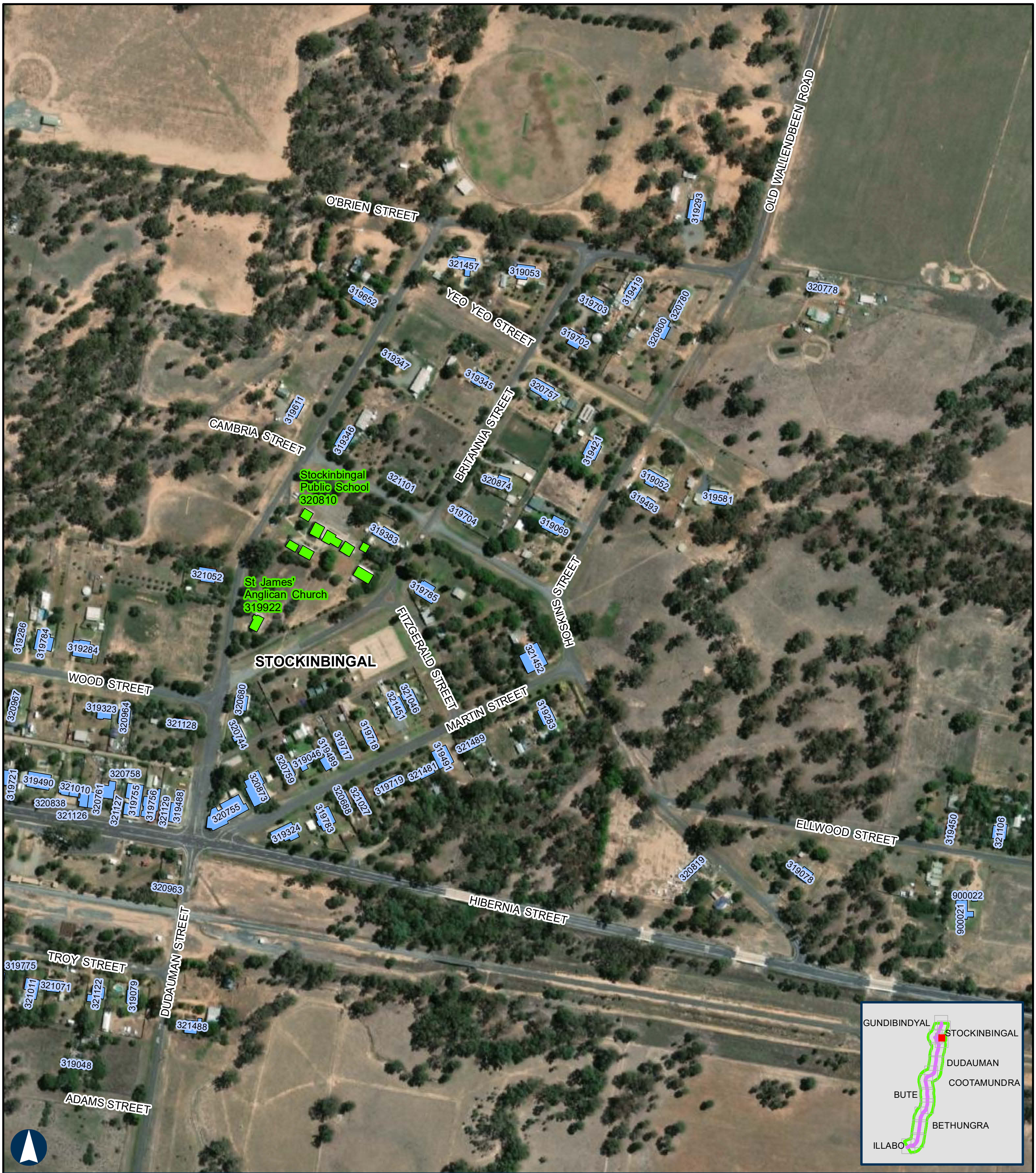

ILLABO TO STOCKINBINGAL Year 2040 Night-time Rail Noise Levels - Detailed

APPENDIX E - Map 13 of 16

100 m

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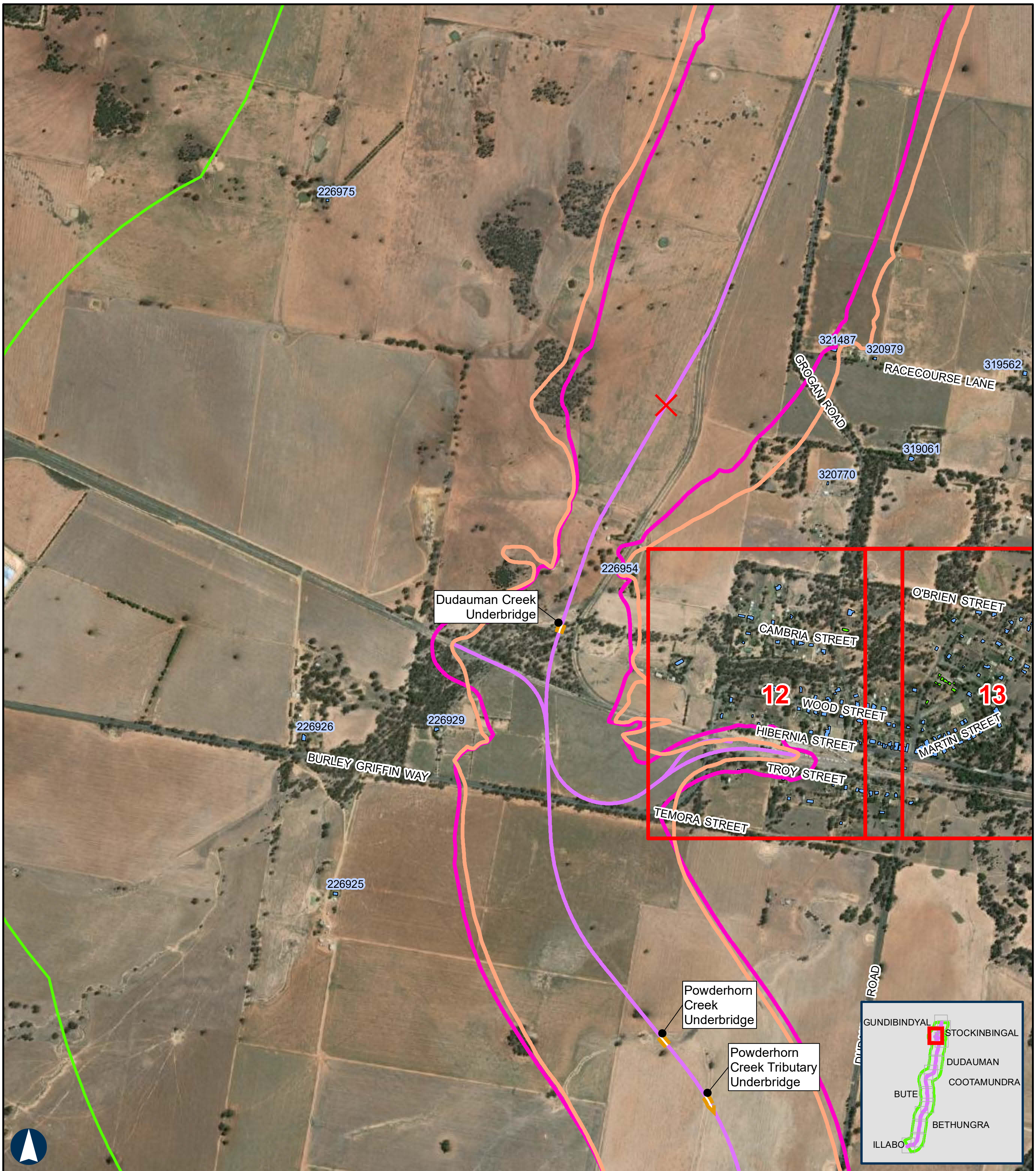

ILLABO TO STOCKINBINGAL Year 2040 Night-time Rail Noise Levels

APPENDIX E - Map 14 of 16

500 m

Coordinate System: GDA 1994 MGA Zone 55

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Author: JG

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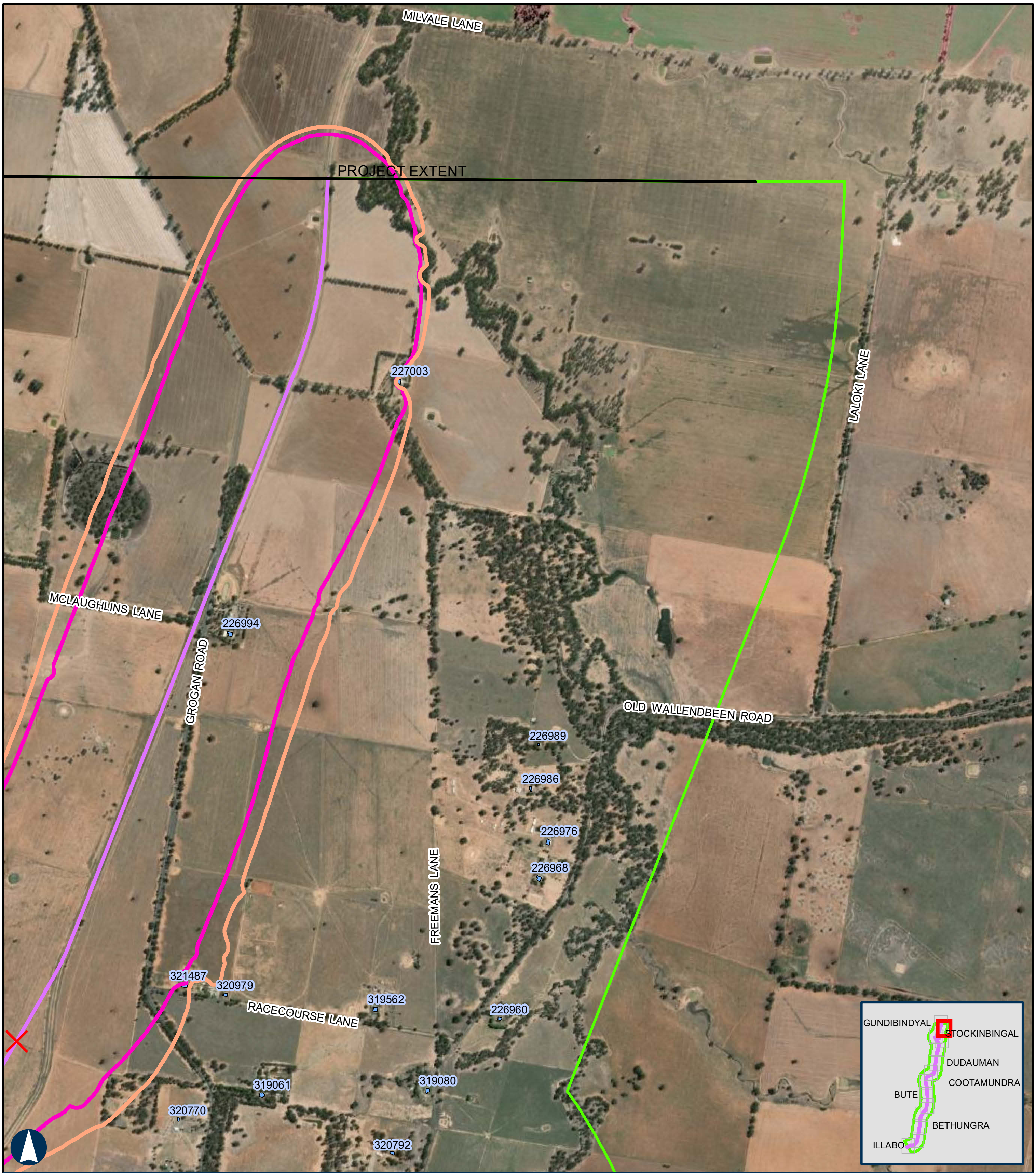

ILLABO TO STOCKINBINGAL Year 2040 Night-time Rail Noise Levels

APPENDIX E - Map 15 of 16

500 m

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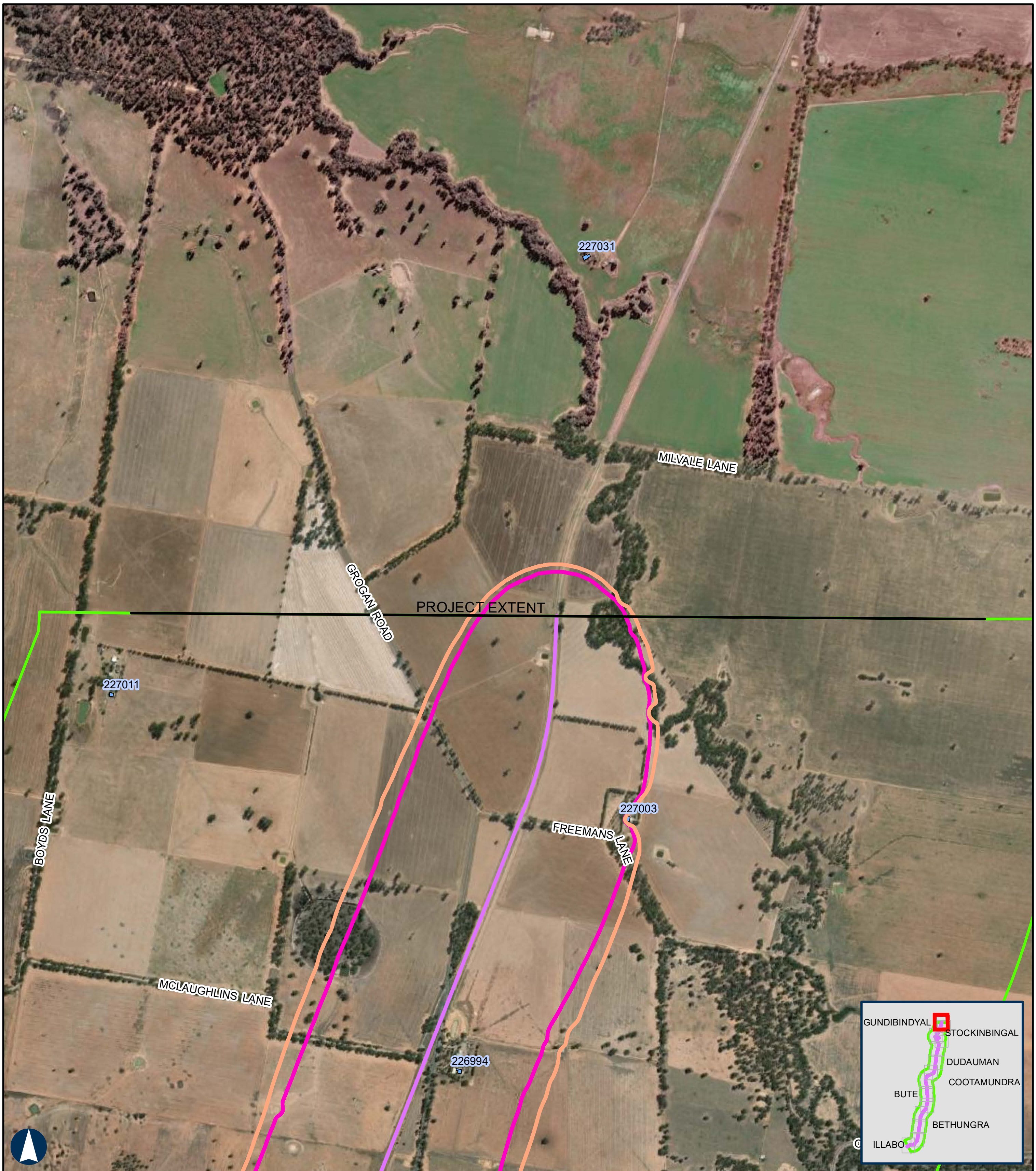

ILLABO TO STOCKINBINGAL

Year 2040 Night-time Rail Noise Levels

APPENDIX E - Map 16 of 16

500 m

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Receptor ID	Rail noise criteria			Project rail noise levels dBA		
	LAeq Day	LAeq Night	Lamax	LAeq,15hr	LAeq,9hr	LAmax
226598	60	55	80	49	46	73
226601	60	55	80	46	43	69
226607	60	55	80	43	40	67
226610	60	55	80	51	48	76
226611	60	55	80	43	40	66
226614	60	55	80	57	54	**81**
226616	60	55	80	52	50	76
226622	60	55	80	31	32	56
226645	60	55	80	42	45	70
226651	60	55	80	39	39	67
226668	60	55	80	44	47	73
226688	60	55	80	50	53	80
226702	60	55	80	51	54	**82**
226722	60	55	80	44	47	75
226725	60	55	80	41	44	71
226735	60	55	80	41	43	70
226746	60	55	80	43	46	70
226777	60	55	80	47	50	78
226778	60	55	80	42	45	72
226799	60	55	80	45	48	75
226810	60	55	80	41	44	68
226830	60	55	80	45	48	72
226853	60	55	80	50	52	79
226863	60	55	80	44	46	72
226879	60	55	80	40	42	69
226887	60	55	80	45	47	71
226894	60	55	80	45	48	72
226902	60	55	80	45	47	72
226907	60	55	80	47	49	75
226912	60	55	80	47	50	75
226914	60	55	80	47	50	75
226925	60	55	80	48	51	75
226926	60	55	80	47	49	74
226929	60	55	80	49	51	76
226954	60	55	80	53	55	79
226960	60	55	80	47	48	72
226968	60	55	80	48	50	73
226975	60	55	80	40	42	65
226976	60	55	80	46	48	71
226986	60	55	80	47	48	72
226989	60	55	80	47	48	72
226994	60	55	80	57	**59**	**83**
227003	60	55	80	54	**56**	80
227011	60	55	80	46	48	71
227031	60	55	80	44	46	69
318976	60	55	80	49	52	76
318977	60	55	80	51	53	**81**
319046	60	55	80	44	46	69
319048	60	55	80	48	50	74
319050	60	55	80	49	51	72
319052	60	55	80	46	47	69
319053	60	55	80	47	49	71
319058	60	55	80	49	51	73
319061	60	55	80	50	52	76
319063	60	55	80	50	52	77
319069	60	55	80	46	48	69
319076	60	55	80	49	51	73
319078	60	55	80	46	48	71
319079	60	55	80	48	50	73
319080	60	55	80	46	48	70
319176	60	55	80	50	52	75

Receptor ID	Rail noise criteria			Project rail noise levels dBA		
	LAeq Day	LAeq Night	Lamax	LAeq,15hr	LAeq,9hr	LAmax
319177	60	55	80	48	50	73
319178	60	55	80	49	51	73
319283	60	55	80	44	47	68
319284	60	55	80	48	50	72
319285	60	55	80	50	52	73
319286	60	55	80	49	51	72
319293	60	55	80	45	47	70
319295	60	55	80	50	52	75
319322	60	55	80	49	51	74
319323	60	55	80	48	50	72
319324	60	55	80	46	48	72
319343	60	55	80	49	51	73
319345	60	55	80	47	49	71
319346	60	55	80	47	49	71
319347	60	55	80	47	49	71
319348	60	55	80	48	50	72
319349	60	55	80	50	51	74
319419	60	55	80	49	50	73
319421	60	55	80	46	48	69
319488	60	55	80	46	48	70
319489	60	55	80	45	47	69
319490	60	55	80	47	49	72
319491	60	55	80	44	46	70
319492	60	55	80	50	52	73
319493	60	55	80	45	47	69
319535	60	55	80	51	53	76
319561	60	55	80	51	53	75
319562	60	55	80	48	49	73
319563	60	55	80	49	51	75
319573	60	55	80	49	51	74
319581	60	55	80	45	47	69
319611	60	55	80	47	49	72
319613	60	55	80	50	51	74
319614	60	55	80	49	51	73
319652	60	55	80	48	50	73
319655	60	55	80	50	52	76
319701	60	55	80	49	51	74
319702	60	55	80	48	49	71
319703	60	55	80	48	50	72
319704	60	55	80	47	48	70
319716	60	55	80	48	50	72
319717	60	55	80	46	48	68
319718	60	55	80	46	48	70
319719	60	55	80	46	48	70
319720	60	55	80	48	50	72
319721	60	55	80	48	50	72
319755	60	55	80	47	49	71
319756	60	55	80	47	49	71
319774	60	55	80	49	51	74
319775	60	55	80	48	50	75
319783	60	55	80	46	48	71
319784	60	55	80	49	51	72
319785	60	55	80	45	47	68
320032	60	55	80	50	52	77
320680	60	55	80	47	49	71
320688	60	55	80	44	46	70
320739	60	55	80	52	54	80
320744	60	55	80	47	49	72
320746	60	55	80	52	54	80
320755	60	55	80	46	48	71
320756	60	55	80	49	51	73

Receptor ID	Rail noise criteria			Project rail noise levels dBA		
	LAeq Day	LAeq Night	Lamax	LAeq,15hr	LAeq,9hr	LAmax
320757	60	55	80	47	49	71
320758	60	55	80	48	50	72
320759	60	55	80	46	48	69
320761	60	55	80	47	49	72
320769	60	55	80	48	49	73
320770	60	55	80	52	54	77
320775	60	55	80	49	51	75
320776	60	55	80	49	51	73
320778	60	55	80	47	48	70
320780	60	55	80	46	48	70
320781	60	55	80	50	52	75
320792	60	55	80	49	50	74
320800	60	55	80	46	48	70
320819	60	55	80	45	47	70
320838	60	55	80	48	50	73
320840	60	55	80	49	51	74
320849	60	55	80	50	51	75
320859	60	55	80	50	52	80
320873	60	55	80	46	48	71
320874	60	55	80	46	48	71
320890	60	55	80	52	54	77
320963	60	55	80	48	50	73
320964	60	55	80	48	50	70
320967	60	55	80	48	50	72
320979	60	55	80	54	55	80
321010	60	55	80	47	50	74
321011	60	55	80	49	51	74
321013	60	55	80	49	51	74
321018	60	55	80	49	51	73
321027	60	55	80	46	49	71
321028	60	55	80	49	51	73
321046	60	55	80	45	47	68
321050	60	55	80	49	51	74
321051	60	55	80	50	52	74
321052	60	55	80	48	50	72
321056	60	55	80	52	54	78
321071	60	55	80	48	50	74
321101	60	55	80	46	48	69
321111	60	55	80	49	50	72
321120	60	55	80	49	51	74
321122	60	55	80	48	50	72
321126	60	55	80	48	50	73
321127	60	55	80	47	50	72
321128	60	55	80	48	50	71
321129	60	55	80	45	48	71
321451	60	55	80	46	48	69
321452	60	55	80	46	48	69
321457	60	55	80	48	49	71
321481	60	55	80	45	48	70
321482	60	55	80	50	52	74
321486	60	55	80	49	51	73
321487	60	55	80	55	**57**	**81**
321488	60	55	80	48	50	74
321489	60	55	80	46	48	70
900004	60	55	80	42	44	67
900005	60	55	80	44	47	73
900008	60	55	80	40	42	67