INLAND RAIL

CHAPTER 15

Noise and vibration

HELIDON TO CALVERT ENVIRONMENTAL IMPACT STATEMENT

ARTC

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 Summary

The construction and operation of the Helidon to Calvert (H2C) Project (the Project) have the potential to be a source of noise and vibration emissions within the local environment. The Environmental Impact Statement (EIS) for the Project has included detailed studies to assess the noise and vibration emissions, and potential impacts, associated with:

- Construction of the Project, including the railway infrastructure, civil earthworks, local road network upgrades and the Little Liverpool Range tunnel and associated infrastructure
- Use of road networks during the construction works and the upgrades to road networks as a result of the Project
- Railway operations including train pass-bys on the main line track, within the Little Liverpool Range tunnel along with the operation of level crossings and train movements at the crossing loops
- The operation of mechanical plant and ventilation infrastructure associated with the Little Liverpool Range tunnel.

The assessment works have been carried out consistent with the Terms of Reference (ToR) for the Project and the strategies that ARTC will implement to inform the management of potential environmental impacts.

This chapter provides a summary of the assessment methodologies, key findings and the recommended reasonable and practicable measures to reduce noise and vibration levels and ameliorate potential impacts. The assessments are detailed in the following technical reports:

- Appendix O: Noise and Vibration (construction, fixed Infrastructure and operational road noise) Technical Report.
- Appendix P: Operational Railway Noise Vibration Technical Report.

Noise and vibration during construction

Scenarios were developed to assess the reasonable worst-case noise and vibration emissions for each of the main construction activities. Noise prediction modelling was undertaken to determine noise levels associated with the temporary construction works at the fixed work sites and the mobile construction activities along the Project alignment.

While both temporary and transient, the construction activities carried out in proximity of nearby communities can be inherently noisy. The noise levels calculated at sensitive receptors identified the Project will need to develop and implement a range of reasonable and practicable measures to reduce and control noise emissions during the construction program.

The proposed construction works can also be a source of ground-borne vibration, and the assessment determined minimum safe working distances between vibration-intensive construction works and sensitive receptors. The assessment identified where management measures may be required to control ground-borne vibration based on minimising potential impacts to both human comfort and potential structural (cosmetic) damage.

The construction works may require blasting and the assessment has defined blasting parameters that are designed to manage airblast overpressure and blast vibration at nearby sensitive receptors.

The recommendations represent standard industry best practices that can be applied during the construction works to reduce and control the potential impacts from noise, vibration and blasting. These measures will be included in the environmental management plans developed and implemented throughout the construction of the Project.

Road traffic noise

The Project is expected to influence local road traffic networks both temporarily during the construction works and long term through the development of new and upgraded local roads that are required as a result of the Project's railway infrastructure.

The ToR requires that noise from road traffic is assessed and managed in accordance with the Department of Transport and Main Road's (DTMR) *Transport Noise Management Code of Practice: Volume 1—Road Traffic Noise* (CoP Vol. 1) (DTMR, 2013a).

The additional road traffic associated with the construction of the Project will temporarily increase traffic volumes on the road network. Road traffic noise levels would be highest during the first two years of construction, as a result of the expected civil earthworks, with decreasing road traffic noise levels forecast over the rest of the five-year construction program. The calculated road traffic noise during construction works triggered the assessment criteria at nearby sensitive receptors adjacent to seven roads accessed by the Project.

There are five new roads and three proposed upgraded roads where the future (operational) road traffic has been calculated to potentially trigger the adopted assessment criteria at nearby sensitive receptors adjacent to the road network.

Measures to reduce road traffic noise, and manage associated impacts, have been recommended. Options to control road traffic noise through infrastructure, such as noise barriers or earth mounds, will need to be evaluated further during the detailed design and construction of the Project.

Noise from the operation of fixed infrastructure

The assessment determined the implementation of standard noise control measures to the mechanical plant can control noise emissions and predicted noise levels at sensitive receptors would meet the objectives of the EPP Noise Policy. Noise control measures would be verified during detail design and could include attenuators (silencers) for ventilation fans and acoustic lining within the ventilation shaft structures.

Noise and vibration from railway operations

The assessment of noise and vibration from railway operations was undertaken in accordance with the ToR and considered the following DTMR guidelines for the assessment and management of noise from railway infrastructure: *Policy for Development on Land Affected by Environmental Emissions from Transport and Transport Infrastructure* (DTMR Policy) and the *Interim Guideline—Operational Railway Noise and Vibration Government Supported Transport Infrastructure* (Interim Guideline).

The assessment of railway noise has primarily adopted railway noise criteria proposed by ARTC to manage railway noise throughout the national Inland Rail Program (Inland Rail). The noise criteria were developed with reference to regulatory guidelines for railway noise, including those referenced in the ToR. To provide a robust and consistent approach to manage railway noise on Inland Rail, the railway noise criteria adopted by ARTC are generally more stringent than the railway noise assessment criteria from the regulatory guidelines referenced in the ToR.

A detailed noise prediction model for the Project and the surrounding environment was developed to assess airborne noise from railway operations, including daily train pass-bys, trains idling on crossing loops, the operation of level crossings (train horn and crossing alarms) and trains accessing the tunnel portals.

The noise predictions cover an approximately 180 square kilometres (km^2) study area and applied train noise emissions specifically developed for the rolling stock proposed on the Project and the existing trains that will access the new and upgraded railway corridors.

Based on the forecast typical daily train movements with the Project, railway noise levels were calculated at sensitive receptors for the commencement of railway operations in the year 2026 and the forecast railway operations for the future design year 2040.

The assessment identified that railway noise levels would achieve the criteria at the majority of the 7,000 sensitive receptors identified to be within the study area. A total of 328 identified residences and other noise-sensitive uses indicated predicted noise levels that were above the assessment criteria, which triggered a review of reasonable and practicable measures to reduce and control railway noise.

A range of standard, industry best practice noise mitigation options were identified to reduce railway noise levels and mitigate noise impacts, far as reasonable and practicable.

Mitigation measures may include a range of options such as at-property treatment to reduce the intrusion of railway noise and measures to reduce railway noise at its source or restrict the travel of noise outside of the railway corridor (for example railway noise barriers or earth mounds).

An assessment of the potential ground-borne vibration from the railway operations determined that rail movements, on the railway outside of the tunnel achieved the vibration assessment criteria for managing impacts to human comfort and structural (cosmetic) damage at the majority of sensitive receptors. Based on the distance from the outer rail there were two sensitive receptors where the vibration criteria may trigger the consideration of mitigation measures during detail design.

The vibration from train pass-bys can be a potential source of ground-borne noise. The assessment identified that sensitive receptors within 50 metres (m) of the outer rail may experience ground-borne noise levels above the relevant assessment criteria. However, the potential impacts of ground-borne noise may not be fully experienced as the airborne railway noise levels can be the dominant source of noise at the building façades nearest to and facing the rail corridor.

A screening assessment of ground-borne vibration from the train movements within the Little Liverpool Range tunnel determined potential levels at the nearest sensitive receptors to the tunnel would achieve the vibration assessment criteria. The potential ground-borne noise levels from the train movements within the tunnel achieved the assessment criteria at most receptors but triggered a review of noise mitigation at seven sensitive receptors above the tunnel alignment in Laidley.

The detailed design and construction will revise (and update where necessary) the assessment of railway noise and vibration to verify the expected outcomes and, where required, confirm the reasonable and practicable measures to be implemented for the control of railway noise and vibration levels.

Noise and vibration management

The draft Outline Environmental Management Plan (Draft Outline EMP) (refer Chapter 23: Draft Outline Environmental Management Plan) provides measures to managed and mitigate noise and vibration impacts on nearby sensitive receptors. Specific noise management and mitigation measures will be developed and implemented through the Noise and Vibration Sub-plan of the draft Outline EMP.

The potential railway noise and vibration mitigation measures will be confirmed during detailed design and following verification of railway noise and vibration levels once the Project commences operations.

15.2 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 – Helidon to Calvert project, dated October 2017* included:

- Identifying the noise and vibration impact assessment areas appropriate for the construction and operation of the Project
- Identifying nearby noise and vibration sensitive receptors and land uses within the impact assessment areas
- Undertaking baseline noise and vibration measurements within the environment surrounding the Project
- Assessing potential construction and road traffic noise impacts taking into consideration the *Transport Noise Management Code of Practice: Volume 2—Construction Noise and Vibration* (COP Vol.2) and the *Transport Noise Management Code of Practice: Volume 1—Road Traffic Noise* (COP Vol.1)
- Undertaking an operational noise impact assessment for fixed tunnel infrastructure at nearby sensitive receptors, in accordance with the Environmental Protection (Noise) Policy 2019 (EPP Noise)
- Establishing noise assessment criteria for the railway operations of the Project with consideration to the DTMR Policy and the Interim Guideline and the operational railway noise criteria adopted by ARTC for Inland Rail.
- Establishing assessment criteria for ground-borne noise and vibration from railway operations, taking into consideration the DTMR Policy, Interim Guideline, ARTC's proposed criteria for managing ground-borne noise and vibration from railway activities and relevant standards and guidelines.
- Calculating and predicting noise and vibration levels from:
  - construction activities, including blasting
  - construction road traffic
  - railway operations (existing, project opening in 2026 and design year 2040)
  - operation of mechanical plant and infrastructure associated with the tunnel
  - future road traffic once the Project is constructed.
- Evaluating the predicted noise and vibration levels and blasting levels against the assessment limits, goals and objectives to identify where Project sections could trigger an investigation of measures to control noise and vibration emissions and mitigate the identified potential impacts.
- Reviewing reasonable and practicable measures to reduce noise and vibration levels and mitigate potential impacts in line with current industry best practice.
- Assessing the potential residual noise and vibration impacts for the construction and operation of the Project, once mitigation measures were implemented.

15.3 Terms of Reference requirements

The ToR for the Project are defined in *Terms of Reference for an environmental impact statement: Inland Rail—Helidon to Calvert project*, dated October 2017, issued by the Department of State Development, Tourism and Innovation (DSDTI) (formerly Department of State Development, Manufacturing, Infrastructure and Planning (DSDMIP)).

The key requirements, as they related to noise and vibration, are provided in Table 15.1. Compliance of the Environmental Impact Statement (EIS) against the full ToR is documented in Appendix B: Terms of Reference Compliance Table.

TABLE 15.1: TERMS OF REFERENCE—NOISE AND VIBRATION

Terms of Reference requirements		Where addressed
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 15.6 Appendix O: Noise and Vibration (construction, fixed infrastructure and operational road noise) Technical Report, Section 3 Appendix P: Operational Railway Noise and Vibration Technical Report, Sections 6 and 8
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 15.6.1 Appendix O: Noise and Vibration (construction, fixed infrastructure and operational road noise) Technical Report, Section 3.2 and Appendix A Appendix P: Operational Railway Noise and Vibration Technical Report, Sections 6.1, 6.2 and 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.	Section 15.6.2 Appendix O: Noise and Vibration (construction, fixed infrastructure and operational road noise) Technical Report, Section 3.3 Appendix P: Operational Railway Noise and Vibration Technical Report, Section 6.4
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.	Section 15.7 and 15.8 Appendix O: Noise and Vibration (construction, fixed infrastructure and operational road noise) Technical Report, Sections 5 and 6 Appendix P: Operational Railway Noise and Vibration Technical Report, Sections 7, 12.6 and Appendix C
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: a) Environmental Protection Policy (Noise) 2008 (EPP (Noise)), 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	Section 15.4, 15.7 and 15.8 Appendix O: Noise and Vibration (construction, fixed infrastructure and operational road noise) Technical Report, Sections 2, 5 and 6 Appendix P: Operational Railway Noise and Vibration Technical Report, Sections 4, 9 to 14 re b) No Environmentally Relevant Activities (ERAs) are being sought as part of this approval process (i.e. EIS). Where an ERA is required to be sourced for the Project during detailed design, the required approval process will consider this guideline
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.	Section 15.7 and 15.8 Appendix O: Noise and Vibration (Construction, Fixed Infrastructure and Operational Road Noise) Technical Report, Sections, 1.2, 5 and 6 Appendix P: Operational Railway Noise and Vibration Technical Report, Sections 2 and 7

Terms of Reference requirements		Where addressed
11.124.	Taking into account the practices and procedures that would be used to avoid or minimise impacts, the impact prediction must address the: a) activity's consistency with the objectives of documentation referenced in 11.122 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 c) potential impacts of any low-frequency (<200 Hz) noise emissions.	Section 15.8, 15.9, and 15.10 Appendix O: Noise and Vibration (construction, fixed infrastructure and operational road noise) Technical Report, Sections 5 to 7 Appendix P: Operational Railway Noise and Vibration Technical Report, Sections 8 to 15
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.	Section 15.9 Chapter 23: Draft Outline Environmental Management Plan, Section 23.13.8 Appendix O: Noise and Vibration (construction, fixed infrastructure and operational road noise) Technical Report, Section 8 Appendix P: Operational Railway Noise and Vibration Technical Report, Section 16
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.	Section 15.9.3 Appendix O: Noise and Vibration (construction, fixed infrastructure and operational road noise) Technical Report, Section 8.3 Appendix P: Operational Railway Noise and Vibration Technical Report, Section 17
11.127.	Describe how the achievement of the objectives would be monitored and audited, and how corrective actions would be managed.	Chapter 15: Noise and vibration, Section 15.9.2 Chapter 23: Draft Outline Environmental Management Plan, Section 23.13.8 Appendix O: Noise and Vibration (construction, fixed infrastructure and operational road noise) Technical Report, Section 8 Appendix P: Operational Railway Noise and Vibration Technical Report, Section 16.7
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.	Commentary on the influence of local weather conditions on the propagation of railway noise is provided in Section 15.8.8

15.4 Legislation, policies, standards and guidelines

Queensland legislation that defines requirements for the noise and vibration assessment and environmental approval processes for this Project includes:

- *Transport Infrastructure Act 1994* (Qld) (TI Act)
- *Environmental Protection Act 1994* (Qld) (EP Act)
- *Environmental Protection (Noise) Policy 2019*, (EPP(Noise)), subordinate to the EP Act.

Table 15.2 lists key policies, guidelines and plans relevant to the noise and vibration assessment. 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

Guideline or policy	Relevance to Project
Application requirements for activities with noise impacts: ESR/2015/1838 Department of Environment and Science (DES) (DES, 2019b)	Under the EP Act, this guideline provides guidance on the requirements for assessments of noise impacts, including the requirement for supplementary approvals for Environmentally Relevant Activities (ERAs). Approval for ERAs that may be required by the Project will be sought separately to the approval being sought through the EIS process. Appropriate noise and vibration assessments, as required, will be undertaken at a later date, to inform the necessary development approval application(s).
Australian Standard AS 1055.1-1997—Acoustics—Description and measurement of environmental noise, Part 1: General procedures (Standards Australia, 1997b)	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 15.6 was undertaken in accordance with this standard.
Australian Standard 2187.2-2006 Explosives—Storage and Use1 (Standards Australia, 2006a)	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.
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 also used in the operational noise and vibration assessment to inform the establishment of assessment criteria and assessment methodologies for ground vibration.
British Standard BS5228-1:2009 Code of practice for noise and vibration control on construction and open sites—Part 1: Noise (British Standards, 2009a)	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 (British Standards, 2009b)	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.
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.
Development Affected by Environmental Emissions from Transport Policy (DTMR, 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.
Environmental Protection Act 1994 (Qld), Section 440ZB	The EP Act is Queensland overarching environmental legislative framework for the protection and management of environmental values. Environmental Protection Act 1994 (Qld), Section 440ZB Section 440ZB provides requirements for blasting. This standard is prescribed by CoP Vol. 2. Provides blasting
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.

Guideline or policy	Relevance to Project
German Standard DIN 4150-3:1999 Vibration in Buildings—Part 3: Effects on Structures (Deutsches Institut für Normung (DIN), 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.
Guideline—Noise: Noise and Vibration from Blasting Department of Environment and Heritage Projection (DEHP) (DEHP, 2016h)	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.
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 DTMR Interim Guideline has been considered as part of the EIS. ARTC's approach to noise and vibration assessment and management for the operation of Inland Rail is generally more stringent when compared to the DTMR's Interim Guideline. ARTC's approach allows for uniform and consistent assessments (with consideration to public health, amenity and disturbance) across the Inland Rail program.
Technical Basis for Guidelines to Minimise Annoyance due to Blasting Overpressure and Ground Vibration (Australian and New Zealand Environment Council (ANZEC) (ANZEC, 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.
Transport Noise Management Code of Practice Volume 1—Road Traffic Noise (DTMR, 2013a)	The CoP Vol. 1 is a legislative requirement under the 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 (DTMR, 2015a)	The CoP Vol. 2 is gazetted under the 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.
World Health Organisation (WHO) guideline Night Noise Guidelines for Europe (WHO, 2009)	This document provides commentary on environmental noise impacts during the night-time period. The document has not been used to establish criteria, objectives, limits or assessment goals, but rather provides context on contemporary approaches to considering potential night-time noise impacts. The document provides an example of applying the L_{Amax} noise level to evaluate potential for sleep disturbance within the European context. Advice from the WHO acknowledges the establishment of relationships between single event noise indicators, such as $L_{Amax,}$ and long-term health outcomes remains tentative.

15.5 Methodology

The assessment methodology for noise and vibration impacts involved:

- Identifying the noise and vibration impact assessment areas appropriate for the construction and operation of the Project
- Identifying and classifying noise and vibration sensitive receptors and land uses within the impact assessment areas
- Monitoring noise and vibration levels within the environmental surrounding the Project to quantify and characterise the existing acoustic environment and determine baseline noise levels
- Establishing relevant airborne noise, ground-borne noise, ground-borne vibration and blasting criteria for the assessment of potential impacts at sensitive receptors
- Modelling of noise emissions associated with the construction and operation of the Project
- Assessing Project:
  - Noise level predictions against the adopted assessment criteria
  - Ground-borne vibration, ground-borne noise and blasting levels from construction and operation
  - Airblast overpressure and vibration from blasting associated with construction
- Identify reasonable and practicable measures to reduce noise and vibration levels and mitigate potential impacts in line with current industry best practice.

With reference to proposed mitigation measures, assess any potential residual noise and vibration impacts associated with the construction and operation of the Project.

15.6 Existing environment

The EIS investigation corridor is provided as Figure 15.1 and includes the temporary construction disturbance footprint and the permanent operational disturbance footprint for the Project and land within a 1 kilometre (km) radius of the alignment.

The study area for the assessment of noise and vibration covers the land within a 2 km radius of the Project alignment This area is purposely greater than the extents required to demonstrate compliance to the assessment criteria in order to present relevant noise and vibration information to the wider communities and local stakeholders.

The assessment of construction impacts applied Noise Catchment Areas (NCAs) within the noise study area to assist with calculating and evaluating noise and vibration associated with the construction stage of the Project. The assessment of operational noise impacts adopted a catchment extending 2 km either side of the alignment. The land around the EIS investigation corridor is predominantly disturbed rural land. The Project alignment crosses a number of local and private roads, townships, creeks and privately-owned properties.

The Project is located adjacent to the Warrego Highway—a major connecting route to Toowoomba and large western Queensland towns. There are both existing brownfield sections with existing rail infrastructure and proposed greenfield sections along the Project alignment.

There are several towns located along the Project alignment including Helidon, Gatton, Forest Hill, Laidley, Grandchester and Calvert. Outside of the townships, there are several scattered rural residential properties.

The Project also passes through Little Liverpool Range (below Range Crescent in Laidley), which includes mountainous terrain requiring the construction of the Little Liverpool Range Tunnel.

15.6.1 Sensitive receptors

Potentially affected sensitive receptors have been identified throughout the noise and vibration study area. Not all receptor types are considered sensitive in all circumstances. Sensitive receptors considered in the 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 other 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)
- Outdoor recreational area, such as public park or gardens open to the public 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.

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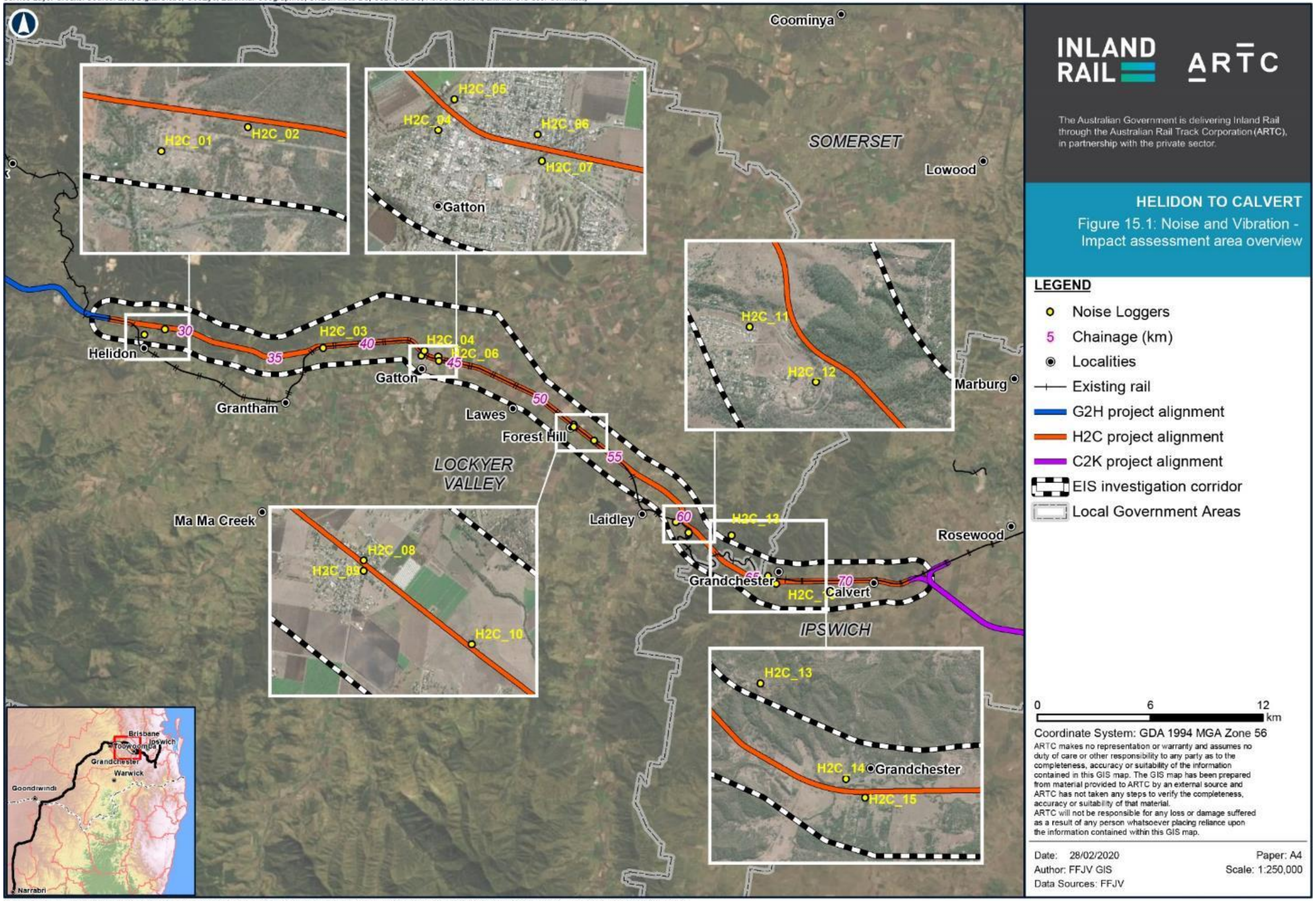

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15.6.2 Noise and vibration monitoring

Baseline noise monitoring was conducted at 15 locations within the noise and vibration study area during November and December in 2018. The monitoring locations were based on aerial photography, identification of nearby sensitive receptors and sites suitable for land access.

The long-term monitoring was used to define the existing noise environment and quantify baseline noise levels for application in establishing the construction noise assessment criteria. The noise surveys were supplemented with noise measurements to determine identify and quantify sources of noise within the local environment of the noise monitors.

The noise and vibration monitoring locations are shown in Figure 15.1. The results of the background noise monitoring are provided in Table 15.3. The Rating Background Levels (RBLs) are typical of rural environments with relatively low noise levels. Key ambient sources influencing existing environs include local road traffic, intermittent train pass-bys events on the existing railway and natural sources, such as birdsong and insects.

TABLE 15.3: EXISTING RATING BACKGROUND NOISE LEVELS

	Rating background level (RBL), A-weighted Decibel (dBA)		
Monitoring location	Day[1]	Evening[1]	Night[1]
H2C_01	39	34	26
H2C_02	38	37	35
H2C_03	44	42	31
H2C_04	38	36	29
H2C_05	38	38	31
H2C_06	39	36	29
H2C_07	48	43	33
H2C_08	39	35	32
H2C_09	40	40	38
H2C_10	32	33	32
H2C_11	31	29	21
H2C_12	33	28	22
H2C_13	34	38	36
H2C_14	38	40	35
H2C_15	35	34	25

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 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.

Ground surface vibration measurements were completed at three locations in July 2019 to quantify the existing ambient vibration levels. A summary of the monitored existing ground vibration levels are provided in Table 15.4.

The monitored levels are presented as the Peak Particle Velocity (PPV) vibration levels for each 15-minute monitoring period. Sources of existing background vibration include vehicle movements and nearby fauna. Each measurement was conducted with a triaxial geophone and the sum of each vector is in Table 15.4. These measurements highlight that the baseline (existing) vibration levels are low with no specific existing dominant sources of vibration identified at the monitoring locations.

TABLE 15.4: BACKGROUND VIBRATION MEASUREMENTS

Site[1]	Date	Time	Peak particle velocity (PPV), mm/s
H2C_V01	04/07/2019	7:05 am–7:26 am	0.13
H2C_V02	03/07/2019	4:55 pm–5:12pm	0.09
H2C_V03	03/07/019	3:25pm–3:57pm	0.10

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.

15.7 Assessment criteria

A range of criteria were applied to assess the potential impacts associated with the noise and vibration from the construction and operation of the Project. In the assessments, where calculated or predicted noise and vibration levels were deemed above the criteria at sensitive receptors, it triggered a review of reasonable and practicable mitigation measures.

The assessment criteria address the airborne noise, ground-borne noise, ground-borne vibration, airblast overpressure and blast vibration emissions associated with the construction and operational activities of the Project are summarised in this section.

15.7.1 Construction noise assessment criteria

15.7.1.1 Construction working hours

The assessment of noise from construction works has referenced DTMR's CoP Vol. 2 (DTMR, 2015a). The CoP includes a definition of standard and non-standard construction works hours, as presented in Table 15.5. The construction hours in the table have been marginally adjusted to reflect the construction work hours proposed for the Project (surface works).

TABLE 15.5: CODE OF PRACTICE VOL. 2 WORK PERIODS FOR CONSTRUCTION ACTIVITIES

<table>
<tr><th>Work period</th><th>General construction and construction traffic</th><th>Blasting</th></tr>
<tr><td>Standard hours</td><td>Monday–Friday 7.00 am to 6.00 pm
Saturday 8.00 am to 1.00 pm</td><td>Monday–Friday 9.00 am to 5.00 pm
Saturday 9.00 am to 1.00 pm</td></tr>
<tr><td>Non-standard hours—day/evening</td><td>Monday–Friday 6.00 pm to 10.00 pm
Saturday 1.00 pm to 10.00 pm
Sunday 7.00 am to 10.00 pm</td><td rowspan="2">Generally, blasting is not to be conducted outside standard hours.
Any blasting outside of standard hours will be approved by DTMR before blasting. It is noted that reduced limits may be required to be achieved.</td></tr>
<tr><td>Non-standard hours—night-time</td><td>Monday–Sunday 10.00 pm to 7.00 am</td></tr>
</table>

Source: DTMR, 2015a

15.7.1.2 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 Table 15.6. The criteria have been adopted from DTMR's CoP Vol. 2 and are for the noise contribution from construction only. The noise criteria levels apply at external façade of receptor buildings and are typically assessed as a façade noise levels at 1.5 m above floor level.

The lowest measured background noise levels from measurement locations within each NCA are shown in Table 15.6. The lower and upper limit for each working period has been based of the methodology outlined in the CoP Vol. 2 and shown in detailed in Appendix O: Noise and Vibration (construction, fixed Infrastructure and operational road noise) Technical Report.

TABLE 15.6: EXTERNAL CONSTRUCTION NOISE CRITERIA

Noise Catchment Area	Period	RBL dBA	External noise level $L_{Aeq,adj,15\ min}$ dBA	
			Lower limit[2]	Upper limit
NCA_01[1]	Standard hours (day)	39	50	65
	Non-standard hours (evening)	34	45	45
	Non-standard hours (night)	26	45	45
NCA_02	Standard hours (day)	44	54	70
	Non-standard hours (evening)	42	47	47
	Non-standard hours (night)	31	47	47
NCA_03[1]	Standard hours (day)	38	50	65
	Non-standard hours (evening)	36	45	45
	Non-standard hours (night)	29	45	45
NCA_04[1]	Standard hours (day)	35	50	65
	Non-standard hours (evening)	32	45	45
	Non-standard hours (night)	31	45	45
NCA_05[1]	Standard hours (day)	31	50	65
	Non-standard hours (evening)	29	45	45
	Non-standard hours (night)	21	45	45
NCA_06[1]	Standard hours (day)	35	50	65
	Non-standard hours (evening)	34	45	45
	Non-standard hours (night)	25	45	45

Table notes:
Equivalent continuous sound level (L_{eq})—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.

1. 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.
2. Where the lower limit value exceeds the upper limit value, the lower limit value is taken to equal the upper limit value.

The definition of standard and non-standard hours as stated in the CoP Vol. 2 is presented in Table 15.5. These have been adjusted slightly to apply to the proposed construction work hours for the Project (surface works).

Other sensitive land uses

The CoP Vol. 2 defines internal construction noise management criteria for critical facilities, which are required to be met, where reasonable and practicable. The criteria, and assessment of potential impacts, apply where the facilities are in operation or occupied. The criteria for sensitive receptors, other than residential, are presented in Table 15.7. A detailed breakdown of each critical facility assessed is included in Appendix O: Noise and Vibration (construction, fixed Infrastructure and operational road noise) Technical Report.

TABLE 15.7: CODE OF PRACTICE VOL. 2 INTERNAL CONSTRUCTION NOISE CRITERIA FOR CRITICAL FACILITIES

Type of occupancy/activity	Internal noise level $L_{Aeq,adj,15min}$ 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

Source: DTMR, 2015a

15.7.2 Construction road traffic noise criteria

Haulage/transportation associated with construction activities on public roads have the potential to create noise issues for existing sensitive receptors. To assess and manage the potential change in road traffic noise with the temporary introduction of construction traffic the CoP Vol. 2 specifies the following criteria:

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

15.7.3 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 15.8.

TABLE 15.8: 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_{Amax} 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.

15.7.4 Construction vibration criteria

Ground-borne vibration criteria for construction works have been referenced from the CoP Vol. 2. The effects of ground-borne vibration are separated into two categories:

- Human comfort—disturbance to building occupants arising from vibration which 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, 2009a)
- Building damage—vibration that may compromise the integrity of the building structure itself or may result in cosmetic damage. The vibration criteria are based on the requirements of *German Standard DIN 4150-3:1999 Vibration in Buildings—Part 3: Effects on Structures* (DIN, 1999).

15.7.4.1 Human comfort

To minimise potential annoyance due to ground-borne construction vibration, the CoP Vol. 2 adopts the vibration criteria in Table 15.9. The lower limits are generally considered to be just perceptible if exceeded. The upper limits are considered to potentially cause significant annoyance if exceeded.

The Project will adopt all reasonable and practicable measures to achieve the lower limit. The CoP Vol. 2 also requires that 'exceedance of the upper limit requires immediate action and extensive community consultation to determine if further mitigation measures are warranted'.

TABLE 15.9: HUMAN COMFORT VIBRATION LIMITS TO MINIMISE ANNOYANCE

Building	Work period	Resultant PPV, mm/s	
		Lower limit	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 (courtrooms)			
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			

Source: CoP Vol. 2 (DTMR, 2016)

15.7.4.2 Building/structural damage

The CoP Vol. 2 refers to the use of DIN 4150-3 (DIN, 1999) as well as BS 5228.2 (British Standards, 2009a) for building damage. DIN 4150-3 (DIN, 1999) provides recommended maximum vibration levels in Table 15.10 to reduce the likelihood of building damage caused by vibration. DIN 4150-3 (DIN, 1999) states that buildings exposed to higher levels of vibration than recommended limits would not necessarily result in damage.

'Damage' is defined by DIN 4150-3 (DIN, 1999) 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 (DIN, 1999) also states that when vibrations higher than the 'safe limits' are present, it does not necessarily follow that damage will occur.

TABLE 15.10: DIN 4150-3 STRUCTURAL DAMAGE 'SAFE LIMITS' FOR 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.

DIN 4150-3 also provides guideline values for evaluating the effects of vibration on buried pipework, which are summarised in Table 15.11. Short-term vibration is defined in DIN 4150-3 as vibration that does not occur often enough to cause structural fatigue, and that does not produce resonance in the structure being evaluated.

TABLE 15.11: DIN 4150-3 GUIDELINE VALUES FOR BURIED PIPEWORK

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

Source: DIN 4150-3

As part of the constructability assessment identification of high-risk utility clashes (with 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.

15.7.5 Blasting

Controlled blasting is anticipated to be required to excavate material along some sections of the Project alignment. Construction blasting can result in two adverse environmental effects related to acoustics—airblast over pressure and ground vibration. The airblast over pressure and ground vibration may cause human discomfort and inappropriately designed and implemented blasts may cause damage to structures, architectural elements and services.

The DEHP *Guideline—Noise and Vibration from Blasting* was 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.

15.7.5.1 Recommended hours and frequency of blasting activities

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

- Blasting will 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 with no blasting on Sundays or Public Holidays
- Generally blasting is not to be conducted outside Standard Hours. Any blasting outside standard hours will be approved by regulatory authorities before blasting. Reduced limits may be required to be achieved.

15.7.5.2 Blasting criteria

The following criteria has been adopted to assess the annoyance from airblast overpressure:

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

For the purposes of the Project, the AS 2187.2 ground vibration criteria for structural/building damage have been adopted, these are detailed in Table 15.12.

TABLE 15.12: BLASTING GROUND VIBRATION FOR STRUCTURAL/BUILDING DAMAGE SUMMARY

Category	Human comfort	Structural damage[1]
Sensitive structures (e.g. residential, theatres, schools etc.)	5 mm/s for 95% blasts per year 10 mm/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)	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 will be kept below manufacture's 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 will be kept below manufacture's 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	50 mm/s maximum unless agreement is reached with the occupier 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

Source: Standards Australia, 2006a

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 additional measurements on the structure. A review of the sensitive receptors did not identify buildings of this nature within the assessment study area.

15.7.6 Operational noise criteria

15.7.6.1 Operational rail—airborne noise

ARTC is implementing a uniform approach for the assessment and management of operational railway noise across Inland Rail to ensure the potential noise related impacts to public health, amenity and disturbance are managed consistently.

The rail noise criteria from the DTMR Policy, Interim Guideline and other Australian railway noise guidelines were considered in the development of the airborne railway noise criteria for the Project. The airborne railway noise criteria adopted by ARTC for residential receptors are detailed in Table 15.13.

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 15.13: AIRBORNE RAILWAY NOISE ASSESSMENT CRITERIA FOR RESIDENTIAL RECEPTORS

Type of development	Noise management levels (external)			
	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:

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, which may result in the widening of an existing rail corridor.

A detailed review of the assessment criteria was undertaken in Appendix P: 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 and the Interim Guideline. 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 non-residential sensitive receptors. On this Project, ARTC is adopting the noise assessment criteria for non-residential sensitive receptors in Table 15.14.

TABLE 15.14: AIRBORNE NOISE MANAGEMENT LEVELS FOR OTHER SENSITIVE RECEPTORS

Type of development	Noise management levels (when receptor premises are in use)	
	New rail line development[1]	Redevelopment of existing rail line[2]
	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)	$L_{Aeq(15hour)}$ 60 dBA (external)	$L_{Aeq(15hour)}$ 65 dBA (external)
Open space—active use (e.g. sports field, golf course)	$L_{Aeq(15hour)}$ 65 dBA (external)	$L_{Aeq(15hour)}$ 65 dBA (external)

Table notes:

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 which may result in the widening of an existing rail corridor.

15.7.6.2 Operational road traffic noise criteria—proposed new roads

There are seven new roads proposed within the noise and vibration study area. Table 15.15 presents the applicable CoP Vol. 1 assessment criteria for different noise sensitive land uses with potential to be affected by new roads.

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

TABLE 15.15: ROAD TRAFFIC ASSESSMENT CRITERIA FOR NEW ROADS

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)

Source: (CoP Vol. 1)

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 higher. Outdoor educational and passive recreational areas are assessed externally and 3.5 m from any reflective surfaces also known as the free field.

15.7.6.3 Operational road traffic noise criteria—upgraded roads

The upgrade of seventeen roads is proposed within the noise and vibration study area. Table 15.16 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 approximate mid window height, whichever is higher.

TABLE 15.16: AIRBORNE NOISE CRITERIA FOR UPGRADED ROADS

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 L_{A10} (18h)	65 L_{A10} (1h)	63 L_{A10} (12h)

Source: (CoP Vol. 1)

15.7.6.4 Fixed infrastructure airborne noise objectives

Noise from fixed infrastructure such as tunnel ventilation fans, pumps and transformers has been assessed against criteria adopted from the EPP (Noise). As maintenance operations can occur in any period during a 24-hour span, the most stringent criteria will be during the night-time period (10.00 pm to 7.00 am). The night-time acoustic quality objectives from the EPP (Noise), Table 15.17 have been used to establish appropriate noise level emissions from fixed infrastructure.

TABLE 15.17: ACOUSTIC QUALITY OBJECTIVES (QUEENSLAND ENVIRONMENTAL PROTECTION (NOISE) POLICY 2019)

Sensitive receptor	$L_{Aeq,1hr}$, dB	$L_{A10,1hr}$, dB	$L_{A1,1hr}$, dB
Residential (indoors— night-time)	30	35	40

Source: EPP (Noise)

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 as a conservative assumption.

15.7.7 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 the train pass-bys in the assessment period. The VDV considers the combined effects of the level of the ground-borne vibration and the duration of the vibration-generating events and, as such, is suited for the assessment of transient sources such as train pass-bys.

The ground-borne vibration assessment criteria for railway operations are detailed in Table 15.18.

TABLE 15.18: RAILWAY GROUND-BORNE VIBRATION ASSESSMENT CRITERIA

		Internal ground-borne vibration criteria	
Type	Sensitive receptors	Use period[1]	Vibration dose value
New railway or upgrading existing railway	Accommodation activities	Daytime	≤ 0.20 m/s1.75
		Evening	
		Night-time	≤ 0.13 m/s1.75
	Educational establishment, childcare centres, health care services, hospitals, community uses, places of worship and offices.	While in use	≤ 0.40 m/s1.75 (all areas)
			≤ 0.10 m/s1.75 (critical areas)

Table notes:
m/s—metres per second.
1 Daytime 7.00 am to 6.00 pm; evening 6.00 pm to 10.00 pm; night-time 10.00 pm to 7.00 am.

15.7.8 Operational railway ground-borne noise assessment criteria

Ground-borne vibration from passing trains 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 comprised by passing trains. The reradiation of vibration as noise within a building is commonly termed ground-borne noise.

ARTC is applying the ground-borne noise criteria in Table 15.19 on the Project, which have been developed with reference to ground-borne noise management levels adopted for Inland Rail. Where ground-borne noise levels are above the trigger levels, the Project will investigate the implementation of reasonable 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 15.19: RAILWAY GROUND-BORNE NOISE ASSESSMENT CRITERIA

		Internal ground-borne noise criteria	
Type of development	Sensitive receptors	Use period[1]	SEM[2]
New railway or upgrading existing railway	Accommodation activities	Daytime	≤ 40 dBA
		Evening/night-time	≤ 35 dBA
	Educational establishments, childcare centres health care services and hospitals	While in use	≤ 35 dBA
	Community uses (excluding a court of law), places of worship and 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; 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.

15.8 Predicted impacts

15.8.1 Airborne construction noise impacts

15.8.1.1 Construction works

In this section, a summary of the predicted noise levels and potential impacts associated with each stage of construction are presented for both standard and non-standard hours construction activities. The assessment considers the number of individual sensitive receptors where the predicted construction noise levels triggered the consideration of reasonable and practicable noise management and mitigation measures.

The predicted noise levels and presented noise triggers conservatively assume construction:

- Works are relatively intensive with the expected plant and equipment required for the activities in simultaneous operation
- Can be carried out at the nearest potential distance from the nearby sensitive receptors.

There is potential for the construction works to be undertaken during both the standard hours and non-standard hours of construction. Consequently, the more stringent noise criteria for non-standard hours could apply for assessing and managing construction noise.

The assessment is representative of a typical worst-case 15-minute periods of noise generating works. The predicted noise levels and potential criteria triggers will be less where; the works are less intensive, such as with fewer plant in operation, undertaken at increasing distance away from sensitive receptors or scheduled to only be conducted during the standard hours of construction.

Furthermore, the construction activities in many locations will be temporary and transient as works move along the alignment. As such, the reported impacts may only be experienced for relatively short time periods, likely ranging from a few days to a few weeks in duration.

Table 15.20 presents the external noise criteria and the number of sensitive receptors that trigger each criteria for different construction activities. Both lower and upper criteria triggers are included for standard and non-standard hours.

The number of noise triggers is broken down for the six different NCAs as the criteria differs for each area. It should be noted that due to the low background noise levels measured during non-standard hours of construction the lower and upper limit are both set to the minimal level as per the CoP Vol. 2.

The Project will require constriction works within several towns and in areas with densely populated communities alongside the railway corridor. Consequently, the assessment has identified the noise criteria are predicted to be triggered at a relatively large number of sensitive receptors given the conservatism in the assessment and the proximity of local communities to the works.

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 each of the assessed construction work scenarios.

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.

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 O: Noise and Vibration (construction, fixed Infrastructure and operational road noise) Technical Report for more detail.

TABLE 15.20: PREDICTED CONSTRUCTION NOISE IMPACTS—NUMBER OF SENSITIVE RECEPTORS EXCEEDING

NCA	Standard hours limits (dBA)		Non-standard hours lower and upper limit[1] (dBA)	Standard hours exceedances		Non-standard hours exceedances
	Upper limit	Lower limit		Exceeding upper limit	Exceeding lower limit	
Laydown						
NCA_01	65	50	45	12	207	309
NCA_02	70	54	47	0	11	49
NCA_03	65	50	45	303	1583	2268
NCA_04	65	50	45	2	202	252
NCA_05	65	50	45	5	461	1027
NCA_06	65	50	45	90	430	642
Structures						
NCA_01	65	50	45	3	202	328
NCA_02	70	54	47	0	29	101
NCA_03	65	50	45	289	1932	2408
NCA_04	65	50	45	15	235	270
NCA_05	65	50	45	1	513	825
NCA_06	65	50	45	49	480	598
Earthworks						
NCA_01	65	50	45	48	308	331
NCA_02	70	54	47	22	212	258
NCA_03	65	50	45	787	2347	2425
NCA_04	65	50	45	201	260	270
NCA_05	65	50	45	179	1136	1182
NCA_06	65	50	45	308	672	734
Drainage						
NCA_01	65	50	45	17	202	298
NCA_02	70	54	47	3	61	220
NCA_03	65	50	45	418	1613	2194
NCA_04	65	50	45	152	225	252
NCA_05	65	50	45	80	625	1069
NCA_06	65	50	45	145	451	625
Rail civil works						
NCA_01	65	50	45	28	258	331
NCA_02	70	54	47	8	128	255
NCA_03	65	50	45	518	1966	2422
NCA_04	65	50	45	174	247	270
NCA_05	65	50	45	120	960	1182
NCA_06	65	50	45	205	549	733
Road civil works						
NCA_01	65	50	45	15	226	313
NCA_02	70	54	47	2	34	172
NCA_03	65	50	45	273	1807	2409
NCA_04	65	50	45	118	220	254
NCA_05	65	50	45	7	332	782
NCA_06	65	50	45	60	406	535

NCA	Standard hours limits (dBA)		Non-standard hours lower and upper limit[1] (dBA)	Standard hours exceedances		Non-standard hours exceedances
	Upper limit	Lower limit		Exceeding upper limit	Exceeding lower limit	
Flash butt welding						
NCA_01	65	50	45	0	0	0
NCA_02	70	54	47	0	0	6
NCA_03	65	50	45	0	66	139
NCA_04	65	50	45	0	0	0
NCA_05	65	50	45	0	0	0
NCA_06	65	50	45	0	0	0
Concrete batching plant						
NCA_01	65	50	45	0	0	0
NCA_02	70	54	47	0	0	2
NCA_03	65	50	45	0	0	0
NCA_04	65	50	45	0	0	0
NCA_05	65	50	45	0	8	24
NCA_06	65	50	45	0	3	8

15.8.1.2 Construction road traffic

During the construction works it is expected that the movement of construction vehicles through the noise and vibration study area will increase, particularly along key roads that will provide access to the alignment for construction.

As part of this assessment, 136 sections of roads have been identified as potential haul routes, for personnel to access the sites and for the delivery and removal of plant, equipment and materials. The relevant noise impacts to each of these sections of roads have been completed based on a desktop assessment of forecast road traffic noise levels allowing for the additional construction traffic. The calculated road traffic noise levels applied the Calculation of Road Traffic Noise methodology, which is recognised in the CoP Vol. 1 as a reliable approach for calculating road traffic noise levels.

Table 15.21 presents the increase in noise levels for additional traffic flows along the roads where noise levels trigger the assessment criteria. The results are presented as the number of identified sensitive receptors where the road traffic noise levels were predicted to trigger the road traffic noise triggering the criteria included in Section 15.7.2.

Sixteen road sections have been predicted to result in a potential increase of 3 dBA or more in LA10(1hr) road traffic noise levels. Road traffic noise from all other roads/routes was assessed to achieve the criteria, and not trigger a review of noise mitigation measures.

Table 15.21 shows that early construction activities require higher volumes of construction traffic and the number of roads triggering the criteria by 2025 drops significantly to just five roads.

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 15.21: ADDITIONAL AIRBORNE NOISE LEVELS FROM CONSTRUCTION TRAFFIC PER YEAR OF CONSTRUCTION

Road name	Road section	Base AADT	AADT with construction	Base $L_{A10(1hr)}$ dBA	Construction $L_{A10(1hr)}$ dBA	Increase in $L_{A10(1hr)}$ dBA
Assessment year—2022						
Calvert Station Road	Between Rosewood Laidley Road and Gipps Street	476	681	46	52	5
Neumann Road	Full extent	108	158	41	46	5
Burgess Road	Between Old Toowoomba Road and Smithfield Road	86	230	40	49	10
Connors Road	Between Airforce Road and Wrights Road	621	911	49	54	5
Hickey Street	Between Old College Road and Buaraba Street	621	918	49	54	5
Mary McKillop Street	Between Turner Street and Arthur Street	563	727	47	51	5
Paroz Road	Between Summer Street and East of Summer Street	20	325	31	52	21
Philps Road	Between Boxmoor Street and Warrego Highway	20	25	31	36	5
Western Drive	Between Warrego Highway and Tenthill Creek Road	58	281	41	51	10
Assessment year—2023						
Calvert Station Road	Between Rosewood Laidley Road and Gipps Street	486	691	46	52	5
Hiddenvale Road	Between Gipps Street and Neumann Road	486	630	46	51	4
Neumann Road	Full extent	110	254	41	49	8
School Road	Between Rosewood Laidley Road and Rafters Road	411	556	47	51	4
Thagoona Haigslea Road	Between Karrabin Rosewood Road and Schumanns Road	411	593	47	52	5
Burgess Road	Between Old Toowoomba Road and Smithfield Road	87	232	40	49	9
Connors Road	Between Airforce Road and Wrights Road	634	924	49	54	4
Hickey Street	Between Old College Road and Buaraba Street	634	931	49	54	5
Mary McKillop Street	Between Turner Street and Arthur Street	575	775	47	52	5
Paroz Road	Between Summer Street and East of Summer Street	20	204	31	50	19
Philps Road	Between Boxmoor Street and Warrego Highway	20	32	31	39	8
Railway Street	Between Summer Street and Laidley Plainland Road	243	498	46	52	6
Western Drive	Between Warrego Highway and Tenthill Creek Road	60	282	41	51	10

Road name	Road section	Base AADT	AADT with construction	Base $L_{A10(1hr)}$ dBA	Construction $L_{A10(1hr)}$ dBA	Increase in $L_{A10(1hr)}$ dBA
Assessment year—2024						
Haigslea Malabar Road	Between Warrego Highway and Mount Marrow Quarry Road	458	757	51	54	4
Neumann Road	Full extent	113	162	41	46	5
Paroz Road	Between Summer Street and East of Summer Street	20	58	31	35	4
Philps Road	Between Boxmoor Street and Warrego Highway	20	50	31	42	11
Railway Street	Between Summer Street and Laidley Plainland Road	248	404	46	51	5
Hampton Street	Between Hursley Road and Rob Street	230	710	45	54	10
Herries Street	Between Dent Street and Water Street North	466	777	49	54	5
Assessment year—2025						
Neumann Road	Full extent	115	112	39	43	4
Paroz Road	Between Summer Street and East of Summer Street	21	67	28	36	8
Western Drive	Between Warrego Highway and Tenthill Creek Road	62	253	38	43	5
Hampton Street	Between Hursley Road and Rob Street	235	442	42	53	11
Herries Street	Between Dent Street and Water Street North	476	650	46	54	8

Table note:
AADT—Average Annual Daily Traffic.

In addition to the roads in Table 15.21, there are state-controlled roads that are proposed to be used for construction traffic movements. The predicted increase in the existing total traffic volumes for these roads is below 20 per cent throughout each year of construction. This is a relatively minor temporary increase to the traffic volumes on these roads and consequently the predicted increase in road traffic noise levels is expected to be below 3.0 dBA and would not trigger the assessment criteria at sensitive receptors adjacent to the state-controlled roads.

15.8.2 Construction vibration impacts

Vibration-intensive work is likely to be undertaken at times as part of the construction works. This may include the use of piling rigs and vibratory rolling activities at the ground surface. These sources would be the primary source of ground-borne vibration and have been the subject to the development of recommended minimum safe working distances from nearby sensitive receptors to achieve the assessment criteria adopted for the control of cosmetic or structural damage and human discomfort impacts. Results are provided in Table 15.22.

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.

TABLE 15.22: RECOMMENDED MINIMUM WORKING DISTANCES FOR VIBRATION-INTENSIVE EQUIPMENT

	Predicted setback distance, meters						
Plant Item	Human comfort—lower limit (night)	Human comfort—lower limit (day) upper limit (night)	Human comfort—upper limit (day)	Building damage limit (Heritage)	Building damage	Buried pipework (masonry, plastic or metal)	Buried pipework (steel)
Limit (PPV)	0.3 mm/s	1.0 mm/s	2.0 mm/s	2.5 mm/s	5.0 mm/s	50 mm/s	100 mm/s
Vibratory roller—vibration start-up/ rundown	45–330	20–130	10–70	7–65	5–30	<5	<5
Vibratory roller—steady state	35–200	10–90	6–50	6–50	5–30	<5	<5
Vibratory piling	45–280	20–100	10–60	10–40	5–30	<5	<5
Percussive piling, impact breakers[1]	145–690	60–275	35–160	30–120	20–80	<5	<5

Table note:

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.

The CoP Vol. 2 recommends the use of practicable and reasonable mitigation to minimise vibration impacts. These mitigation measures are discussed in Section 15.9.2.

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 minimum working distances for cosmetic damage are generally considered to be conservative and working within these distances will not necessarily result in damage. However, as factors such as work practices and intervening ground conditions can affect vibration levels, vibration monitoring would be carried out at the beginning of the work to refine the minimum working distances for site-specific conditions. This monitoring will be important for sensitive locations, including residential areas and heritage buildings and structures as vibration may be an issue in these areas.

A summary of the total exceedances for each construction activity is in Table 15.23.

There are approximately 50 sensitive receptors within the temporary construction disturbance footprint. Consistent with the construction noise assessment, these receptors will require specific management and mitigation measures to control potential impacts to receptors in close proximity to the works.

Additional detail is provided in Appendix O: Non-Operational Noise and Vibration Technical Report.

TABLE 15.23: 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			
	Best [1]	Worst [2]	Best [1]	Worst [2]	Best [1]	Worst [2]	Best [1]	Worst [2]	Best [1]	Worst [2]
Site setup/laydown areas										
Vibratory roller —start- up/run-down	2	205	0	117	17	587	2	179	0	33
Vibratory roller —steady-state vibration	1	144	0	67	12	313	1	136	0	20
Structures										
Piling —vibratory	1	2	0	1	6	17	1	2	0	0
Piling —percussive	7	282	2	95	70	1299	7	239	1	11
Earthworks/drainage/rail civil works										
Vibratory roller —start- up/run-down	31	560	13	375	90	1093	28	528	2	199
Vibratory roller —steady-state vibration	21	428	11	310	63	730	20	402	1	160
Road civil works										
Vibratory roller —start- up/run-down	17	253	14	177	49	608	17	234	6	94
Vibratory roller —steady-state vibration	14	199	12	141	30	347	14	188	6	75

Table notes:
1. Best-case calculation assumes scaling factors and parameters in formulae to produce lowest number of predicted exceedances.
2. Worst-case calculation assumes scaling factors and parameters in formulae to produce highest number of predicted exceedances.

15.8.3 Blasting

There are five locations that have been identified where blasting may be required along the Project alignment. Two of these locations are part of the tunnel construction (with blasting from tunnel construction discussed further in Section 15.8.6). The other three locations are part of the construction works for the surface railway infrastructure, with predicted blast management recommendations included in Table 15.24.

The closest sensitive receptor outside the construction footprint has been assessed to identify conservative maximum permissible charge weights for each location. The recommended blasting parameters have been calculated using the method outlined in BS 5228 (British Standards, 2009a).

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.

The maximum charge weight has been calculated for the distance to the closest sensitive receptor for each potential blasting locations. These limits have been assessed based on worst-case assumptions for a confined blast and applying reasonable technical assumptions based on information available at the time of the EIS. Once detailed geotechnical information is known these limits may be able to be increased.

The closest sensitive receptor is located 31 m from the construction footprint, as such the permissible charge weight is under 2 kg to comply with the airblast overpressure structural damage limit. This is a low amount of charge mass and other excavation methods such as rock breaker attached to an excavator to reduce the impacts will likely need to be considered to avoid blasting in close proximity to sensitive receptors.

All locations where blasting is required will need to be confirmed by the contractor and the mitigation measures included in Section 15.9 are to be applied.

TABLE 15.24: MAXIMUM PREDICTED PERMISSIBLE CHARGE WEIGHT RANGES (INDICATIVE BLASTING LOCATIONS)

			Predicted maximum permissible charge weight (kilograms (kg))			
Chainage reference	Closest sensitive receptor	Distance from earthworks footprint (m)	Ground vibration—human comfort	Ground vibration—structural damage	Airblast overpressure—human comfort	Airblast overpressure—structural damage
Ch 28.33 km–Ch 29.45 km	RES0372	31	<2	4	<2	<2
Ch 32.91 km–Ch 33.27 km	RES0424	208	45	190	7	520
Ch 59.83 km–Ch 60.65 km	RES4708	184	35	150	5	360

15.8.4 Tunnel construction

15.8.4.1 Ground-borne vibration from roadheader operations

A roadheader is proposed as part of the excavation of the Little Liverpool Range tunnel. Ground-borne vibration, and potential associated ground-borne noise, due to the operation of the roadheader have been calculated using the detailed methodologies presented in Appendix O: Noise and Vibration (construction, fixed Infrastructure and operational road noise) Technical Report.

The assessment is generally conservative, relying on technical assumptions for the vibration emitted by the excavation activity and the surrounding geotechnical conditions. The forecast PPV (mm/s) vibration levels trigger the ground-borne vibration criteria at the sensitive receptors in the vicinity of the tunnel were applied to evaluate the potential for impacts to structural damage to property and/ or disturbance to human comfort within occupied buildings. The assessment considered the closest 70 sensitive receptors to the tunnel, properties beyond this distance (greater than 430 m) were a sufficient distance from the proposed works for potential vibration levels to meet the assessment criteria.

15.8.4.2 Building damage

The vibration levels predicted at the foundations of sensitive receptors were well below the conservative criterion of 2.5 mm/s for damage due to vibration at heritage and sensitive buildings. This means that there is a low risk of damage from ground-borne vibration during the excavations with the roadheader works.

The eastern tunnel portal is located within 63 m of the existing West Moreton System rail corridor. A PPV of 0.6 mm/s is predicted at the rail line, which is below that of the heritage/sensitive building limit for structural damage, and below that of the long-term plastic/masonry pipe vibration guideline of underground services.

15.8.4.3 Amenity

Vibration levels predicted on the ground floor slab or floors of buildings were found to comply with the upper limit for dwellings during non-standard working hours criteria in the CoP Vol. 2 (1 mm/s). However, vibration levels are predicted to be above the lower limit for dwellings during non-standard working criteria of 0.3 mm/s at approximately 10 properties along Range Crescent and Kessling Drive in Laidley.

At the EIS stage, the assessment is a risk assessment of potential impacts, consequently further detailed investigation of potential ground-borne vibration levels at sensitive receptors will be required during detailed design and construction once the use of the roadheader is further developed and geotechnical investigation are completed.

15.8.4.4 Existing underground services and infrastructure

The assessment of vibration from the roadheader also includes the potential for structural damage impacts to buried services and infrastructure. At the EIS stage, general assumptions were applied with respect to the potential services buried in proximity of the tunnel alignment.

The long-term vibration guideline values from the DIN 4150-3 (DIN, 1999) were referenced to adopt an assessment guideline criteria of 25 mm/s to evaluate potential impacts to structures of masonry and plastic. The forecast vibration emission levels identified the ground-borne vibration levels would potential be less than 25 mm/s at 5 m or greater from the roadheader.

In practice, there is potential that the Project could relocate any services located with 5 m of the roadheader alignment prior to the commencement of tunneling construction. As such the assessment concludes there is a low risk of vibration impacts to buried services during the tunnel construction, but this will need to be verified during the detail design phase.

15.8.5 Ground-borne construction noise impacts

The prediction of ground-borne noise associated with the vibration generated from roadheader operations applied conservative assumptions i.e. propagation through rock, no impedance changes at below-ground formation change, or losses for foundation types at receiving buildings. Applying peak velocity values to determine ground-borne noise was assessed as the L_{ASMax} noise metric.

Ground-borne noise due to the roadheader has been predicted to trigger the ground-borne noise criteria defined in the DTMR CoP Vol. 2 within 430 m of the 3-dimensional distance from the tunnel centre line. Each receptor predicted to exceed the ground-borne noise criteria has been presented in Appendix O: Noise and Vibration (construction, fixed Infrastructure and operational road noise) Technical Report, with their respective predicted level labelled. In summary, it was found that:

- Properties within an approximate diagonal distance of 430 m from the works will exceed the dwellings—standard hours criteria of 40 dB L_{ASMax}. There are 39 sensitive receptors predicted to exceed the criteria.
- Properties within an approximate distance of 430 m will exceed the dwellings – non-standard hours criteria of 35 dB L_{ASMax}. There are 29 sensitive receptors predicted to exceed the criteria.

Mitigation measures to manage ground-borne construction noise exceedances are included in Section 15.9.2.

15.8.6 Blasting vibration predictions from tunnelling construction

There is potential for the tunnel construction to require some blasting. Vibration due to blasting is predicted based upon 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 was conducted.

A range of site constants were assessed against a range of instantaneous charge sizes as presented in Table 15.25. The predicted PPV levels at various distances for different site constants and charge sizes are presented in Figure 15.2.

Figure 15.2 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 would occur before major blasting works to determine site-specific site constants to understand the potential impacts.

Vibration from blasting has been assessed at a distance equivalent to the closest property to the alignment. This property is approximately 55 m from the outer tunnel dimension. Using a site and rock constant of 3,724 and 1.72 (the value that results in the highest PPVs, as the tunnel site is presumed to be 100 per cent rock formation and therefore minimal damping), it was found that the instantaneous charge size should be no more than 1.39 kg to achieve the human comfort criteria of 5 mm/s at this property; however, charge size will be assessed for site-specific constants based on site-specific (much smaller) test charges.

Vibration due to blasting would also be assessed for underground services after true site constants have been determined.

There are no explicit criteria to assess sleep disturbance from blasting. The DTMR CoP Vol. 2 states '*Generally, blasting is not to be conducted outside standard hours. Any blasting outside of standard hours will be approved by the department prior to blasting. It is noted that reduced limits may be required to be achieved*'.

15.8.7 Commissioning 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.

TABLE 15.25: INSTANTANEOUS CHARGE SIZE (KG) AND SITE CONSTANTS

Plot shading in Figure 15.2	Instantaneous charge size (kg)	Site constant (K_g)	Rock constant (*B*)	Source of site constant
Red	500	1140	1.60	AS2187.2
		2062	1.60	Average from literature search quoting no more than 5% of blasts should exceed assessment's criterion
		3724/2550	1.72/1.60	Maximum predicted 5th percentile PPV from literature search[1]
Blue	100	1140	1.60	AS2187.2
		3099	1.60	Average from literature search quoting no more than 5% of blasts should exceed assessment's criterion
		3724/2550	1.72/1.60	Maximum predicted 5th percentile PPV from literature search[1]
Green	10	1140	1.60	AS2187.2
		3099	1.60	Average from literature search quoting no more than 5% of blasts should exceed assessment's criterion
		3724/2550	1.72/1.60	Maximum predicted 5th percentile PPV from literature search[1]
Yellow	1	1140	1.60	AS2187.2
		3099	1.60	Average from literature search quoting no more than 5% of blasts should exceed assessment's criterion
		3724/2550	1.72/1.60	Maximum predicted 5th percentile PPV from literature search

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

Table note:

1. K_g 3724 and *B* 1.72 predicted a higher PPV for a specific charge size closer to the receiver, and K_g 2550 and *B* 1.6 predicted higher PPV for the same charge size but at further distances. Distance depends on charge size.

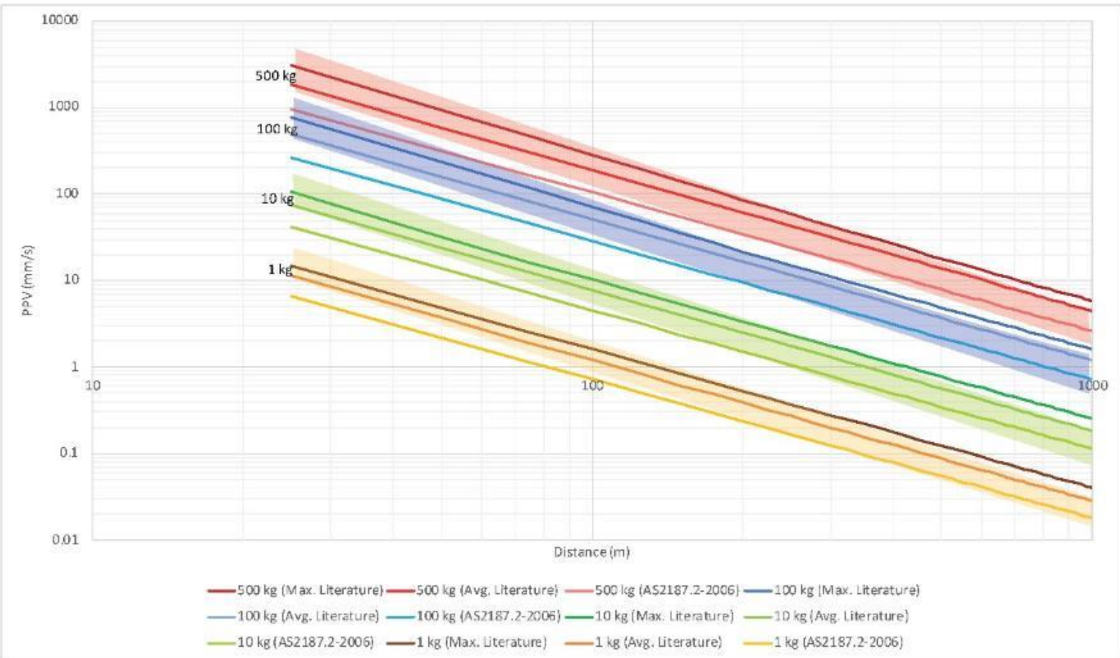


FIGURE 15.2: PREDICTED PPV (MM/S) AT A DISTANCE (M) BASED ON INSTANTANEOUS CHARGE SIZE (KG) AND SITE CONSTANTS

15.8.8 Operational noise impacts

The following sections discuss the assessment of noise from the operation of the Project, which includes the daily train movements along the sections of existing and new railway corridors and the future road traffic on the new and upgraded road networks.

15.8.8.1 Rail freight operations

A detailed noise prediction model was developed to calculate the noise emission levels from the forecast train operations on the Project. The railway noise levels were predicted, at approximately 7,000 sensitive receptors, for the commencement of railway operations on the Project in the year 2026 and the future design year for railway operations in 2040.

The noise modelling and predicted railway noise levels at the sensitive receptors are discussed in detail in Appendix P: Operational Railway Noise and Vibration Technical Report. The railway noise levels, and key assessment outcomes, have been summarised in this chapter.

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 L_{Aeq} and L_{Amax} 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 the 7,000 (approximate) assessed sensitive buildings included within the noise assessment study area.

The railway noise criteria from the DTMR Policy (2010; 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 15.26.

The predicted noise levels identified that noise mitigation would need to be investigated for up to 285 sensitive residential receptors at project opening in 2026. An additional 30 sensitive residential receptors triggered the assessment criteria at the design year 2040, a total of 315 sensitive residential receptors.

The totals in Table 15.26 include the residential receptors and the other sensitive receptor categories.

These sensitive receptors are located within the townships of Gatton, Forest Hill and the Valley Vista Estate and individual dwellings located along the Project alignment. The majority were identified from aerial imagery to be residential receptors with an additional 13 non-residential sensitive receptors, including places of workshop and local schools identified to trigger the assessment criteria.

The location of the sensitive receptors are presented in a series of maps in Appendix P: Operational Railway Noise and Vibration Technical Report, which includes mapping of both the receptors triggering a review of mitigation and noise contour maps for the Project alignment.

Table 15.26 shows that approximately half of the noise criteria triggers are by 3 dBA or less, which is a relatively minor margin given that mitigation measures to screen noise, such as noise barriers or earth mounds, can often achieve noise level reductions of more than 5 dBA at adjacent receptors.

TABLE 15.26: OPERATIONAL RAILWAY NOISE ASSESSMENT SUMMARY

Assessment criteria margin	Sensitive receptors triggering the criteria (number)
Year 2026—Project opening	
1 dBA to 3 dBA	142
>3 dBA to 5 dBA	48
>5 dBA to 10 dBA	61
>10 dBA	34
Total residential receptors triggering noise mitigation—Project opening	285
Year 2040—design year	
1 dBA to 3 dBA	154
>3 dBA to 5 dBA	51
>5 dBA to 10 dBA	73
>10 dBA	37
Total residential receptors triggering noise mitigation—design year	315 [1]

Table note:
1. Including the 285 receptors triggering in 2026.

The investigation of noise mitigation was primarily triggered by night-time railway operations, based on:

- Noise criteria for the night-time are typically 5 dBA more stringent than during the daytime.
- 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 noise mitigation measures, including concept options for railway noise barriers, are discussed in Section 15.9.2.1.

The railway noise levels will continue to be assessed during the detail design and construction phases of the Project to verify the outcomes of this assessment and confirm the requirement for noise mitigation measures.

15.8.8.2 Residential sensitive receptors

The predicted noise levels at the sensitive residential receptors triggering an investigation of noise mitigation for the highest predicted railway noise levels for operations in 2040 are detailed in Table 15.27.

To aid in the assessment of the results, predicted noise contour maps are provided as Figure 15.3a to Figure 15.3g.

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 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 P: Operational Railway Noise and Vibration Technical Report.

TABLE 15.27: PREDICTED NOISE LEVELS AT RESIDENTIAL RECEPTORS TRIGGERING NOISE MITIGATION

Sensitive receptor ID	Noise level from main line and crossing loops, dBA		Noise from 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}
275291	57	82	60	82	61	82
275520	58	83	60	83	62	83
275660	60	84	61	83	64	84
275674	59	85	62	85	64	85
275926	61	84	59	81	63	84
275977	59	82	59	82	62	82
276007	58	83	59	83	62	83
276084	59	84	60	84	63	84
276117	61	85	60	83	63	85
276134	63	87	59	82	64	87
276140	59	85	61	85	63	85
276186	62	86	52	75	63	86
276207	64	90	67	90	69	90
276215	62	86	63	85	66	86
276246	62	87	63	87	66	87
276249	63	90	66	90	68	90
276288	60	83	59	82	62	83
276378	65	96	73	96	73	96
276388	61	85	55	78	62	85
276470	67	91	52	75	67	91
276505	66	90	65	89	68	90
276507	65	89	55	78	65	89
276517	66	90	66	90	69	90
276534	71	96	<40	<60	71	96
276546	67	91	55	78	67	91
276585	71	95	66	90	72	95
276593	70	94	62	85	70	94
276634	73	97	72	96	76	97
276783	64	88	51	74	64	88
276801	65	93	69	93	70	93
276829	59	82	48	70	59	82
276898	64	93	69	93	70	93
276907	64	88	65	88	67	88
276942	61	87	64	87	66	87
276950	65	94	70	94	71	94
277198	61	85	59	81	63	85
277503	59	83	58	80	62	83
277504	58	83	60	83	62	83
277592	58	82	60	82	62	82
277601	65	88	45	68	65	88
277711	57	81	60	81	62	81

Sensitive receptor ID	Noise level from main line and crossing loops, dBA		Noise from 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}
277774	56	82	59	82	61	82
277921	61	85	42	64	61	85
278401	61	84	<40	<60	61	84
278569	61	82	<40	<60	61	82
278640	61	85	<40	<60	61	85
278958	57	84	<40	<60	57	84
283220	56	78	<40	<60	56	78
283365	56	79	<40	<60	56	79
284665	61	84	<40	<60	61	84
284772	63	86	<40	60	63	86
285425	60	83	40	62	60	83
285505	58	81	<40	61	58	81
285513	56	79	<40	<60	56	79
285769	57	80	<40	<60	57	80
285796	59	83	<40	<60	59	83
285798	59	82	<40	<60	59	82
285802	60	84	<40	<60	60	84
285813	57	82	<40	<60	57	82
285827	58	81	<40	<60	58	81
285836	58	82	<40	<60	58	82
285848	56	80	<40	<60	56	80
285850	59	82	<40	<60	59	82
285873	59	84	<40	<60	59	84
285902	61	84	<40	<60	61	84
285903	57	81	<40	<60	57	81
285918	59	83	<40	<60	59	83
285946	63	87	<40	<60	63	87
285962	59	83	<40	<60	59	83
285964	62	86	<40	<60	62	86
285988	60	84	<40	<60	60	84
286034	56	79	<40	<60	56	79
286035	60	84	<40	<60	60	84
286048	61	84	<40	<60	61	84
286063	60	84	<40	<60	60	84
286080	61	84	<40	<60	61	84
286120	58	81	<40	<60	58	81
286124	64	88	<40	<60	64	88
286131	57	80	<40	<60	57	80
286147	58	82	<40	<60	58	82
286156	64	88	<40	<60	64	88
286215	58	82	<40	<60	58	82
286222	67	92	<40	<60	67	92

Sensitive receptor ID	Noise level from main line and crossing loops, dBA		Noise from 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}
286336	63	87	<40	<60	63	87
286349	64	88	<40	<60	64	88
286363	66	90	<40	<60	66	90
286864	68	92	<40	<60	68	92
286928	57	81	<40	<60	57	81
287013	70	94	<40	<60	70	94
287076	70	94	<40	<60	70	94
287217	69	94	<40	<60	69	94
287534	59	83	<40	<60	59	83
287571	56	80	<40	<60	56	80
287627	57	81	<40	<60	57	81
287780	56	80	<40	<60	56	80
287818	56	80	<40	<60	56	80
287856	57	81	<40	<60	57	81
287863	58	82	<40	<60	58	82
287887	57	81	<40	<60	57	81
287895	58	82	<40	<60	58	82
287905	56	80	<40	<60	56	80
287906	57	81	<40	<60	57	81
287910	58	82	<40	<60	58	82
287914	59	83	<40	<60	59	83
287919	57	81	<40	<60	57	81
287932	59	82	<40	<60	59	82
287933	57	81	<40	<60	57	81
287935	57	81	<40	<60	57	81
287946	57	81	<40	<60	57	81
287952	57	81	<40	<60	57	81
287969	56	80	<40	<60	56	80
287972	57	81	<40	<60	57	81
287979	57	81	<40	<60	57	81
287991	56	80	<40	<60	56	80
287999	57	81	<40	<60	57	81
288001	57	81	<40	<60	57	81
288041	59	83	<40	<60	59	83
288074	57	81	<40	<60	57	81
288105	58	82	<40	<60	58	82
288181	57	81	<40	<60	57	81
288204	63	87	<40	<60	63	87
288247	56	80	<40	<60	56	80
288372	57	81	<40	<60	57	81
288431	58	82	<40	<60	58	82
292051	69	92	46	68	69	92

Sensitive receptor ID	Noise level from main line and crossing loops, dBA		Noise from 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}
292640	70	94	52	74	70	94
292861	58	81	58	81	61	81
293015	56	84	61	84	62	84
293023	59	85	61	85	63	85
293036	57	81	59	81	61	81
293060	59	82	59	82	62	82
293078	63	87	63	86	66	87
293186	57	82	59	82	61	82
293422	66	95	71	95	72	95
293460	56	81	60	81	61	81
293482	67	96	72	96	73	96
293501	60	86	63	86	65	86
293519	67	96	73	96	74	96
293542	67	95	72	95	73	95
293562	57	84	61	84	62	84
293582	67	95	71	95	73	95
293620	66	96	72	96	73	96
293635	60	87	63	87	65	87
293640	66	90	68	90	70	90
293684	67	94	70	94	72	94
293724	67	91	69	91	71	91
293753	67	93	71	93	72	93
293785	68	95	72	95	73	95
293786	58	81	58	81	61	81
293808	66	94	70	94	72	94
293829	59	82	58	82	62	82
293834	67	95	71	95	73	95
293900	70	97	73	97	75	97
293930	62	87	64	87	66	87
293949	70	94	71	94	73	94
293987	58	83	59	83	62	83
293988	61	84	61	84	64	84
294040	68	98	75	98	75	98
294061	59	83	59	83	62	83
294070	70	96	72	96	74	96
294127	63	86	62	86	66	86
294131	60	84	57	79	62	84
294169	69	101	77	101	77	101
294205	61	86	64	86	66	86
294229	64	99	75	99	75	99
294244	59	82	56	78	61	82
294251	61	93	69	93	70	93

Sensitive receptor ID	Noise level from main line and crossing loops, dBA		Noise from 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}
294269	61	87	63	87	65	87
294323	62	95	72	95	72	95
294331	58	86	63	86	64	86
294352	70	94	69	93	72	94
294368	58	83	60	83	62	83
294377	58	86	63	86	64	86
294378	64	87	54	76	64	87
294381	60	91	67	91	68	91
294407	70	93	69	93	73	93
294411	60	83	53	75	61	83
294431	58	82	58	82	61	82
294433	59	88	64	88	65	88
294468	63	86	57	81	64	86
294485	57	85	61	85	62	85
294486	59	86	63	86	64	86
294493	63	86	57	80	64	86
294521	58	87	63	87	64	87
294525	56	82	60	82	61	82
294529	63	86	57	79	64	86
294562	63	86	56	79	64	86
294583	56	83	60	83	62	83
294604	63	86	56	78	63	86
294607	62	85	54	76	62	85
294617	55	81	59	81	61	81
294623	57	81	60	81	61	81
294629	55	82	59	82	61	82
294648	60	83	53	73	61	83
294676	55	82	59	82	61	82
294690	60	83	55	77	61	83
294719	61	84	50	72	61	84
294751	63	86	57	80	64	86
294822	62	85	52	74	62	85
294930	64	88	52	75	64	88
295052	67	91	52	74	67	91
295281	70	93	54	76	70	93
295387	59	83	58	81	62	83
297282	65	91	68	91	70	91
297312	70	95	72	95	74	95
298858	63	87	52	74	64	87
304636	66	90	<40	<60	66	90
305136	66	90	<40	<60	66	90
305635	61	84	<40	<60	61	84

Sensitive receptor ID	Noise level from main line and crossing loops, dBA		Noise from 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}
305652	62	86	<40	<60	62	86
305678	61	84	<40	<60	61	84
305687	67	90	<40	<60	67	90
305697	61	85	<40	<60	61	85
305724	61	85	<40	<60	61	85
305746	61	84	<40	<60	61	84
305775	61	85	<40	<60	61	85
305881	62	85	<40	<60	62	85
305889	68	92	<40	<60	68	92
305921	62	86	<40	<60	62	86
305947	61	85	<40	<60	61	85
305967	61	85	<40	<60	61	85
305995	61	85	<40	<60	61	85
306402	71	95	<40	<60	71	95
306631	63	89	<40	<60	63	89
306676	63	88	<40	<60	63	88
306773	65	91	<40	<60	65	91
306898	68	92	<40	<60	68	92
306903	62	86	<40	<60	62	86
306939	69	93	<40	<60	69	93
306948	69	93	<40	<60	69	93
306950	69	93	<40	<60	69	93
306961	65	89	<40	<60	65	89
306985	64	88	<40	<60	64	88
307023	63	87	<40	<60	63	87
307027	70	93	<40	<60	70	93
307028	69	93	<40	<60	69	93
307071	70	94	<40	<60	70	94
307081	61	84	<40	<60	61	84
307096	66	90	<40	<60	66	90
307132	62	86	<40	<60	62	86
307157	61	85	<40	<60	61	85
307192	70	96	<40	<60	70	96
307196	61	84	<40	<60	61	84
307198	61	85	<40	<60	61	85
307284	66	93	<40	<60	66	93
307297	71	96	<40	<60	71	96
307304	65	88	<40	<60	65	88
307305	70	96	<40	<60	70	96
307353	62	88	<40	<60	62	88
307407	61	87	<40	<60	61	87
307413	65	88	<40	60	65	88

Sensitive receptor ID	Noise level from main line and crossing loops, dBA		Noise from 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}
307486	57	81	<40	<60	57	81
307489	61	86	<40	<60	61	86
307525	65	89	40	62	65	89
307526	61	85	42	65	61	85
307599	61	85	<40	<60	61	85
307775	61	84	<40	61	61	84
307824	63	87	<40	62	63	87
307910	61	84	<40	61	61	84
307941	61	85	<40	<60	61	85
307954	62	86	<40	63	62	86
307957	63	86	<40	<60	63	86
307966	63	86	<40	60	63	86
308066	68	92	<40	61	68	92
308119	61	84	<40	<60	61	84
308190	61	83	<40	<60	61	83
308252	61	84	<40	<60	61	84
308275	64	87	<40	<60	64	87
308289	63	87	<40	<60	63	87
308305	52	79	56	79	58	79
308318	61	84	<40	<60	61	84
308384	65	89	<40	<60	65	89
308391	62	85	<40	<60	62	85
308490	56	80	<40	<60	56	80
308511	54	79	57	79	59	79
308640	60	83	42	64	60	83
308672	68	91	46	67	68	91
308679	65	91	<40	<60	65	91
308747	61	88	64	88	66	88
308768	62	86	51	73	62	86
308913	56	80	<40	<60	56	80
308988	62	85	<40	<60	62	85
309080	70	93	49	72	70	93
309105	70	93	54	76	70	93
309126	56	79	<40	<60	56	79
309129	61	85	61	85	64	85
309133	60	84	55	78	61	84
309146	62	86	59	82	64	86
309161	59	83	55	77	60	83
309175	57	81	49	71	58	81
309205	57	81	51	74	58	81
309813	69	93	<40	<60	69	93
309839	61	85	<40	<60	61	85

Sensitive receptor ID	Noise level from main line and crossing loops, dBA		Noise from 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}
309918	63	86	<40	<60	63	86
310159	61	84	<40	<60	61	84
324136	57	81	<40	<60	57	81
324139	56	79	<40	<60	56	79
324140	56	80	<40	<60	56	80
324141	58	82	<40	<60	58	82
324142	58	81	<40	<60	58	81
324157	57	81	51	74	58	81
324211	64	88	<40	<60	64	88
324212	60	84	<40	<60	60	84
324213	66	90	<40	<60	66	90
324214	59	83	<40	<60	59	83
324215	61	85	<40	<60	61	85
324216	59	83	<40	<60	59	83
324223	61	84	<40	<60	61	84
324224	59	83	<40	<60	59	83
324225	63	87	<40	<60	63	87
324244	56	80	<40	<60	56	80
324245	57	80	<40	<60	57	80
324262	57	81	<40	<60	57	81
324263	58	81	<40	<60	58	81
324264	58	83	<40	<60	58	83

Table note:
While overall noise levels are presented as integers, the noise levels were assessed to one decimal place.

15.8.8.3 Trains accessing the crossing loops

The assessment of L_{Aeq} and L_{Amax} railway noise included the contribution of railway operations at the crossing loops. A review of the predicted noise levels at the sensitive receptors determined the noise level contribution from the crossing loops were up to $L_{Aeq(15hour)}$ 50 dBA daytime, $L_{Aeq(9hour)}$ 52 dBA night-time and L_{Amax} 56 dBA for both the daytime and night-time periods.

The predicted noise levels from the crossing loops were within the ARTC noise management criteria and are lower than the railway noise levels from the daily train 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 predicted daytime and night-time predicted noise levels at the sensitive receptors.

15.8.8.4 Operation of the level crossings

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

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.

At each active level crossing the noise sources included; a single alarm bell and two train horn source emissions, one located on either side of the crossing to account for trains approaching from either direction.

The number of sensitive receptors where the level crossing events are triggering the railway noise criteria are summarised in Table 15.28. 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.

TABLE 15.28: SUMMARY OF LEVEL CROSSING NOISE

Level crossing	Number of receptors trigger noise criteria
Connors Road, Helidon	4
Jamiesons Road. Gatton	1
Dodt Road, Forest Hill	2
Glenore Grove Road, Forest Hill	42
Grandchester Mount Mort Road, Grandchester	8
Calvert Station Road, Calvert	10

Based on this analysis, the Project will review reasonable and practicable noise mitigation options for the level crossings and train horns at the identified level crossings.

15.8.8.5 Non-residential sensitive receptors

The predicted railway noise levels also triggered an investigation of noise mitigation at the thirteen non-residential sensitive receptors in Table 15.29.

The estimated internal noise levels, and potential trigger of noise mitigation, is sensitive to the applied 7 dBA reduction achieved by the building façade. The 7 dBA adjustment is commonly applied in Queensland with consideration to the age and style of residential property and buildings in the rural regions of the State.

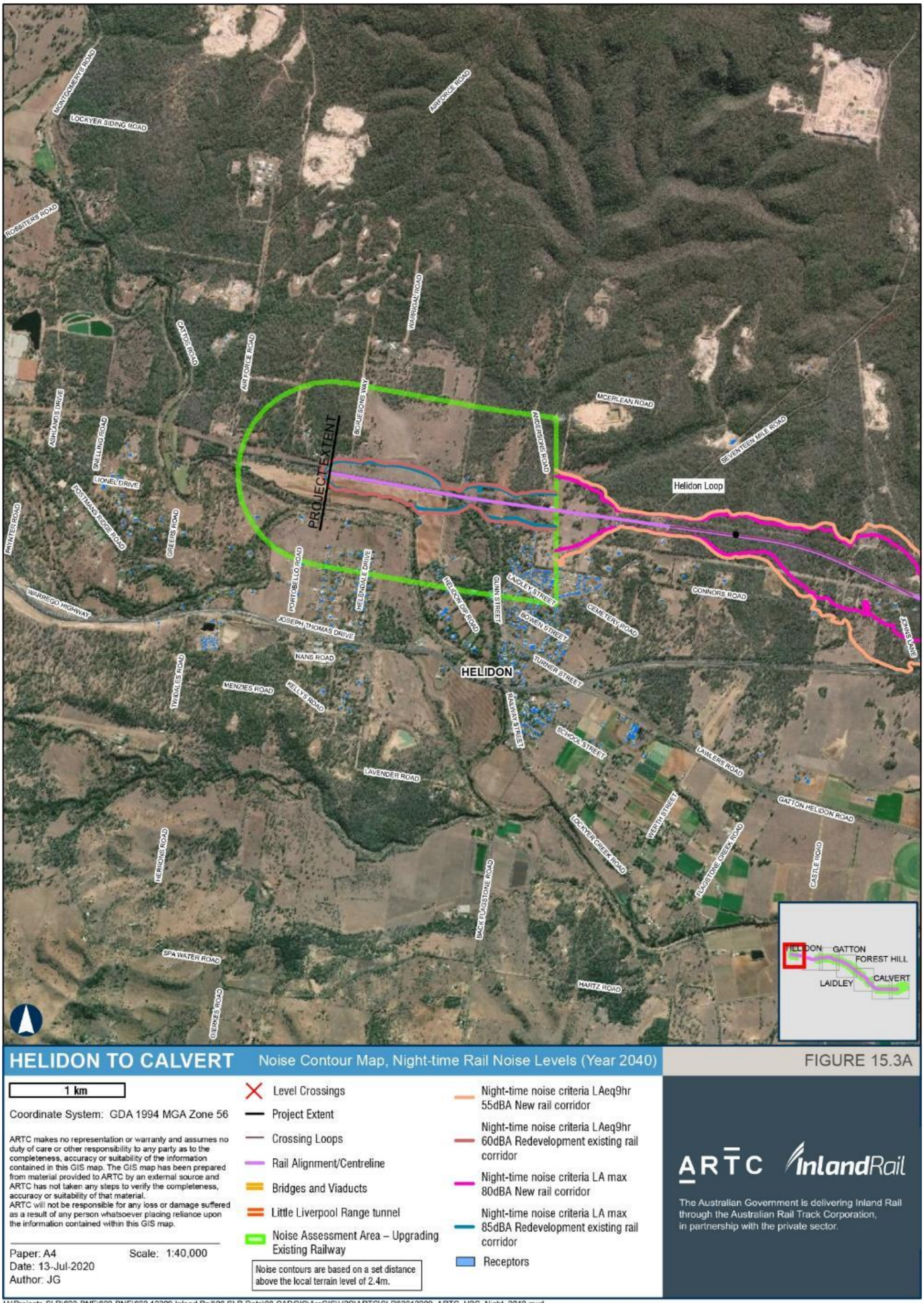
In practice, many of the buildings listed in Table 15.29 will be a modern building construction and/or have air-conditioning so windows do not need to be opened or the façade would provide more than 7 dBA reduction to the intrusion of railway noise. This would result in lower railway noise levels within the buildings greater likelihood of achieving the criteria and potentially reduce the noise mitigation requirements.

TABLE 15.29: PREDICTED NOISE LEVELS AT OTHER SENSITIVE RECEPTORS TRIGGERING NOISE MITIGATION

	$L_{Aeq(1\ hour)}$ noise levels Year 2026, dBA				$L_{Aeq(1hour)}$ noise levels Year 2040, dBA			
	Daytime		Night-time		Daytime		Night-time	
Sensitive receptor	Outside	Inside	Outside	Inside	Outside	Inside	Outside	Inside
Laidley District State School	53	46	55	48	55	48	55	48
Laidley Cultural Centre	60	53	61	54	61	54	61	54
Christian Life Centre	56	49	57	50	57	50	57	50
New Hope Church	55	48	56	49	56	49	57	50
St Mary Catholic Church	53	46	54	47	54	47	54	47
Forest Hill State School	57	50	57	50	58	51	58	51
Grandchester School	62	55	62	55	63	56	63	56
St Peter's Catholic Church[1]	59	52	59	52	60	53	60	53
Free Range Kids Childcare	53	46	54	47	54	47	55	48
Peace Lutheran Primary School	53	46	54	47	54	47	54	47
Forest Hill Presbyterian Church	56	49	56	49	57	50	57	50
Gatton Kindergarten	52	45	53	46	54	47	54	47
Little Angels	54	47	55	48	56	49	55	48

Source: Appendix P: Operational Railway Noise and Vibration Technical Report

Table note:
1. Due to the change from existing railway noise, the noise levels only triggers the noise assessment criteria in the year 2040.



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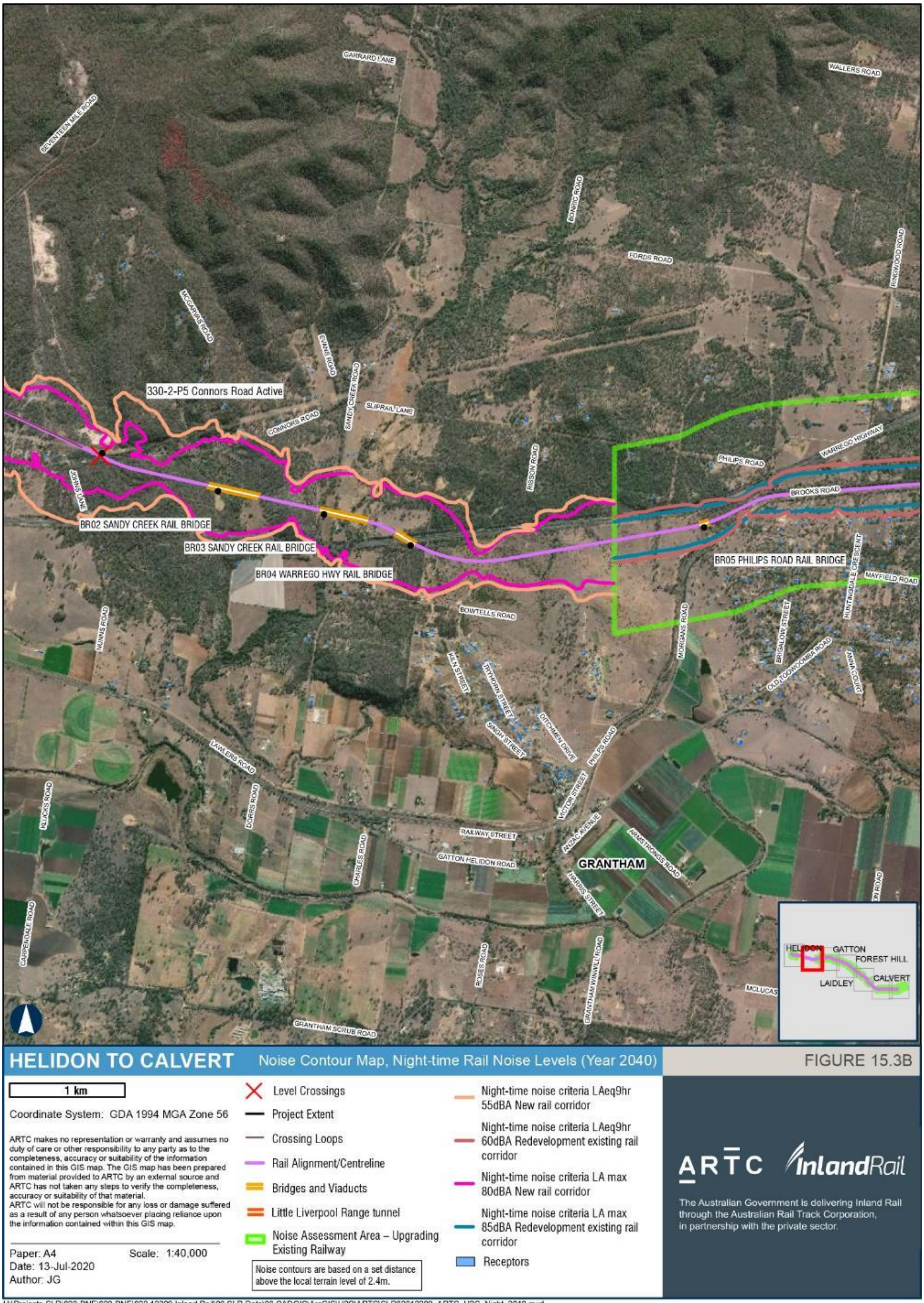
Service Layer Credits: Imagery ESRI Basemap

FIGURE 15.3A: NOISE CONTOUR MAP, NIGHT-TIME RAIL NOISE LEVELS (YEAR 2040)



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Service Layer Credits: Imagery ESRI Basemap

FIGURE 15.3B: NOISE CONTOUR MAP, NIGHT-TIME RAIL NOISE LEVELS (YEAR 2040)

HELIDON TO CALVERT Noise Contour Map, Night-time Rail Noise Levels (Year 2040)

FIGURE 15.3C

1 km

Coordinate System: GDA 1994 MGA Zone 56

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Paper: A4 Scale: 1:40,000
Date: 13-Jul-2020
Author: JG

- Level Crossings
- Project Extent
- Crossing Loops
- Rail Alignment/Centreline
- Bridges and Viaducts
- Little Liverpool Range tunnel
- Noise Assessment Area – Upgrading Existing Railway

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

- Night-time noise criteria LAeq9hr 55dBA New rail corridor
- Night-time noise criteria LAeq9hr 60dBA Redevelopment existing rail corridor
- Night-time noise criteria LA max 80dBA New rail corridor
- Night-time noise criteria LA max 85dBA Redevelopment existing rail corridor
- Receptors

ARTC InlandRail

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

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Service Layer Credits: Imagery ESRI Basemap

FIGURE 15.3C: NOISE CONTOUR MAP, NIGHT-TIME RAIL NOISE LEVELS (YEAR 2040)

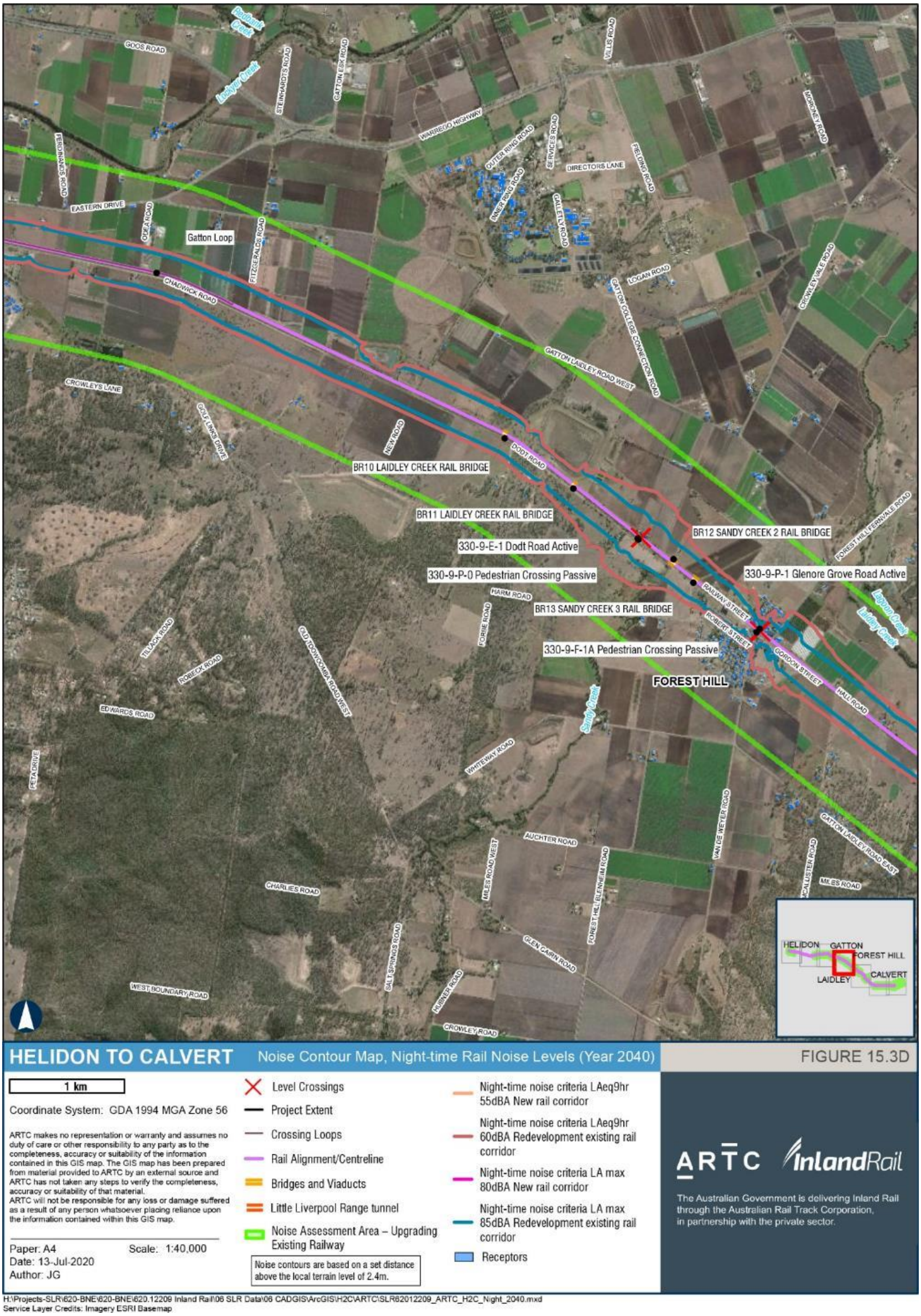
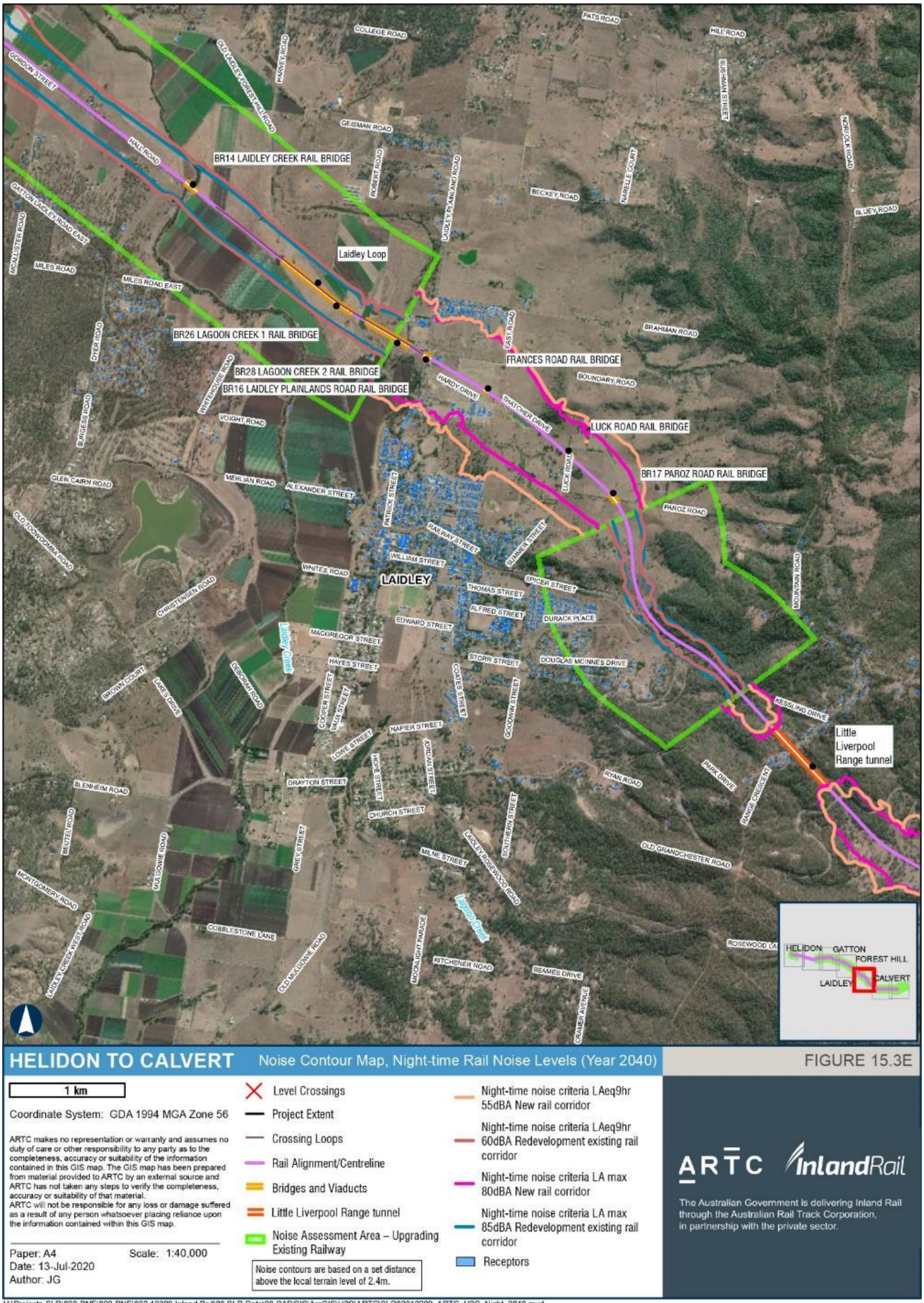
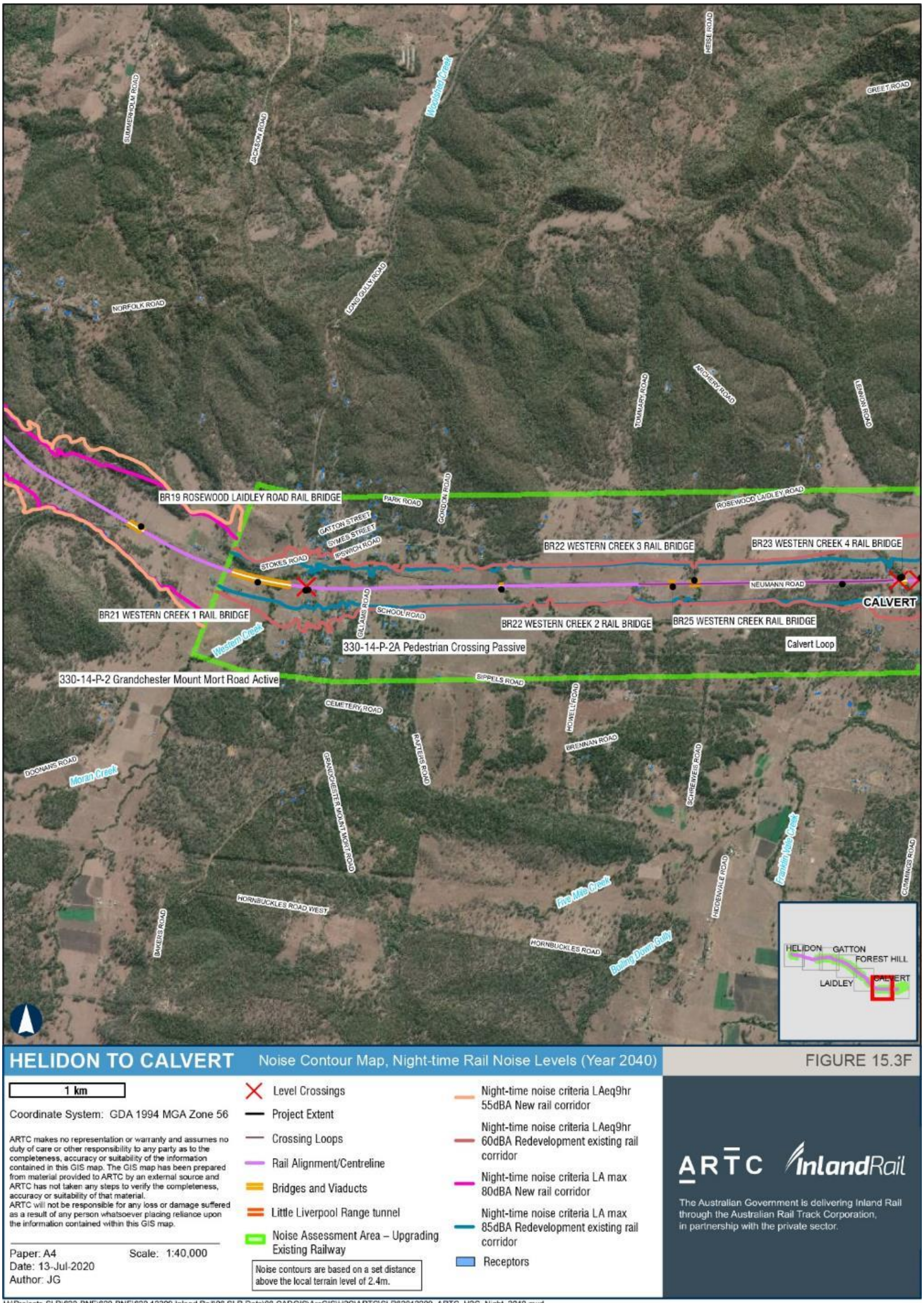


FIGURE 15.3D: NOISE CONTOUR MAP, NIGHT-TIME RAIL NOISE LEVELS (YEAR 2040)



H:\Projects-SLR\620-BNE\620-BNE\620.12209 Inland Rail\06 SLR Data\06 CADGIS\ArcGIS\H2C\ARTC\SLR62012209_ARTC_H2C_Night_2040.mxd
Service Layer Credits: Imagery ESRI Basemap

FIGURE 15.3E: NOISE CONTOUR MAP, NIGHT-TIME RAIL NOISE LEVELS (YEAR 2040)



H:\Projects-SLR\620-BNE\620-BNE\620.12209 Inland Rail\06 SLR Data\06 CADGIS\ArcGIS\H2C\ARTC\SLR62012209_ARTC_H2C_Night_2040.mxd
Service Layer Credits: Imagery ESRI Basemap

FIGURE 15.3F: NOISE CONTOUR MAP, NIGHT-TIME RAIL NOISE LEVELS (YEAR 2040)

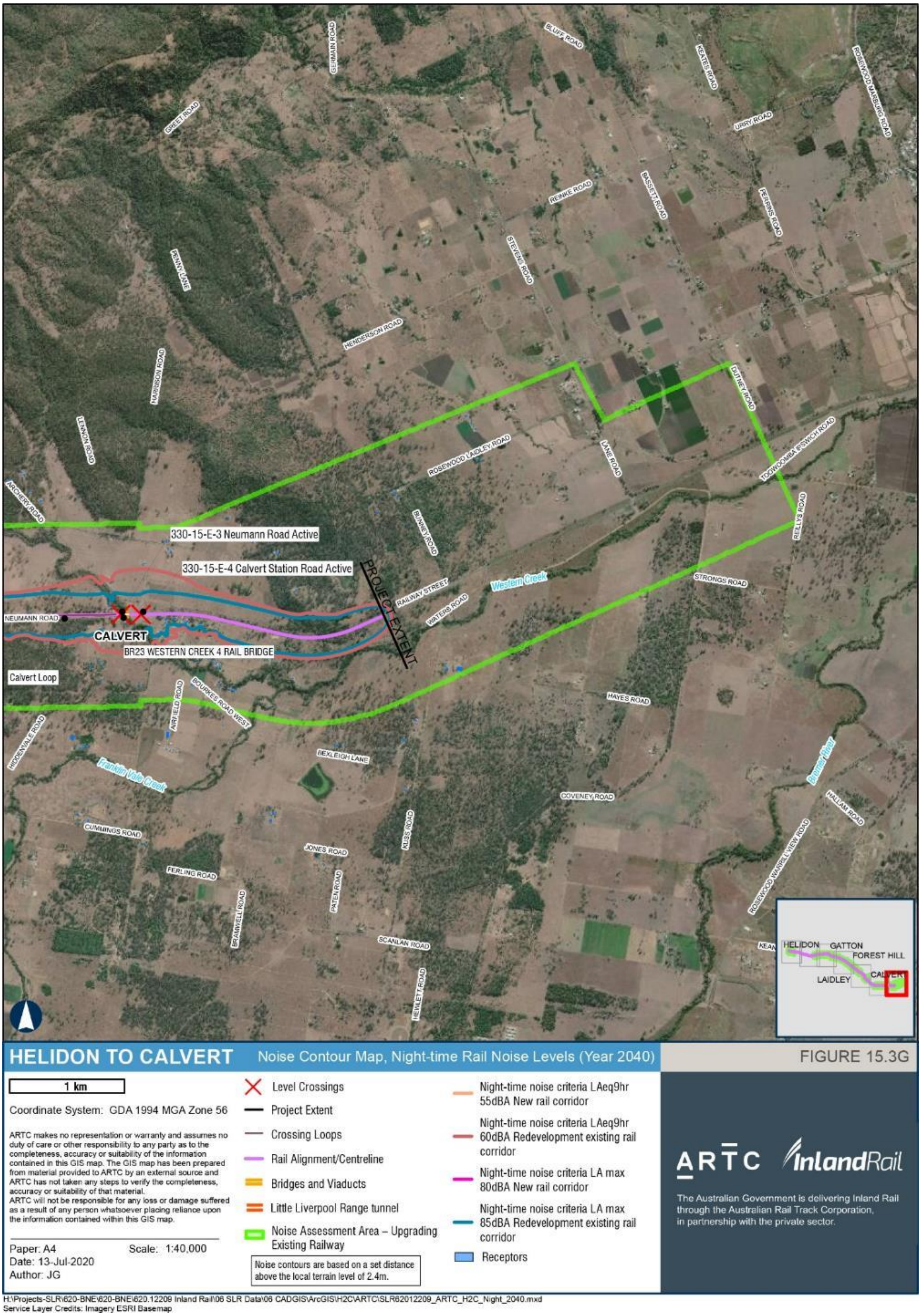


FIGURE 15.3G: NOISE CONTOUR MAP, NIGHT-TIME RAIL NOISE LEVELS (YEAR 2040)

15.8.8.6 Rail 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 is summarised, with more detailed discussion provided in the Appendix P: Operational Railway Noise and Vibration Technical Report.

- The diesel-electric locomotive engines and exhaust systems are the primary source of the low-frequency noise, between 80 Hz and 250 Hz, 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, within 15 m, it does not mean that low- frequency noise characteristics will necessarily be experienced at sensitive receptors located within the immediate surrounding vicinity
- 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 that 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 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, which can cause short-lived squeaks and bangs. Events of this nature may have subjective impulsive noise emission characteristics, although not necessarily quantified as impulsive noise at nearest sensitive receptors. Noise events of this nature have been assessed at the four crossing loops proposed on the Project
- When the trains depart from the crossing loops the locomotives are required to initially operate under a high-notch setting to accelerate from a standing position. This can cause higher noise emissions from the locomotives, which may result in a perceptible increase in railway noise for a short time nearby to the crossing loops, but would not be expected to influence the noise levels over the 15-hour daytime and 9-hour night-time assessment periods
- 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; however, the Project does not include sections of tight-radius curved track
- The Project will be newly constructed rail track that will be specifically designed for freight rail operations and subject to routine maintenance. This can reduce potential for features such as corrugation (deformation of the track) to occur that may otherwise 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.

15.8.8.7 Assessment of sleep disturbance

The night-time maximum (L_{Amax}) 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 to 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 175 receptors where the predicted L_{Amax} noise levels trigger the assessment criteria.

Railway noise has the potential to be audible at sensitive receptors, 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). This guidance acknowledges the establishment of relationships between single event noise indicators, such as L_{Amax}, and long-term health outcomes remains tentative.

The WHO guideline *Night Noise Guidelines for* Europe (WHO, 2009) recommends that internal (indoor) noise levels are not above L_{Amax} 42 dBA to preserve sleep quality. The WHO guideline level corresponds to a conservative external (outdoor) level of L_{Amax} 49 dBA, allowing for a conservative 7 dBA difference between indoor and outdoor noise levels where windows at rural residential properties are open for ventilation.

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.

15.8.8.8 Weather

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

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 would diminish the influence of weather conditions on the railway noise levels assessed over the 15-hour daytime and 9-hour night-time periods.

15.8.8.9 Ground vibration impacts

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 of 15 m 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 15.30, noting that subjective annoyance is possible at larger distances.

Throughout the majority of the alignment there are no sensitive receptors currently identified to be within the 15 m offset distance. The nearest caravan dwellings at the southern boundary of the Gatton Caravan Park in Gatton were identified to be marginally within the off-set distance and trigger a review of vibration mitigation options. These caravans may be within the permanent disturbance footprint of the Project and acquired by the Constructing Authority.

The outcomes of the assessment will 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 identified that ground-borne vibration is not anticipated to impact non-Indigenous cultural heritage sites adjacent to the Project alignment.

TABLE 15.30: PREDICTED OPERATIONAL GROUND-BORNE VIBRATION (OFF-SET DISTANCE)

	Estimated off-set to meeting vibration criteria[1,2]		
Year of operation	Daytime	Night-time	Receptors within the off-set distance
2026 Project opening	11 m (21 trains)	15 m (17 trains)	The nearest dwelling at the Gatton Caravan Park, Gatton.
2040 design year	12 m (25 trains)	15 m (20 trains)	

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 BS 6472 (British Standards, 2008).

15.8.8.10 Ground-borne noise impacts

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 off-set distance, as shown in Table 15.31, there are approximately 39 sensitive receptors where the screening assessment identified ground-borne noise levels may be above the assessment criteria.

TABLE 15.31: LOCATIONS TRIGGERING A REVIEW OF GROUND-BORNE NOISE MITIGATION

Project location	Approximate number of receptors within 50 m ground-borne noise off-set
Gatton Caravan Park	Individual caravan dwellings immediately adjacent to the existing and Project rail tracks. Some of the caravans may be within the permanent disturbance footprint of the Project and acquired by the Constructing Authority.
Hickey Street, Gatton	11 residences immediately adjacent to the existing and Project rail tracks
Railway Street, Forest Hill	Seven residences immediately adjacent to the existing and Project rail tracks
General alignment	Approximately four sensitive receptors (residences) distributed across the alignment

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

While ground-borne noise levels at all other sensitive receptors were calculated to be within the assessment criteria did not trigger investigation of mitigation, there can still be a risk of minor perceptible ground-borne noise at sensitive receptors. Consequently, the assessment outcomes are proposed to be reviewed during the detailed design phase to verify any future requirements to mitigate ground-borne noise.

15.8.8.11 Ground-borne vibration and noise—Little Liverpool Range tunnel

The movement of the trains through the Little Liverpool Range 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 may 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).

A detailed assessment of ground-borne noise is provided in Appendix P: Operational Railway Noise and Vibration Technical Report. The calculation of ground-borne noise applied a screening assessment model based on guidance from International Organization for Standardization (ISO) *ISO 148327-1 2005 Mechanical vibration—Ground-borne noise and vibration arising from rail systems—Part 1 General guidance* (ISO, 2005).

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.

The assessment concluded that the ground vibration assessment criterion is predicted to be achieved at 90 m from the tunnel alignment. The nearest sensitive receptors at Range Crescent in Laidley are within 92 m to 128 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.

The screening assessment identified that railway operations within the tunnel would not be expected to trigger the ground-borne vibration criteria. At eight of the sensitive receptor buildings on Range Crescent, the ground-borne noise criteria may be triggered, and on this basis, a more detailed calculation of ground-borne noise levels will be undertaken during the detailed design phase to determine if mitigation to control ground-borne noise levels is required.

15.8.8.12 Operational fixed infrastructure

The ventilation fans in the Little Liverpool Range tunnel were identified as the primary source of mechanical plant (fixed source) noise emissions.

The ventilation fan design includes large plenums (pressurised chambers) between the fans and the outlet to the environment. These have been treated as large concrete rooms and the fan sound power levels (total sound energy emitted by a source) were empirically derived from fan specifications in the tunnel ventilation design (Bies and Hansen, 2009). Further detail is provided in Appendix O: Noise and Vibration (construction, fixed Infrastructure and operational road noise) Technical Report.

Based on the adopted sound power levels and distance to nearest sensitive receptors, the noise from fixed infrastructure has the potential to exceed the EPP (Noise) acoustic quality objectives. Noise mitigation, fan noise attenuators, were considered in the assessment on the understanding the installed fans will include noise mitigation.

The minimum insertion losses of attenuators are presented in Table 15.32 and assume the attenuation will also control potential tonal and low-frequency noise characteristics. The fan design includes an allowance for sound absorption linings in plenums and attenuators.

TABLE 15.32: MINIMUM INSERTION LOSS OF ATTENUATORS FOR THE PROJECT

Fan	Location in reference to fans	Ventilation station	Octave band centre frequency, Hz Insertion Loss, dB							
			63	125	250	500	1k	2k	4k	8k
Maintenance	Ambient side	East	5	12	19	26	24	16	14	12
LEP			2	5	8	13	13	10	9	8
Maintenance	Ambient side	West	20	31	59	68	75	43	25	23
LEP			2	5	8	13	13	10	9	8
Maintenance	Tunnel side	East/West	18	30	44	55	58	41	33	28
LEP			10	17	32	41	44	26	17	15

Table notes:
LEP—Longitudinal Egress Passage.
1. Silencers are to be sized so that regenerated noise is negligible compared to the actual noise level.
2. Ambient side refers to attenuators located between the fan and the ventilation station emission point.
3. Tunnel side refers to attenuators located between the fan and the tunnel. This is to control noise within the tunnel and thus noise emission from the portal.
4. In the absence of custom-built attenuator data, attenuator octave band insertion loss is based on extrapolation of readily available attenuator data.

Noise levels predicted with the proposed mitigation measures are presented in Table 15.33.

TABLE 15.33: PREDICTED NOISE LEVEL AT THE NEAREST NOISE SENSITIVE RECEPTOR

Scenario	Maintenance fan operation location	Internal noise criteria $L_{Aeq,1hr}$, dB	Predicted noise level $L_{Aeq,1hr}$, dB
Maintenance	East	30	27
	West		17
Emergency	East		30
	West		23

With the mitigation proposed, the EPP (Noise) Acoustic Quality Objectives are predicted to be achieved at the sensitive receptors. The above mitigation is indicative, and other mitigation options such as to be achieved at the sensitive receptors:

- Installation of acoustic louvres on the ventilation station façade.
- Internal acoustic lining within the tunnel and/or ventilation system.
- Upgrade of external receiver façades (off-reservation treatment).
- Use of quieter plant equipment, including the 'best technology available'.

Once fans are selected during detailed design, if the sound power levels differ from those assumed then mitigation requirements will need to be reassessed.

Other 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) would typically be implemented, and if required, will be designed to meet appropriate noise level emissions.

15.8.8.13 Operational road traffic noise—proposed new roads

In assessing the potential noise impacts of the proposed construction of seven new roads, a desktop assessment was undertaken applying the Calculation of Road Traffic Noise method. The required setback distance in meters from the road to achieve the new road criteria of 60 $L_{A10(18hr)}$ dBA has been calculated.

The number of sensitive receptors within this setback distance and predicted to be above the criteria are in Table 15.34. The AADT road traffic volumes are based on information gathered as part of the reference design phase. The assessment year used for these predictions is 10 years after the Project commences operations (approximately 2035).

The proposed new roads, Brooks Road, Off Beavan Street, Chadwick street, Rosewood Laidley Road, Neumann Road will result in exceedance of the 60 $L_{A10(18hr)}$ dBA road traffic noise criteria for proposed new roads.

These new roads will need to be assessed in more detail during future stages of the Project to confirm exceedances against relevant legislation. Potential road traffic noise attenuation strategies are included in Section 15.9.

TABLE 15.34: OPERATIONAL ROAD TRAFFIC NOISE PREDICTIONS FOR PROPOSED NEW ROADS

Location	Type[1]	Posted speed (km/h)	Surface	AADT[2] 2035[3]	Minimum setback distance (m)[4]	Number of sensitive receptors within setback distance
Airforce Road	Rural Collector	60	Sealed	1,049	39	0
Brooks Road	Rural Access	60	Unsealed	1,098	53	1
Off Beavan Street	Urban Access	40	Sealed	1,524	39	5
Chadwick Street	Rural Access	60	Sealed	1,098	53	4
Rosewood Laidley Road	Rural Access	80	Sealed	4,280	205	5
Doonans Access Road	Rural Access	40	Unsealed	1,098	42	0
Neumann Road	District Road	100	Sealed	4,453	42	2

Table notes:
1. LGA classification.
2. Annual Average Daily Traffic.
3. 2035 Annual Average Daily Traffic estimated based on annual growth factor of 2% from 2017 traffic volumes.
4. Minimum setback distance is based on distance to achieve the criteria for road traffic noise levels for proposed new roads of 60 $L_{A10(18h)}$.

15.8.8.14 Operational road traffic noise—upgraded roads

Applying the same approach as discussed above for new roads, the required setback distance in metres from the road to comply with the upgraded roads criteria of 68 $L_{A10(18hr)}$ dBA has been calculated. The quantity of sensitive receptors that are within this setback distance and predicted to exceed the criteria are included in Table 15.35.

Three of the proposed road upgrades, Eastern Drive, Glenore Grove Road and Laidley Plainland Drive are predicted to result in exceedance of the 68 $L_{A10(18hr)}$ dBA road traffic noise criteria for upgrades roads. These road upgrades will need to be assessed in more detail during future stages of the Project to confirm exceedances against relevant legislation. Potential road traffic noise attenuation strategies are included in Section 15.9.

Table 15.35 presents a summary of the predicted noise increases due to the proposed upgrade of nineteen roads at the closest residential receptors.

Applying the same approach as discussed above for new roads, the required setback distance in metres from the road to comply with the upgraded roads criteria of 68 $L_{A10(18hr)}$ dBA has been calculated. The quantity of sensitive receptors that are within this setback distance and predicted to exceed the criteria are included in Table 15.35.

TABLE 15.35: OPERATIONAL ROAD TRAFFIC NOISE PREDICTIONS FOR UPGRADED ROADS

Location	Type[1]	Posted speed (km/h)	Surface	AADT[2] 2035[3]	Minimum setback distance (m)[4]	Number of sensitive receptors within setback distance
Lockyer Valley Regional Council						
Warrigal Road	Rural Access	50	Spray seal	1,098	7	0
Wrights Road	Rural Access	50	Spray seal	74	1	0
Seventeen Mile Road	Rural Collector	60	Spray seal	302	1	0
Connors Road	Rural Access	60	Spray seal	108	1	0
Johns Lane	Rural Access	50	Unsealed	1,098	7	0
Philps Road	Rural Access	60	Spray seal	5,491	43	0
Burgess Road	Rural Access	60	Unsealed	2,122	15	0
Jamiesons Road	Rural Access	60	Spray seal	2,472	17	0
Smithfield Road	Rural Access	70	Spray seal	2,361	22	0
Crescent Street	Urban Collector	40	Spray seal	3,418	13	0
East Street	Local Road	50	Spray seal	1,098	7	0
Old College Road	Urban Collector	40	Spray seal	1,098	1	0
Beavan Street	Local Road	50	Spray seal	1,098	7	0
Eastern Drive	Regional Road	60	Asphalt	16,855	95	79
Golf Links Drive	Urban Collector	60	Spray seal	6,576	30	0
Dodt Road	Rural Access	60	Spray seal	18	1	0
Gordon Street	Residential Access	50	Spray seal	1,098	7	0
Railway Street Forest Hill	Rural Access	50	Spray seal	1,098	7	0
Old Laidley Forest Hill Drive	Sub-Arterial	80	Spray seal	2,015	25	0
Boundary Road	Sub-Arterial	50	Spray seal	1,098	7	0
Paroz Road	Rural Access	80	Spray seal	660	3	0
Luck Road	Rural Access	40	Spray seal	1,098	6	0
State of Queensland						
Glenore Grove Road	District Road	30	Spray seal	3,258	14	2
Laidley Plainlands Road	District Road	60	Spray seal	7,188	46	3
Ipswich City Council						
Grandchester Mount Mort Road	Rural Collector	60	Spray seal	1,052	8	0
School Road	Rural Access	60	Spray seal	1,098	9	0
Calvert Station Road	Local Road	70	Spray seal	604	2	0

Table notes:
km/h—kilometres per hour.
1. LGA classification.
2. Annual Average Daily Traffic.
3. 2035 Annual Average Daily Traffic estimated based on annual growth factor of 2% from 2017 traffic volumes.
4. Minimum setback distance is based on distance to achieve the criteria for road traffic noise levels for upgrade roads of 68 $L_{A10(18h)}$.

15.9 Mitigation of noise and vibration impacts

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 options have been presented as 'initial mitigations', which will be considered during the early stages of the detail design and construction of the Project. Further, more specific, mitigation measures have been provided, which are based on the detailed assessments conducted in support of the EIS.

15.9.1 Initial mitigation

15.9.1.1 Construction noise and vibration initial mitigation

The mitigation measures and controls in Table 15.36 are to be factored into the design for the Project. They were applied to the design considered in the EIS and were included in the assessment of construction noise and vibration impacts (refer Appendix O Noise and Vibration (construction, fixed Infrastructure and operational road noise) Technical Report.

TABLE 15.36: INITIAL CONSTRUCTION NOISE AND VIBRATION MITIGATION MEASURES

Action	Mitigation measure
Project design	The Project will be designed and constructed with the aim of achieving construction noise and vibration criteria adopted by the CoP Vol. 2 and summarised in Section 15.7.4. For example, track features such as crossing loops, crossovers, turnouts, and rail joints will be avoided near vibration sensitive structures where practicable.
Construction noise and vibration assessment	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.
Communication	Local residents and 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.
	The ARTC Community Engagement Team or service provider are to provide a community liaison phone number and permanent site contact so that noise and/or vibration-related complaints or inquiries can be received and addressed in a timely manner.

15.9.1.2 Operational noise initial mitigation

The mitigation measures and controls presented in Table 15.37 have been factored into the designs for the project. They have been applied prior to the prediction of operational railway noise and vibration impacts detailed in Section 15.8.8.

TABLE 15.37: OPERATIONAL NOISE INITIAL MITIGATION MEASURES

Aspect	Mitigation measure
Project design	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.
Operational noise assessment	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/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 inquiries can be received and addressed in a timely manner.

15.9.2 Proposed mitigation measures

The assessed construction noise and vibration levels are above the assessment criteria in some locations. To control the noise and vibration emissions and mitigate potential forecasted impacts the following additional mitigation measures are detailed in Table 15.38.

The proposed mitigation measures have been presented in the Construction Noise and Vibration Management Plan of Chapter 23: Draft Outline Environmental Management Plan in accordance with the relevant phase during which they would be implemented during: detailed design, pre-construction and/or construction.

Mitigation measures for operational road traffic (upgrades or re-alignments) and the proposed tunnel infrastructure are provided in Table 15.38.

Regarding operational railway noise, review and, if necessary, update of the operational railway noise and vibration assessment to reflect/inform the detailed design will be undertaken. Compliance and verification works will also be undertaken post-commissioning (refer Table 15.39).

TABLE 15.38: ADDITIONAL PROJECT NOISE AND VIBRATION MITIGATION MEASURES

Delivery phase	Aspect	Mitigation and management 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 Construction Noise and Vibration Management Plan to achieve the performance criteria and inform the Construction Noise and Vibration Management Plan.

	Operational railway noise and vibration impacts on sensitive receptors	Review and, if necessary, update the operational railway 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 in close proximity 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 (DIN, 1999) and recommended by the CoP Vol 2 (DTMR, 2015a) (or other suitable standard/guideline):
		▸ 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. 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 landowners.

	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 will be considered as part of detailed design where operational road traffic noise impacts are predicted to exceed adopted road traffic noise limits: ▸ Pavement surface treatment ▸ Provision of acoustic façade treatments to affected sensitive receptors ▸ Noise transmission control in the form of a landscaped earth mound and/or a noise transmission treatments to affected sensitive receptors. A combination of mitigation measures may be appropriate.
	Operational fixed infrastructure noise impacts on sensitive receptors	Noise from fixed infrastructure is predicted to exceed established acoustic quality objectives at the closest sensitive receptors. Mitigation is expected to be required. Indicative mitigation proposed consists of sound absorption linings (Noise Reduction Coefficient of 0.85, covering a minimum area of 150 m^2) in plenums and attenuators. Mitigation has been identified to achieve compliance and this information has been included in the design. This mitigation will also need to be reviewed and audited (where appropriate) during future stages of the Project to confirm compliance is achieved.

Delivery phase	Aspect	Mitigation and management 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 including 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 Project disturbance footprint and other relevant stakeholders are to 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 noise 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/dilapidation 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 heritage 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 will be undertaken prior to the activity commencing and monitored and audited (where appropriate) 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.

	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 which at which vibration impacts are expected to exceed the adopted structural damage criteria. Vibration monitoring will be undertaken by a suitably qualified professional.

Delivery phase	Aspect	Mitigation and management measures
Construction and commissioning (continued)	Noise impacts on sensitive receptors	▸ Where reasonable and practicable, noise monitoring will be undertaken at noise sensitive receptors where the potential for noise impacts to exceed relevant criteria has been identified. ▸ Noise and/or vibration monitoring will also be undertaken in response to noise or vibration complaints.
	Noise impacts on sensitive receptors—hours of work	▸ Project works will be undertaken in accordance with the nominated hours of work within the Construction Noise and Vibration 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 onsite 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 reasonable and practicable. 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 BS 5228 (British Standards, 2009a).
	Noise and vibration impacts on 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).
	Noise and vibration impacts on sensitive receptors—blasting	Where blasting impacts are expected to exceed the adopted vibration limits, 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.

Delivery phase	Aspect	Mitigation and management measures
Construction and commissioning (continued)	Noise and vibration impacts on sensitive receptors—during hours of construction	‣ Where reasonable and practical, 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 down or shut off. ‣ 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 reasonable and practicable. ‣ 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, and cable slap and chain clink minimised.
	Noise and vibration impacts on sensitive receptors—mechanical plant management	‣ All mechanical plant near sensitive receptors will be silenced by best practical means, such as: ‣ Internal combustion engines will be fitted with a suitable muffler in good repair, operating as per the manufacturer's specifications, as a minimum ‣ Pneumatic tools will be fitted with an effective silencer on their air exhaust port, where reasonable and practicable ‣ Aggregate bins and chutes will be lined with a rubber material, to dampen the vibration of the structure ‣ When piling, acoustic damping will be provided to sheet steel piles to reduce vibration and resonance ‣ When piling, resilient pads will be used between pile and hammerhead. Care will be taken when selecting a resilient pad as energy is transferred to the pad in the form of heat. Based on manufacturer 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 reasonable and practicable. Acoustic shielding will 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 reasonable and practicable 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 limits 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.
	Noise impacts on sensitive receptors	‣ Non-tonal reversing beepers (or an equivalent mechanism) will be fitted and used on all construction vehicles and mobile plant regularly used on site 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. ‣ Off-site 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 such that delivery vehicles are able to drive through the site and not be required to reverse.

Delivery phase	Aspect	Mitigation and management measures
Construction and commissioning (continued)	Noise impacts on sensitive receptors – construction traffic	- Where reasonable and practicable, unsealed areas will be regularly graded and potholes filled in sealed access roads and hardstand areas to reduce noise from construction vehicles. - Where reasonable and 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 6 months post commencement of Project railway operations (post-commissioning train movements). - ARTC will investigate reasonable and practicable mitigation measures where monitored operational noise and/or vibration levels at sensitive receptors are confirmed to be above the railway noise and vibration criteria.

15.9.2.1 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.

Further to this strategy, the selection and specification of as-required noise mitigation also requires the consideration a range of safety, community, visual amenity, engineering, environmental and cost factors. These factors are considered in determining whether a mitigation option is reasonable and practicable to implement.

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 15.39.

A comprehensive review of reasonable and practicable railway noise and vibration mitigation measures, including railway noise barriers, is discussed further in Appendix P: 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 15.39: 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 treatment would depend on a number of factors and is expected to only apply to habitable rooms or acoustically significant rooms/uses of sensitive buildings. Typically, measures such as upgraded acoustic glazing, acoustic window and door seals, 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 prior to the 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.
	The UK Department of Environment, Food and Rural Affairs has published a reference curve for assessing low-frequency noise indoors (UK Department of Environment, Food and Rural Affairs, 2005). This curve should be adopted as a design target for architectural treatments where measured external façade rail noise levels at sensitive receptors are above the assessment criteria and identify prominent low-frequency noise content.
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. Whilst the noise reduction performance will be specific to individual properties, upgrades to existing property fencing are likely to be suitable only where noise reductions of less than 10 dBA are required. The potential for upgrading existing property fencing can be limited by the line of sight between the railway and the 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	
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 alignment that are not highly susceptible to prominent or regular wear. These sections would be most suited for consideration of rail dampers.
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.

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

Action required	Safeguard details
Low-height noise barriers	In situations where the primary noise source is from the wheel-rail interface, low height barriers (for example less than 2 m in height) can be constructed close to the outer rail track. Such barriers can achieve similar noise reductions to noise walls or barriers at the rail corridor boundary. Typically, this mitigation option only suits single tracks and where only the rolling noise needs to be controlled. Given the overall noise levels from rail freight are a combination of rolling noise and locomotive noise emissions the low height noise barriers could have a negligible influence on achieving the adopted noise criteria. In some cases, the use of low height barriers may achieve a perceptible change in railway noise. Reductions in noise levels by at least 3 dBA could result in a perceptible improvement to the loudness of train pass-by events.
Earth mounds at the rail corridor boundary	Earth mounds at the rail corridor boundary can be an alternative to or complement noise walls and barriers. The earth mounds can mitigate noise on the principle of impeding the direct line of sight between the noise source and receptor. To reduce noise levels between 5 dBA to 10 dB potential earth mounds would need to be a comparable height and length to potential rail noise walls or barriers. The required height of noise walls or barriers can be achieved where the structure is constructed on an earth mound base. This approach provides the required screening of noise and can reduce the associated costs of the noise wall or barrier. When reviewing the practical application of earth mounds, the following will be considered: - The construction of earth bunds can be constrained by the available space between the rail corridor and neighbouring infrastructure - Earth mounds require considerably more space than the footprint of a rail noise barrier. A 2 m high earth mound could require an 8 m wide base - Earth mounds could provide a benefit to control perceptible rail noise impacts. Reductions in noise levels by at least 3 dB could result in a perceptible improvement to the loudness of train pass-by events - A review of concept earth mounding identified that outside the main townships, earth mounds up to 3 m in height could reduce the L_{Aeq} noise levels by at least 3 dBA - While earth mounds may not achieve the specific noise reduction performance that can be achieved with noise walls or barriers, they can assist in reducing the overall noise levels to be closer to the assessment criteria - The implications to water through-flow and flooding will need careful consideration to ensure the earth mounding does not adversely impede the movement of surface water.
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.

Based on both the location of the sensitive receptors and the margin by which the noise criteria triggered, the reasonable and practicable options for noise management is expected to be limited to:

- Consideration of rail noise barriers (or similar) where railway noise levels are above the noise assessment criteria and met a range of engineering, environmental, community, safety and cost requirements
- Architectural acoustic treatments to the building to control rail noise within the internal environment of the building
- Upgrades to any existing property boundary fencing to improve screening of rail noise.

The at-property treatments may also need to be considered for the following sensitive receptors (13 in total):

- Christian Life Centre, Gatton.
- Laidley District State School, Laidley.
- Lockyer Valley Medical Centre, Gatton.
- St Mary's Catholic Church, Gatton.
- Peace Lutheran Primary School, Gatton.
- Gatton Kindergarten, Gatton.
- New Hope Church, Gatton.
- Forest Hill State School, Forest Hill.
- Forest Hill Presbyterian Church, Forest Hill.
- Little Angels Childcare, Forest Hill.
- Laidley Cultural Centre, Laidley.
- Grandchester School, Grandchester.
- St Peter's Catholic Church, Grandchester.

The noise assessment criteria apply to specific, noise-sensitive room uses where aspects such as acoustic amenity and speech intelligibility are important. During the detailed design phase, it will be necessary to survey the buildings to exclude rooms and buildings that are not noise sensitive from the consideration of at-property treatments.

The existing facade attenuation for each building will also require confirmation given that the criteria for non-residential are based on internal noise levels.

Concept railway noise barriers

The predicted noise levels triggered an investigation of noise mitigation at sensitive receptors adjacent to the existing West Moreton System in the townships of Gatton and Forest Hill and the new rail corridor near the Valley Vista Estate in Laidley.

Detailed in Appendix P: Operational Railway Noise and Vibration Technical Report, concept noise barrier options were investigated at these three communities. Concept railway noise barriers are considered a potential noise mitigation option in these areas as the noise levels were modelled to be more than 5 dBA above the assessment criteria and the sensitive receptors were in groups adjacent to the rail corridor.

The location and approximate extent of concept railway noise barriers are shown in Figure 15.4, Figure 15.5, Figure 15.6 and Figure 15.7 and are summarised in Table 15.40. At Gatton, two concept noise barrier arrangements were reviewed to control noise at the Gatton Caravan Park.

The design and construction of the Project at Gatton may overlap with the boundary of the caravan park which can limit the practical location of noise mitigation. Furthermore, the caravans can potentially be moved within the site and may not be permanently occupied, which can influence the potential requirements for noise mitigation.

Based on these constraints, the option 2 noise barrier concepts were not included in the noise modelling at this time as the concept barrier option at the caravan park may not be reasonable or practicable. The concept layouts are provided to demonstrate the potential for alternative noise barrier options outside of the railway corridor.

TABLE 15.40: CONCEPT NOISE BARRIER OPTIONS

Location	Concept noise barrier extents
Gatton	720 m barrier north of the rail corridor adjacent to Hickey Street 585 m barrier south of the rail corridor adjacent to Chadwick Road 330 m barrier north of the rail corridor adjacent to Gatton Caravan Park (Gatton Caravan Park option 1) 280 m barrier north of the rail corridor adjacent to Gatton Caravan Park and 150 m barrier on the eastern boundary of the site (Gatton Caravan Park option 2).
Forest Hill	270 m barrier north of the rail corridor adjacent to Railway Street 775 m barrier north of the rail corridor adjacent to William Street 190 m barrier south of the rail corridor adjacent to Gordon Street.
Laidley	1,130 m barriers on both the north and south of the rail corridor between Old Laidley Forest Hill Road and the Valley Vista Estate.

The selection of the concept railway noise barrier options was based on the following key assumptions:

- All concept noise barriers were considered within the existing rail corridor, with the exception of the Gatton Caravan Park, where an alternative (option 2) design was considered on the premise upgrades to the property boundary could be feasible.
- The option 2 design at Gatton included a noise wall at the eastern boundary of the Gatton Caravan Park, which would be outside the rail corridor. The noise wall was investigated at 2 m and 3 m heights consistent with typical noise wall/fence designs on non-railway land that may be subject to local government planning schemes.
- Concept noise barriers extents and heights were investigated to effectively screen rail noise levels at nearby sensitive receptors from the wheel–rail interface and the elevated locomotive exhausts.
- All concept noise barriers were considered as solid structures constructed from material such as autoclaved aerated concrete or pre-cast concrete.
- The worst-case predicted daytime and night-time L_{Aeq} and L_{Amax} noise levels for railway operations in the year 2040 were adopted to review the concept noise barrier performance.
- The concept noise barrier design has been developed for the purpose of evaluating the control of railway noise levels at the property façade 2.4 m above ground level.
- The proposal rail tracks would be elevated on the ballasted track system and concept noise barriers 2 m or less in height were identified to not substantially impede the propagation of railway noise between the top of the rail and the sensitive receptors.

A summary of the potential performance of the concept noise barrier options is detailed in Table 15.41. The concept noise barrier performance has been evaluated as the number of additional local sensitive receptors that have been predicted to achieve the noise criteria with the barrier options, and the highest predicted noise-level reduction at the sensitive receptors. The residual triggers are the sensitive receptors where noise levels may remain above the assessment criteria with the inclusion of the concept rail noise barriers.

TABLE 15.41: SUMMARY OF CONCEPT NOISE BARRIER PERFORMANCE

	Additional receptors achieving the criteria		Highest predicted noise reduction performance	
Noise	L_{Aeq}	L_{Amax}	L_{Aeq}	L_{Amax}
Gatton—Option 1				
3 m barriers	18 (25 residual triggers)	3 (16 residual triggers)	5 dBA	4 dBA
4 m barriers	31 (12 residual triggers)	3 (16 residual triggers)	8 dBA	9 dBA
5 m barriers	39 (4 residual triggers)	11 (8 residual triggers)	10 dBA	11 dBA
6 m barriers	39 (4 residual triggers)	17 (2 residual triggers)	12 dBA	11 dBA
Forest Hill				
3 m barriers	15 (56 residual triggers)	6 (33 residual triggers)	4 dBA	4 dBA
4 m barriers	24 (47 residual triggers)	12 (27 residual triggers)	5 dBA	6 dBA
5 m barriers	33 (38 residual triggers)	15 (24 residual triggers)	6 dBA	8 dBA
6 m barriers	36 (35 residual triggers)	26 (13 residual triggers)	9 dBA	10 dBA
Valley Vista Estate, Laidley				
3 m barriers	9 (77 residual triggers)	32 (40 residual triggers)	5 dBA	5 dBA
4 m barriers	23 (63 residual triggers)	42 (30 residual triggers)	7 dBA	6 dBA
5 m barriers	27 (59 residual triggers)	49 (23 residual triggers)	7 dBA	7 dBA
6 m barriers	31 (55 residual triggers)	59 (13 residual triggers)	8 dBA	10 dBA

Note: The Gatton Caravan Park has been considered as one sensitive receptor.

In terms of achieving the noise assessment criteria, the assessment identified that the concept noise barriers at the rail corridor boundary would need to be at least 4 m or above in height to be effectively control at the majority of the grouped sensitive receptors. The 4 m barrier height is typically the minimum required height to impede the propagation of noise from the rolling noise from the wheel-rail interface and the elevated sources such as the locomotive exhausts and discrete events such as train horns.

The analysis indicated that the concept railway noise barriers at the rail corridor boundary would reduce noise levels at nearby sensitive receptors and increase the number of sensitive receptors achieving the noise assessment criteria.

In addition, the concept railway noise barriers would assist in reducing outdoor railway noise levels at the non-residential sensitive receptors, which would be expected to reduce the potential internal noise levels within these buildings.

The analysis also identifies that the concept noise barrier options could typically reduce railway noise levels by 5 dBA or more which, compared to the noise levels without concept railway noise barriers, can be a perceptible reduction in the loudness of the railway noise levels within the communities and would improve the local amenity.

During the detailed design phase, ARTC will review where concept noise barriers are a reasonable and practicable noise mitigation option. This analysis will need to be undertaken on a refined concept noise barrier design that further considers the existing railway noise levels, the detail design of the Project and other design and engineering factors that determine the location, extent and height of the concept noise barriers. In particular, the detailed design will need to carefully consider aspects such as flooding and management of surface water, cross drainage flooding, stabilisation, vandalism, wind loading, visual amenity and safety within and outside the railway corridor.

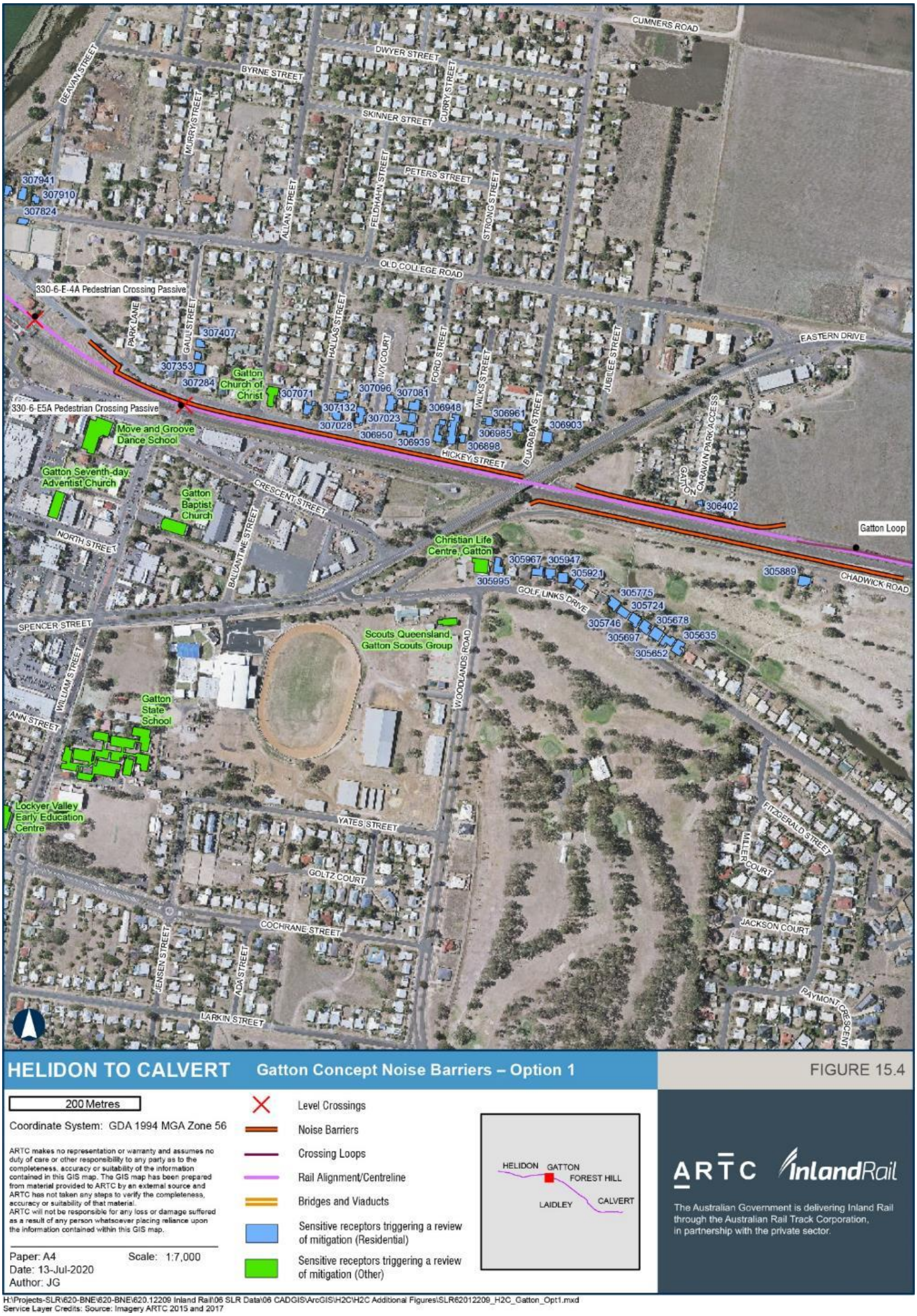
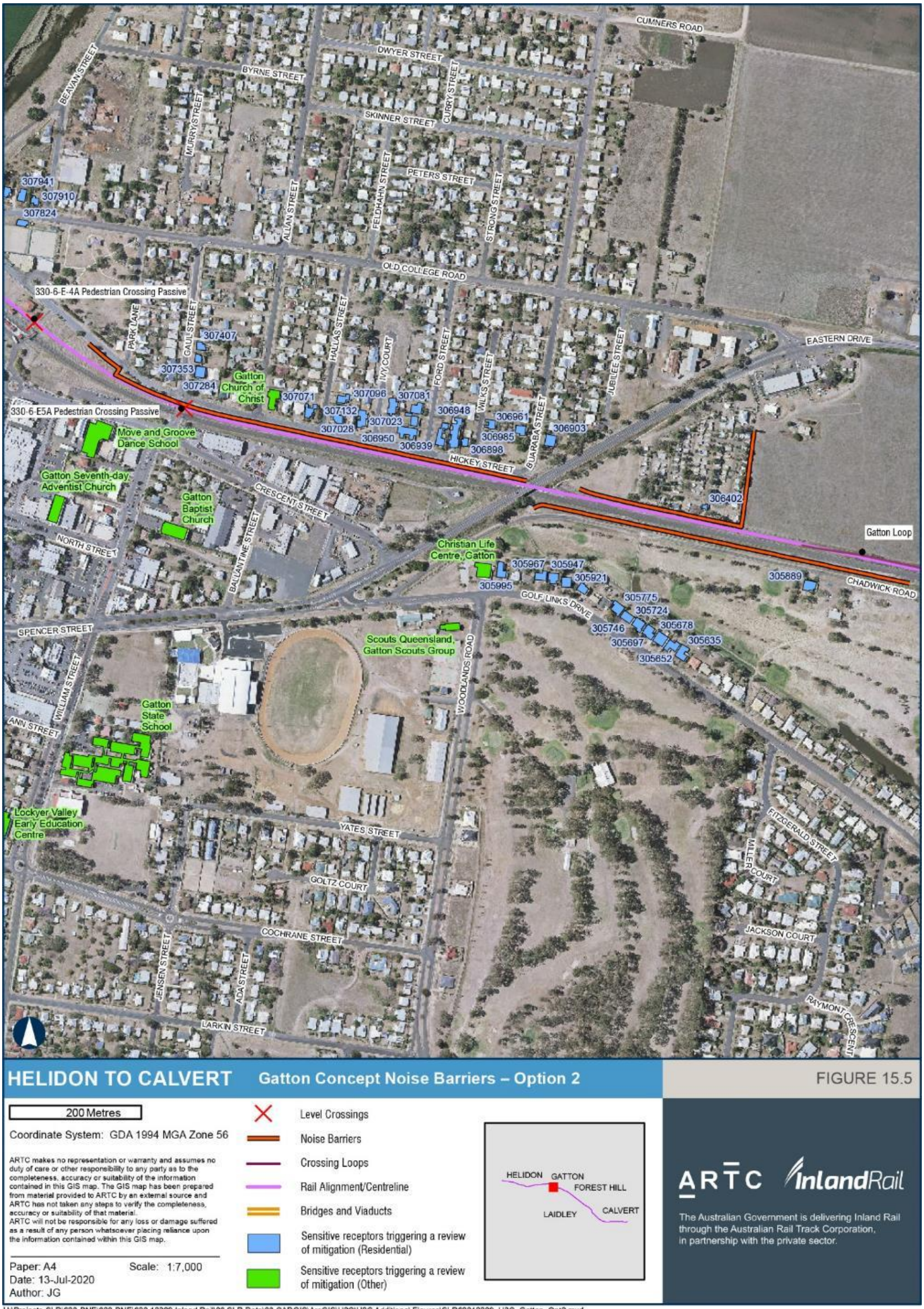


FIGURE 15.4: GATTON CONCEPT NOISE BARRIERS—OPTION 1



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Service Layer Credits: Source: Imagery ARTC 2015 and 2017

FIGURE 15.5: GATTON CONCEPT NOISE BARRIERS—OPTION 2

FIGURE 15.6: FOREST HILL CONCEPT NOISE BARRIERS

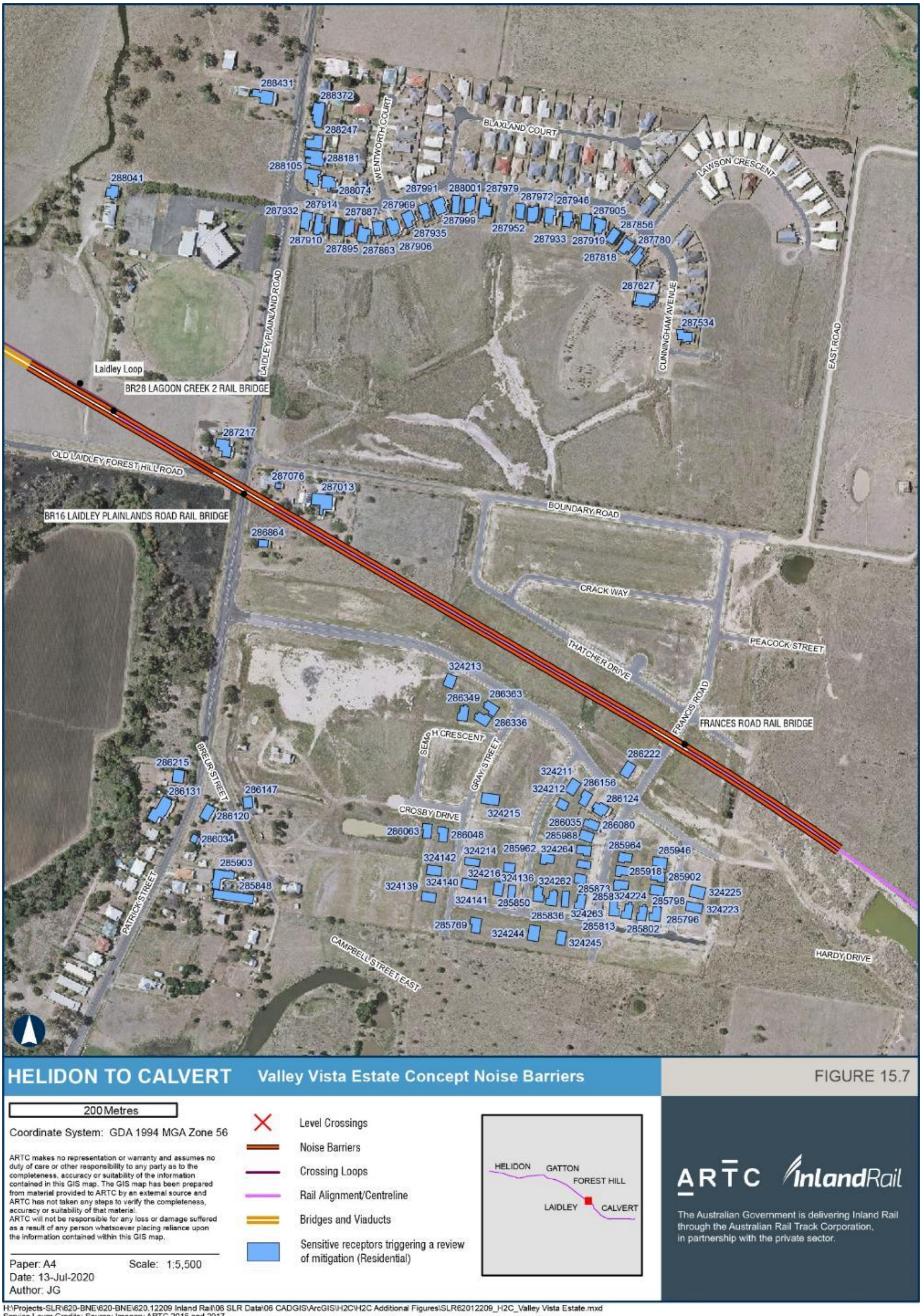

FIGURE 15.7: VALLEY VISTA ESTATE CONCEPT NOISE BARRIERS

Operational rail—vibration mitigation

Based on the proximity of the sensitive receptors to the rail corridor, the assessment has identified the potential ground-borne vibration and ground-borne noise levels would achieve the assessment criteria at most of the sensitive receptors.

The screening assessment identified at least 39 sensitive receptors where either ground-borne vibration and/or ground-borne noise levels could potentially be above the assessment criteria. It is proposed that further assessment is undertaken during the detailed design phase to verify the screening assessment outcomes. Where feasible, this assessment will include the measurement of existing ground-borne vibration and ground-borne noise levels from railway operations on the West Moreton System to inform the detailed assessment.

In the event the detailed assessment or verified (measured) ground-borne noise levels triggers an investigation of mitigation measures for ground-borne vibration or ground-borne noise, options for mitigation include the use of more resilient track support pads, under-sleeper pads and under-ballast matting. Each option has different implications in terms of cost and performance and softer track supports tend to increase airborne noise emissions.

At the EIS phase of the Project, it is not possible to verify appropriate mitigation options for ground-borne noise at the Little Liverpool Range tunnel—until prediction of ground-borne noise levels has been further refined with detailed design information on the track form and pad stiffness and the local geological conditions. The sensitive receptors identified as potentially triggering the ground-borne noise levels do so at the upper threshold of the predicted levels where 95 out of 100 events are forecast to be below these levels.

Typically, ground-borne noise is managed through the application of softer rail-pad systems. The effectiveness of measures such as rail dampers may be limited by the stiffness of the track and concrete sleepers, the forces exerted by the passage of heavy rail freight and the long-term durability and maintenance of such measures. The trackform in the Little Liverpool Range tunnel is to be an effective high vibration attenuation class trackform, such as Vossloh 300 NG with the 17 MN/m static stiffness 'Cellentic' pad.

15.9.3 Residual impacts

15.9.3.1 Construction noise and vibration

The construction works will need to involve noise generating plant and equipment in proximity of the sensitive receptors and the assessment has identified detailed management of construction noise emissions will be required. Due to construction being inherently noisy in nature, there is potential for noise levels to remain above the assessment criteria with the implementation of noise management and mitigation measures.

Across all construction activities, 62 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 51 per cent of exceedances of the evening non-standard hours noise limit. Of the construction noise mitigation measures proposed in Section 15.9.1, those which can be quantified can be expected to provide between 4 and 11 dBA attenuation. The remaining approximate 32 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 will need to be managed.

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 and the provision of at-property treatments.

It is proposed that these residual impacts would be addressed through community consultation and impact management that could include respite periods for high noise generating works, temporary relocation of applicable residents and the provision of at-property treatments to limit noise intrusion.

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

- 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 the 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.
- At-property treatments will only be considered for residential dwellings where noise impacts and the duration of the impact is such that it cannot be addressed by mitigation or management measures, or temporary relocation. In addition, the condition of the dwelling will influence the feasibility of architectural treatments.

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

15.9.3.2 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.

15.9.3.3 Operational infrastructure

Nominal mitigation strategies (such as attenuators, solid barriers and enclosures) would typically be implemented, and if required, will be designed to meet appropriate noise level emissions. Residual impacts are not anticipated. Operational rail—residual impacts

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 outside the townships of Gatton, Forest Hill and the Valley Vista Estate at Laidley.

Any at-property treatments do not address the source of railway noise or the external rail noise levels within the environment surrounding the rail corridor. In this regard, the external rail noise levels have the potential to be clearly audible above the ambient noise environment within relatively close proximity of the Project, such as the initial 400 m from the rail corridor. Similarly, noise emissions from train horns and level crossings, which are required for safety obligations at level crossings, need to be clearly audible.

Consequently, there will remain the potential for the operation of the Project to influence the external (outdoor) noise environment at sensitive receptors. Given the high level of noise that can be experienced close to a rail corridor during train pass-bys, there can still be potential for noise related impacts, including sleep disturbance, where noise mitigations and at-property treatments are implemented.

The concept noise barriers have been proposed Gatton, Forest Hill and the Valley Vista Estate at Laidley as an option to assist the Project in achieving the noise assessment criteria and managing noise related impacts. There are a range factors that can constrain the location and extents of the barriers such as the location of the alignment relative to the receptors, the engineering practicality of constructing noise barriers and the access to the local road networks.

Due to influence of these factors, there is potential for reasonable and practicable railway noise barriers to not achieve the assessment criteria at all the sensitive receptors. Indicative number of residual noise triggers are detailed in Table Table 15.41: Summary of concept noise barrier performance. To address residual impacts of this nature the Project may need to consider other mitigation measures, in addition to railway noise barriers, such as the provision of at-property treatments. This will be confirmed during the detail design phase.

15.10 Cumulative impacts

15.10.1 Construction noise and vibration

Only the ARTC projects adjacent to the Project have been considered in the cumulative impact assessment (CIA) for construction noise and vibration. Other projects in the region are considered too far from the Project alignment compared to the localised nature of construction noise and vibration impacts and, as such, have not been included within this chapter.

Table 15.42 details major projects that may be constructed simultaneously with the Project and close enough to contribute to cumulative noise levels at sensitive receptors potentially affected by the Project.

TABLE 15.42: MAJOR PROPOSED PROJECTS (NEAR TO PROJECT)

Project and Proponent	Gowrie to Helidon (G2H)—Inland Rail (ARTC)	Calvert to Kagaru (C2K)—Inland Rail (ARTC)
Location	Rail alignment from Gowrie to Helidon	Rail alignment from Calvert to Kagaru
Description	26 km single-track dual-gauge freight railway as part of the ARTC Inland Rail Project	53 km single-track dual-gauge freight railway as part of the ARTC Inland Rail Project
EIS status	Draft EIS being prepared by proponent	Draft EIS being prepared by proponent
Relationship to the Project	Potential overlap on construction commencement for G2H and finalisation of the Project	Potential overlap of finalisation of H2C and commencement of C2K

Simultaneous noise from construction works of sections G2H or C2K project sections of Inland Rail has the potential to increase noise levels at nearby sensitive receptors affected by noise from the H2C Project.

Due to the conservative modelling methodology used for the Project, the noise impacts are assessments of worst-case construction scenarios from construction equipment operating in proximity of nearby sensitive receptors. As a result, the noise levels from construction works at sensitive receptors within the noise and vibration study area are expected to be dominated by construction activity on the Project.

15.10.2 Operational noise and vibration

The Project directly links to the west with the adjoining G2H project section and links directly to the C2K project section to the east. At the sensitive receptors within the Project area, the primary source of noise will be the Inland Rail trains as they travel on the Project alignment. Rail noise from the arrival and departure of the trains on the adjacent G2H and C2K project sections are not expected to result in a cumulative increase in daily railway noise levels at the sensitive receptors adjacent to the Project alignment.

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

On the Project alignment, the Inland Rail trains and existing rail operations will be collocated within the same rail corridor. The overall railway noise levels from all train operations within the corridor have been assessed in this report. Where required by the noise criteria and assessment methodologies, the potential cumulative noise from the existing rail traffic and the future additional rail traffic introduced by the Project was included in the assessment of noise and vibration levels and associated related impacts.

15.10.3 Cumulative road traffic noise and railway noise

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 and noise and railway noise to be assessed and, if necessary, mitigated separately. The assessment of road traffic noise and railway is discussed in this chapter with the detailed noise assessments provided in Appendix O: Noise and Vibration (construction, fixed Infrastructure and operational road noise) Technical Report and Appendix P: 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 and the assessed road traffic 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 noise or railway noise is within 10 dBA of each other (where the same noise metric and timeframes are applied to quantify both sources of transport noise)
- The majority of the new and upgraded roads with the Project are adjacent to or intersect with the rail alignment of the Project. Consequently, at the nearest sensitive receptors to the local road networks, the predicted road traffic and railway noise levels are typically within 10 dBA of each other. The future noise environment could therefore be influenced by the cumulative noise from both sources of transport noise
- Any increase in the overall daily transport noise at sensitive receptors in proximity to both the local road traffic and the Project's rail alignment would be a marginal perceptible increase of not more than 3 dBA. Because road traffic noise and railway noise are perceived differently, there may not be an increased potential for noise-related impacts where there is a cumulative increase in transport noise levels
- The road and railway traffic will not be continuous and there will be periods throughout the daytime and night-time where there could be minimal or no transport noise
- 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. Any specific mitigations implemented to control road traffic noise and railway noise would be expected to also assist in reducing and controlling perceived cumulative noise impacts.

15.11 Conclusions

15.11.1 Construction noise

The construction noise assessment included predicted of noise levels and noise related impacts for reasonable worst-case noise emission scenarios for each of the main construction activities.

The assessment of noise associated with the construction of the Project has been based on a number of conservative assumptions designed to identify the full extent of potential noise impacts. A high number of triggers of both the lower and upper external noise criteria was identified within the communities adjacent to the Project construction sites. The communities that have the highest predicted noise impacts are in Gatton and Forest Hill due to the proximity of sensitive receptors to the existing rail corridor. The 'earthworks' and 'rail civil works' construction stages are predicted to have the greatest impact from construction noise, due to the need for heavy-vehicle equipment and high-intensity works to complete these stages. Other construction stages may have greater overall impact depending on actual timing and duration of each construction stage.

Measures are proposed to mitigate construction noise impacts on nearby sensitive receptors in line with the Inland Rail Environmental Management System. Further detail on specific mitigation measures have also been included for a range of construction activities to reduce the noise impacts to sensitive receptors.

15.11.2 Construction road traffic noise

For sixteen road sections intended to be used to carry construction traffic, the maximum predicted increase in noise level is greater than the assessment criteria. The predicted road traffic noise levels and any associated impacts would be temporary during the construction works and the early construction activities require higher volumes of construction traffic and the number of roads triggering the criterion by the third year drops significantly. The number of roads triggering the criteria by 2025 drops significantly to just five roads.

A number of these roads are in rural locations and the existing base traffic volumes have relatively low traffic volumes. As such the initial road traffic noise levels are low before the addition of construction traffic, which increases the potential for noise impacts with the introduction of the construction road traffic.

Noise mitigation measures will be applied to each of these roads to reduce the noise impacts to nearby sensitive receptors. The key mitigation measure would be to ensue traffic movement is kept to a minimum, for example, ensuring trucks are fully loaded so that the volume of each delivery is maximised.

15.11.3 Construction vibration

Minimum working distances for vibration-intensive construction work have been predicted for human comfort and structural damage limits. These setback distances have been presented in ranges to highlight the reduction in exceedance for smaller plant. Equipment size would be selected by the contractor considering the minimum working distances and the distance between the area of construction and the most-affected sensitive receptor.

If works are needed to be carried out within minimum working distances, vibration monitoring would be carried out. Heritage, sensitive structures and critical facilities would need to be considered on a case-by-case basis, depending on their sensitivity.

15.11.4 Blasting

There are five locations that have been identified as part of the design phase that may require blasting along the Project alignment. The closest sensitive receptor outside the construction footprint has been assessed to identify conservative maximum permissible charge weights for each location to manage impacts from potential airblast overpressure and vibration.

These limits have been assessed based on worst-case assumptions for a confined blast and with the limited geotechnical information currently known. Once detailed geotechnical information is known these limits may be able to be increased. Each blast will be carefully designed to meet a range of blast requirements, including the control of airblast overpressure and vibration. All blasting will require a Blasting Management Plan including the mitigation measures such as those included in this assessment.

15.11.5 Operational road traffic noise

An assessment of potential road traffic noise issues (future operational) for seven proposed new roads and 27 upgraded roads was undertaken.

The road traffic noise levels from three proposed upgraded roads; Eastern Drive, Glencore Grove Drive and Laidley Plainlands Road are predicted to exceed the 68 dBA, $L_{A10(18hr)}$ criteria—at up to 84 existing sensitive receptors.

Of the seven new roads, five are predicted to exceed the new roads criteria of 60 dBA, $L_{A10(18hr)}$—at up to 17 existing sensitive receptors.

During detailed design, the noise attenuation outlined as part of this assessment can be used, either individually or in combination, to reduce the impacts and achieve compliance with the road traffic noise criteria.

15.11.6 Operational fixed infrastructure noise

Noise from fixed infrastructure has been assessed for the emergency and maintenance operations of the Little Liverpool Range tunnel. The assessment was based on in-principle noise mitigations that will be included in the ventilation fan designs and concluded noise levels can be designed to achieve the objectives of the EPP Noise.

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 and enclosures) would typically be implemented, and if required, will be designed to meet appropriate noise-level emissions.

15.11.7 Operational rail noise

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, Interim Guideline and ARTC's noise management strategy at the majority of sensitive receptors included in the noise prediction modelling.

Approximately 7,000 sensitive receptor buildings were included in the railway noise predictions. At a total of 298 sensitive receptors (285 residential and an additional 13 non-residential buildings) had predicted noise levels potentially above ARTC's noise assessment criteria at the Project opening (2026) without mitigation. To mitigate this impact, consideration has been given to reasonable and practicable noise mitigation options for these receptors. For the design year 2040, an additional 30 sensitive receptors were above the assessment criteria, resulting in a total of 328 sensitive receptors (315 residential and an additional 13 non-residential buildings) potentially triggering an investigation of noise mitigation.

Many of the sensitive receptors are isolated and individual buildings where noise levels trigger the assessment criteria by less than 10 dBA. In these circumstances, the reasonable and practicable noise mitigation is likely to be mitigated by at-property acoustic treatments to the buildings to manage noise intrusion and potential noise impacts within habitable rooms.

The decisions to implement at-property 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.

At the townships of Gatton, Forest Hill and Valley Vista Estate at Laidley, the nearest sensitive receptors to the Project are more densely populated within approximately 300 m of the rail corridor at Gatton and Forest Hill and up to 600 m from the elevated track at the Valley Vista Estate. The assessment considered concept railway noise barriers at these locations to screen noise at the groups of properties adjacent to the rail corridor. The specific location, extent and height of noise barriers, if implemented, will be subject to a detailed review of reasonable and practicable mitigation options during the detailed design phase. Depending on the noise barrier design, there may be some sensitive receptors where the noise assessment criteria are not fully achieved, and these receptors may be considered for additional mitigations such as at-property treatment.

While noise mitigation can ameliorate potential noise impacts within the external and internal environment at a sensitive property, the 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 400 m from the rail corridor.

15.11.8 Operational rail vibration

An assessment of ground-borne vibration identified where vibration and its effects from railway operations may be significant for surface track and also the train movements in the Little Liverpool Range tunnel. The assessment identified that triggers for further investigation are expected where receptors are located within 50 m of the surface outer rail line or 160 m from the Little Liverpool Range tunnel.

There were approximately 39 sensitive receptors within 50 m of the alignment where the screening assessment identified the potential for ground-borne noise impacts. The forecast ground-borne vibration levels achieved the assessment criteria at all receptors with the exception of one caravan dwelling immediately adjacent to the alignment at the Gatton Caravan Park.

The screening assessment identified seven sensitive receptors on Range Crescent in Laidley where potential ground-borne noise levels from train movements within the Little Liverpool Range tunnel could be more than 2 dBA above the ground-borne noise assessment criteria.

It is proposed that ground-borne noise and ground-borne vibration will be assessed in further detailed during the detailed design phase to verify the outcomes of this assessment and determine, as-required, mitigation measures. Potential reasonable and practicable mitigation includes the use of more resilient track support pads, under-sleeper pads and under ballast matting.

15.11.9 Noise and vibration management

Overall, the assessments have identified that noise and vibration during the construction and operation has the potential to influence the noise environment along the Project alignment.

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

Due to the nature of the proposed construction works and railway operations and the proximity of nearby sensitive receptors, it is expected the Project will change the local noise environment for some 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 in a reasonable and practical manner (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 both during construction and when Project railway commence.