CHAPTER 15

Noise and Vibration

CALVERT TO KAGARU ENVIRONMENTAL IMPACT STATEMENT

The Australian Government is delivering Inland Rail through the Australian Rail Track Corporation (ARTC), in partnership with the private sector.

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15.1 Scope of chapter

The scope for assessing potential noise and vibration impacts in accordance with the *Terms of Reference for an environmental impact statement: Inland Rail—Calvert to Kagaru project*, dated 8 December *October* 2017 included:

- Identifying nearby noise-sensitive receptors potentially affected by the construction and operation of the Calvert to Kagaru Project (the Project)
- Undertaking baseline noise and vibration measurements within the environment surrounding the Project
- Establishing construction and operational noise and vibration assessment criteria based on the measured background noise levels, the *Transport Noise Management Code of Practice: Volume 2—Construction Noise and Vibration* (CoP Vol. 2) and the *Environmental Protection (Noise) Policy 2019* (EPP (Noise))
- Establishing noise assessment criteria for operational road traffic and construction road traffic in accordance with the Department of Transport and Main Roads' (DTMR) *Transport Noise Management Code of Practice Volume 1—Road Traffic Noise* (CoP Vol. 1), and CoP Vol. 2 respectively
- Establishing noise assessment criteria for the railway operations of the Project with consideration to the *Development Affected by Environmental Emissions from Transport Policy* (DTMR, 2017a) (previously named *Policy for Development on Land Affected by Environmental Emissions from Transport and Transport Infrastructure*), the DTMR's *Interim Guideline—Operational Railway Noise and Vibration, Government Supported Transport Infrastructure* (DTMR, 2019b) and ARTC's operational railway noise management criteria for Inland Rail
- Establishing assessment criteria for ground-borne noise and vibration from railway operations with consideration to the DTMR Policy, Interim Guideline and ARTC's operational railway criteria for ground-borne noise and vibration
- Undertaking a noise-and-vibration impact assessment for the proposed construction works
- Assessing the potential noise impact resulting from construction activities and potential mitigation methods, where required, including buffer distances, silencing treatment of mobile plant, management of mobile plant, community consultation and other management mitigation measures, such as respite periods
- Reviewing vibration-intensive construction works and recommending mitigation measures where required, including the minimum working distances, use of alternative equipment and construction methods, respite periods and other management mitigation measures
- Undertaking a noise impact assessment of proposed steady-state operational noise sources such as fixed tunnel infrastructure and new or upgraded roads that are part of the Project
- Undertaking detailed modelling to determine the potential noise levels from the proposed daily railway operations for the Project opening in year 2026 and the design year for the Project (2040)
- Evaluating the predicted railway noise levels against the assessment criteria to identify where railway operations could trigger an investigation of measures to control noise emissions and mitigate potential impacts
- Assessing the impact of potential ground-borne noise and vibration levels associated with railway operations for the above-ground rail operations and train movements within the Teviot Range Tunnel
- Recommending a range of feasible and reasonable mitigation measures to, as required, assist in the control of railway noise and vibration emissions and minimise the potential for noise, ground-borne noise and vibration impacts from the railway operations on the Project
- Assessing the potential residual noise and vibration impacts for the construction and operation of the Project, once mitigation measures were implemented.

15.2 Terms of Reference

The chapter addresses the ToR for the Project as summarised in Table 15.1. Compliance of the EIS against the full ToR is documented in Appendix B: Terms of Reference Compliance Table.

TABLE 15.1: TERMS OF REFERENCE COMPLIANCE TABLE—NOISE AND VIBRATION

Terms of Reference requirement				Where addressed
Noise and vibration	Existing environment	11.118	Describe the existing noise and vibration environment that may be affected by the project in the context of the environmental values.	Section 15.5 Appendix P: Non-operational Noise and Vibration Technical Report, Section 3 Appendix Q: Operational Railway Noise and Vibration Technical Report, Sections 5 and 7
		11.119	Describe and illustrate on maps at a suitable scale, the location of all sensitive noise and vibration receptors adjacent to all project components and estimate typical background noise and vibration levels based on surveys at representative sites.	Section 15.5.1 Appendix P: Non-operational Noise and Vibration Technical Report, Section 3.2 and Appendix A Appendix Q: Operational Railway Noise and Vibration Technical Report, Appendix A
		11.120	If the proposed project could adversely impact on the noise and vibration environment, undertake baseline monitoring at a selection of sensitive receptors potentially affected by the project. Describe the results of any baseline monitoring.	Sections 15.4 and 15.5 Appendix P: Non-operational Noise and Vibration Technical Report, Section 3.3 and Appendix B Appendix Q: Operational Railway Noise and Vibration Technical Report, Section 5.4
	Impact assessment	11.121	Describe the characteristics of the noise and vibration sources that would be emitted when carrying out the activity (point source and general emissions). Describe noise and vibration emissions (including fugitive sources) that may occur during construction, commissioning and operation.	Sections 15.4, 15.6 and 15.7 Appendix P: Non-operational Noise and Vibration Technical Report, Sections 5 and 6 Appendix Q: Operational Railway Noise and Vibration Technical Report, Section 6
		11.122	Predict and map the impacts of the noise and vibration emissions from the construction and operation of the project on the environmental values of the receiving environment, including sensitive receptors. The assessment of impacts on noise and vibration consider, as applicable the following:	Section 15.7 Appendix P: Non-operational Noise and Vibration Technical Report, Sections 5 and 6, and Appendices C and D Appendix Q: Operational Railway Noise and Vibration Technical Report, Sections 7–12, and Appendices D and E The assessment has considered the relevant policies and guidelines listed in ToR 11.122 (a) to (f), as described in Chapter 15: Noise and Vibration, Section 15.3
			(a) EPP (Noise) 2008, using recognised quality assured methods	
			(b) Environmentally Relevant Activities—DEHP Application Requirements for ERAs with noise impacts (Guideline ESR/2015/1838)	
			(c) Construction—The Department of Transport and Main Roads Transport Noise Management Code of Practice: Volume 2— Construction Noise and Vibration dated March 2016 and gazetted on 29 July 2016	
			(d) Operational Noise—The Department of Transport and Main Roads Policy for Development on Land Affected by Environmental Emissions from Transport and Transport Infrastructure Version 2, 10 May 2013 (Rail noise external criteria contained in Table 3 of the document)	

Terms of Reference requirement				Where addressed
Noise and vibration (continued)	Impact assessment (continued)	11.122 (cont'd)	(e) Operational vibration—British Standard BS 6472-1:2008 Guide to evaluation of human exposure to vibration in buildings—Vibration sources other than blasting. British Standards Institution, London	
			(f) The Department of Transport and Main Roads Policy for Development on Land Affected by Environmental Emissions from Transport and Transport Infrastructure Version 2, 10 May 2013 (criteria contained in Table 6 of the document)	
		11.123	Discuss separately the key project components likely to present an impact on noise and vibration for the construction and operation phases of the project.	Sections 15.4.2–15.4.5 Appendix P: Non-operational Noise and Vibration Technical Report, Sections 5 and 6 Appendix Q: Operational Railway Noise and Vibration Technical Report, Sections 2 and 6
		11.124	Taking into account the practices and procedures that would be used to avoid or minimise impacts, the impact prediction must address the:	Refer sub-sections below.
			(a) Activity's consistency with the objectives of documentation referenced in TOR—11.122	Sections 15.3 and 15.7 Appendix P: Non-operational Noise and Vibration Technical Report, Sections 2 and 5.4 Appendix Q: Operational Railway Noise and Vibration Technical Report, Sections 7–13 and Appendices D and E
			(b) Cumulative impact of the noise and vibration with other known emissions of noise associated with existing major projects and/or developments and those which are progressing through planning and approval processes publicly available	Section 15.9 Chapter 22: Cumulative Impacts, Section 22.5.8 Appendix P: Non-operational Noise and Vibration Technical Report, Section 7 Appendix Q: Operational Railway Noise and Vibration Technical Report, Section 13
			(c) Potential impacts of any low-frequency (<200 Hz) noise emissions	Sections 15.6 and 15.7 Appendix P: Non-operational Noise and Vibration Technical Report, Section 4.1.1 Appendix Q: Operational Railway Noise and Vibration Technical Report, Section 10.6
	Mitigation measures	11.125	Describe how the proposed project and, in particular, the key project components described above, would be managed to be consistent with best practice environmental management for the activity. Where a government plan is relevant to the activity, or the site where the activity is proposed, describe the activity's consistency with that plan.	Chapter 15: Noise and Vibration, Sections 15.3 and 15.8 Appendix P: Non-operational Noise and Vibration Technical Report, Sections 2.1 and 8 Appendix Q: Operational Railway Noise and Vibration Technical Report, Sections 14 and 15

Terms of Reference requirement				Where addressed
Noise and vibration (continued)	Mitigation measures (continued)	11.126	Describe any expected exceedances of noise and vibration goals or criteria following the provision or application of mitigation measures and how any residual impacts would be addressed.	
		11.127	Describe how the achievement of the objectives would be monitored and audited, and how corrective actions would be managed.	
Hazard, health and safety	Climate	11.166	Describe the climate patterns with particular regard to discharges to water and air and the propagation of noise related to the project.	Effect of climate patterns on the propagation of construction noise is described in accordance with the CoP Vol 2 in Section 15.4.2.1. Construction noise emissions will persist for a period far shorter than the assessment period of changes of climate relative to the propagation of noise. Appendix P: Non-operational Noise and Vibration Technical Report, Section 3.3 Appendix Q: Operational Railway Noise and Vibration Technical Report, Section 10.5
		11.167	Climate information should be presented in a statistical form including long-term averages and extreme values, as necessary.	Effect of climate patterns on the propagation of construction noise is described in accordance with the CoP Vol 2 in Section 15.4.2.1. Construction noise emissions will persist for a period far shorter than the assessment period of changes of climate relative to the propagation of noise. Appendix P: Non-operational Noise and Vibration Technical Report, Section 3.3

15.3 Legislation, policies, standards and guidelines

Table 15.2 lists the policies, guidelines, standards and plans relevant to the noise and vibration assessment. No other government plans were considered to be relevant. Legislation that is of relevance to noise and vibration aspects of the Project are discussed in Chapter 3: Project Approvals.

TABLE 15.2: GUIDELINES AND POLICIES RELEVANT TO THE NOISE AND VIBRATION ASSESSMENT

Policy or Guideline	Relevance to Project
Transport Noise Management Code of Practice Volume 1—Road Traffic Noise (CoP Vol. 1) (DTMR, 2013c)	The CoP Vol. 1 is a legislative requirement under the *Traffic Infrastructure Act 1994* (Qld) (TI Act). It identifies the requirements for road traffic noise associated with completion of the Project. Applicable criteria and assessment methodologies were adopted from the CoP Vol. 1 to assess noise and vibration associated with road traffic noise.
Transport Noise Management Code of Practice: Volume 2—Construction Noise and Vibration (CoP Vol. 2) (DTMR, 2016)	The CoP Vol. 2 is gazetted under the *Environmental Protection Act 1994* (Qld) (EP Act). It identifies the noise and vibration requirements for construction activities completed for the Project. Applicable criteria and potential mitigation measures were adopted from the CoP Vol. 2 to assess noise and vibration associated with construction works.
Development Affected by Environmental Emissions from Transport Policy (DTMR Policy, 2017a)	The DTMR Policy identifies the requirements for the development of land affected by environmental emissions, including noise and vibration, from transport corridors and infrastructure. It provides criteria for noise and vibration for development on land affected by environmental emissions from linear state corridors and infrastructure. This has been considered in this document for the development of ARTC's noise and management criteria for the operation of Inland Rail.

Policy or Guideline	Relevance to Project
Interim Guideline—Operational Railway Noise and Vibration, Government Supported Infrastructure (DTMR, 2019b)	The DTMR's Interim Guideline provides assessment criteria for operational noise and vibration emissions generated by railway activities . It provides guidance for the prediction, assessment and management of noise and vibration and related impacts to sensitive receptors. This has been considered in this document for the development of ARTC's noise and management criteria for the operation of Inland Rail.
German Standard DIN 4150-3:1999 Vibration in Buildings—Part 3: Effects on Structures (Deutsches Institut für Normung, 1999)	This standard is prescribed by CoP Vol. 2. It recommends maximum levels of vibration that reduce the likelihood of potential cosmetic and structural damage to buildings that have been adopted for the assessment of potential related impacts from construction works. .
British Standard BS 6472-1:2008 Guide to evaluation of human exposure to vibration in buildings. Vibration sources other than blasting (British Standards, 2008)	This standard is prescribed by the DTMR Policy. It provides recommended levels of ground-borne vibration that reduce the likelihood of vibration-related impacts to building occupants. This standard was used in the operational noise and vibration assessment for the establishment of assessment criteria for ground vibration.
Australian Standard AS 1055.1-1997—Acoustics—Description and measurement of environmental noise, Part 1: General procedures (Standards Australia, 1997a)	The CoP Vol. 2 prescribes that noise measurement and reporting should be conducted in accordance with the construction and ambient noise provisions included in this standard. The environmental noise monitoring described in Section 15.1 was undertaken in accordance with this standard.
Technical Basis for Guidelines to Minimise Annoyance due to Blasting Overpressure and Ground Vibration (Australian and New Zealand Environment Council, 1990)	This document specifies recommended blasting overpressure and vibration impact limits to minimise annoyance and discomfort. The CoP Vol 2 references the blasting airblast overpressure criteria contained within this document. This document also suggests mitigation measures for blasting noise and vibration impacts. Airblast overpressure criteria were instead sourced from the DEHP guideline *Noise and vibration from blasting*, in accordance with the CoP Vol 2.
Australian Standard 2187.2-2006 Explosives—Storage and Use, Part 2: Use of Explosives—Appendix J (Australian Standards, 2006b)	The CoP Vol. 2 recommends the use of AS 2187.2 with respect to blasting vibration criteria for human comfort and structural damage. These ground vibration criteria have been adopted for this assessment.
Department of Environment and Heritage Projection (DEHP) *Guideline—Noise: Noise and Vibration from Blasting* (DEHP, 2016e)	This guideline sets out performance criteria to be used when setting operating requirements in conditions of environmental approvals under the EP Act. The CoP Vol. 2 presents the criteria to minimise annoyance from airblast resulting from blasting from this document. Predicted Project blasting airblast overpressure impacts have been assessed against these criteria.
Department of Environment and Science (DES) *Guideline—Environmental Protection Act 1994: Application requirements for activities with noise impacts* (DES, 2019a)	This guideline provides guidance on the requirements for assessments of noise impacts, including the requirement for supplementary approvals for Environmentally Relevant Activities (ERAs). The current proposal includes no ERAs with a significant noise impact. Final ERAs and applications will be finalised at later stages of the Project and if ERAs are required, then the application will use this guideline. Refer Chapter 3: Project Approvals for further detail on ERAs.
British Standard BS5228-1:2009 Code of practice for noise and vibration control on construction and open sites—Part 1: Noise (British Standards 2009)	Noise source data from this standard is recommended for the modelling of construction noise impacts by the CoP Vol. 2. This noise source data was used in the modelling of construction noise for this assessment.
British Standard BS5228-2:2009 Code of practice for noise and vibration control on construction and open sites—Part 2: Vibration	Calculation methods for the propagation of ground-borne vibration from this standard have been used to predict ground-borne vibration levels, and potential impacts, associated with the construction activities.
Environmental Protection (Noise) Policy 2019 (Qld) (EPP (Noise))	The EPP (Noise) provides support to the operation of the EP Act by identifying environmental values to be enhanced or protected, stating acoustics quality objectives for enhancing or protecting environmental values and providing a framework for consistent, equitable and informed decisions about the acoustic environment. EPP (Noise) acoustic quality objectives have been used to assess operational fixed infrastructure noise impacts of the Project.

15.4 Methodology

The assessment methodology for noise and vibration impacts has involved:

- Identifying noise and vibration study areas
- Identifying and classifying noise and vibration-sensitive receptors
- Baseline monitoring to establish existing environmental conditions
- Establishing relevant airborne noise, ground-borne noise, ground-borne vibration and blasting criteria
- Modelling of noise emissions associated with the construction and operation of the Project
- Assessing noise-level predictions against the adopted assessment criteria
- Assessing Project ground-borne vibration and ground-borne noise from construction and operationAssessing Project airblast overpressure and vibration from blasting associated with construction
- Where the assessment criteria were triggered, best practice measures have been identified to reduce noise and vibration emissions and mitigate, so far as is reasonably practicable, potential noise and vibration impacts associated with the construction and operation of the Project
- Identifying potential cumulative and/or residual impacts.

15.4.1 Noise and vibration study area

The non-operational noise and vibration study area is the area that extends 2 kilometres (km) in all directions from the disturbance footprint designated as part of the Project design. The Project disturbance footprint is described in Chapter 6: Project Description. The non-operational noise and vibration study area is shown in Figure 15.1. The operational railway noise study area is the area 2 km either side of the proposed rail alignment.

15.4.2 Construction noise and vibration

A summary of the methodology for each construction noise and vibration impact is included below. Further details can be found in Appendix P: Non-operational Noise and Vibration Technical Report.

Airborne noise

The following construction activities were identified:

- Site setup/laydown areas
- Earthworks
- Structures—including the construction of substructures, foundations and bridge piers
- Drainage—installation of cross drainage
- Rail civil works
- Road civil works.

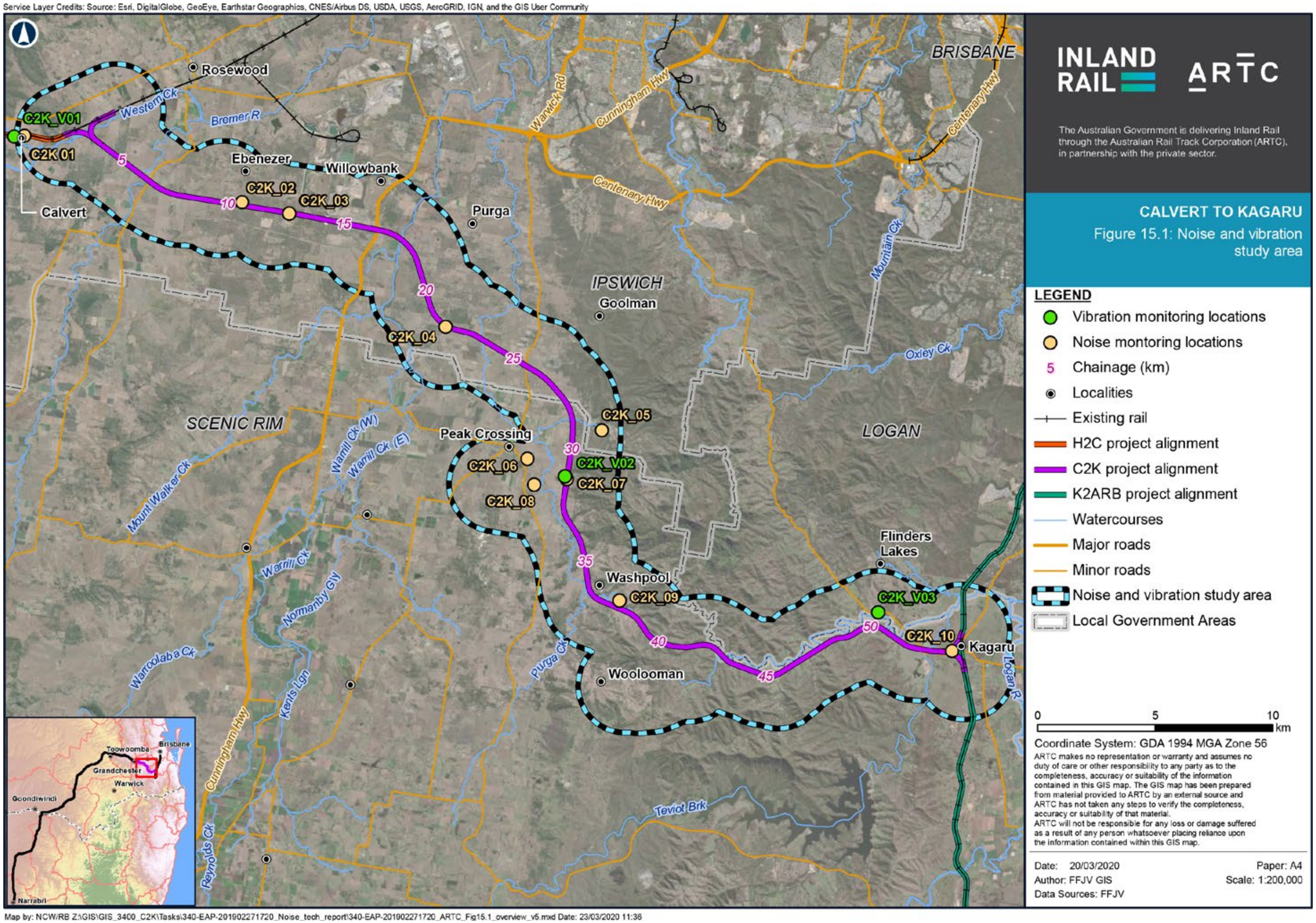
Noise-intensive plant and equipment associated with each construction activity are detailed in Appendix P: Non-operational Noise and Vibration Technical Report. Noise emissions from these plant and equipment were adopted from *BS5228-1:2009 Code of practice for noise and vibration control on construction and open sites—Part 1: Noise* (British Standards, 2009).

The potential noise levels from these construction activities was modelled using noise-modelling software to represent a typical worst-case, 15-minute period of noise intensive construction work.

The following features were included in the noise model:

- Ground topography (terrain)
- Absorption and reflection of noise by the local ground
- Identified sensitive receptors
- Construction noise sources.

In accordance with the CoP Vol 2, different meteorological conditions were considered in the assessment. These parameters are summarised in Table 15.3.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INLAND RAIL
ARTC
The Australian Government is delivering Inland Rail through the Australian Rail Track Corporation (ARTC), in partnership with the private sector.
CALVERT TO KAGARU
Figure 15.1: Noise and vibration study area
LEGEND
Vibration monitoring locations
Noise montoring locations
Chainage (km)
Localities
Existing rail
H2C project alignment
C2K project alignment
K2ARB project alignment
Watercourses
Major roads
Minor roads
Noise and vibration study area
Local Government Areas
Rosewood
Western Ck
Bremer R
C2K_V01
C2K 01
Calvert
Ebenezer
Willowbank
C2K_02
C2K_03
Purga
BRISBANE
Warwick Rd
Cunningham Hwy
Centenary Hwy
IPSWICH
Goolman
C2K_04
SCENIC RIM
Peak Crossing
C2K_05
C2K_06
C2K_V02
C2K_07
C2K_08
LOGAN
Oxley Ck
Mountain Ck
Mount Walker Ck
Warrill Ck (W)
Warrill Ck (E)
Warrill Ck
Normanby Gly
Washpool
C2K_09
Flinders Lakes
C2K_V03
C2K_10
Kagaru
Logan R
Woolooman
Purga Ck
Warroolaba Ck
Kents Lgn
Cunningham Hwy
Reynolds Ck
Teviot Brk
Toowoomba
Brisbane
Grandchester
Warwick
Goondiwindi
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Data Sources: FFJV
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TABLE 15.3: COP VOL 2 METEOROLOGICAL CONDITIONS FOR USE IN NOISE MODELLING

Time	Temperature °C	Humidity %	Wind speed m/s	Wind direction	Temperature lapse rate	Pasquil stability class (implied by temperature lapse rate)
Day	20	70	3	All	0 degrees C/100 m	E
Evening	15	70	2	Drainage flow	+3 degrees C/100 m	F
Night	15	70	None	None	F+3 degrees C/100 m	F

The following assumptions were made in modelling the construction noise activities:

- All site equipment would be operating simultaneously, which is unlikely and is therefore a conservative assumption.
- Specific equipment locations are not known at this stage. The Project design provides areas for each construction activity. Equipment was assumed to be operating at the closest point in these areas to each receptor to represent the worst-case scenario. During operation, the equipment could only operate at the closest point to each receptor for a limited period and could not do so simultaneously.
- All sensitive receptors were modelled as being two storeys, 4.6 m above ground level. This is an estimate of the height 1.5 m above the finished floor level of a two-storey dwelling, as per CoP Vol. 2. This is a conservative approach as noise impacts are typically greatest at the highest storey.

15.4.2.1 Ground-borne vibration

Formulae for the prediction of ground-borne vibration impacts were adopted from *British Standard BS 5228-2:2009 Code of Practice for Noise and Vibration Control on Construction and Open Sites, Part 2: Vibration* (BS 5228.2). These formulae were used in conjunction with the construction vibration criteria outlined in Section 15.7.3 to give minimum setback distances of receptors from the following vibration-intensive activities:

- Vibratory roller—vibration start-up/run-down
- Vibratory roller—steady state
- Vibratory piling
- Percussive (impact) piling
- Tunnel construction—roadheader.

Construction blasting

Formulae for the prediction of vibration and airblast overpressure due to blasting were adopted from Australian Standards *AS 2187.2-2006 Explosives—Storage and Use, Part 2: Use of Explosives—Appendix J*. (AS 2187.2). A worst-case assumption of a confined blast and geotechnical parameters for vibration transmission were used. Potential locations requiring blasting were identified based on information derived from the geotechnical interpretive report for the Project. Maximum permissible charge weights were calculated based on the distance of each sensitive receptor from the nearest potential blasting location, and the blasting criteria outlined in Section 15.7.4.

15.4.2.2 Construction road traffic noise

Construction vehicle movements and existing traffic flows have been based on information derived from Appendix U: Traffic Impact Assessment Technical Report. A desktop assessment using these traffic flows was used to predict the $L_{A10(1hr)}$ for each year from 2021 to 2026, both with and without the expected construction traffic.

15.4.2.3 Tunnel construction

Roadheader—tunnel construction

The roadheader source vibration spectrum has been derived from that of a similar project—the Melbourne Metro Rail project. This project was selected due to its similarity to the Project and because it provides information that is publicly referenceable. As vibration propagates differently via different substrates, vibration levels were back-calculated to a distance of close proximity to the source, and repropagated through the ground type relevant to the Teviot Range Tunnel.

Details of the modelling of vibration propagation, which is based on relevant literature, is included within Appendix P: Non-operational Noise and Vibration Technical Report.

For each vibration source, it has been assumed that the peak particle velocity (PPV) values at each frequency all occur simultaneously, resulting in a conservative PPV sum for the purpose of assessment against the nominated criteria. For a roadheader used in rock, it is assumed that the PPV will be 8 millimetres per second (mm/s) at 5 m, as per the Melbourne Metro Rail project.

The (diagonal) distance between the source and the building foundation of each sensitive receptor is based on the following horizontal and vertical data for the tunnel:

- LiDAR elevation terrain contours at the sensitive receptor
- Tunnel outer edge
- Rail centreline (vertical and horizontal profile)
- Shortest horizontal distance between the sensitive receptor and rail centreline (typically perpendicular, with the exception of houses near the portals).

No other vibration-intensive plant equipment has been identified in use for these tunnelling works. Ground-borne vibration due to tunnelling is assumed to be long-term vibration as defined by DIN 4150-3. Ground-vibration transmission losses and typical building corrections have then been applied based on a review of relevant literature and are detailed in Appendix P: Non-operational Noise and Vibration Technical Report.

Blasting due to tunnel construction

Vibration due to blasting has been calculated using methodologies outlined in AS 2187.2:2006.

Ground-borne noise

Once the vibration velocity levels were predicted inside the building, a vibration-to-airborne noise correction as per Chapter 11 of the US Federal Transit Authority's *Transit Noise and Vibration Impact Assessment*[1] was used to predict the re-radiated ground-borne noise levels. As the peak vibration values of the roadheader have been used as the source it is assumed that the predicted ground-borne noise levels are a reasonable approximation of the maximum (L_{ASMax}) ground-borne noise levels.

15.4.3 Operational rail noise and vibration

The assessment of airborne noise, ground-borne vibration and ground-borne noise from railway operations adopted the following approach:

- Identification of sensitive receptors and occupancy type
- Development of a noise emissions database for the rollingstock (locomotives and wagons) proposed for the Project
- Determination of source ground-borne vibration levels for rollingstock based on measured ground-borne vibration levels on existing rail freight corridors
- Prediction of airborne noise levels at the sensitive receptors
- Comparison of the predicted airborne noise levels against the Project's railway noise criteria
- Calculation of minimum buffer distances from the rail alignment where ground-borne vibration and ground-borne noise levels would achieve the relevant assessment criteria
- Identification of any sensitive receptors within the minimum buffer distances for ground-borne vibration and ground-borne noise
- Development of management and mitigation measures to meet the airborne noise, ground-borne vibration and ground-borne noise objectives.

The following operational scenarios were included in the assessment:

- The railway operations have been assessed for the Project opening in 2026 and the future design year 2040, which represents the railway operations defined in the *Inland Rail Program Business Case* (ARTC, 2015a).
- The assessment of airborne noise from the Project considered areas where new railway infrastructure is being constructed (greenfield project areas) and the areas where the Project represents an upgrade or redevelopment of existing railway infrastructure (brownfield project areas).
- The railway noise and vibration levels were assessed for the train movements (trains up to 1,800 m long) on the mainline and crossing loops and the associated noise events from the level crossing alarm bells and train horns
- The noise and vibration levels were assessed for the daytime and night-time periods for the Project opening in 2026 and for the design year 2040.

1. Department of Transportation (Office of Planning and Environment, Federal Transit Authority), 2006. *Transit Noise and Vibration Impact Assessment*, May.

15.4.4 Operational fixed infrastructure noise

Noise impacts of the operation of fixed infrastructure included in the design of the Project have been assessed under EPP (Noise). Fixed infrastructure identified as part of the design includes:

- Tunnel ventilation fans for emergency, maintenance and degraded operations
- Pumps and pump stations
- Transformers, substations and generators.

Railway safety systems have been assessed under the operational railway noise and vibration assessment, not as operational fixed infrastructure. These noise sources include:

- Level crossing alarms
- Train horns.

The following approach has been used to assess airborne noise due to operation of fixed infrastructure associated with the tunnel:

- Identification of sensitive receptor and occupancy type
- Derivation of empirical sound power level of noise sources based on specifications from the tunnel engineers
- Prediction of airborne noise levels at the sensitive receptors
- Comparison of the predicted internal airborne noise levels with the acoustic quality objectives
- Development of acoustic mitigation options to meet the environmental noise objectives.

Ancillary fixed infrastructure noise sources other than tunnel ventilation fans, such as pumps and transformers, will be located at the eastern and western tunnel portals for the Project. While noise from these sources is not yet confirmed, nominal mitigation strategies (such as attenuators, solid barriers, enclosures) would be implemented and will be designed to meet the EPP (Noise) acoustic quality objectives at noise-sensitive receptors.

A conservative scenario of tunnel ventilation fan operations during maintenance was assessed. This includes the operation of two jet fans together at either the western or eastern end of the tunnel, and one long egress passage fan each end of the tunnel. To predict the worst-case $L_{Aeq,1}$hr impacts, these fans have been modelled as running for 100 per cent of the time over the one-hour period. It was assumed that all fans will run at full duty during maintenance operations.

Calculations of fan noise emissions were undertaken using the methodology in ISO 9613-2[2], which is used to predict the equivalent continuous octave-band sound pressure level at a specified distance away , based on downwind favourable meteorological conditions for propagation.

Fan specifications were provided by the FFJV tunnel engineers. The jet fan sound power level (SWL) was based on manufacturer data[3], and the SWLs for the long egress passage fans[4] were empirically derived. Appendix P: Non-operational Noise and Vibration Technical Report details the noise source characteristics and the calculation methodology.

15.4.5 Operational road traffic noise

In assessing the potential noise impacts of the proposed changes to the road network, a desktop assessment was undertaken. Road changes were categorised as either new roads or road upgrades, as per the definitions adopted from DTMR's CoP Vol. 1. These definitions are provided in Table 15.4 and are based on road traffic noise terminology. Consequently, these categories may not align with those used in other chapters and assessments of this EIS.

The nearest sensitive receptors to the proposed works have been taken into consideration, as well as the realignment distance to predict the change in noise levels brought about by the realignment of the road closer to residents.

2. *ISO 9613-2: Acoustics—Attenuation of sound during propagation outdoors, Part 2: General method of calculation*
3. Axijet, *Jet Fans for Tunnel Ventilation—Sales Catalogue,* 50 Hz
4. American Society of Heating, Refrigerating and Air-Conditioning Engineers, *ASHRAE Handbook—HVAC Applications*

TABLE 15.4: COP VOL 1 ROAD CATEGORY DEFINITIONS

Road category	CoP Vol. 1 definition
New road	A new access-controlled road in a proposed or existing unused corridor adjacent to existing residences or in a proposed corridor where formal approval by a local government or other statutory authority for adjacent land development is current at the date of acquisition, even if the development is not yet in existence. A new road may include the upgrading of a road (State or local government) to one of a higher functional road hierarchy where there is an increase in the contribution to road traffic noise exposure of at least 3 dBA. The higher functional road hierarchy must be an access-controlled road of at least a collector/distributor function. Also, a new road is applicable to the situation where land acquisition (resumption) is taken beside an existing corridor and all State-controlled road lanes fall outside the existing corridor.
Upgrading existing road	A substantial upgrading such as duplication or additional through lanes within some portion of the existing road corridor. Some additional lanes may fall outside the existing road corridor where land acquisition (resumption) is required.

The assessed Project changes to the existing road network based on the design are listed in Table 15.5. Private access and maintenance access roads are not assessed as part of the operational road traffic noise assessment.

TABLE 15.5: PROJECT ROAD CHANGES

Road name	Approximate chainage (km)	Proposed treatment	CoP Vol 1 category
Hayes Road	4.40	Active level crossing	Existing road upgrade
Mt Forbes Road	9.80	Grade separation—road over rail, within existing corridor	Existing road upgrade
Paynes Road	9.80	Realignment outside existing corridor	New road
M Hines Road	12.00	Passive level crossing, within existing corridor	Existing road upgrade
Cunningham Highway	16.40	Grade separation—road over rail, within existing corridor	Existing road upgrade
Middle Road	21.80	Active level crossing, within existing corridor	Existing road upgrade
Ipswich–Boonah Road	25.60	Grade separation—rail over road, within existing corridor	Existing road upgrade
Truloff Road	27.50	Realignment outside existing corridor	New road
Mt Flinders Road	27.80	Grade separation—rail over road, within existing corridor	Existing road upgrade
Dwyers Road	32.00	Active level crossing, realignment outside existing corridor	New road
Washpool Road	34.00	Grade separation—rail over road, realignment outside existing corridor	New road
Wild Pig Creek Road Section 1	42.60	Grade separation—rail over road, realignment outside existing corridor	New road
Wild Pig Creek Road Section 2	45.60	Active level crossing, realignment inside existing corridor	Existing road upgrade
Wild Pig Creek Road Section 3	48.40	Realignment outside existing corridor	New road
Undullah Road Section 1	51.60	Grade separation—rail over road, realignment outside existing corridor	New road
Undullah Road Section 2	53.60	Grade separation—road over rail, realignment within existing corridor	Existing road upgrade

15.5 Existing environment

The land around the Project is predominantly rural land. The Project crosses a number of local and private roads, creeks and privately-owned properties. There are several towns located in the vicinity of the Project including Calvert, Lanefield, Ebenezer, Peak Crossing and Kagaru. In addition, there are a number of scattered rural residential properties. The Project is also near the Cunningham Highway, a connecting route to Warwick and western Queensland towns, and Ipswich–Boonah Road, a major connecting route between Ipswich and Boonah.

While the predominant land use is recognised as rural, consultation with stakeholders and the community has highlighted the importance of managing construction noise and vibration and operational noise because there are dwellings, work places and other sensitive receptors within the noise and vibration study area.

15.5.1 Sensitive receptors

Sensitive receptors applicable to the Project have been identified throughout the noise and vibration study area, as shown in Appendix P: Non-operational Noise and Vibration Technical Report and Appendix Q: Operational Railway Noise and Vibration Technical Report.

Sensitive land uses or receptors that were considered for these assessments included:

- Dwelling (detached or attached) including house, townhouse, unit, reformatory institution, caravan park or retirement village
- Library, childcare centre, kindergarten, school, school playground, college, university, museum, art gallery or other educational institution, hospital, respite care facility, nursing home, aged-care facility, surgery or medical centre
- Community building including a place of public worship
- Court of law
- Hotel, motel or other premises that provides accommodation for the public
- Commercial (office) or retail facility
- Protected area, or an area identified under a conservation plan as a critical habitat or an area of major interest under the *Nature Conservation Act 1992* (Qld) (NC Act)
- Outdoor recreational area (such as public park or gardens open to the public, whether or not on payment of a fee, for passive recreation other than for sport or organised entertainment) or a private open space.
- Industrial land use is only classified vibration sensitive to vibration emissions and is not included within the airborne noise impact assessments.

Each sensitive receptor within the study areas were identified using a combination of land property information and investigation of aerial imagery. The noise and vibration study area is shown in Figure 15.1. A total of 906 sensitive receptors were included in the study area for the construction assessment and 1,350 sensitive receptors included in the study area for the railway noise and vibration assessment.

The number of sensitive receptors varies due to the geographical extent of the study areas applied in the assessments.

Of these receptors, 12 sensitive receptors were found to be used for industrial purposes and are not classified as 'noise sensitive' and have only been included within the vibration and blasting assessments. Thirteen historic heritage structures were identified within the noise and vibration study area, six of which are also residential receptors. The remaining seven were deemed to be unoccupied and, therefore, not noise sensitive and have only been included within the vibration and blasting assessments.

Other sensitive receptors within the noise and vibration study area are further away from the receptors and if the EPP (Noise) acoustic-quality objectives can be met at the receptor, it follows that they will be met at the receptors located further away.

15.5.2 Noise monitoring

Ambient noise monitoring was conducted at ten locations within the noise and vibration study area during November 2018. This monitoring included both long-term monitoring and short-term attended measurements. The long-term monitoring was used to identify existing sources of noise within the study areas, quantify and characterise the existing noise environment and establish background noise level referenced in establishing relevant noise criteria.

Noise-monitoring locations are shown in Figure 15.1 and were selected to be representative of clusters of sensitive receptors, particularly those most at risk of being impacted by noise from the Project. Attended noise measurements were undertaken to determine the nature of the local noise environment.

The results of the background noise monitoring are provided in Table 15.6. The monitoring results are typical of noise levels experienced in rural environments with low background noise levels, dominated by environmental noise such as birds and insects. Additional detail on the existing noise environment can be found in Appendix P: Non-operational Noise and Vibration Technical Report. The monitoring of the existing environment takes into consideration any potential cumulative noise impacts of existing developments in the vicinity of the Project. Cumulative impacts are discussed in Section 15.9 and discussed in detail within Chapter 22: Cumulative Impacts.

TABLE 15.6: EXISTING RATING BACKGROUND LEVELS

Monitoring location[1]	Rating background level, dBA		
	Day[2]	Evening[2]	Night[2]
C2K_01	35	32	27
C2K_02	33	31	1
C2K_03	33	28	23
C2K_04	32	33	25
C2K_05	39	32	22
C2K_06	34	39	35
C2K_07	29	29	22
C2K_08	35	31	23
C2K_09	35	25	<21
C2K_10	<21	<21	<21

Table notes:
Decibel (dB)—the measurement unit of sound.
Rating background level (RBL)—the overall background level for each day, evening and night period for the entire length of noise monitoring. The background noise is the underlying level of noise present in the ambient noise when extraneous noise is removed.
Background noise—the underlying level of noise present in the ambient noise when extraneous noise (such as transient traffic and dogs barking) is removed.
A-weighted decibels (dBA)—the A-weighting is a frequency filter applied to measured noise levels to represent how humans hear sounds. The overall sound level is A-weighted it is expressed in units of dBA.
1. Shown on Figure 15.1
2. In accordance with the CoP Vol. 2, time of day is defined as follows:
    - Day—the period from 7.00 am to 6.00 pm Monday to Friday or 8.00 am to 1.00 pm on Saturday
    - Evening—6.00 pm to 10.00 pm Monday to Friday, 1.00 pm to 10.00 pm on Saturday or Sunday 7.00 am to 10.00 pm on Sunday
    - Night—Sunday to Friday 10.00 pm to 7.00 am and 10.00 pm to 8.00am Saturday.

15.5.3 Vibration monitoring

Table 15.7 contains the vibration measurement site summary showing the PPV vibration levels from the monitoring period. Sources of existing background vibration include vehicle movements, wind gusts, and nearby fauna movements.

TABLE 15.7: BACKGROUND VIBRATION MEASUREMENTS

Site	Date	Start time	End time	PPV (mm/s)
C2K_01	7/03/2019	2:31 pm	2:47 pm	0.21
C2K_02	7/03/2019	1:09 pm	1:26 pm	0.15
C2K_03	7/03/2019	11:22 am	11:37 am	0.12

Table notes:
Peak particle velocity (PPV)—A measure of ground vibration magnitude, PPV is the maximum instantaneous particle velocity at a point during a given time interval in mm/s
mm/s—millimetre per second.

15.6 Assessment criteria

Noise and vibration criteria are specific to the type of the source of noise or vibration. Noise and vibration criteria for different types of noise use various parameters, as well as various numerical levels. Each of the following categories of noise and vibration sources is assessed individually, consistent with the relevant standards, legislation, policies and guidelines:

- External construction noise limits applied to the assessment of construction activities and construction sites
- Noise assessment criteria for road traffic during construction
- Vibration assessment standards for intensive vibration-generating construction activities
- Vibration and airblast overpressure for blasting activities
- Operational railway airborne noise, ground-borne vibration and ground-borne noise management levels
- Operational noise management criteria for the fixed infrastructure associated with the Project
- Operational road traffic noise management criteria for the proposed locations with road and rail interface.

15.6.1 Construction noise assessment criteria

15.6.1.1 External construction noise criteria

Residential dwellings

For dwellings (including hotels and motels), noise emissions associated with construction activities are to be assessed using the noise criteria in , adopted from the CoP Vol. 2. Exceeding the 'upper limit' is considered to cause significant annoyance, and the upper limits are used as noise criteria. The 'lower limit' is generally considered to be just perceptible and the CoP Vol. 2 states that all reasonable and practicable measures should be implemented to achieve the lower limit. The criteria are for the noise contribution from construction only (component limit) and are defined as external façade-corrected noise levels at 1.5 m above the highest floor level.

TABLE 15.8: EXTERNAL CONSTRUCTION NOISE CRITERIA

CoP Vol. 2 work period		External noise level $L_{Aeq,adj,15\ min}$ dBA	
		Lower limit	Upper limit
Standard hours	Day	50	65
Non-standard hours	Evening	-	45
	Night	-	

Table notes:
Equivalent continuous sound level (Leq)—the constant sound level that, when occurring over the same period of time, would result in the receptor experiencing the same amount of sound energy.
In accordance with the CoP Vol. 2, a minimum lower limit of 50 dBA for standard hours and 45 dBA for non-standard hours has been adopted. Where the lower limit value exceeds the upper limit value, the lower limit value is taken to equal the upper limit value.

The CoP Vol. 2 definitions of standard and non-standard hours that are applicable to the noise criteria listed in Table 15.8 are presented in Table 15.9.

TABLE 15.9: COP VOL 2 CONSTRUCTION NOISE AND VIBRATION WORK PERIODS FOR CONSTRUCTION ACTIVITIES

Work period	General construction and construction traffic	Blasting
Standard hours	Monday to Friday 7.00 am to 6.00 pm Saturday 8.00 am to 1.00 pm	Monday to Friday 9.00 am to 5.00 pm Saturday 9.00 am to 1.00 pm
Non-standard hours—day/evening	Monday to Friday 6.00 pm to 10.00 pm Saturday 1.00 pm to 10.00 pm Sunday 7.00 am to 10.00 pm	Generally, blasting is not to be conducted outside standard hours. Any blasting outside standard hours must be approved by the DTMR prior to blasting. It is noted that reduced limits may be required to be achieved.
Non-standard hours—night-time	Monday to Sunday 10.00 pm to 7.00 am	

Other sensitive land uses

The CoP Vol. 2 defines critical facilities and the internal noise criteria for them. These criteria are intended to be met where reasonable and practicable and apply during the operational hours of the facility. Receptors were categorised using a combination of QLD cadastral data and aerial imagery. No critical facilities were identified within the noise and vibration study area. Critical facility definitions and noise criteria are summarised in Table 15.10.

TABLE 15.10: COP VOL 2 INTERNAL CONSTRUCTION NOISE CRITERIA FOR CRITICAL FACILITIES

Type of occupancy/activity	Internal noise level $L_{Aeq,adj,15\text{-}minute,}$ dBA
Medical/health buildings (wards, surgeries, operating theatres, consulting rooms)	40
Educational/research facilities (rooms designated for teaching/research purposes)	45
Court of law (court rooms)	35
Court of law (court reporting and transcript areas, judges' chambers)	40
Community buildings (libraries, places of worship)	45

Noise characteristics

Noise characteristics, such as low-frequency noise, have been taken into consideration through the application of correction factors as per the CoP Vol. 2. Details of the correction factors can be found in Appendix P: Non-operational Noise and Vibration Technical Report.

15.6.2 Construction road traffic noise criteria

Haulage and transportation associated with construction activities on public roads within the noise and vibration study area or beyond has the potential to create noise issues for existing sensitive receptors. CoP Vol. 2 specifies the following criteria to limit traffic noise caused by construction traffic:

- Construction traffic should not increase the pre-construction traffic noise level $L_{A10,\,1\,hour}$ by more than 3 dBA.

15.6.3 Construction ground-borne noise criteria

Ground-borne noise has been identified as a potential source of impact from the ground-borne vibration generated by the tunnel construction and use of a road header for excavation works. The construction ground-borne noise investigation limits set out in the CoP Vol. 2 are in Table 15.11.

TABLE 15.11: CONSTRUCTION GROUND-BORNE NOISE INVESTIGATION LIMITS

	Ground-borne noise limit[1,2]	
Building	**Work period[3]**	**L_{ASMax}, dBA**
Dwellings (including hotels and motels)	(Standard hours—day)	40
	(Non-standard hours—day/evening)	35
	(Non-standard hours—night)	35
Commercial (offices)	While in use	40

Source: DTMR, 2015a

Table notes:

L_{max} The maximum sound pressure level (i.e. the amount of sound at a specified point) measured over the measurement period.

1. There is no applicable ground-borne noise limit for industrial buildings.
2. If the limits are predicted to be exceeded, practicable mitigation options will be investigated.
3. Standard hours (day): Monday to Friday 7.00 am to 6.00 pm, Saturday 8.00 am to 1.00 pm. Non-standard hours (evening): Monday to Friday 6.00 pm to 10.00 pm, Saturday 1.00 pm to 10.00 pm, Sunday 7.00 am to 10.00 pm. Non-standard hours (night) Monday to Sunday 10.00 pm to 7.00 am

15.6.4 Construction vibration criteria

Ground-vibration criteria are defined in CoP Vol. 2. The effects of ground vibration from construction activities may be split into the following two categories:

- Human comfort—disturbance to building occupants, arising from vibration that inconveniences or possibly disturbs the occupants or users of the building. The vibration criteria are based on the requirements of *British Standard BS 5228-2:2009 Code of Practice for Noise and Vibration Control on Construction and Open Sites, Part 2: Vibration* (British Standards, 2009Standards, 2009)
- Building damage—vibration that may compromise the integrity of the building structure itself. The vibration criteria are based on the requirements of *German Standard DIN 4150:1999 Vibration in Buildings—Part 3: Effects on Structures* (DIN, 1999).

15.6.4.1 Human comfort

In order to minimise annoyance due to ground-borne construction vibration, CoP Vol. 2 adopts the vibration levels that are presented in Table 15.12. The lower limits are generally considered to be just perceptible, if exceeded. The upper limits under CoP Vol. 2 are considered to cause significant annoyance, if exceeded.

All reasonable and practicable measures should be implemented to achieve the lower limit. The CoP Vol. 2 also provides that '*exceedance of the upper limit requires immediate action and extensive community consultation to determine further mitigation measures*'.

TABLE 15.12: HUMAN COMFORT VIBRATION LIMITS TO MINIMISE ANNOYANCE

Building	Work period	Resultant PPV (mm/s) Lower limit	Resultant PPV (mm/s) Upper limit
Dwellings (including hotels and motels)	Standard hours	1.0	2.0
	Non-standard hours— evening	0.3	1.0
	Non-standard hours—night	0.3	1.0
Medical/health buildings (wards, surgeries, operating theatres, consulting rooms)	All	0.3	1.0
Educational facilities (rooms designated for teaching purposes)	While in use		
Court of law (court rooms)			
Court of law (court reporting and transcript areas, judges' chambers)			
Community buildings (libraries, places of worship)	While in use	1.0	2.0
Commercial (offices) and retail areas			

Table notes:
mm/s—millimetre per second

15.6.4.2 Building and structural damage

DIN 4150-3 provides recommended maximum levels of vibration that reduce the likelihood of building damage and are presented in Table 15.13. These levels have been adopted as short-term vibration criteria against building or structural damage.

TABLE 15.13: DIN 4150-3 STRUCTURAL DAMAGE 'SAFE LIMITS' FOR SHORT-TERM BUILDING VIBRATION

Group	Type of structure	PPV in mm/s based on frequency at building foundation		
		1 to 10 Hz	10 to 50 Hz	50 to 100 Hz[1]
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50
2	Dwellings and buildings of similar design and/or use (i.e. residential)	5	5 to 15	15 to 20
3	Structures that because of their particular sensitivity to vibration, do not correspond to those listed in Group 1 or 2 and have intrinsic value (e.g. heritage listed)	3	3 to 8	8 to 10

Table notes:
The frequency of vibration is the number of oscillations that occur in one second. The frequency unit used is Hertz (Hz) where, for example, 1 Hz equals 1 cycle per second and 100 Hz equals 100 cycles per second.
1. For frequencies above 100 Hz, the higher values in the 50 to 100 Hz column should be used.

The DIN 4150-3 limits listed in Table 15.14 have been adopted as long-term vibration criteria against building or structural damage.

TABLE 15.14: DIN 4150-3 STRUCTURAL DAMAGE 'SAFE LIMITS' FOR LONG-TERM BUILDING VIBRATION

Group	Type of structure	PPV in mm/s of vibration in horizontal plane of highest floor, at all frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	10
2	Dwellings and buildings of similar design and/or use (i.e. residential)	5
3	Structures that, because of their particular sensitivity to vibration, cannot be classified under groups 1 or 2 and are of great intrinsic value (e.g. listed buildings under preservation orders)	2.5

Table notes:
mm/s—millimetre per second
PPV—peak particle velocity

'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 vibrations that are higher than the 'safe limits' are present; it does not necessarily follow that damage will occur.

DIN 4150-3 also provides guideline values for evaluating the effects of vibration on buried pipework, summarised in Table 15.15.

TABLE 15.15: DIN 4150-3 GUIDELINE VALUES FOR EVALUATING THE EFFECTS OF VIBRATION ON BURIED PIPEWORK

		Guideline values for PPV measured on the pipe in mm/s	
Line	**Pipe material**	**Short-term vibration**	**Long-term vibration**
1	Steel (including welded pipes)	100	50
2	Clay, concrete, reinforced concrete, pre-stressed concrete, metal (with or without flange)	80	40
3	Masonry, plastic	50	25

Source: Deutsches Institut für Normung (1999). German Standard DIN 4150-: Part 3

Table notes:
mm/s—millimetre per second
PPV—peak particle velocity

As part of the constructability assessment, identification of high-risk utility underground pipe work used for gas pipelines, oil pipes, utilities, electricity, power lines, water pipes, sewer gravity main, communication cables and unknown pipelines was completed. The distances between the Project's construction and operation and these items will need to be confirmed to ensure impacts are adequately managed.

15.6.5 Blasting

Controlled blasting is anticipated to be used in order to excavate material along some sections of the proposed alignment. Construction blasting can result in two adverse environmental effects: airblast over pressure and ground vibration. The airblast overpressure and ground vibration produced may cause human discomfort and inappropriately designed and implemented blasts may have the potential to cause damage to structures, architectural elements and services.

The DEHP *Guideline—Noise: Noise and Vibration from Blasting* (DEHP, 2016e) is adopted by the CoP Vol. 2 to minimise annoyance and discomfort to persons at noise sensitive land uses as a result of blasting. The CoP Vol. 2 also recommends the use of AS 2187.2 with respect to criteria for human comfort and structural damage.

This includes consideration of different types of structures such as more-sensitive masonry and plasterboard buildings and less-sensitive reinforced concrete buildings.

15.6.5.1 Blasting criteria

In relation to airblast overpressure, the following criteria have been adopted from the DEHP Guideline. These criteria should be used to assess the annoyance from airblast overpressure to sensitive receptors:

- Not more than 115 dB(linear) peak for 9 out of any 10 consecutive blasts
- Not more than 120 dB(linear) peak for any blasts.

For the purposes of the Project, the AS 2187.2 ground vibration criteria were adopted for the assessment of vibration impacts from blasting and are summarised in Table 15.16.

TABLE 15.16: BLASTING GROUND VIBRATION CRITERIA SUMMARY

Category	Human comfort	Structural damage[1]
Sensitive structures (e.g. residential, theatres, schools)	5 mm/s for 95% blasts per year 10mm/s maximum unless agreement is reached with the occupier that a higher limit may apply[2]	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above
Occupied, non-sensitive structures of reinforced concrete or steel construction (e.g. factories and commercial premises)	25mm/s maximum unless agreement is reached with the occupier that a higher limit may apply. For sites containing equipment sensitive to vibration, the vibration should be kept below manufacturers' specifications or levels that can be shown to adversely affect the equipment operation	50 mm/s maximum unless agreement is reached with the occupier that a higher limit may apply
Occupied, non-sensitive structures that include masonry, plaster and plasterboard in their construction (e.g. factories and commercial premises)	25 mm/s maximum unless agreement is reached with the occupier that a higher limit may apply. For sites containing equipment sensitive to vibration, the vibration should be kept below manufacturers' specifications or levels that can be shown to adversely affect the equipment operation	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above
Unoccupied, non-sensitive structures of reinforced concrete or steel construction (e.g. factories and commercial premises)	N/A	100 mm/s maximum unless agreement is reached with the owner that a higher limit may apply
Unoccupied, non-sensitive structures that include masonry, plaster and plasterboard in their construction	N/A	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above
Buildings of special value or significance (may include historical buildings, monuments)	2mm/s	N/A

Source: Standards Australia (2006b) AS 2187.2-2006

Table notes:

1. The values are less stringent than values in DIN 4150-3 because DIN 4150-3 considers resonance in buildings from continuous vibration. The short duration of blast events reduces the propensity for resonance within buildings resulting in higher criteria.
2. The human comfort limits should be based off the values presented above from the DEHP guideline as per the CoP Vol. 2.

These requirements do not cover buildings with long-span floors, specialist structures such as reservoirs, dams and hospitals, or buildings housing equipment sensitive to vibration. These buildings require special considerations, which may necessitate taking additional measurements on the structure itself. No such receptors have been identified within the noise and vibration study area as part of the EIS. Should structures with a particular sensitivity to vibration be identified, they should be addressed on a case-by-case basis.

15.6.5.2 Recommended hours and frequency of blasting activities

The CoP Vol. 2 defines the working periods for blasting activities as follows:

- Blasting should generally only be permitted during the hours of 9.00 am to 5.00 pm Monday to Friday and Saturday 9.00 am to 1.00 pm
- Generally, blasting is not to be conducted outside standard hours. Any blasting outside standard hours must be approved by the DES prior to blasting. It is noted that reduced limits may be required to be achieved.

15.6.6 Operational noise and vibration criteria

The following noise assessment criteria are relevant to the operation of the proposed activities of the Project:

- Noise, vibration and ground-borne noise impact assessment criteria for the management of railway noise
- Noise assessment levels for operational road traffic noise impacts due to road–rail interface within the noise and vibration study area
- Noise criteria applied to the fixed tunnel infrastructure required for adequate ventilation of the tunnel.

15.6.6.1 Operational railway noise assessment criteria

ARTC is implementing a uniform approach for the assessment and management of operational railway noise across the Inland Rail Program in Victoria, New South Wales (NSW) and QLD. The key objective of ARTC's approach is to ensure the potential noise-related impacts to public health, amenity and disturbance are managed consistently.

If the railway noise levels are predicted or measured to be above the noise criteria at sensitive receptors, reasonable and practicable mitigation measures are to be considered, with the aim to reduce the noise levels to meet criteria and ameliorate potential impacts.

The rail noise criteria from the DTMR Policy, (DTMR, 2017a) and the Interim Guideline (DTMR, 2019b) and other railway noise guidelines in use in Australia were considered in the development of the airborne railway noise criteria for the Project.

On the Project, ARTC is adopting the airborne railway noise assessment criteria for residential receptors in Table 15.17. To provide an equitable and best practice approach to managing noise on the Project, the criteria implemented by ARTC are more stringent than the criteria from the DTMR Policy and the Interim Guideline.

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.

TABLE 15.17: AIRBORNE RAILWAY NOISE ASSESSMENT CRITERIA FOR RESIDENTIAL RECEPTORS

	Noise management levels (external)	
Type of development	**Daytime (7.00 am to 10.00 pm)**	**Night-time (10.00 pm to 7.00 am)**
New rail line development[1]	Predicted railway noise levels exceed:	
	$L_{Aeq(15hour)}$ 60 dBA	$L_{Aeq(9\ hour)}$ 55 dBA
	L_{AFmax} 80 dBA	L_{AFmax} 80 dBA
Redevelopment of existing rail line[2]	Development increase 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

Table notes:

$L_{Aeq(9\ hour)}$ = A-weighted equivalent noise level measured in decibels over a period of 9 hours

$L_{Aeq(15\ hour)}$ = A-weighted equivalent noise level measured in decibels over a period of 15 hours

L_{Amax} = The maximum A-weighted noise level during a measurement period

$L_{Aeq(period)}$ = A-weighted equivalent noise level measured in decibels over an unspecified period of time

1. A new rail line development is a rail infrastructure project on land that is not currently an operational rail corridor.
2. A redeveloped 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 that may result in the widening of an existing rail corridor.

A detailed review of the assessment criteria was undertaken in Appendix Q: Operational Railway Noise and Vibration Technical Report, which identified the noise levels from ARTC's noise management criteria are more stringent than the DTMR Policy (DTMR, 2017a) and the Interim Guideline. (DTMR, 2019b). On this basis, the ARTC noise management criteria were applied in the assessment and where the Project achieves these trigger levels at residential receptors, the criteria from DTMR guidelines would also be achieved.

The ARTC noise management approach also includes rail-noise management levels for sensitive receptors other than residential land uses. On the Project, ARTC is adopting the noise assessment criteria for sensitive receptors other than residential land use in Table 15.18.

TABLE 15.18: AIRBORNE NOISE MANAGEMENT LEVELS FOR OTHER SENSITIVE RECEPTORS

	Noise management levels (when receptor premises are in use)	
	New rail line development[1]	Redevelopment of existing rail line[2]
Type of development	Resulting rail noise levels exceed:	Development increases existing rail noise levels by 2 dBA or more in L_{Aeq} for that period, and resulting rail noise levels exceed:
Schools, educational institutions and childcare centres	L_{Aeq},(1 hour) 40 dBA (internal)	L_{Aeq},(1 hour) 45 dBA (internal)
Places of worship	L_{Aeq},(1 hour) 40 dBA (internal)	L_{Aeq},(1 hour) 45 dBA (internal)
Hospital wards	L_{Aeq},(1 hour) 35 dBA (internal)	L_{Aeq},(1 hour) 40 dBA (internal)
Hospital other uses	L_{Aeq},(1 hour) 60 dBA (external)	L_{Aeq},(1 hour) 65 dBA (external)
Open space—passive use (e.g. parkland, bush reserves)	L_{Aeq},(15 hour) 60 dBA (external)	L_{Aeq},(15hour) 65 dBA (external)
Open space—active use (e.g. sports field, golf course)	L_{Aeq},(15 hour) 565 dBA (external)	L_{Aeq},(15hour) 65 dBA (external)

Table notes:

L_{Aeq} = A-weighted equivalent noise level measure in decibels

1. A new rail line development is a rail infrastructure project on land that is not currently an operational rail corridor.
2. A redeveloped 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 that may result in the widening of an existing rail corridor.

15.6.6.2 Operational railway ground-borne vibration assessment criteria

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

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 within 2 km of the Project alignment did not identify premises expected to have these types of scientific equipment.

For intermittent events, such as train pass-by events, the vibration dose value (VDV) is applied as a cumulative measure of the vibration levels associated with all rolling stock operations in the assessment period. The VDV considers the combined effects of the level of the ground-borne vibration and the duration of vibration-generating events and, as such, is suited for the assessment of transient sources such as rolling stock activities.

The ground-borne vibration assessment criteria for railway operations are detailed in Table 15.19.

TABLE 15.19: RAILWAY GROUND-BORNE VIBRATION ASSESSMENT CRITERIA

		Internal ground-borne vibration criteria[2]	
Type	Sensitive receptors	Use period[1]	Vibration dose value
New railway or upgrading existing railway	Accommodation activities	Daytime	⩽ 0.20 $m/s^{1.75}$
		Evening	
		Night-time	⩽ 0.13 $m/s^{1.75}$
	Educational establishment, childcare centres, health care services, hospitals, community uses, places of worship and offices.	While in use	⩽ 0.40 $m/s^{1.75}$ (all areas)
			⩽ 0.10 $m/s^{1.75}$ (critical areas)

Table notes:

$m/s^{1.75}$ = The root mean quad of acceleration, which is measured in metres per second

1. Daytime 7.00 am to 6.00 pm, evening 6.00 pm to 10.00 pm and night-time 10.00 pm to 7.00 am.
2. Table 6—Vibration Criteria (internal) for New Sensitive Development (Development Affected by Environmental Emissions from Transport Policy (DTMR, 2017a)).

15.6.6.3 Operational railway ground-borne noise assessment criteria

Ground-borne vibration from passing trains can cause perceptible vibration impacts to occupants of nearby buildings. Ground-borne vibration can also result in audible impacts inside buildings in the form of a low-frequency rumble if the vibration is sufficient to cause floors or walls of the structure to vibrate, noting the integrity of building structures is unlikely to be compromised by passing trains.

ARTC is applying the ground-borne noise criteria in Table 15.20 on the Project, which have been developed with reference to ground-borne noise management levels adopted in NSW and Victoria on the Inland Rail program. Where ground-borne noise levels are above the trigger levels, the Project will investigate the implementation of feasible and practicable measures to control ground-borne noise.

The ground-borne noise criteria are generally implemented where the ground-borne noise levels are higher than the airborne noise from the rail operations, and where the ground-borne noise levels are expected to be audible within habitable rooms.

TABLE 15.20: RAILWAY GROUND-BORNE NOISE ASSESSMENT CRITERIA

		Internal ground-borne noise criteria	
Type of development	**Sensitive receptors**	**Use period[1]**	**SEMs[2]**
New railway or upgrading existing railway	Accommodation activities	Daytime	≤ 40 dBA
		Evening/night-time	≤ 35 dBA
	Educational establishments Childcare centres Health care services Hospitals	While in use	≤ 35 dBA
	Community uses (excluding a court of law) Places of worship Offices		≤ 40 dBA
	Court of law (court rooms)		≤ 30 dBA

Table notes:

1. Daytime 7.00 am to 6.00 pm, evening 6.00 pm to 10.00 pm and night-time 10.00 pm to 7.00 am.
2. Single Event Maximum: Arithmetic average of L_{ASmax} levels from the 15 single highest events, or all events if less than 15, during a 'use period' within a 24-hour period.

15.6.6.4 Operational road traffic noise criteria—proposed new roads

Seven new roads are proposed within the noise and vibration study area. A desktop noise assessment approach has been implemented for each of the new roads. The assessment has been completed in accordance with CoP Vol. 1.

Table 15.21 presents the applicable CoP Vol. 1 assessment criteria for different noise sensitive land uses with potential to be affected by new roads. The external criteria are assessed 1 metre (m) from the façade at a height of 1.5 m from finished floor level or mid-window height, whichever is the higher.

TABLE 15.21: ROAD TRAFFIC ASSESSMENT CRITERIA FOR NEW ROADS (COP VOL. 1)

	Criteria		
Category	**Existing residences (façade corrected)**	**Educational, community and health buildings (façade corrected)**	**Outdoor educational and passive recreational areas (including parks) (free field)**
New road—access controlled	63 L_{A10} (18h), existing level > 55 L_{A10} (18h) 60 L_{A10} (18h), existing level ≤ 55 L_{A10} (18h)	58 L_{A10} (1h)	63 L_{A10} (12h)

Table notes:

L_{A10}—the sound pressure level exceeded for 10 of the measurement period. For 10% of the measurement period it was louder than the L_{A10}.

In cases where existing traffic noise levels are above the noise assessment criteria, the primary objective is to reduce these levels through reasonable and practicable measures to meet the assessment criteria.

15.6.6.5 Operational road traffic noise criteria—road upgrades

The upgrade of nine existing road sections is proposed within the noise and vibration study area. A desktop assessment approach has been implemented for each of the proposed upgrades. The assessment has been completed in accordance with CoP Vol. 1.

Table 15.22 presents the applicable CoP Vol. 1 assessment criteria for sensitive land uses with potential to be affected by upgraded roads. The external criteria are assessed 1 m from the façade at a height of 1.5 m from finished floor level or mid-window height, whichever is higher.

TABLE 15.22: AIRBORNE NOISE CRITERIA FOR UPGRADED ROADS

	Criteria		
Description	Existing residences (façade corrected)	Educational, community and health buildings (façade corrected)	Outdoor educational and passive recreational areas (including parks) (free field)
Upgrading existing road	68 $_{LA10}$ (18h)	65 $_{LA10}$ (1h)	63 $_{LA10}$ (12h)

15.6.6.6 Operational fixed infrastructure noise objectives

The potential noise emissions from the operational fixed infrastructure has been assessed against criteria adopted from the EPP (Noise). As operations can occur any time during the day or night, the most onerous criteria are during the night-time (10.00 pm to 7.00 am). The following acoustic quality objectives from the EPP (Noise) have been used to assess fixed infrastructure noise impacts, shown in Table 15.23.

TABLE 15.23: ACOUSTIC QUALITY OBJECTIVES (EPP (NOISE))

	Internal noise level criterion		
Sensitive receptor	$L_{Aeq,1hr}$ dBA	$L_{A10,1hr}$ dBA	$L_{A1,1hr}$ dBA
Residential (indoors—night-time)	30	35	40

To predict the noise levels inside a property:

- Noise levels due to simultaneous operation of the operating noise sources were predicted at the façade of the nearest noise sensitive property
- 7 dB was subtracted from the predicted value, corresponding to the indicative outside-to-inside noise reduction of an open window, resulting in the internal noise level.

15.7 Predicted impacts

15.7.1 Airborne construction noise impacts

A summary of the predicted construction noise impacts associated with each stage of construction are presented for both standard and non-standard CoP Vol. 2 hours in Table 15.24.

Appendix P: Non-operational Noise and Vibration Technical Report presents the L_{Aeq} noise-level contours for the construction activities for individual properties. Details on the airborne construction noise impact assessment methodology, including plant and equipment modelled for each construction activity and the associated noise emission characteristics can also be found in Appendix P: Non-operational Noise and Vibration Technical Report.

Table 15.24 presents the external noise criteria and the number of sensitive receptors that are above the adopted noise criteria for different construction activities.

It should be noted that due to the low background noise levels measured during both standard and non-standard hours of construction, the lower limit and upper limit are both set to the minimal level as per CoP Vol. 2.

It is important to consider that this assessment is representative of the worst-case 15-minute period of construction activity, while the construction equipment is at the nearest location to each sensitive receptor location. In practice, the distances will vary between plant and sensitive receptors. The assessed scenario does not represent the ongoing day-to-day noise impact at noise-sensitive receptors for an extended period. This approach is consistent with the CoP Vol. 2, as required by the ToR.

Particularly noisy activities, such as piling, are likely to persist for only a portion of the overall construction period. In addition, the predictions use the shortest separation distance to each sensitive receptor; however, distances will vary between plant and sensitive receptors. For works that move along the rail alignment, rather than works located at a fixed location, such as construction compound, the noise exposure at each receptor would reduce due to increases in distance loss as the works progress along the alignment.

The construction staging is indicative, but conservative, and is subject to change during detailed design.

TABLE 15.24: CONSTRUCTION NOISE ASSESSMENT IMPACT SUMMARY

CoP Vol. 2 time of day	CoP Vol. 2 limit	Number of sensitive receptors exceeding criterion					
		Drainage	Earthworks	Site setup/ laydown	Rail civil works	Road civil works	Structures
Standard hours	Upper: 65 dBA	89	159	40	120	43	22
	Lower: 50 dBA	285	507	213	394	225	239
Non-standard hours	45 dBA	438	781	358	723	402	541

Eighteen residential noise-sensitive receptors are located within the disturbance footprint. It is anticipated that land within the disturbance footprint will either be permanently or temporarily acquired for the Project. The noise impact at receptors within the disturbance footprint has, therefore, not been assessed.

The assessment has identified that measures to reduce and control construction noise will need to be developed and implemented for the reasonable and practicable mitigation of potential noise-related impacts at sensitive receptors. The measures will need to be developed for all major construction works.

While not quantitatively assessed, based on the results of the construction noise modelling, the noise levels from worst-case construction works during non-standard hours would likely be audible above the night-time ambient noise levels. On this basis, there is potential for the works to result in sleep disturbance or annoyance impacts at nearby receptors during the night-time. To address these potential impacts, ARTC will develop and implement reasonable and practicable mitigation measures specifically for the non-standard construction works.

Individuals will respond to noise differently, and just because noise can be audible does not mean it will cause disturbance or annoyance impacts. The subjective response to the potential construction noise levels is discussed further in Appendix P: Non-Operational Noise and Vibration Technical Report for more detail.

15.7.2 Construction road traffic

During construction, there would be a number of construction vehicle movements, increasing noise levels. The construction traffic noise is predicted to exceed the criteria for 18 roads within the noise and vibration study area, with a maximum predicted increase of 12 dBA.

Table 15.25 presents the roads where the increase in the $L_{A10(1hr)}$ exceeds the criterion. The $L_{A10(1hr)}$ noise levels in the table are not predictions of noise levels at sensitive receptors but are instead measures of road traffic noise emissions at a reference distance of 10 m, corrected for traffic speed and percentage volume of heavy vehicles. The potential change in road traffic noise is used as the basis for assessing road traffic noise during construction and the predicted change in noise levels at a distance of 10 m in Table 15.25 are assumed to also be experienced at sensitive receptors adjacent to the road networks.

For 18 roads intended to be used to carry construction traffic, the maximum predicted increase in noise level is greater than 3.0 dBA. A number of these roads are in rural locations and the existing base traffic volumes are low and the construction road traffic represents a substantial, temporary, change to daily traffic volumes. Consequently, the current road traffic noise levels are relatively low before the addition of construction traffic and the potential change in road traffic noise may be more likely to result in a noise impact than the overall road traffic noise levels.

Construction traffic may vary throughout the day and the results of this assessment should be confirmed during detailed design, based on detailed construction scheduling.

TABLE 15.25: ADDITIONAL AIRBORNE NOISE LEVELS FROM CONSTRUCTION TRAFFIC PER YEAR

		$L_{A\ 10,\ (1\ hr)}$ dBA											
		Level without Project						Increase in level by Project					
Road name	**Road section**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**
Hayes Road	Full extent	54	54	54	55	55	55	1	5	3	3	3	1
Middle Road	Between Cunningham Highway and Bill Morrow Road	62	62	62	62	62	62	0	0	4	1	0	0
Reillys Road	Between Strongs Rd and Rosewood Warrill View Rd	50	50	50	50	50	50	0	8	8	7	8	0
Strongs Road	Between Coveney Road and Rileys Road	51	51	51	51	51	51	0	7	7	7	8	0
Kilmoylar Road	Between Lobb Street and Cunningham Highway	59	60	60	60	60	60	1	2	4	2	2	1
Undullah Road	Between Lane Road and Kuss Road	54	54	54	55	55	55	3	3	4	4	3	3
Undullah Road	Between LCC Council Boundary and Wyatt Road	54	54	54	55	55	55	3	5	7	4	4	2
Wyatt Road	Between Mount Lindesay Highway and LCC Council Boundary	54	54	54	55	55	55	3	5	7	4	4	2
Allan Creek Road	Between Kilmoylar Road and Undullah Road	62	62	62	62	63	63	0	2	5	4	2	0
Brookland Road	Between Allan Creek Rd and Beaudesert Boonah Rd	61	61	61	61	61	62	0	2	6	5	2	0
Kilmoylar Road	Between Beaudesert Boonah Rd and Thiedke Rd	60	61	61	61	61	61	1	2	3	1	1	1
Mutdapilly Churchbank Weir Road	Between ICC Council Boundary and Peak Crossing Churchbank Weir Road	56	56	56	57	57	57	0	7	7	0	0	0
Peak Crossing Churchbank Weir Road	Between Peak Crossing Churchbank Weir Rd and Cunningham Highway	57	57	58	58	58	58	0	5	5	0	0	0
Undullah Road	Between Beaudesert Boonah Rd and Allan Creek Road	54	54	54	55	55	55	3	3	4	4	3	3
Undullah Road	Between LCC Council Boundary and Brookland Rd	54	54	54	55	55	55	3	6	12	7	5	3
Washpool Road	Between Kilmoylar Rd and S of Brennans Dip Road	57	57	57	57	57	57	1	7	10	2	2	1
Wild Pig Creek Road	Between Wyatt Road and Wild Pig Creek Road	53	53	54	54	54	54	3	6	8	5	5	3
Warrill View Peak Crossing Road	Between Pine Mountain Road and Cunningham Highway	61	61	61	62	62	62	0	5	4	0	0	0

Table notes:
$L_{A\ 10,\ 1\ hr}$ dBA = The A-weighted sound pressure level, which over aa 1-hour time period, is exceeded 10 per cent of the time by the actual fluctuating sound pressure level. The L_{A10} is the standard noise descriptor for assessment of traffic noise.

15.7.3 Construction vibration impacts

Vibration-intensive work is likely to be undertaken as part of the construction works. This may include the use of piling rigs and vibratory rolling activities. Vibration impacts were calculated based on formulae and parameters given by BS 5228-2, so that the predictions represent worst-case impacts. Appendix P: Non-operational Noise and Vibration Technical Report details this methodology, including the formulae and parameters adopted.

In order to comply with the cosmetic/structural damage and human discomfort criteria presented in Section 15.6.4, the minimum working distances to various vibration-sensitive receptors presented in Table 15.26 should not be encroached.

TABLE 15.26: RECOMMENDED MINIMUM WORKING DISTANCES FOR VIBRATION-INTENSIVE EQUIPMENT

	Predicted setback distance (m)							
	Human comfort		Building damage				Buried pipework	
Plant Item	Lower limit (night) 0.3 mm/s PPV	Lower limit (day) / upper limit (night) 1.0 mm/s PPV	Upper limit (day) 2.0 mm/s PPV	Heritage structures 3 mm/s PPV	Dwellings 5.0 mm/s PPV	Industrial 20 mm/s PPV	Masonry, plastic or metal construction 50 mm/s PPV	Steel construction 100 mm/s PPV
Vibratory roller—vibration start-up/run down	330	130	80	55	40	10	< 10	< 5
Vibratory roller—steady state	200	90	60	40	30	10	< 10	< 5
Vibratory piling	290	110	60	40	30	< 10	< 5	< 5
Percussive piling[1]	690	275	160	115	80	25	< 5	< 5

Table notes:
1. Impacts breakers have been assumed generate similar vibration emissions to percussive piling.

The lower night-time vibration human comfort limit of 0.3 mm/s is predicted to be triggered at the majority of sensitive receptors adjacent to the Project due to their relative distance to the disturbance footprint. However, it is expected that vibration-intensive equipment are unlikely to be regularly operated during the night period and the assessment is conservative, based on worst-case vibration generating works during the most sensitive period for potential impacts.

In this instance, the CoP Vol. 2 recommends the use of practicable and reasonable mitigation to minimise vibration impacts. These mitigation measures are discussed in Section 15.8.2.

The primary form of mitigation of vibration would be ensuring vibration-intensive works do not occur within the minimum working distances. If vibration-intensive works are planned within the minimum working distances, additional vibration management and mitigation measures may be required, such as adopting alternative construction techniques or equipment or implementing specific approaches to control vibration emissions.

The predicted vibration limit to individual sensitive receptors has also been calculated and detailed results included in Appendix P: Non-operational Noise and Vibration Technical Report. A summary of the total exceedances for each construction activity is shown in Table 15.27.

TABLE 15.27: CONSTRUCTION VIBRATION EXCEEDANCES

Activity	Number of sensitive receptors exceeding criterion				
	Human comfort—standard hours		Human comfort—non-standard hours		Structural limit
	Lower limit	Upper limit	Lower limit	Upper limit	
Site setup/laydown areas					
Vibratory roller—steady-state vibration	0	0	3	0	0
Vibratory roller—vibration start-up/run-down	2	0	11	2	0
Structures					
Vibratory piling	0	0	13	0	0
Percussive piling	11	1	71	11	0
Earthworks/drainage/rail civil works					
Vibratory roller—steady-state vibration	29	21	29	21	8
Vibratory roller—vibration start-up/run-down	38	27	38	27	13
Road civil works					
Vibratory roller—steady-state vibration	13	9	13	9	4
Vibratory roller—vibration start-up/run-down	18	11	18	11	5

Currently, specific locations of works are not known, and vibration sources are represented as areas of works. Eighteen residential and one industrial vibration-sensitive receptors are located within the disturbance footprint. It is anticipated that land within the disturbance footprint will either be permanently or temporarily acquired for the Project. The vibration impacts at receptors within the disturbance footprint of a construction activity have, therefore, not been assessed.

Thirteen sensitive receptors were identified as being buildings of special value or significance as part of the cultural heritage assessment in Appendix T: Non-Indigenous Heritage Technical Report. Six of these sensitive receptors are also occupied dwellings and have been assessed against both residential and heritage criteria. Each heritage receptor has the potential to be particularly sensitive to vibration. As a conservative approach, the heritage building structural damage criterion outlined in Table 15.16 is applied to these receptors. The minimum setback distances at which this criterion is predicted to be met are given in Table 15.28.

TABLE 15.28: MINIMUM SETBACK DISTANCES FOR HERITAGE STRUCTURES FROM VIBRATION-INTENSIVE EQUIPMENT

Plant item	Predicted setback distance (m) structural damage criterion 3 mm/s PPV
Vibratory roller—vibration start-up/run-down	55
Vibratory roller—steady-state vibration	40
Vibratory piling	40
Percussive piling	115

Table notes:
mm/s—millimetres per second

The minimum working distances presented in Table 15.26 and Table 15.28 assume individual items of plant would be operating independently. Concurrent operation of vibration-intensive equipment should be avoided; however, if it is necessary to operate multiple items of equipment concurrently, close to the minimum working distance, then vibration monitoring is recommended.

The number of heritage structures predicted to exceed the heritage building criterion is given in Table 15.29. More detailed vibration impacts predicted for heritage buildings are given in Appendix P: Non-operational Noise and Vibration Technical Report.

TABLE 15.29: CONSTRUCTION VIBRATION EXCEEDANCES—HERITAGE STRUCTURES

Activity	Number of exceedances of structural damage criterion
Site setup/laydown areas	
Vibratory roller—steady-state vibration	1
Vibratory roller—vibration start-up/run-down	2
Structures	
Vibratory piling	1
Percussive piling	1
Earthworks/drainage/rail civil works	
Vibratory roller—steady-state vibration	2
Vibratory roller—vibration start-up/run-down	2
Road civil works	
Vibratory roller—steady-state vibration	0
Vibratory roller—vibration start-up/run-down	0

Currently, specific locations of works are not known, and vibration sources are represented as areas of works. Six of the thirteen heritage vibration sensitive receptors are located in the disturbance footprint. These buildings may be permanently or temporarily impacted by the Project. The construction methodology near these receptors will need to be detailed on a case-by-case basis. These receptors have not been included in Table 15.29.

15.7.4 Construction blasting impacts

The airblast overpressure and vibration from blasting can be managed through the careful design and execution of individual blasting events. At the time of this assessment, the locations requiring blasting throughout the disturbance footprint are yet to be confirmed. As such, the maximum permissible charge weight to meet the criteria outlined in Section 15.6.5 is shown in Table 15.30 to inform the design of blasting events. The maximum permissible charge weight has been calculated for indicative setback distances for sensitive receptors. Once the location of blasting is known, a detailed blasting assessment can be finalised. The information in Table 15.31 is based on a worst-case assumption of a confined blast and geotechnical parameters for good vibration transmission.

TABLE 15.30: CHARGE MASS RANGES FOR SET DISTANCES

		Maximum permissible charge weight (kg)			
Distance to sensitive receptor	Number of receptors	Ground vibration—human comfort	Ground vibration—structural damage	Airblast overpressure—human comfort	Airblast overpressure—structural damage
0 to 200 m	1	Specific blast design required or blasting not feasible at these distances.			
200 to 400 m	2	45	175	<1	<5
400 to 800 m	2	180	710	<1	30
800 to 1,600 m	22	720	>2,000	<5	250

Thirteen sensitive receptors were identified as being buildings of special value or significance as part of the cultural heritage assessment in Appendix T: Non-Indigenous Heritage Technical Report. Six of these sensitive receptors are also occupied dwellings and have been assessed against both residential and heritage criteria. While these buildings of historical value may not be particularly sensitive to blasting, each may potentially be so. For this reason, the maximum permissible charge weight to meet the heritage building criteria outlined in Section 15.6.5.1 has been calculated for indicative setback distances in Table 15.31.

TABLE 15.31: CHARGE MASS RANGES FOR SET DISTANCES FOR HERITAGE BUILDINGS

Distance to receptor	Number of receptors within distance range	Maximum permissible charge weight (kg)
Receptor within blasting area of works	2	Specific blast design required or blasting not feasible at these distances
0 to 200m	1	
200 to 400 m	0	14
400 to 800 m	0	57
800 to 1,600 m	0	230

Currently, specific blasting locations are not known, and blasting airblast overpressure and vibration sources are represented as areas of works. Of the 13 heritage receptors, two are located in the blasting areas of works with an additional heritage receptor within 200 m of blasting areas. The construction methodology near these receptors will need to be detailed on a case-by-case basis once specific blasting locations are known. The remaining ten heritage vibration receptors are located more than 1,600 m away from the potential blasting locations.

15.7.5 Tunnel construction

15.7.5.1 Roadheader vibration and ground-borne noise predictions

Vibration and ground-borne noise due to the operation of the roadheader have been calculated. The predicted PPV (mm/s) vibration levels at the sensitive receptors in the vicinity of the tunnel and assessment against the criteria for damage and human comfort are presented in Figure 15.2 and Figure 15.3 respectively. Dotted lines represent the relevant criteria; receptor dots are coloured by the criteria exceeded at those dots, if any. Tunnel construction is not predicted to result in exceedances (triggers) of the adopted vibration criteria at any sensitive receptors.

The predictions undertaken are based on conservative assumptions, i.e. propagation through rock, no impedance changes at below-ground formation change, foundation types and use of peak velocity values to determine L_{ASMax} noise levels.

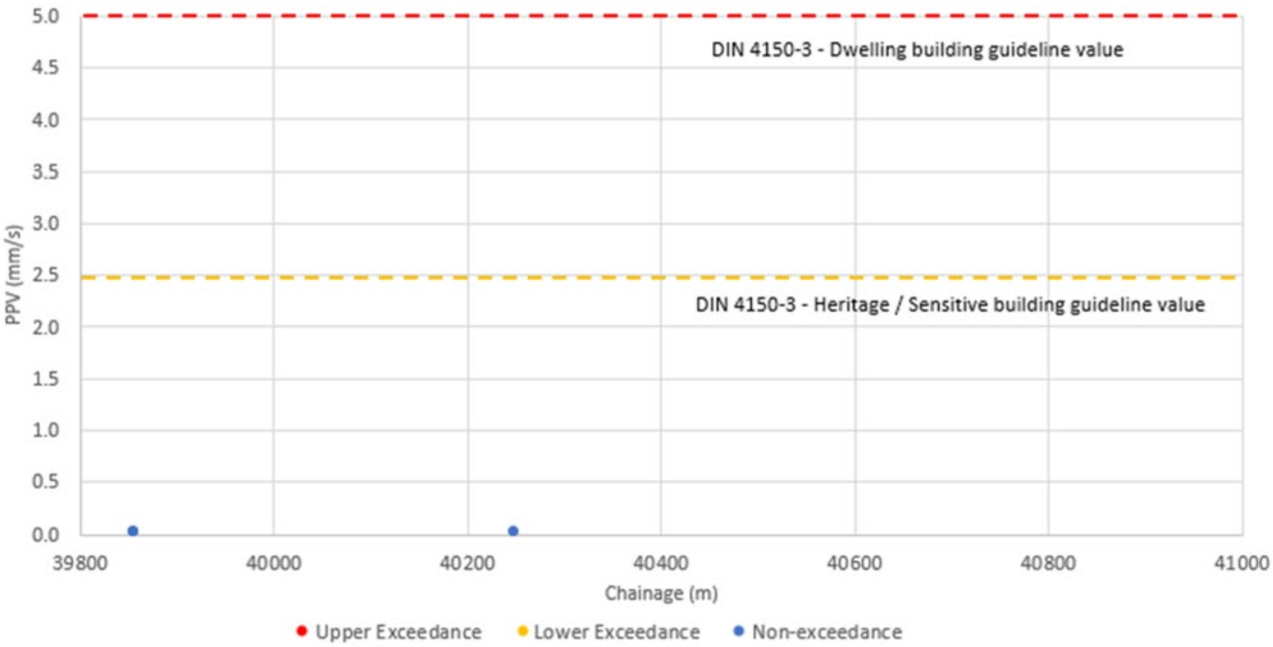

FIGURE 15.2: PREDICTED ROADHEADER PEAK PARTICLE VELOCITY (MM/S) AT THE SENSITIVE RECEPTORS ALONG THE TUNNEL ALIGNMENT AND THE LONG-TERM DIN 4150-3 DAMAGE GUIDELINE VALUES

FIGURE 15.3: PREDICTED ROADHEADER PEAK PARTICLE VELOCITY (MM/S) AT SENSITIVE RECEPTORS ALONG THE TUNNEL ALIGNMENT AND THE *TRANSPORT NOISE MANAGEMENT CODE OF PRACTICE: VOLUME 2—CONSTRUCTION NOISE AND VIBRATION* HUMAN COMFORT VIBRATION CRITERIA

The predicted ground-borne noise levels at the sensitive receptors in the vicinity of the tunnel are presented in Figure 15.4. Standard hours and non-standard hours are in reference to the times denoted in Table 15.9. Compliance is predicted to occur when ground-borne noise from construction is predicted to be less than 35 dBA L_{ASMax} inside a habitable room. Tunnel construction is not predicted to result in exceedances (triggers) of the adopted ground-borne noise criteria at any sensitive receptors.

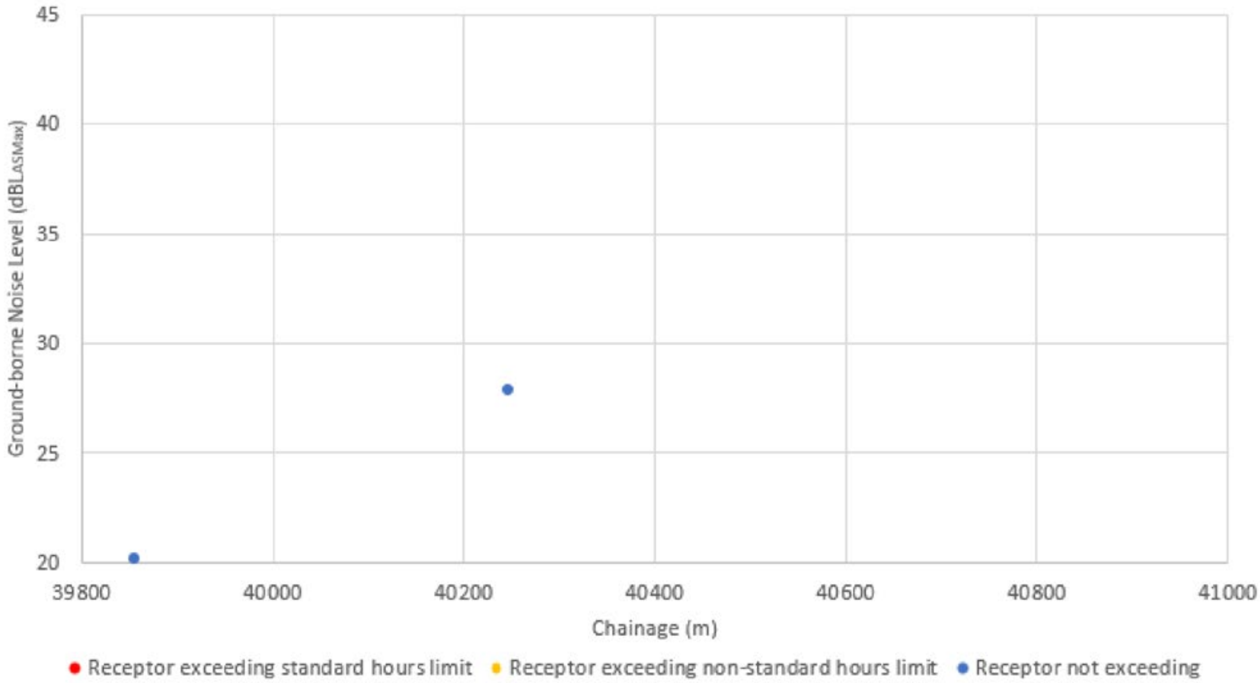

FIGURE 15.4: PREDICTED ROADHEADER GROUND-BORNE NOISE LEVEL (DB L_{ASMax}) AT SENSITIVE RECEPTORS ALONG THE TUNNEL ALIGNMENT AGAINST THE *TRANSPORT NOISE MANAGEMENT CODE OF PRACTICE: VOLUME 2—CONSTRUCTION NOISE AND VIBRATION* CRITERIA, ROUNDED TO THE NEAREST INTEGER

15.7.5.2 Building damage

The vibration levels predicted at the foundations of sensitive receptors were well below the criterion for heritage and sensitive buildings (2.5 mm/s) for damage due to vibration, outlined in Table 15.14. This criterion applies to the vibration at the highest floor level; however, it was assumed that the receptors assessed were single-storey dwellings, as is typical of residences in the noise and vibration study area, and that the vibration impacts at the foundations are also representative of the vibration impacts at the highest floor level. This is a conservative approach as vibration impacts are typically greatest at the foundations.

15.7.5.3 Amenity

Vibration levels predicted on the ground-floor slab or floors of buildings were found to comply with the lower limit for dwellings during non-standard working hours criteria adopted from the CoP Vol. 2. The criterion for human comfort is 0.3 mm/s.

15.7.5.4 Existing underground services and infrastructure

Compliance against the 25 mm/s underground infrastructure criterion adopted from DIN 4150-3 and listed in Table 15.15 has been assessed. This is the most conservative criterion for underground infrastructure specified by DIN 4150-3. During detailed design, utility owners should be consulted to determine any specific criteria for gas or water pipes. Compliance with this criterion is predicted when the roadheader is at least 5 m from the pipework. Vibration measurements should be undertaken onsite during construction to confirm that these predictions are representative of the vibration levels onsite.

It is recommended that the minimum setback distance of 5 m be observed between the roadheader and all buried services. The results of vibration predictions are less accurate when construction equipment is within 5 m of a vibration-sensitive item. Consequently, the construction team will need to undertake vibration monitoring when working within 5 m of infrastructure to assess whether the vibration from the works meet the criteria.

15.7.5.5 Ground-borne construction noise impacts

Ground-borne noise due to the roadheader has not been predicted to exceed the ground-borne noise criteria defined in the CoP Vol. 2 at any residence. This is because the distance between the alignment and sensitive receptors is at least 930 m.

15.7.5.6 Blasting vibration impacts—tunnel construction

Vibration due to blasting is predicted based on several variables, with the site constant and instantaneous charge size (in kg) the dominant variables in the prediction model. The site-specific constants for the noise and vibration study area are not known at this stage. Consequently, a literature review of site constants for similar projects has been conducted.

It was found that most blasting assessments state that no more than 5 per cent of blasts should exceed the relevant assessment's PPV criteria. The site constants in AS2187.2 have a 50 per cent chance of exceedance and, therefore, are not considered to be appropriate. A range of site constants was assessed against a range of instantaneous charge sizes and are presented in Table 15.32.

The predicted PPV levels at various distances for different site constants and charge sizes are presented in Figure 15.5. Lines indicate the predicted relationship between PPV at a sensitive receptor and the receptor's distance to the blast location for various sets of site constants and charge sizes.

TABLE 15.32: INSTANTANEOUS CHARGE SIZE (KG) AND SITE CONSTANTS

Plot shading in Figure 15.5	Instantaneous charge size (kg)	Site constant (K_g)	Source of site constant
Red	500	1,140	AS2187.2
		3,099	Average from literature search quoting no more than 5% of blasts should exceed assessment's criterion
		6,210	Maximum site constant from literature search
Blue	100	1,140	AS2187.2
		3,099	Average from literature search quoting no more than 5% of blasts should exceed assessment's criterion
		6,210	Maximum site constant from literature search
Green	10	1,140	AS2187.2
		3,099	Average from literature search quoting no more than 5% of blasts should exceed assessment's criterion
		6,210	Maximum site constant from literature search
Yellow	1	1,140	AS2187.2
		3,099	Average from literature search quoting no more than 5% of blasts should exceed assessment's criterion
		6,210	Maximum site constant from literature search

Sources: Standards Australia, 2006; Wilkinson Murray, 2012; Melbourne Metro Rail Authority, 2018; HLA Envirosciences, 2002; Tipathy et al., 2016.

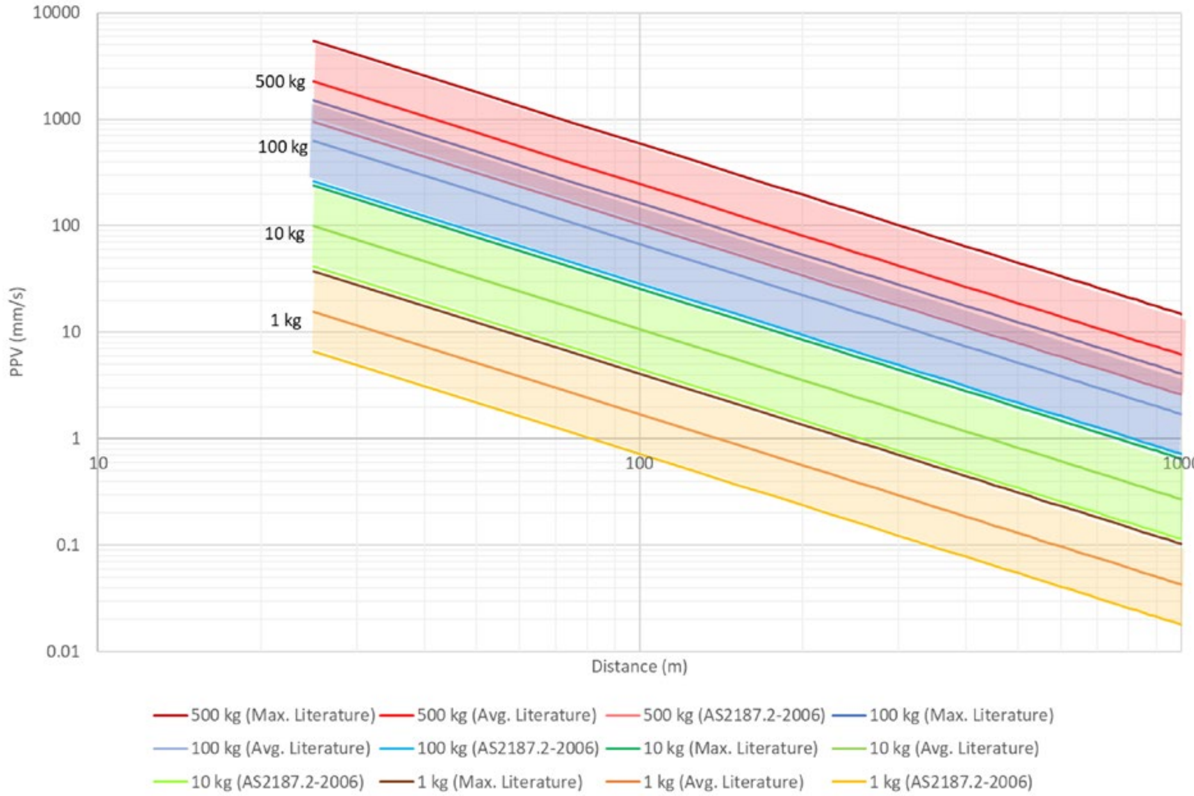

FIGURE 15.5: PREDICTED PEAK PARTICLE VELOCITY (MM/S) AT A DISTANCE (M) BASED ON INSTANTANEOUS CHARGE SIZE AND SITE CONSTANTS

Figure 15.5 shows a significant range in PPV values when using different site constants and charge sizes. Because of this large range in predicted PPV, small-scale, site-specific blast testing should occur before major blasting works to determine the 'true' site constants in order to understand the potential impacts.

The closest sensitive receptor is approximately 930 m from the outer dimensions of the tunnel; therefore, it is likely that suitable charge sizes will be able to be determined that comply with the CoP Vol. 2 criteria.

15.7.6 Commissioning noise and vibration impacts

The commissioning stage involves testing and checking the rail line and communication and signalling systems to ensure that all systems and infrastructure are designed, installed and operating according to ARTC's operational requirements. Due to the nature of the Project, the noise and vibration associated with commissioning would be considered as no worse than the operational impacts and have not been assessed further.

15.7.7 Operational noise and vibration impacts

15.7.7.1 Rail freight operations

The predicted railway noise levels at the sensitive receptors are detailed in the Appendix Q: Operational Railway Noise and Vibration Technical Report. The predicted railway noise levels are presented for the daytime and night-time railway operations for the Project opening in the year 2026 and the future design year of 2040.

The noise modelling considered Project-specific assumptions to calculate typical worst-case railway noise emissions and conservatively assess potential impacts at sensitive receptors. These assumptions included:

- The railway operations assumed all forecast daytime and night-time rail traffic would be in operation
- All trains would be operating at the upper threshold of their designed track speed
- All trains would be required to sound their horns on approach to each level crossing
- Discrete correction factors were applied to consider the various noise emissions from track features such as tight radius curves, road crossings and higher locomotive noise emissions when trains are expected to travel uphill or under dynamic breaking when travelling downhill
- Noise levels were calculated at the individual façades of each sensitive receptor building and the highest individual noise levels referenced for each receptor
- A noise level correction of 2.5 dBA, for reflected sound at building façades was added to all noise predictions
- The noise levels for the daytime and night-time are reported as the L_{Aeq} and L_{Amax} noise metrics and include the contributions from the train movements (pass-bys) on the mainline and crossing loops along with the noise emissions from the tunnel portals, level-crossing alarm bells and the train horns.

The railway noise levels are at, or below, the assessment criteria, and did not trigger investigation of noise mitigation at the majority of assessed sensitive buildings included within the study area.

The railway noise criteria from the DTMR policy (DTMR, 2017a) and the Interim Guideline (DTMR, 2019b) are generally less stringent than the noise assessment criteria applied by ARTC. Consequently, the noise criteria of the DTMR Policy and Interim Guideline are expected to be more readily achieved and fewer properties would trigger a review of noise mitigation under these guidelines.

A summary of the number of sensitive receptors where the predicted rail noise levels are above the assessment criteria, and trigger the investigation of noise mitigation, are provided in Table 15.25. The investigation of noise mitigation was primarily triggered by the night-time operations because the number of trains per hour is greater during the night-time. The noise criteria are also 5 dBA more stringent for the night-time period than the daytime.

At Project opening in the year 2026, there are 59 sensitive receptors where the predicted railway noise levels have triggered the investigation of reasonable and practicable noise mitigation measures. The majority of train movements are expected at the Project opening, however the growth in forecast rail traffic has identified an additional six sensitive receptors triggered the noise mitigation review for the design year of 2040 (total 65 receptors triggering a review of mitigation).

A summary of the number of sensitive receptors where the predicted rail noise levels are above the assessment criteria and trigger the investigation of noise mitigation, are provided in Table 15.33.

TABLE 15.33: OPERATIONAL RAILWAY NOISE ASSESSMENT SUMMARY

Assessment criteria margin	Sensitive receptors triggering the criteria
Year 2026—Project opening	
1 dBA to 3 dBA	27
>3 dBA to 5 dBA	13
>5 dBA to 10 dBA	14
>10 dBA	5
Total receptors triggering noise mitigation—Project opening	**59**
Year 2040—design year	
1 dBA to 3 dBA	28
>3 dBA to 5 dBA	13
>5 dBA to 10 dBA	14
>10 dBA	10
Total receptors triggering noise mitigation—design year	**65**

The investigation of noise mitigation was primarily triggered by night-time railway operations due to the following factors:

- Noise criteria for the night-time are typically 5 dBA more stringent than during the daytime
- There is a higher proportion of rail traffic during the 9-hour night-time period than the longer 15-hour daytime period
- A result of the number of trains per period and the length and speed of the trains, the L_{Aeq} noise criteria were more frequently triggered than the L_{Amax} criteria
- For some receptors, noise criteria were triggered by the train pass-bys and the noise from train horns and alarm warnings at the level crossings.

The outcomes of the assessment at the EIS stage have been applied to identify the range of industry standard best practice measures that could be implemented for the reasonable and practicable control of railway noise and management of potential noise-related impacts.

The predicted operational railway noise levels at the 65 sensitive receptors triggering a review of noise (year 2040) are presented in Table 15.34. The railway noise levels will continue to be assessed during the detailed design and construction phases of the Project to verify the outcomes of this assessment and confirm the requirement for noise mitigation measures.

Some of the sensitive receptors are located more than 2 km from the nearest level crossings and noise levels are relatively minor (<30 dBA L_{Aeq} and 50 dBA L_{Amax}), when compared to the railway noise from the mainline and crossing loops.

TABLE 15.34: SENSITIVE RECEPTORS TRIGGERING A REVIEW OF OPERATIONAL RAILWAY NOISE MITIGATION

	Noise level from main line and crossing loop, dBA		Noise from active level crossings, dBA		Overall night-time railway noise levels, dBA	
Sensitive receptor ID	$L_{Aeq(9hour)}$	L_{Amax}	L_{Aeq}(9hour)	L_{Amax}	L_{Aeq}(9hour)	L_{Amax}
Noise criteria	**55**	**80**	**55**	**80**	**55**	**80**
256637	**60**	**83**	52	73	**61**	**83**
256650	**62**	**94**	**71**	**94**	**72**	**94**
256661	**57**	80	44	64	**57**	80
256662	**56**	78	45	65	**56**	78
256793	**56**	79	49	71	**57**	79
256797	**56**	80	<30	<50	**56**	80

Sensitive receptor ID	Noise level from main line and crossing loop, dBA		Noise from active level crossings, dBA		Overall night-time railway noise levels, dBA	
	$L_{Aeq(9hour)}$	L_{Amax}	$L_{Aeq}(9hour)$	L_{Amax}	$L_{Aeq}(9hour)$	L_{Amax}
Noise criteria	**55**	**80**	**55**	**80**	**55**	**80**
256832	**56**	80	34	55	**56**	80
256848	**58**	**82**	<30	<50	**58**	**82**
256876	**58**	**81**	<30	<50	**58**	**81**
256908	**59**	**83**	31	51	**59**	**83**
256911	**58**	**82**	35	56	**58**	**82**
257380	**61**	**86**	**64**	**86**	**66**	**86**
257687	54	78	52	74	**56**	78
258288	**61**	**85**	50	71	**61**	**85**
259276	**64**	**88**	**60**	**82**	**65**	**88**
259451	54	77	51	73	**56**	77
259541	**58**	**81**	55	76	**59**	**81**
259806	**60**	**84**	48	69	**60**	**84**
259959	**70**	**94**	48	69	**70**	**94**
260751	**61**	**85**	<30	<50	**61**	**85**
260785	**64**	**88**	<30	<50	**64**	**88**
260863	**56**	79	<30	<50	**56**	79
260950	**57**	**81**	<30	<50	**57**	**81**
260994	**66**	**90**	<30	<50	**66**	**90**
261010	**56**	79	<30	<50	**56**	79
261041	**60**	**84**	<30	<50	**60**	**84**
261048	**56**	80	<30	<50	**56**	80
261951	**60**	**84**	<30	<50	**60**	**84**
262146	**59**	**83**	<30	<50	**59**	**83**
262240	**61**	**85**	<30	<50	**61**	**85**
262746	**58**	**81**	<30	<50	**58**	**81**
262785	**60**	**84**	<30	<50	**60**	**84**
262909	**58**	**82**	<30	<50	**58**	**82**
263433	**56**	79	45	66	**56**	79
263538	54	77	**56**	76	**58**	77
263606	53	76	55	75	**57**	76
263634	53	78	**57**	78	**58**	78
263798	54	80	**59**	80	**60**	80
264005	**66**	**93**	**70**	**93**	**71**	**93**
264159	**59**	**84**	**64**	**84**	**65**	**84**
264269	**57**	80	**60**	80	**62**	80
264283	53	77	55	76	**57**	77
264340	55	78	**56**	76	**59**	78
264366	**63**	**87**	55	76	**64**	**87**
264487	**65**	**89**	**56**	76	**66**	**89**

Sensitive receptor ID	Noise level from main line and crossing loop, dBA		Noise from active level crossings, dBA		Overall night-time railway noise levels, dBA	
	$L_{Aeq(9hour)}$	L_{Amax}	L_{Aeq}(9hour)	L_{Amax}	L_{Aeq}(9hour)	L_{Amax}
Noise criteria	**55**	**80**	**55**	**80**	**55**	**80**
264543	**56**	79	53	74	**58**	79
264650	**62**	**85**	**63**	**85**	**65**	**85**
264801	**64**	**87**	**65**	**85**	**67**	**87**
265011	**58**	**81**	**58**	79	**61**	**81**
265035	**56**	79	**57**	78	**60**	79
266281	**56**	79	<30	<50	**56**	79
266502	54	76	52	72	**56**	76
266696	55	78	**56**	76	**59**	78
268183	**64**	**89**	44	65	**64**	**89**
268538	**60**	**83**	47	68	**60**	**83**
268681	**58**	80	41	62	**58**	80
268808	55	78	55	76	**58**	78
269156	**56**	78	38	58	**56**	78
269645	**57**	79	39	59	**57**	79
270651	**60**	**83**	35	56	**60**	**83**
271173	**61**	**84**	40	60	**61**	**84**
273122	**65**	**88**	**58**	79	**66**	**88**
273695	**58**	**82**	**61**	**82**	**63**	**82**
274584	**67**	**90**	**64**	**86**	**69**	**90**
324070	**67**	**96**	**73**	**96**	**74**	**96**

Table notes:
While overall noise levels are presented as integers, the noise levels were assessed to one decimal place.
Refer Appendix Q: Operational Railway Noise and Vibration Technical Report for sensitive receptor mapping for the operational rail noise and vibration assessment.
Predicted railway noise levels that have been assessed to trigger the relevant noise assessment criteria are shown in bold.

To aid in the assessment of the results, predicted noise contour maps are provided as Figure 15.6a-g. Predicted night-time ($L_{Aeq, 9hr}$) and L_{AMax} levels are presented. The noise contours provide an overview of the predicted railway noise levels and assist in the help interpretation of assessment outcomes. The tabulated noise levels at the individual sensitive receptors should be referenced when assessing railway noise levels against the criteria.

The results of all operational railway noise modelling undertaken are included in Appendix Q: Operational Railway Noise and Vibration Technical Report.

15.7.7.2 Trains accessing the crossing loops

A review of the predicted noise levels at the sensitive receptors for the crossing loops were up to L_{Aeq}(15hour) 40 dBA daytime, L_{Aeq}(9hour) 41 dBA night-time and L_{Amax} 55 dBA for both the daytime and night-time periods.

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

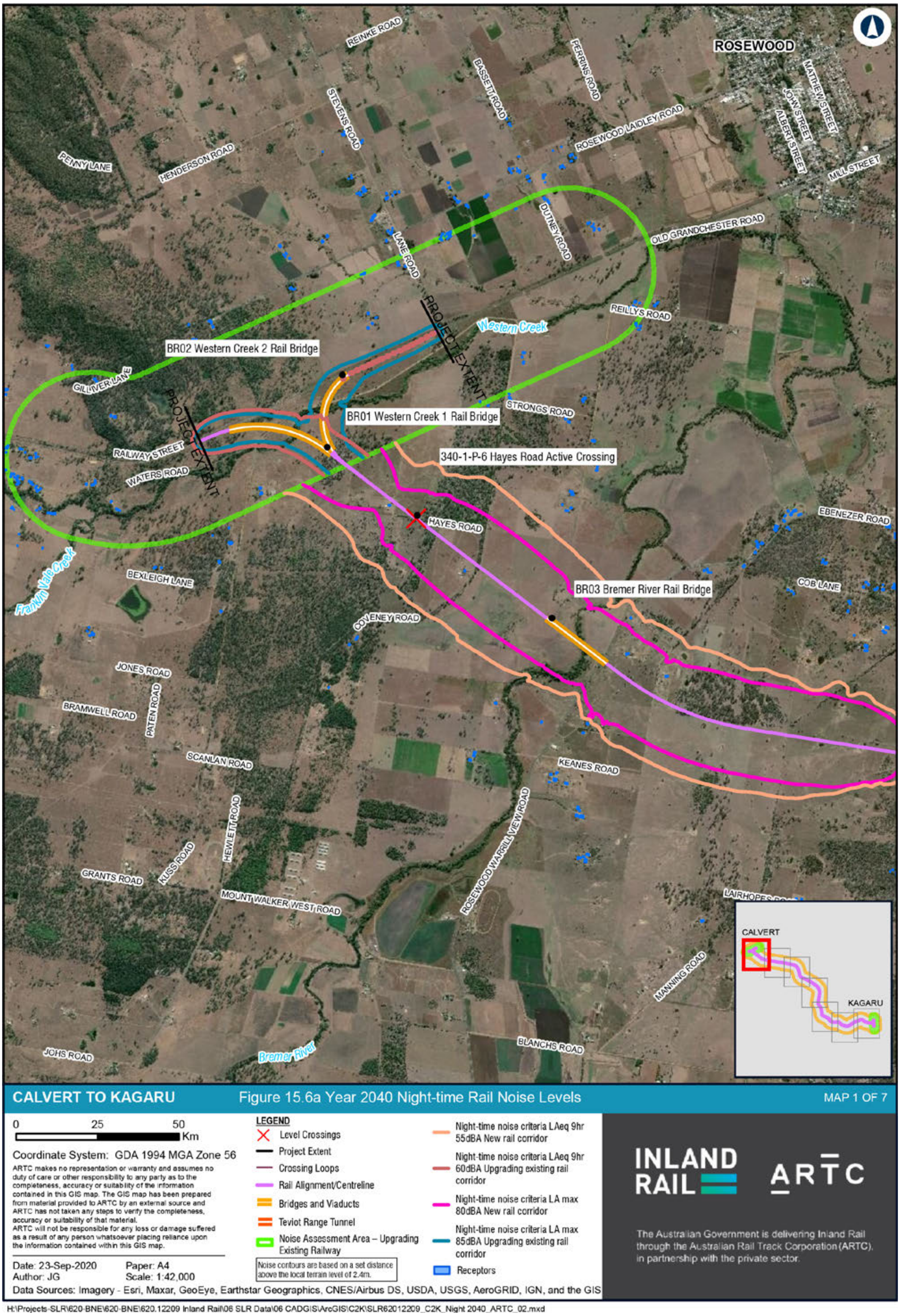

FIGURE 15.6A: NOISE CONTOUR MAP, NIGHT-TIME RAIL NOISE LEVELS (YEAR 2040)

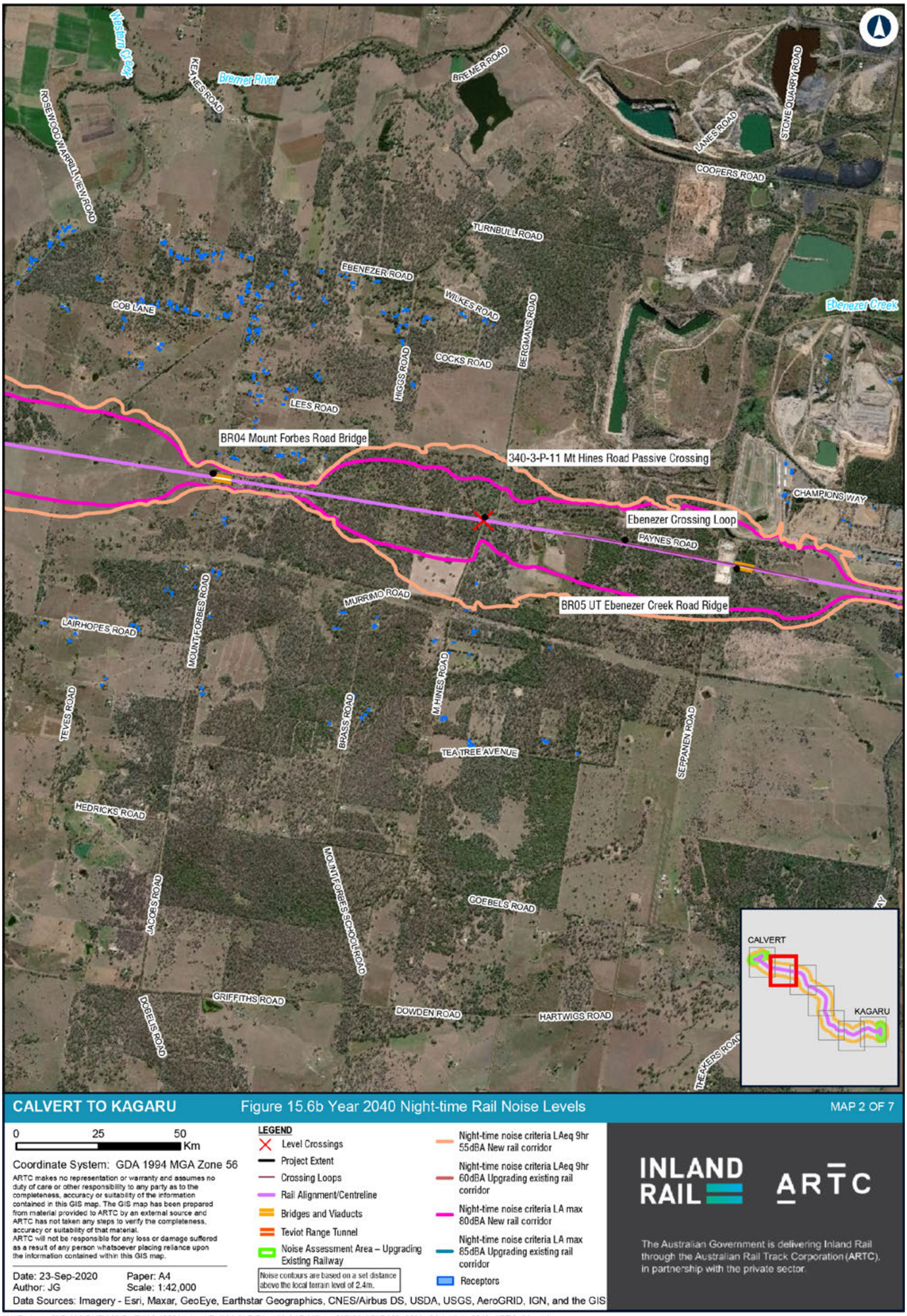

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FIGURE 15.6B: NOISE CONTOUR MAP, NIGHT-TIME RAIL NOISE LEVELS (YEAR 2040)

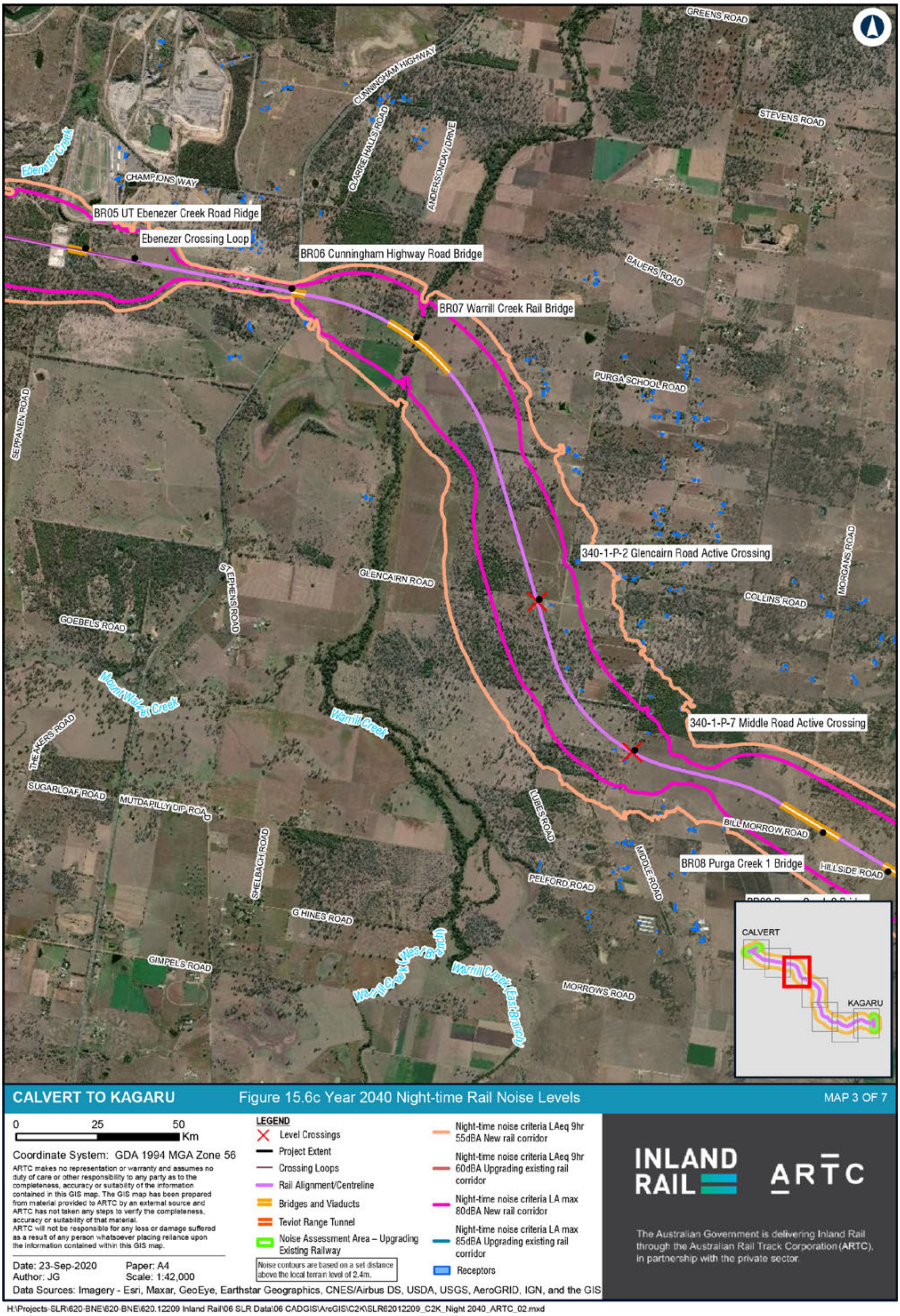

FIGURE 15.6C: NOISE CONTOUR MAP, NIGHT-TIME RAIL NOISE LEVELS (YEAR 2040)

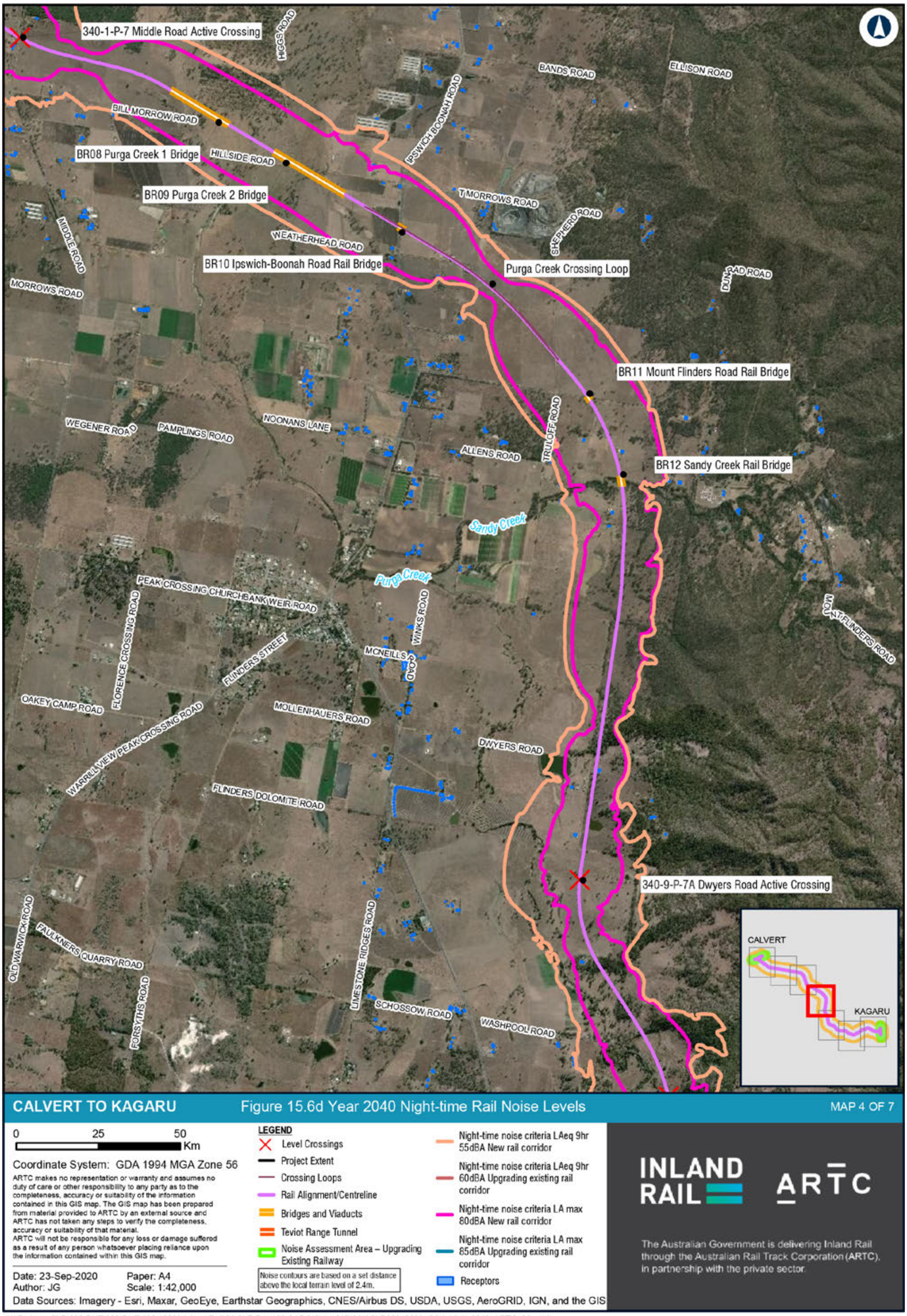

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FIGURE 15.6D: NOISE CONTOUR MAP, NIGHT-TIME RAIL NOISE LEVELS (YEAR 2040)

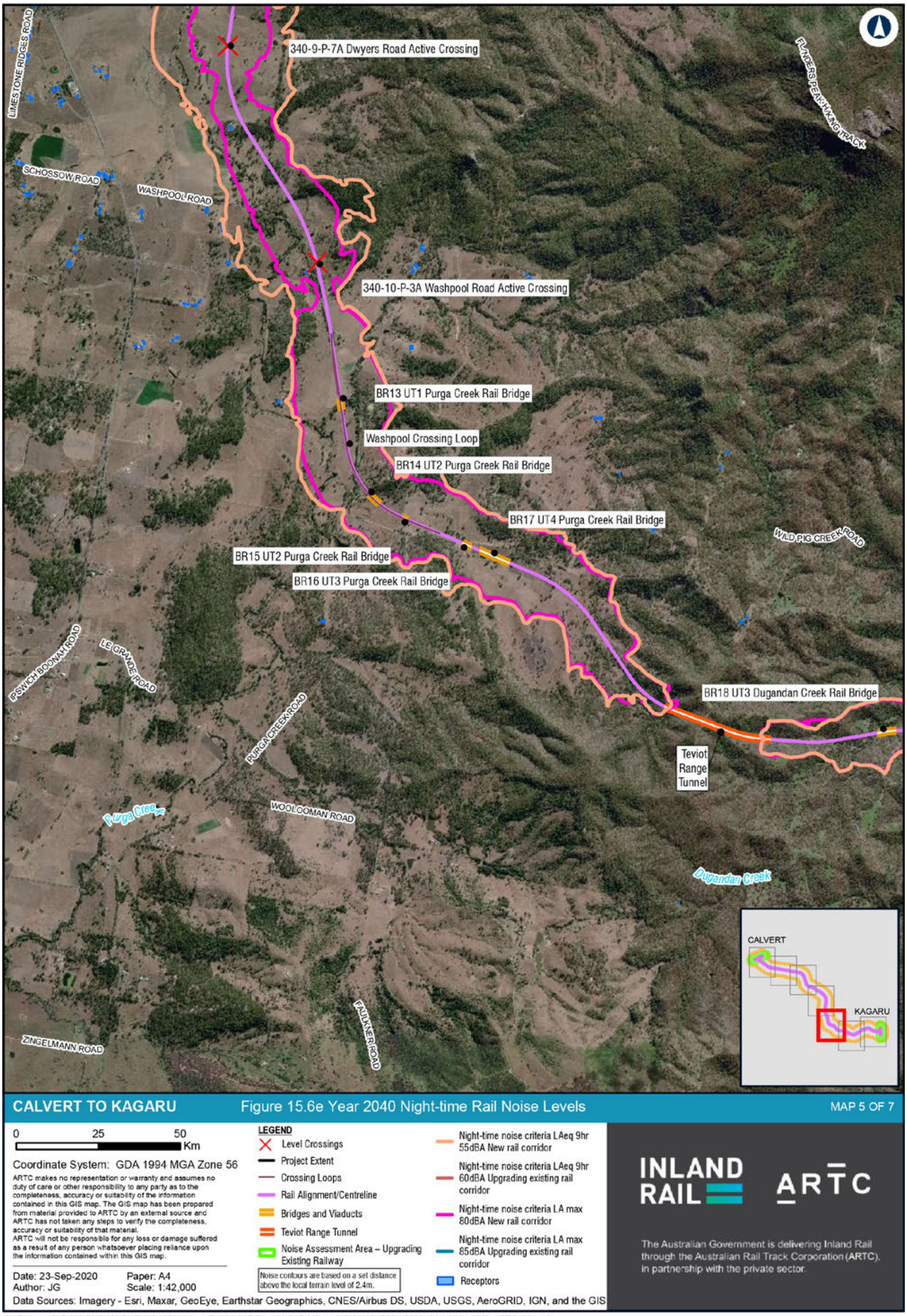

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FIGURE 15.6E: NOISE CONTOUR MAP, NIGHT-TIME RAIL NOISE LEVELS (YEAR 2040)

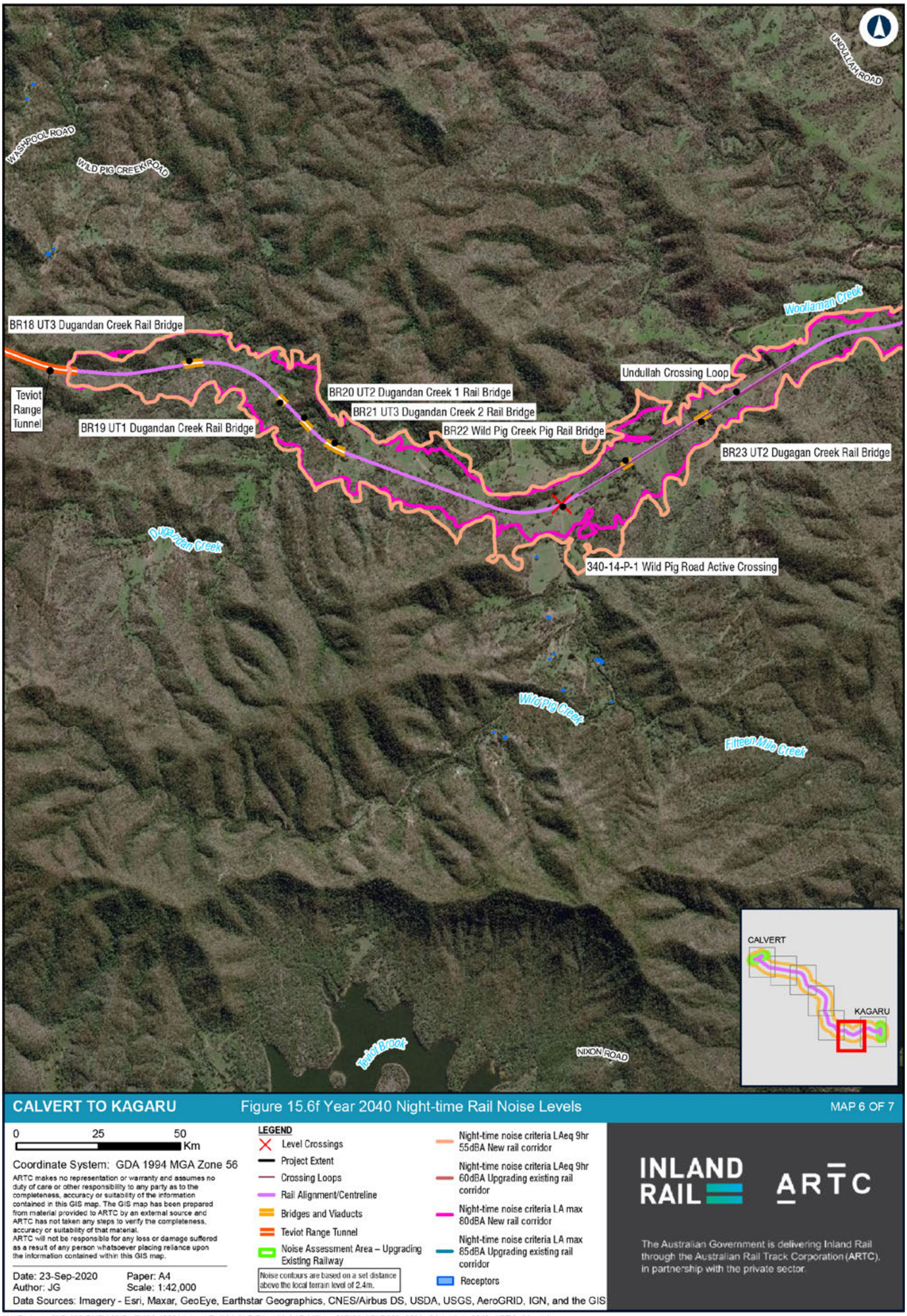

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FIGURE 15.6F: NOISE CONTOUR MAP, NIGHT-TIME RAIL NOISE LEVELS (YEAR 2040)

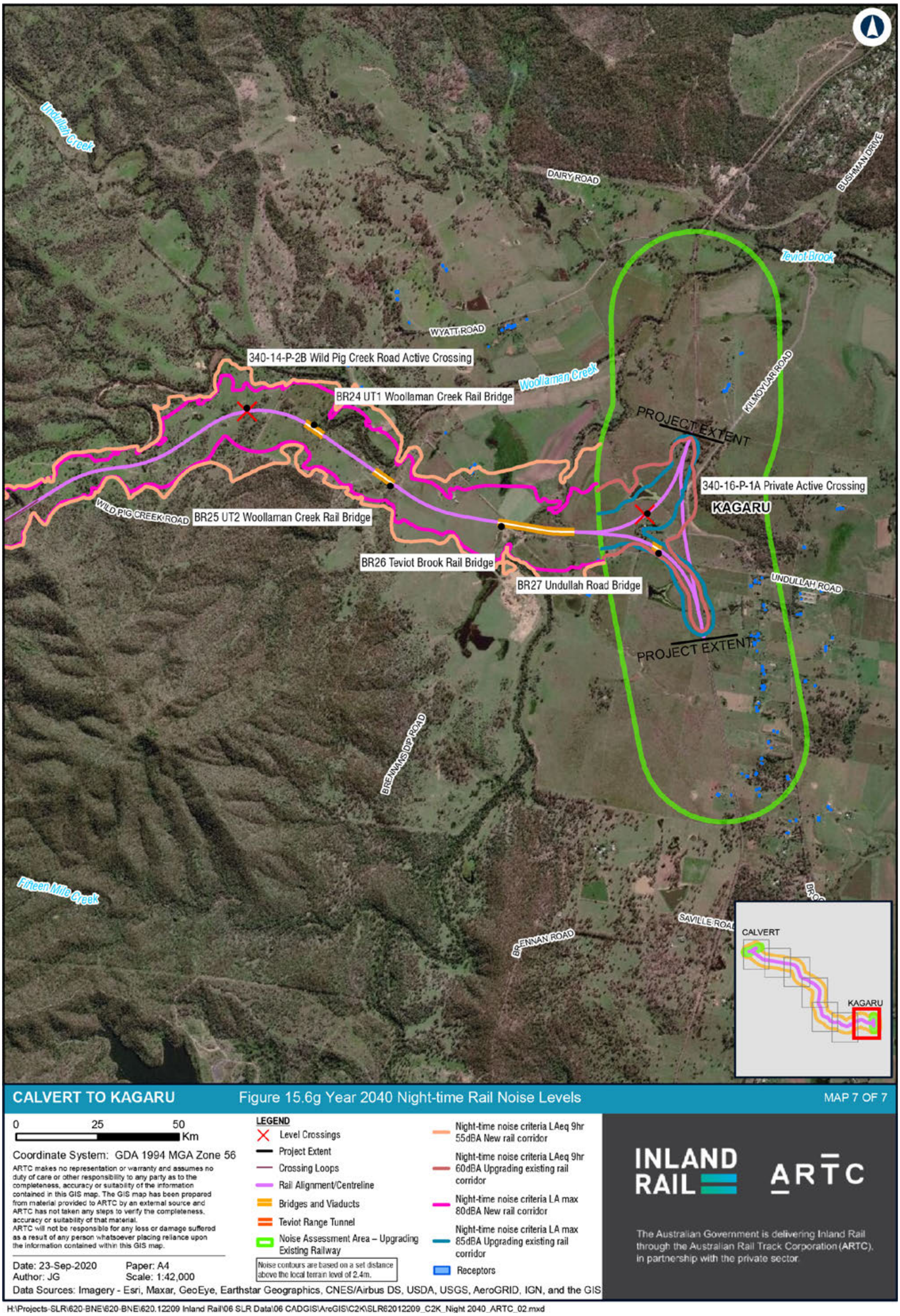

FIGURE 15.6G: NOISE CONTOUR MAP, NIGHT-TIME RAIL NOISE LEVELS (YEAR 2040)

15.7.7.3 Operation of the level crossings

In most cases, while the level crossings are a potential source of noise in the local environment, the predicted noise levels at the sensitive receptors was primarily influenced by the train pass-bys on the main line track.

The number of sensitive receptors where the level crossing events are triggering the L_{Amax} railway noise criteria are summarised in Table 15.35. The train horns are sounded on approach to the level crossing and it is the maximum (L_{Amax}) noise from the train horns that is the principal source of the noise criteria triggers.

Based on this analysis, the Project will review reasonable and practicable noise mitigation options for the level crossings and train horns at the level crossings at Hayes Road, Glencairn Road, Middle Road, Washpool Road and the private road crossing near the tie-in to the Interstate Line.

TABLE 15.35: SUMMARY OF LEVEL CROSSING NOISE

Level crossing	Number of receptors trigger L_{Amax} noise criteria
Hayes Road	1
Mount Hines Road	0
Glencairn Road	2
Middle Road	4
Dwyers Road	1
Washpool Road	1
Wild Pig Creek Road	0
Wild Pig Creek Road	0
Private road	1

15.7.7.4 Railway noise characteristics

The potential impacts of noise from railway operations can be influenced by the characteristics of rolling stock noise. An overview on the potential noise characteristics from freight rail operations are summarised below:

- There can be a prominent contribution of noise in the low-frequency range between 80 Hz and 250 Hz within close proximity of rail corridors (at 15 m from the rail line). The diesel-electric locomotive engines and exhaust systems are the primary source of the low-frequency noise during the train pass-by events.
- While the noise emissions of the locomotives have a low-frequency noise content in close proximity to the rail line, it does not mean that low-frequency noise characteristics will necessarily be experienced at sensitive land uses.
- The ability to detect features, such as low-frequency noise, will also depend on the contribution of the other sources of noise in the local environment, which may influence an individual's perception of the loudness and character of the rolling stock noise.
- Analysis of locomotive noise emissions did not identify prominent tones at specific frequencies, and the noise emission from the rolling stock operations is not expected to include tonal noise characteristics.

Other general characteristics of railway noise are summarised below and are usually specific to individual items of rollingstock and track features:

- Bunching or stretching can occur when the couplings on a train are subject to sudden changes in force during acceleration and deceleration, this can cause short-lived squeaks and bangs. Events of this nature may have subjective impulsive noise emission characteristics, although not necessarily quantified as impulsive noise at the nearest sensitive receptors. Noise events of this nature have been assessed at the four crossing loops proposed on the Project.
- A short-lived booming noise with potential low-frequency characteristics can be caused by empty containers and wagons resonating.
- Curving noise can result in prominent tonal noise emissions. The Project includes relatively short sections of tight-radius curves at the tie-ins to the existing rail corridors and the potential noise emissions from curving noise were included in the noise predictions.
- The Project will be newly constructed rail that will be specifically designed for freight rail operations and subject to periodic maintenance. This can reduce potential for features such as corrugation (deformation of the track) to increase noise emissions.
- The track for Inland Rail will be continuously welded rail, which reduces the likelihood of 'clickety-clack' sounds from the wheel–rail interface.

A more detailed discussion is provided in Appendix Q: Operational Railway Noise and Vibration Technical Report.

15.7.7.5 Potential for sleep disturbance from railway operations

The night-time L_{Amax} (maximum) rail noise management criteria have been adopted across the Inland Rail Program to assess potential sleep disturbance impacts, such as: awakening, disrupted sleep or a general reduction in the quality of sleep over time. The L_{Amax} noise management criteria account for the highest level of noise during train pass-bys and the number of pass-by events in the night-time. There were up to 38 receptors where the predicted L_{Amax} noise levels trigger the assessment criteria.

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

The WHO guideline *Night Noise Guidelines for Europe*[5] recommends that internal (indoor) noise levels are not above L_{Amax} 42 dBA to preserve sleep quality. 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. 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.

Based on the noise modelling, the noise levels from rolling stock could be above L_{Amax} 49 dBA within approximately 1 km from the rail corridor. The 1 km distance is a guide to where night-time noise levels may have the potential to result in sleep disturbance impacts.

Individuals will respond to noise differently, and just because railway noise can be audible does not mean it will cause disturbance or annoyance impacts. Furthermore, where sensitive residential land uses are proposed to be developed within 1 km of rail freight corridors, it would be expected that residential property, complying to Australian building codes and standards, would achieve façade noise reductions greater than the conservative 7 dBA assumption applied in this assessment.

15.7.7.6 Weather

The potential for railway noise at individual sensitive receptors to be influenced by the local weather conditions is based on the interaction between the moving noise source (train pass-by), the content of the received noise and local/regional weather conditions.

While there may be periods when the weather conditions influence the propagation of noise from train pass-by events over long distances, the railway operation is forecast to be 1 to 2 train movements per hour with audible pass-by events likely to be 2 to 5 minutes in duration. The combination of the duration and intermittency of the train pass-bys diminish the influence of weather conditions on the railway noise levels assessed over the 15-hour daytime and 9-hour night-time periods. Operational ground-borne vibration assessment

The ground-borne vibration levels have been assessed as a VDV, which considers both the level of vibration during a train pass-by event and the number of pass-by events in each daytime and night-time period. The VDV vibration levels were calculated based on the daily train movements for the 2026 opening year and 2040 design year rail operations.

The vibration levels were applied to determine the minimum offset distance from the outer rail where the ground-borne vibration criteria would be expected to be achieved. Suggested offset distances for the daytime and night-time rail operations are shown in Table 15.36 to allow for variation in rail condition and local factors, noting that subjective annoyance is possible at larger distances.

There are no sensitive receptors currently identified to be within this distance; however, this should be confirmed during detailed design, particularly as VDV levels within the assessment criteria do not eliminate the potential for perceptible vibration during train pass-by events. The assessment also identified that ground-borne vibration is not anticipated to impact non-Indigenous cultural heritage sites adjacent to the Project alignment.

5. World Health Organization, 2009. *Night Noise Guidelines for Europe*.

TABLE 15.36: PREDICTED NOISE LEVEL AT THE CLOSEST NOISE SENSITIVE RECEPTOR

Year of operation	Estimated off-set to meeting vibration criteria[1,2]		Receptors within the off-set distance
	Daytime	Night-time	
2026 Project opening	11 m (23 trains)	15 m (19 trains)	None
2040 design year	12 m (29 trains)	16 m (22 trains)	None

Table notes:

1. The estimated off-set distances are based on the VDV reference, actual vibration levels at individual receptors can vary from the calculated levels due to the rail infrastructure and geological conditions.
2. VDV levels calculated applying the Wb weighted vibration levels as per the 2008 version of British Standard BS6472.

15.7.7.7 Operational ground-borne noise assessment

At a distance of greater than 50 m from the track, the most stringent ground-borne noise criterion of L_{ASmax} 35 dBA is calculated to be achieved. Based on a 50 m offset distance, there are three sensitive receptors that are within 50 m of the outer rail. At these distances, the local environment would be dominated by the airborne noise from train pass-bys, which would be expected to mask the potential ground-borne noise content.

At the EIS stage of design, because the building construction of the sensitive receptors is not known, it is not possible to forecast with certainty the indoor ground-borne noise levels that could eventuate during railway operations. It is recommended that ground-borne noise levels are reviewed through further assessment during the detail design of the Project to confirm the assessment outcomes.

While ground-borne noise levels calculated at sensitive receptors were principally within the assessment criteria, and did not trigger investigation of mitigation, there can still be a risk of minor perceptible ground-borne noise at sensitive receptors. Furthermore, ground-borne noise can be perceptible even where the ground-borne vibration assessment criteria are comfortably achieved.

15.7.7.8 Ground-borne vibration and noise—Teviot Tunnel

The movement of trains through the Teviot Tunnel will induce vibration of the track system and the tunnel structure. The vibration can then propagate into the surrounding soil and this ground-borne vibration can potentially be experienced at sensitive receptors sufficient to impact the amenity of the receptors through perceptible vibration and the generation of noise within properties (ground-borne noise).

The calculation of ground-borne noise applied a screening assessment model based on guidance from *International Standard ISO 148327-1:2005 Mechanical vibration—Ground-borne noise and vibration arising from rail systems—Part 1: General guidance*.

The ground vibration and ground-borne noise model accounted for the key parameters of the track design, ground conditions and proposed rail operations to calculate the required off-set distance where forecast ground-borne vibration and ground-borne noise levels would achieve the assessment criteria.

In summary, the assessment concluded:

- The ground vibration assessment criterion is predicted to be achieved at 90 m from the tunnel alignment
- Ground-borne noise levels of L_{ASmax} 35 dBA are forecast at no more than 160 m from the tunnel alignment.

Because the sensitive receptors are over 4400 m from the tunnel alignment and well in excess of the above off-set distances, the forecast ground-borne noise levels are predicted to be within the daytime and night-time assessment criteria.

The assessed designs include the potential for high - vibration attenuation trackform for track slab sections within the tunnel and bridges and viaducts will consider the use of resilient matting for ballast retention. On the basis of the assessment, specific additional measures to control ground-vibration from railway operations in the Teviot Tunnel are not anticipated to be required to control potential ground-borne vibration and ground-borne noise impacts at the nearest identified sensitive receptors.

15.7.7.9 Operational fixed infrastructure noise

Predicted tunnel ventilation fan noise levels at the nearest noise-sensitive receptor (approximately 1 km from the nearest ventilation fan) are presented in Table 15.37. These impacts are mapped in Appendix P: Non-operational Noise and Vibration Technical Report.

TABLE 15.37: PREDICTED NOISE LEVEL AT THE CLOSEST NOISE SENSITIVE RECEPTOR

Scenario	Jet fan operation location	Receptor	Internal noise criteria $L_{Aeq,1hr}$, dBA	Predicted internal noise level $L_{Aeq,1hr}$, dBA
Maintenance	East and West portals	RES0806	30	26

Based on the adopted sound power levels and distance to nearest sensitive receptors, the EPP (Noise) acoustic quality objectives are predicted to be met at receptors impacted by noise from fixed infrastructure.

Ancillary fixed infrastructure noise sources, such as pumps and transformers, will be located at the eastern and western tunnel portals for the Project. While noise from these sources are not yet known, nominal mitigation strategies (such as attenuators, solid barriers, enclosures etc.) will be implemented and designed to meet the EPP (Noise) quality objectives at noise-sensitive receptors.

15.7.7.10 Operational road traffic noise—proposed new roads

In assessing the potential noise impacts of the seven new road sections, a desktop assessment has been implemented, taking into consideration the nearest sensitive receptors to the proposed works, as well as the realignment distance to predict the change in noise levels brought about by the realignment of the road closer to residents.

The predicted façade corrected $L_{A10\ (18\ hour)}$ does not exceed the criterion at the nearest residential receptor for all proposed new roads.

15.7.7.11 Operational road traffic noise—upgraded roads

In assessing the potential noise impacts of the nine road sections to be upgraded as part of the Project, a desktop assessment has been implemented, taking into consideration the nearest sensitive receptors to the proposed works to predict the change in noise levels brought about by the road upgrade.

The predicted façade corrected $L_{A10\ (18\ hour)}$ exceeds the criterion at residential receptor RES0411, adjacent to the proposed upgrade of Ipswich–Boonah Road. These predicted impacts are based on the design and conservative assumptions. These findings should be revisited during detailed design.

15.8 Mitigation

This section outlines noise and vibration mitigation measures included as part of the Project design and the mitigation measures proposed for the Project as part of this assessment.

15.8.1 Design considerations

The noise and vibration assessments identified the construction and operation of the Project have the potential to trigger the assessment criteria. This section considers the approach to mitigation and management of noise during construction and operation.

The mitigation measures and controls presented in Table 15.38 have been factored into the design for the Project. These design considerations are proposed to minimise the environmental impacts of the Project.

TABLE 15.38: INITIAL MITIGATION MEASURES RELEVANT TO NOISE AND VIBRATION

Aspect	Initial mitigations
Construction noise and vibration	The Project has been designed and will be constructed with the aim of achieving construction noise and vibration criteria adopted by the CoP Vol. 2. For example, track features such as crossing loops, crossovers, turnouts, and rail joints have been avoided near vibration sensitive structures where practicable. Where it is found that proposed mitigation measures are not sufficient to reduce adverse noise and vibration impacts to acceptable levels, additional mitigation measures will be investigated and implemented.
Operational noise and vibration	The Project will be designed and constructed with the aim of achieving the operational noise criteria adopted from ARTC's railway noise management criteria, the CoP Vol. 1 in the case of operational road traffic noise, and environmental noise objectives adopted from the EPP (Noise) for mechanical plant (fixed sources of noise). These criteria may be superseded by specific environmental performance requirements detailed in relevant Project approvals and environmental permits. Where it is found that standard mitigation measures are not sufficient to reduce operational noise impacts to acceptable levels, additional reasonable and practicable mitigation measures will be investigated and implemented.
Communication	Local residents and other stakeholders will be provided with sufficient information to enable them to understand the likely nature, extent and duration of all potential noise impacts.
	A community liaison phone number will be provided to the community so that noise-related complaints or enquiries can be received and addressed in a timely manner.

15.8.2 Proposed mitigation measures

In order to manage and mitigate Project risks, a number of mitigation measures have been proposed. These proposed mitigation measures incorporate ARTC's standard practices, as well as industry best practice and legislative requirements such as CoP Vol. 2 and the Interim Guideline. The proposed mitigation measures are presented in Table 15.39.

The proposed mitigation measures have been presented in the Noise and Vibration Management Plan in Chapter 23: Draft Outline Environmental Management Plan in accordance with the relevant phase during which they would be implemented:

- Detailed design
- Pre-construction
- Construction.

For the operational phase, the results presented in Section 15.7.7.1 and Section 15.7.7.10 show that the predicted noise levels due to operational tunnel infrastructure and upgrade or re-alignment of roads as a part of the Project comply with the noise criteria for sensitive receptors. At this stage, specific mitigation is not required.

Regarding operational railway noise, review and, if necessary, update of the operational railway noise and vibration assessment to reflect/inform the detailed design will occur. Compliance and verification works will also be undertaken post-commissioning.

TABLE 15.39: NOISE AND VIBRATION MITIGATION MEASURES

Delivery phase	Aspect	Proposed mitigation measures
Detailed design	Noise and vibration impacts on sensitive receptors	Avoid/minimise impacts on nearby sensitive receptors during detailed design. Update the construction noise and vibration assessment to reflect/inform the final location of construction sites, construction activities and construction scheduling to inform the development of the Noise and Vibration Management Plan to achieve the performance criteria and inform Construction Noise and Vibration Management Plans.
	Operational railway noise and vibration impacts on sensitive receptors	Review and, if necessary, update the operational noise and vibration assessment to reflect/inform the detailed design, including incorporation of potential noise or vibration treatments. The vibration assessment will include consideration of: ▸ Buildings/structures that will remain near to the Project works ▸ Other vibration-sensitive receptors (including buildings/structures of heritage value). The vibration assessment will identify building condition survey requirements at vibration-sensitive receptors that are expected to exceed the structural damage vibration limits given by DIN 4150-3 and recommended by the CoP Vol 2. The following treatments are to be considered as part of detailed design: ▸ Source controls—mitigations applied to the railway infrastructure to control the emission of noise and vibration at its source. Such measures include: rail dampers, track lubrication (for control of curving noise), identification of rollingstock causing discrete high-noise events or lower noise-emission alarm bells ▸ Pathway controls—measures to impede and limit the propagation of railway noise to the sensitive receptors and typically constructed within the rail corridor. Measures can include: railway noise barriers, low-height noise barriers or earth mounding ▸ Receptor controls—measures to mitigate noise and vibration levels or manage potential noise and vibration impacts at the sensitive receptor properties and land uses. Measures can include: architectural acoustic treatment of property, property construction/relocation, upgrades to existing property fencing or negotiated agreement with property owners.
	Operational road traffic noise impacts on sensitive receptors	Review/update the operational road-traffic noise to reflect/inform the detailed design, including incorporation of potential noise treatments. The following mitigation measures are to be considered as part of detailed design where operational road traffic noise impacts are predicted to exceed adopted road traffic noise limit based on the detailed design: ▸ Pavement surface treatment ▸ Provision of acoustic façade treatments to affected sensitive receptors ▸ Noise barriers in the form of a landscaped earth mound and/or a noise fence. A combination of mitigation measures may be appropriate.

Delivery phase	Aspect	Proposed mitigation measures
Pre-construction	Noise and vibration impacts on sensitive receptors	Develop and implement a Construction Noise and Vibration Management Plan. The Construction Noise and Vibration Management Plan will include: • Location of sensitive receptors in proximity to the disturbance footprint • Requirements for pre-construction dilapidation surveys and/or vibration monitoring at vibration sensitive receptors during construction • Specific management measures for activities that could exceed the construction noise and vibration criteria at a sensitive receptor • Notification process within the community engagement plan (including who to contact in the event of a complaint) to advise of significant works with potential for noise nuisance or vibration at sensitive receptors • Noise management measures may include controlling noise and vibration at the source, controlling noise and vibration on the source to receptor transmission path and controlling noise and vibration at the sensitive receptor • Practicable and reasonable measures to minimise the noise and vibration impacts of construction activities on sensitive receptors • Any other measures necessary to comply with conditions of approval or regulatory requirements Where it is found that existing mitigation measures are not sufficient to reduce noise and vibration impacts to acceptable levels, additional mitigation measures will be investigated and implemented, including consultation with affected sensitive receptors.
Construction and commissioning	Noise and vibration impacts on sensitive receptors	Sensitive receptors identified in the Construction Noise and Vibration Management Plan, as well as residents within at least 2 km of the disturbance footprint and other relevant stakeholders will be provided with sufficient information to enable them to understand the likely nature, extent and duration of noise and vibration impacts during construction. Sensitive receptors with the potential to be affected by exceedances of noise goals will be notified prior to the commencement of relevant works. Construction progress and upcoming activities will be regularly communicated to local residents/stakeholders, particularly when noisy or vibration-generating activities are planned, such as vibratory compaction and piling.

	Damage to buildings and structures	Building condition surveys will be undertaken for vibration sensitive receptors identified as potentially exposed to vibration impacts from the Project works during the detailed design phase modelling and assessment.
		Surveys are to take place prior to commencement and on completion of vibration-generating works (such as pile-driving). Following such surveys, more accurate data may be used to assess the impacts to vibration sensitive receptors.
		If, during detailed design and construction methodology assessments, vibration impacts are predicted to exceed the criteria at a vibration sensitive receptor, the following mitigation must be undertaken:
		• Consultation with the owner of the structure to determine the sensitivity of the structure to construction vibration. A more appropriate criteria to be applied at the location may be agreed upon as a result
		• Baseline vibration monitoring is to be undertaken prior to the activity commencing and monitored throughout the activity to assess compliance with vibration limits set as part of the Construction Noise and Vibration Management Plan for the relevant receptor. Vibration monitoring results are to be assessed and used to refine vibration predictions and management measures as applicable, such as developing and enforcing exclusion zones around the sensitive structure or implementing remediation measures
		• Where reasonable and practicable, modify the construction methodology to reduce the predicted vibration impacts. This could include:
		  ◦ Using smaller equipment, such as a handheld jackhammer instead of a rock breaker
		  ◦ Changing the construction methodology.

Delivery phase	Aspect	Proposed mitigation measures
Construction and commissioning (continued)	Damage to buildings and structures	Vibration monitoring will be undertaken at locations where the potential for building/structural damage risk has been identified during the detailed design and is warranted. This includes vibration sensitive receptors at which vibration impacts are expected to exceed the structural damage criteria recommended by DIN 4150-3 and recommended by the CoP Vol 2. Vibration monitoring will be undertaken by a suitably qualified professional, in accordance with the CoP Vol 2.
	Noise impacts on sensitive receptors	Where practicable and feasible, noise monitoring will be undertaken at noise-sensitive receptors where the potential for noise impacts to exceed the criteria in Table 23.13 (refer Chapter 23: Draft Outline Environmental Management Plan), has been identified. Noise and/or vibration monitoring will also be undertaken in response to valid noise or vibration complaints.
	Noise impacts on sensitive receptors—hours of work	Project works will be undertaken in accordance with the hours of work in Table 23.4 (refer Chapter 23: Draft Outline Environmental Management Plan), and as per advice to stakeholders and sensitive receptors regarding permitted out of hours activities.
	Noise impacts on sensitive receptors—staff	Staff training is to be undertaken so that unnecessary sources of noise are avoided. Training must enforce that: ▶ Unnecessary shouting or loud stereos/radios on site are not tolerated ▶ Materials are not to be dropped from height ▶ Metal items are not thrown ▶ Doors/gates are not slammed ▶ Vehicle radios and engines are to be turned off or volume lowered wherever possible.
	Noise and vibration impacts on sensitive receptors—selection of construction equipment near sensitive receptors	Quieter and non-vibratory construction equipment will be selected for use near sensitive receptors, where feasible and reasonable. This is particularly important for any non-standard/out-of-hours construction activities where sensitive receptors are nearby. This is also particularly important for loud and/or vibration-intensive plant such as mulchers and piling rigs. Appropriately sized equipment is to be selected for the task, such as vibratory compactors and rock excavation equipment. For example, a 22-tonne excavator is expected to operate 8 dBA quieter than a 40-tonne excavator, based on equipment noise emissions given by BS5228.1.
	Noise and vibration impacts on sensitive receptors—selection of construction methods near sensitive receptors	Where reasonable and practicable, alternative construction methods will be adopted to reduce the noise and vibration impacts in the vicinity of sensitive receptors, such as: ▶ Using damped tips on rock breakers, where appropriate ▶ Using rock saws instead of blasting ▶ During clearing, using excavators with grabs and rake attachments instead of chainsaws, and mulching cleared material at locations away from sensitive receptors ▶ Avoiding onsite fabrication work, where possible ▶ Using alternatives to impact pile driving where possible, such as continuous flight auger-injected piles, pressed-in preformed piles, auger-bored piles, impact-bored piles or vibratory piles ▶ When piling, avoiding dynamic compaction using large tamping weights near sensitive and critical receptors, where possible ▶ Reducing energy per blow when piling (consider first whether this may result in prolonged exposure with no realised reduction in community disturbance).

Delivery phase	Aspect	Proposed mitigation measures
Construction and commissioning (continued)	Noise and vibration impacts on sensitive receptors—blasting	Where blasting impacts are expected to exceed the vibration goals, the following measures are to be implemented where reasonable and practicable: ▸ Reducing the charge size by use of delays and reduced charge masses ▸ Ensuring adequate blast confinement to minimise the amount of overpressure ▸ Avoiding secondary blasting where possible; the use of rock breakers or drop hammers may be an acceptable alternative ▸ Avoiding blasting during heavy cloud cover or during strong winds blowing towards sensitive receptors ▸ Establishing a blasting timetable through community consultation, for example, blasts times negotiated with surrounding sensitive receptors.
	Noise and vibration impacts on sensitive receptors—during hours of construction	Where reasonable and practicable, the duration of simultaneous operation of noise or vibration-intensive plant will be minimised. Plant and equipment used intermittently or no longer in use will be throttled or shut down. Vibration-intensive stationary plant located near sensitive receptors will be isolated with resilient mounts. Noise-emitting plant and equipment, construction compounds laydown areas will be orientated away from sensitive receptors where feasible and reasonable. Equipment will be operated in the correct manner and correctly maintained including replacement of engine covers, repair of defective silencing equipment, tightening of rattling components and repair of leakages in compressed air lines. Construction plant, vehicles and machinery will be maintained and operated in accordance with manufacturer's instructions to minimise noise and vibration emissions. When piling, the pile and rig are to be carefully aligned so that cable slap and chain clink are minimised.
	Noise and vibration impacts on sensitive receptors—mechanical plant management	All mechanical plant near sensitive receptors will be modified to reduce noise by practical means, such as: ▸ Internal combustion engines are fitted with a suitable muffler in good repair, operating as per the manufacturer's specifications, as a minimum ▸ Pneumatic tools are fitted with an effective silencer on their air exhaust port, where feasible and practicable ▸ Aggregate bins and chutes are lined with a rubber material, to dampen the vibration of the structure ▸ When piling, acoustic damping are provided to sheet steel piles to reduce vibration and resonance ▸ When piling, resilient pads are used between pile and hammerhead. Care is to be taken when selecting a resilient pad as energy is transferred to the pad in the form of heat. Based on manufacturers' data, between 4 and 11 dBA of attenuation can be achieved by engine mufflers. Various other equipment treatments such as dozer track plate dampers can provide between 6 and 10 dBA of attenuation, based on manufacturer data.
	Noise impacts on sensitive receptors—stationary noise sources	Stationary noise sources near noise-sensitive receptors will be shielded or enclosed where feasible and reasonable. Acoustic shielding must also be considered where works are expected to occur close to sensitive receptors for lengthy periods. Temporary noise barriers or enclosures can provide between 5 and 10 dBA of attenuation, based on preliminary calculations.
	Noise and vibration impacts on sensitive receptors—shielding of noise-emitting plant	Where feasible, structures and noise-emitting plant will be located such that the structures provide some shielding to any nearby receptors. Structures include: ▸ Temporary site buildings, such as sheds ▸ Materials stockpiles ▸ Fencing ▸ Storage/shipping containers. Where vibration impacts at sensitive receptors are expected to exceed the structural damage goals, and where reasonable and safe to do so, cut-off trenches to interrupt the direct transmission path of vibrations between source and receptors will be provided.

Delivery phase	Aspect	Proposed mitigation measures
Construction and Commissioning (continued)	Noise impacts on sensitive receptors	Non-tonal reversing beepers (or an equivalent mechanism) be fitted and used on all construction vehicles and mobile plant regularly used onsite and for any out-of-hours work.
	Noise impacts on sensitive receptors—delivery of materials	Site access points and roads will be sited as far as is practicable from sensitive receptors. Acoustic shielding will be considered if loading/unloading areas are close to sensitive receptors. Delivery vehicles will be fitted with straps rather than chains, where feasible. Offsite truck-parking areas, if required, will be located away from residences and will be nominated, where practicable. The drop height of materials will be minimised, for example, while loading and unloading vehicles or in storage areas. Reversing movements of vehicles are to be minimised to reduce the use of reversing alarms. Where practicable, sites are to be designed so that delivery vehicles are able to drive through the site and not be required to reverse.
	Noise impacts on sensitive receptors—construction traffic	Where reasonable and practicable, unsealed areas will be regularly graded, and potholes filled on sealed access roads and hardstand areas to reduce noise from construction vehicles. Where practicable, night-time construction traffic will be redirected away from noise-sensitive receptors, in accordance with the Construction Traffic Management Plan. Appropriate construction traffic speed limits will be established and managed near noise-sensitive receptors.
Operation	Noise and vibration impacts on sensitive receptors—operation	The operational railway noise and vibration levels will be verified through a program of noise and vibration monitoring once the Project is operational. The monitoring program would be undertaken within the initial six months post-commencement of railway operations (train movements) on the Project. ARTC will investigate where monitored operational noise and/or vibration levels at sensitive receptors are confirmed to be above the railway noise and vibration criteria.

15.8.2.1 Operational railway noise and vibration mitigation

Review of railway noise mitigation measures

ARTC is applying the following strategy for the Project, as the basis for selecting reasonable and practicable noise mitigation:

- Noise barriers are generally only considered where groups of triggered sensitive receptors are apparent. For isolated receptors, such as single dwellings in rural areas, noise barriers are not considered
- The noise mitigation for isolated receptors is expected to include:
  - At-property architectural treatments to the building (such as increased glazing or façade constructions) to control rail noise inside the building
  - Upgrades to the receptor property boundary fencing to improve screening of rail noise levels
- For two receptors 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 receptors in close proximity on the same side of the track noise barriers will be considered as a primary noise mitigation option.

At the time of the EIS, based on the results of the railway noise assessment, and with consideration to ARTC's noise strategy, railway noise barriers within the rail corridor are not considered either reasonable or practicable for the Project.A review of potential reasonable and practicable mitigation options to reduce and control noise levels and noise-related impacts at sensitive land uses is discussed in Table 15.40.

A comprehensive review of reasonable and practicable railway noise and vibration mitigation measures, including railway noise barriers, is discussed further in Appendix Q: Operational Railway Noise and Vibration Technical Report.

The final decision on noise mitigation will be determined during the detailed design and construction of the Project.

TABLE 15.40: NOISE MITIGATION OPTIONS FOR ROLLING STOCK NOISE

Action required	Safeguard details
At-property treatments	
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 treatments 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, acoustic insulation for the roof are considered to mitigate noise intrusion. The provision of upgrades to ventilation, such as fresh air ventilation (acoustic ducting) allow windows to kept closed as a mitigation option while 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 before implementation of at-property noise-control treatments.
	In rural locations, the age and construction of residential properties can influence the practical implementation of modern architectural treatments. The review of architectural treatments will require a further review of the eligible properties and advice from suitably qualified professionals.

Action required	Safeguard details
Consideration of low-frequency noise content	Where the control of locomotive exhaust noise is required, the architectural acoustic treatments would need to consider the control of low-frequency noise intrusion 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.
Upgrades to existing property fencing	Existing fencing at the boundary of individual receptors 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. While 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 receptor, the available land and the requirements of local Councils and regulatory authorities with respect to the height and materials permitted for property boundary fencing. Agreement between the landowner and ARTC would be required for ARTC to undertake works on private property.
Property relocation	In rural locations, individual residential property can be located on large land holdings. It may be possible to relocate the residential property within the same land so that it is further from the rail corridor and noise levels would be lower. The relocation of property would be assessed on a case-by-case basis to ensure there would be a notable improvement to the noise environment at the relocation site.
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 and conditions between ARTC and the property owner.
Source controls	
Managing curving noise	Track lubrication systems: ▶ Diagnosis and control of curving noise can require detailed investigation of the track systems and rollingstock. Track lubrication systems are an effective control measure to reduce, and even eliminate, curving noise. Wayside lubrication systems include gauge-face lubrication and top-of-rail friction modifiers. The Project alignment includes section of curved track with a radius <500 m where the Project connects with the West Moreton System near Calvert. On this basis, track lubrication systems should be considered for the rail spur to control potential curving noise. Other measures: ▶ Depending on the specific source of the rail noise, other measures can include wheel dampers to control aspects such as curving noise (wheel squeal). Because such measures require specifications for the rollingstock, they will not be readily implementable by ARTC without appropriate commitments from rail operators.
Rail dampers	Rail dampers may provide localised benefit for the control of rolling noise where the contribution from the rail is a primary factor. International experience suggests a reduction in rolling noise of 3 dBA could be achieved and there is limited evidence that suggests rail dampers can provide some benefit in controlling curving noise. The effectiveness of rail dampers may be limited by the stiffness of the ballasted track and concrete sleepers, the forces exerted by the heavy rail freight and the long-term durability and maintenance of such measures. Sections of generally straight alignments that are not highly susceptible to prominent or regular wear. These sections would be most suited for consideration of rail dampers.

Action required	Safeguard details
Identification of the causes of rolling stock noise	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. A range of monitoring systems are in place to identify individual rollingstock and the specific sources of noise for the targeted management and mitigation of railway noise. 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, defective rollingstock can be temporarily removed from service and defects 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 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.
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 receptors 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 receptors and provide a notable improvement in volume and potential risk of annoyance, particularly where there can be more than two train horn events every hour with the Project.
Soft-tone alarm bells	The design of level-crossing alarm (warning) bells will be required to conform to specific design standards. Typical, 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 practicable, to reduce maximum noise levels from the alarm bells by approximately 10 dBA. The L_{Aeq} noise level would have a more marginal improvement (probably less than 1 dBA per daytime or night-time period) as the noise environment surrounding level crossings is primarily influenced by the train pass-by 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.
Exhausts and engine shrouds	The exhaust outlets of the locomotives can be a primary source of low-frequency and overall noise emissions from the train pass-bys. 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 freight operators.
Operation	
Operational verification	The operational railway noise and vibration levels will be verified through a program of noise and vibration monitoring once the Project is operational. The monitoring program would be undertaken within six months of commencement of Project railway operations (post-commissioning train movements). ARTC will investigate reasonable and practicable mitigation measures where monitored noise and or vibration levels at sensitive receptors are confirmed to be above the railway noise and vibration criteria.

15.8.3 Residual impact mitigation

15.8.3.1 Construction noise and vibration

Across all construction activities, 65 per cent of exceedances of the upper standard hours noise limit under the CoP Vol. 2 are within 10 dBA of the limit, as are 63 per cent of exceedances of the evening non-standard hours noise limit. Of the construction noise mitigation measures recommended in Section 15.8.2, those that can be quantified can be expected to provide between 4 dBA and 11 dBA attenuation. The remaining approximate 45 per cent of exceedances are not expected to be feasibly mitigated to below the appropriate limit by physical attenuation alone. Where further mitigation is also similarly infeasible or unreasonable, residual exceedances may need to be managed. As with mitigation, management of residual impacts should be undertaken in consultation with the community and affected residents.

When evaluating the feasibility of mitigation measures, it should be taken into consideration that most noise and vibration receptors within the noise and vibration study area are residences in low-density areas. This is particularly true of receptors closest to the Project. Higher-density towns such as Calvert and Peak Crossing are typically further from the Project.

Specific management of residual impacts should be determined during detailed design, following the development of a construction Noise and Vibration Management Plan. As with the application of mitigation, management of residual impacts should be considered in consultation with affected occupants.

Construction works by nature can be inherently noisy and even with the implementation of reasonable and practicable mitigation measures construction noise can be audible within the local environment. There remains potential that where noise levels are managed to achieve the noise criteria from the CoP Vol 2 noise-related impacts, such as disturbance or annoyance, could occur.

Residual exceedances can be expected where noise and vibration impacts are unavoidable and significant after all reasonable and practicable mitigation measures are implemented. Currently these residual impacts would be addressed through respite, temporary relocation of affected occupants and the provision of architectural treatments.

Respite involves scheduling work periods when people are least affected, such as by:

- Scheduling work for when premises are not in operation
- Restricting the works to occur within standard hours as defined by CoP Vol. 2
- Restricting the number of nights per week that works are undertaken near sensitive receptors.

Temporary relocation involves the voluntary relocation of impacted occupants for short periods of time, where all reasonable and practicable measures and respite periods are implemented, and further mitigation is impractical. Examples of temporary relocation may involve the offer of an alternative activity or accommodation.

Architectural treatments may involve the provision of alternative ventilation where the windows are to remain closed. However, the performance of the building envelope may be limited by specific elements (for example, windows and doors) and architectural treatments should primarily focus on those elements.

Residual impacts are reduced for construction activities as these are not permanent sources and will cease once nearby construction is complete.

15.8.3.2 Road traffic noise

Construction

Mitigation measures will be applied to each of the construction traffic transport routes to reduce and manage residual noise impacts to nearby sensitive receptors.

Operation

During detailed design, if the route is not able to be altered, attenuation strategies can be used either individually or in combination to reduce the impacts and achieve compliance with the road traffic noise criteria and to manage residual impacts.

15.8.3.3 Operational fixed infrastructure

Residual impacts are not anticipated.

15.8.3.4 Operational rail

The noise mitigation measures implemented for the Project will be confirmed during the detailed design and construction of the Project. Based on the outcomes of this assessment, it is expected that property treatment would be the primary mitigation measure for sensitive receptors where criteria are exceeded. Noise treatments will be confirmed through consultation with the relevant landholders.

The property treatments do not address the source emission of rollingstock noise or the external (outdoor) rail noise levels within the environment surrounding the rail corridor. On this basis, the external rail noise levels can remain above the rail noise assessment criteria, and be perceptible, at the sensitive receptors with the implementation of at-property noise mitigation measures. Notwithstanding, 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.

The assessment has identified the ground-borne noise and vibration assessment criteria would be met at the majority of sensitive receptors. There is potential for ground-borne noise and vibration to be perceptible even where the assessment criteria are achieved within sensitive receptors. 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 receptors.

Operational road traffic and fixed infrastructure noise impacts will persist and will be mitigated to meet the relevant criteria. Residual operational road traffic and fixed infrastructure noise levels may result in minor increases in background noise levels for a limited number of receptors and are considered acceptable.

15.9 Cumulative impacts

15.9.1 Construction cumulative impacts

For the purposes of noise and vibration, projects that directly interface with the Project and will have temporal overlap in construction are considered to have potential to result in cumulative impacts include:

- Helidon to Calvert (H2C)
- Kagaru to Acacia Ridge and Bromelton (K2ARB).
- Other projects identified and assessed in the Cumulative Impacts Assessment in Chapter 22: Cumulative Impacts have not been considered for noise and vibration due to their distances from the Project.

It is assumed that the above listed projects will meet their legislative requirements. It is therefore unlikely that these projects will materially contribute to the noise environment such that impacts are greater than those predicted in Section 15.7.

The cumulative impact of noise would be managed as far as practically possible to ensure that the potential for adverse impacts at sensitive receptors is minimised. In addition, any overlap of construction works is likely to be for a limited period due to the linear nature of rail Project construction. Therefore, the predicted cumulative noise and vibration impacts during construction of the Project is considered to be of 'low significance'.

15.9.2 Operational cumulative impacts

The rail alignment of the Project will, in places, intersect and be alongside the existing road network and the future new and upgraded roads proposed with the Project. Concern has been raised about the potential for road traffic and railway operations to result in cumulative noise impacts.

The subjective response to the different noise levels and noise characteristics of the intermittent sources of road traffic and railway noise are such that individuals are less likely to perceive or determine impacts based on a cumulative exposure of the combined transport noise. Consequently, the ToR requires road traffic noise and railway noise to be assessed and, if necessary, mitigated separately. The assessment of road traffic noise and railway noise are discussed in this chapter with the detailed noise assessments provided in Appendix P: Non-operational Noise and Vibration Technical Report and Appendix Q: Operational Railway Noise and Vibration Technical Report.

While the policies and guidelines referenced by the ToR do not specify criteria or management objectives for combined road and railway transport noise, an overview assessment of potential cumulative transport noise has been undertaken to inform the EIS.

Based on the predicted existing road traffic noise levels (refer Table 15.16) and the assessed road traffic noise and railway noise with the Project, the overview assessment determined:

- In general terms, cumulative transport noise levels would generally be expected only where road traffic or railway noise is within 10 dBA of each other (where the same noise metric is applied to quantify both sources of transport noise).
- At sensitive receptors adjacent to both the railway alignment and local roads, such as Hayes Road, Rosewood–Warrill View Road, Mt Forbes Road, Middle Road, Ipswich–Boonah Road and Washpool Road, the railway noise levels are expected to be at least 10 dBA above the road traffic noise levels. The railway noise is likely to be the dominant source of noise and an increase in transport noise from the cumulative road traffic and railway noise is not expected at the sensitive receptors.

- The road traffic movements on the Cunningham Highway may contribute noise levels within 10 dBA of the predicted railway noise levels. There are only a few isolated sensitive receptors alongside both the Cunningham Highway and rail alignment where there is potential for cumulative transport noise. Any increase in daily transport noise from the combined road traffic and railway noise would be a marginal perceptible increase of less than 3 dBA.
- At the majority of sensitive receptors close enough to both the road network and railway alignment to potentially experience cumulative transport noise, railway noise levels are expected to be the dominant noise contribution.
- The assessment has identified the potential for noise-related impacts as a result of cumulative noise to be minimal. At the time, specific measures to manage or mitigate cumulative transport noise are not likely to be required in areas where the Project's rail alignment crosses, or is adjacent to, the future local road network.

15.10 Conclusions

15.10.1 Construction noise

A construction noise impact assessment has been carried out in accordance with the CoP Vol. 2 and the Project ToR. Reasonable worst-case construction scenarios have been assessed for each of the main construction activities.

The assessment of noise associated with the construction of the Project indicates up to 781 exceedances of both the lower and upper external noise limits within the noise and vibration study area. The magnitude and number of exceedances are detailed in Section 15.7.1.

The 'earthworks' and 'rail civil works' construction stages are predicted to have the greatest impact on construction noise; however, other construction stages may have greater overall impact depending on actual timing and duration of each construction stage.

Measures have been recommended to mitigate construction noise impacts on nearby sensitive receptors in line with the CoP Vol. 2.

The final number, degree and nature of these measures would be selected by the contractor and be largely dependent on the construction strategy and work carried out. Specific noise management and mitigation measures would be detailed in the contractor's Construction Noise and Vibration Management Plan.

The recommended management and mitigation measures that would be considered in the plan include:

- Effective community consultation
- Training of construction-site workers
- Use of temporary noise barriers
- Monitoring
- Appropriate selection and maintenance of equipment
- Scheduling of work for less-sensitive time periods
- Situating plant in less noise-sensitive locations
- Construction traffic management
- Respite periods.

15.10.1.1 Construction road traffic noise

For the 18 roads intended to be used to carry construction traffic, the maximum predicted increase in noise level is greater than the criteria. Details of these exceedances are given in Section 15.7.1. These roads are primarily in rural locations and the existing base traffic volumes quantities are low. As such, the initial airborne road traffic noise levels are low before the addition of construction traffic. Mitigation measures outlined in Section 15.8 should be applied to these roads expected to exceed the criteria.

15.10.2 Construction vibration

Minimum working distances for vibration-intensive construction work have been predicted for human comfort and structural damage limits in Section 15.7.3. Exceedances of the construction vibration criteria adopted from CoP Vol. 2 have been predicted at a number of sensitive receptors. Specific measures to mitigate vibration have been outlined in Section 15.8, in addition to the standard mitigation measures detailed in Section 15.8.1.

15.10.3 Blasting

Maximum charge mass amounts based on indicative setback distances of sensitive structures and heritage buildings are presented in Section 15.7.4. This type of assessment has been completed in the absences of detailed information for the required blasting works as part of the Project. A detailed assessment of blasting works associated with the tunnel construction is presented in Section 15.7.5.6. Additional assessments incorporating site conditions will need to be completed during future stages of the Project to ensure safe charge mass amounts are used. Mitigation measures are recommended in Section 15.8.

15.10.4 Operational rail noise and vibration

The assessment of noise and vibration considered the proposed daytime and night-time railway operations for the Project. The predicted noise levels achieve the airborne noise assessment criteria from the DTMR Policy and ARTC's noise management strategy at the majority of the sensitive receptors included in the noise prediction modelling.

At a total of 59 sensitive receptors the predicted noise levels are predicted to be above ARTC's noise assessment criteria at the Project opening (2026) without mitigation. To mitigate this impact, consideration has been given to feasible and reasonable noise mitigation options for these receptors. For the design year 2040, an additional six sensitive receptors were above the assessment criteria, resulting in a total of 65 sensitive receptors triggering an investigation of noise mitigation.

Because the sensitive receptors are isolated and individual buildings trigger by less than 10 dBA for small groups of receptors, the feasible and practicable noise mitigation is likely to be mitigated by architectural acoustic treatment of the properties to manage noise impacts within habitable rooms.

The decisions to implement architectural acoustic treatments will be based on validated (measured) rolling stock noise levels and a survey of the property. Where sensitive receptors are isolated along the alignment it is usually not practicable to construct rail noise walls or noise barriers.

While treatment of property can ameliorate potential noise impacts within the internal environment of receptor buildings, the external rail noise levels have the potential to be clearly audible above the ambient noise environment within relatively close proximity of the rail corridor, such as the initial 300 m from the rail corridor.

The assessment of ground-borne vibration identified that vibration levels are expected to be within the assessment criteria further than 16 m from the outer rail line. Any sensitive receptors within 16 m of the outer rail are likely to be within the disturbance footprint of the Project infrastructure. The ground-borne noise assessment criteria from surface railway operations may be triggered where receptors are within 50 m of the outer rail line, noting that at this distance the noise environment is expected to be dominated by airborne noise that would mask the ground-borne noise content.

Railway operations within the Teviot Range Tunnel were assessed to meet the adopted airborne noise, ground-vibration and ground-borne noise criteria. On this basis, the assessment did not identify a need for specific vibration treatments beyond the highly resilient trackform proposed for slab track in the tunnel. Resilient matting for retention of ballast on bridge and viaduct structures would also be considered.

15.10.5 Operational road traffic noise

A desktop assessment of seven new road sections and nine road section upgrades was undertaken in order to predict the potential noise impacts associated with each road alteration. These roads were assessed against relevant criteria from CoP Vol 1. The desktop assessment considered the increase in traffic flows and relative distance to the nearest sensitive receptors for each road. Influence from other dominant noise sources have not been considered.

The operation of the Ipswich–Boonah Road section proposed to be upgraded is predicted to result in one exceedance of the CoP Vol 1 criteria at residential receptor RES0411. These predicted impacts are based on the design and conservative assumptions. These findings should be revisited during detailed design.

15.10.6 Operational tunnel infrastructure noise

Noise from fixed infrastructure has been assessed for the emergency, maintenance and degraded operations of the tunnel. Based on empirically derived fan sound data, the EPP (Noise) acoustic quality objectives are predicted to be achieved at all sensitive receptors.

15.10.7 Noise and vibration management

Overall, the noise and vibration assessment has identified that Project construction works, and railway operational activities, have the potential to influence the local noise environment.

The application of industry standard best practice measures to reduce and control noise and vibration emission(s),emissions, and mitigate potential impacts, have been considered. It is expected the proposed approach to noise and vibration management will achieve the objectives of the relevant policy and guidelines referenced in the ToR for most existing sensitive receptors.

ARTC will develop and implement mitigation measures to manage both temporary (construction) and permanent (operational) noise and vibration emissions generated by the Project. The objective will be to reduce and control noise and vibration in a feasible manner. The intent will be to reduce noise and vibration to levels as low as reasonably practicable (based on engineering, environmental, social and commercial considerations).

The noise and vibration levels will continue to be assessed, and the mitigation requirements verified, during the detail design and construction of the Project.

A program of noise and vibration monitoring will be conducted when the Project railway commences.