# 11. Noise and vibration (amenity impacts)

*This chapter provides a summary of the noise and vibration assessment of the proposal as it relates to the potential for amenity impacts. It describes the existing environment, assesses the impacts of construction and operation, and provides recommended mitigation and management measures. The full noise and vibration assessment report is provided as Technical Report 5.*

*This chapter focuses on the potential for audible noise impacts, and human comfort impacts as a result of vibration. Structural noise and vibration impacts are considered in chapter 12.*

## 11.1 Assessment approach

### 11.1.1 Methodology

The noise and vibration assessment:

- identifies noise and vibration sensitive receivers
- identifies existing noise and vibration levels in the study area
- identifies the main potential noise and vibration sources during construction and operation
- establishes amenity-related noise and human comfort vibration criteria/management levels to:
  - provide a basis for assessing the potential for impacts during construction
  - provide a basis for assessing the potential for impacts during operation, based on the current design
  - use as the basis for monitoring during construction and operation.
- assesses the potential for noise and vibration to exceed the applicable criteria and impact on the amenity of sensitive receivers
- provides amenity related noise and vibration mitigation measures.

A summary of the main tasks involved in the assessment is provided in the following sections. Further information is provided in Technical Report 5.

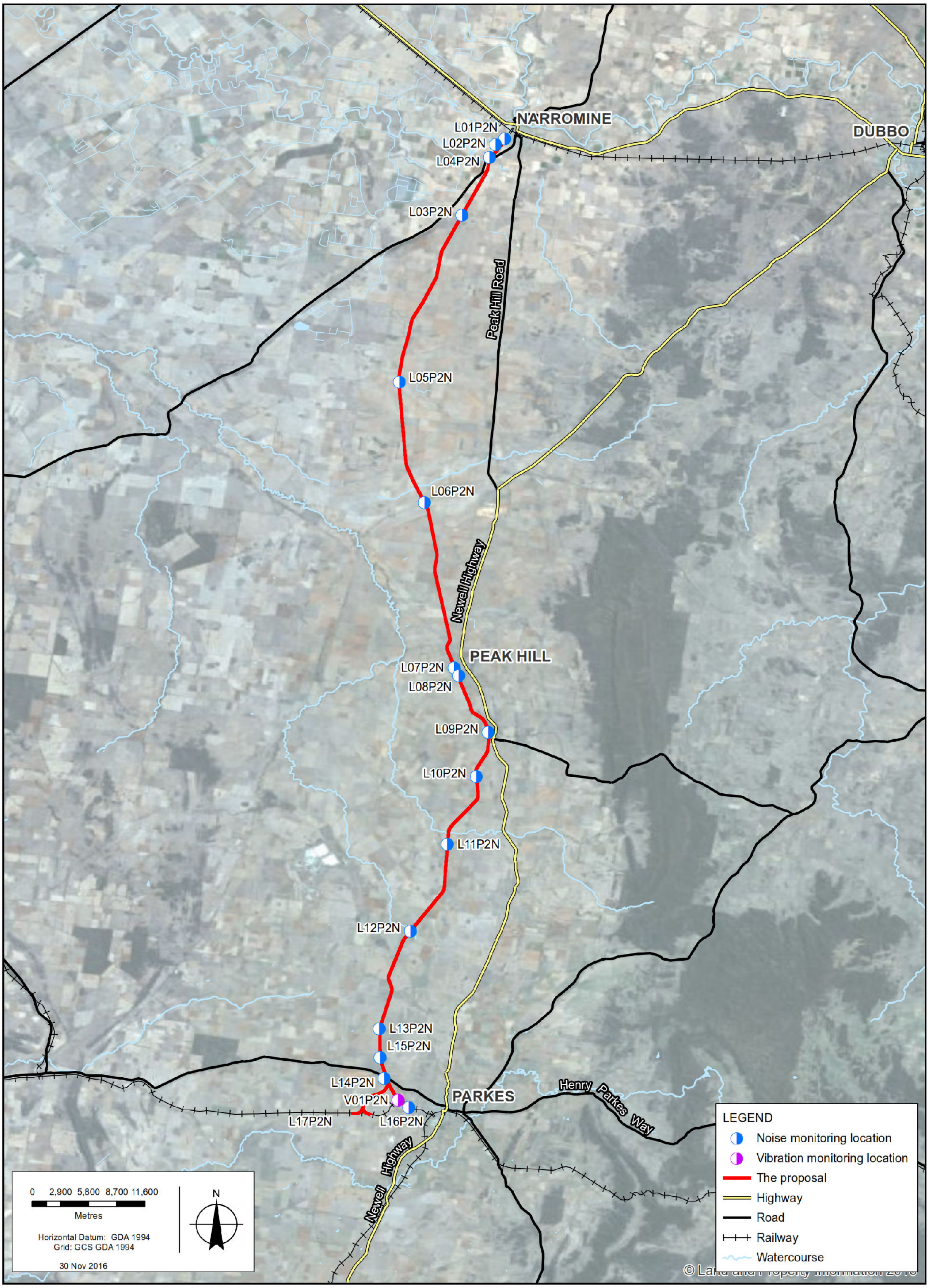
The study area for the noise and vibration assessment is defined as the area that extends about two kilometres from the centreline of the proposal site.

#### Identification of noise and vibration sensitive receivers

Potentially sensitive receivers are those that may be affected by changes in noise and vibration levels within the study area. Noise and vibration sensitive receivers were identified based on the type of land use, the activities undertaken, and the nature of the building, by using aerial imagery and geospatial information. Sensitive receivers are described in section 11.3.

#### Measuring background noise and vibration to determine existing levels

Unattended noise monitoring was undertaken at nine residential properties and eight locations within the proposal site considered to be representative of the existing ambient (background) noise environment. Monitoring was undertaken at various times between 2 September 2015 and 6 April 2016. Monitoring locations are shown in Figure 11.1.

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Data source: LPI, DCDB, Aerial, 2012.

Figure 11.1
Noise and vibration monitoring locations

Attended noise monitoring was also undertaken at the same locations between 21 March 2016 and 6 April 2016 to supplement the noise logger data and identify dominant noise sources.

Vibration measurements were undertaken at one monitoring location adjacent to the proposal site from 22 March 2016 to 23 March 2016. The vibration logger was set up about 15 metres from the existing rail corridor in a location where existing train movements were likely to be the dominant source of vibration levels.

Existing train pass-by noise levels were calculated by reviewing and analysing data from the unattended noise loggers located adjacent to the existing rail corridor.

### Construction noise

Construction working hours are described in section 8.3. An assessment of the potential for construction noise (amenity) impacts was undertaken in accordance with the *Interim Construction Noise Guideline* (DECC, 2009). Noise emissions were assessed during both primary proposal construction hours and outside the primary proposal construction hours. The methodology involved the following tasks:

- Construction noise rating background levels were calculated based on monitoring data and were used to establish the construction noise management levels (that is, the construction noise criteria) in accordance with the *Interim Construction Noise Guideline*. Criteria for road traffic noise were established based on the *Road Noise Policy* (DECCW, 2011).
- Representative sound power levels for likely construction activities and machinery were obtained from the *Construction Noise Strategy* (Transport for NSW, 2012c) and *AS 2436-2010 Guide to noise and vibration control on construction, demolition and maintenance sites.* Noise propagation calculations were then carried out to assess the potential impacts.
- Where noise levels were predicted to exceed the construction noise management levels, mitigation measures were recommended.

### Construction vibration

Vibration from construction plant and equipment was predicted and assessed based on *Assessing Vibration: A Technical Guideline* (DEC, 2006a), *British Standard* (BS) *5228-2:2009 Code of practice for noise and vibration on construction and open sites – Part 2: Vibration* and *BS 6472:1992 Evaluation of human exposure to vibration in buildings.*

Where vibration levels were predicted to exceed the vibration criteria, mitigation measures were recommended.

### Operational noise

Operational noise was assessed in accordance with the *Rail Infrastructure Noise Guideline* (EPA, 2013) ('the RING'). Assessment results were presented for the following modelling scenarios:

1. No build and build scenarios for the year in which the existing train operations recommence following construction (2020).
2. No build and build scenarios when Inland Rail commences operation (2025).
3. No build and build scenarios for the 'design year' – 2040.

Operational (airborne) noise goals were derived from the RING. Airborne noise is defined as noise that reaches a receiver through the air. The RING presents non-mandatory noise goals that trigger the need for an assessment to be conducted. If triggered, the operational noise assessment is required to address the potential noise impacts, and consider mitigation measures that may be feasibly and reasonably applied to mitigate the impacts.

The *Environmental Management System Guide: Noise and Vibration from Rail Facilities* (Sydney Trains, 2013) provides guidance on assessment of sleep disturbance based on the *Industrial Noise Policy* (EPA, 2000).

#### Operational vibration

*Assessing vibration: a technical guideline* (DEC, 2006a) outlines methods of assessing potential impacts and ways to manage vibration from rail operations, such as ground induced vibration created by train movements.

The ground-borne noise trigger levels in the RING were also used. Ground-borne noise is generally only a potential issue where noise levels are higher than the airborne noise levels, such as for underground railways. As there are no underground sections associated with the proposal, the risk of potential adverse ground-borne noise impacts is considered to be low.

#### Mitigation measures

Mitigation measures are provided to avoid or minimise identified impacts. These include standard measures used on similar projects which have been shown to be effective in reducing impacts. They also include project-specific measures which would need to be reviewed as the design progresses to determine whether they are feasible and reasonable to be implemented.

The terms 'feasible' and 'reasonable' are defined by the *Interim Construction Noise Guideline* and the RING. A measure is feasible if it can be engineered and is practical to build, given project constraints such as safety and maintenance requirements. Selecting reasonable measures from those that are feasible involves judging whether the overall noise benefits outweigh the overall adverse social, economic and environmental effects (including costs) of the measure.

### 11.1.2 Legislative and policy context to the assessment

In addition to the guidelines and standards described above, other relevant documents include:

- *Environmental Noise Management Manual* (RTA, 2001)
- *NSW Industrial Noise Policy* (EPA, 2000)
- *Construction Noise Strategy* (Transport for NSW, 2012)
- *AS 1055.1-1997 Acoustics – Description and measurement of environmental noise*
- *AS 2436–2010 Guide to noise and vibration control on construction, demolition and maintenance sites*
- *Transit noise and vibration impact assessment* (USA Federal Transit Administration, 2006).

## 11.2 Noise and vibration management levels/criteria - amenity

### 11.2.1 Construction noise management levels

Table 11.1 lists the construction noise management levels for the proposal. It is noted that, based on the *Interim Construction Noise Guideline*:

- the 'noise affected' management level represents the level above which there may be some community reaction to noise
- the 'highly noise affected' management level represents the level above which there may be strong community reaction to noise.

*Table 11.1 Construction noise management levels*

| Receiver | Period | Times | Background level (dB(A)) $L_{A90(period)}$[1] | Management level (dB(A)) $L_{Aeq(15 min)}$[2] |
|---|---|---|---|---|
| Residential | Standard hours | Mon-Fri: 7am – 6pm<br>Sat: 8am – 1pm<br>Sun/public holidays: no works | 30 | Noise affected level: 40<br>Highly noise affected level: 75 |
| | Outside standard hours - evening | Mon-Fri: 6pm – 10pm<br>Sat: 1pm – 10pm<br>Sun/public holidays: 8am – 6pm | 30 | Noise affected level: 35 |
| | Outside standard hours - night/early morning | Mon-Fri: 10pm – 7am<br>Sat: 10pm – 8am<br>Sun/public holidays: 6pm – 7am | 30 | Noise affected level: 35 |
| Industrial | When in use | - | n/a | 75 dB(A) |

Source: *Interim Construction Noise Guideline (DECC 2009)*

Notes: 1: The Industrial Noise Policy states that where the rating background level is less than 30 dB(A), then it is set to 30 dB(A)
2: The noise affected management level is the background noise level plus 10 dB(A) during recommended standard working hours and the background noise level plus 5 dB(A) outside recommended standard hours.

**Proposal specific construction noise management level**

The proposed construction working hours are described in section 8.3. Construction would be undertaken both during and outside standard construction hours defined by the *Interim Construction Noise Guideline,* and individual activities may span across time periods. As a result, the more stringent construction noise management level of 35 dB(A) has been adopted as the proposal specific management level.

### 11.2.2 Construction traffic noise criteria

Table 11.2 lists the construction road traffic noise criteria for residential land uses.

*Table 11.2 Construction road traffic noise criteria (residential land uses)*

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

Source: *Road Noise Policy (OEH, 2011)*

Note 1: Section 2.4 of the *Road Noise Policy* indicates that, where existing road traffic noise levels already exceed the assessment criteria, an increase of less than two dB(A) represents a minor impact that is barely perceptible to the average person.

### 11.2.3 Operational rail noise criteria

Based on the RING, predicted rail noise levels need to exceed the criteria ('trigger values') listed in Table 11.3 to initiate an assessment of noise impacts and mitigation measures.

For the assessment, the proposal was categorised as follows:

- redevelopment of an existing heavy rail line – track works
- new rail line development - the Parkes north west connection.

For residential receivers, the criteria have two components – $L_{Aeq}$ (assessed over the day or night) and $L_{Amax}$ (train pass by events).

*Table 11.3 Rail traffic noise criteria – residential land uses*

| Type of development | Noise criteria (dB(A)) (external) | |
|---|---|---|
| | Day (7am –10pm) | Night (10pm – 7am) |
| Redevelopment of existing rail line | Development increases existing $L_{Aeq(period)}$ rail noise levels by 2 dB or more, or existing $L_{Amax}$ rail noise levels by 3 dB or more, and predicted rail noise levels exceed: | |
| | 65 $L_{Aeq(15h)}$ OR 85 $L_{AFmax}$ | 60 $L_{Aeq(9h)}$ OR 85 $L_{AFmax}$ |
| New rail line | Predicted rail noise levels exceed: | |
| | 60 $L_{Aeq(15h)}$ OR 80 $L_{AFmax}$ | 55 $L_{AEq(9h)}$ OR 80 $L_{AFmax}$ |

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

In accordance with the RING, other non-residential sensitive land uses (including hospitals, schools and outdoor recreational areas) have their own specific noise trigger levels for rail redevelopments, applicable when the facility or space is in use. The criteria for other sensitive land uses are listed in Table 11.4.

*Table 11.4 Rail traffic noise criteria – non-residential land uses*

| Land use | New rail line development noise criteria (dB(A)) (when in use)[1] | Redevelopment of existing rail line noise criteria (dB(A)) (when in use)[1] |
|---|---|---|
| | Resulting rail noise levels exceed: | Development increases existing $L_{Aeq(period)}$ rail noise levels by 2 dB or more, and resulting rail noise levels exceed: |
| Schools, educational institutions and child care centres | 40 $L_{Aeq(1h)}$ (internal) | 45 $L_{Aeq(1h)}$ (internal) |
| Places of worship | 40 $L_{Aeq(1h)}$ (internal) | 45 $L_{Aeq(1h)}$ (internal) |
| Hospital wards | 35 $L_{Aeq(1h)}$ (internal) | 40 $L_{Aeq(1h)}$ (internal) |
| Hospitals – other uses | 60 $L_{Aeq(1h)}$ (external) | 65 $L_{Aeq(1h)}$ (external) |

| Land use | New rail line development noise criteria (dB(A)) (when in use)[1] | Redevelopment of existing rail line noise criteria (dB(A)) (when in use)[1] |
|---|---|---|
| Open space – Passive use | 60 $L_{Aeq(15h)}$ (external) | 65 $L_{Aeq(15h)}$ (external) |
| Open space – Active use | 65 $L_{Aeq(15h)}$ (external) | 65 $L_{Aeq(15h)}$ (external) |

Source: *Rail Infrastructure Noise Guideline* (EPA, 2013).
Note 1: The RING allows for an open window to provide ventilation. Noise trigger levels for these receivers are applicable as internal or external levels depending on the land use. As construction materials and the facade acoustic performance of these buildings is unknown and may vary, a conservative 10 dB reduction in noise between the external level and internal level has been assumed.

### 11.2.4 Sleep disturbance

Sleep disturbance criteria are based on the *Road Noise Policy,* which suggests that internal noise levels below 50 dB(A) $L_{Amax}$ to 55 dB(A) $L_{Amax}$ are unlikely to cause awakening reactions, and one or two events per night, with internal noise levels of 65 dB(A) $L_{Amax}$ to 70 dB(A) $L_{Amax}$ (inside dwellings), are not likely to significantly affect health and wellbeing.

### 11.2.5 Human comfort vibration criteria

Construction typically generates ground vibration of an intermittent nature. Acceptable vibration levels, defined by *Assessing vibration: A technical guideline*, are listed in Table 11.5 for each type of sensitive receiver.

***Table 11.5 Acceptable vibration values for intermittent vibration***

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

Source: *Assessing vibration: A technical guideline* (DEC, 2006a)

Notes: 1. Daytime is 7am to 10pm, and night-time is 10pm to 7am.

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

Humans are capable of detecting vibration levels well below those that risk causing damage to a building. The degrees of perception for humans are suggested by the vibration level categories provided in *BS 5228-2:2009 Code of practice for noise and vibration on construction and open sites – Part 2: Vibration,* as listed in Table 11.6.

*Table 11.6 Guidance on the effects of vibration levels*

| Approximate vibration level (mm/s) | Degree of perception |
|---|---|
| 0.14 | Vibration might be just perceptible in the most sensitive situations for most vibration frequencies associated with construction. At lower frequencies, people are less sensitive to vibration. |
| 0.3 | Vibration might be just perceptible in residential environments. |
| 1 | It is likely that vibration of this level in residential environments would cause complaint, but can be tolerated if prior warning and explanation has been given to residents. |
| 10 | Vibration is likely to be intolerable for any more than a very brief exposure to this level. |

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

# 11.3 Existing environment

## 11.3.1 Sensitive receivers

As described in chapter 2, the majority of the proposal site passes through rural land. Sensitive receivers are concentrated in the main towns (Parkes, Peak Hill, and Narromine), with scattered residential receivers located on rural properties surrounding the proposal site. Receiver locations are shown in Figure 11.2. The closest residential receiver is located about 45 metres from the proposal site.

Non-residential noise receivers include two places of worship, three educational facilities, one medical facility, six active and two passive recreation areas. A number of commercial and industrial facilities are also located near the proposal site, and are subject to assessment for construction noise only.

The baseline noise monitoring results indicate that background noise levels are dominated by natural sounds, usually wind through long grass or trees, with occasional train pass-by noise events.

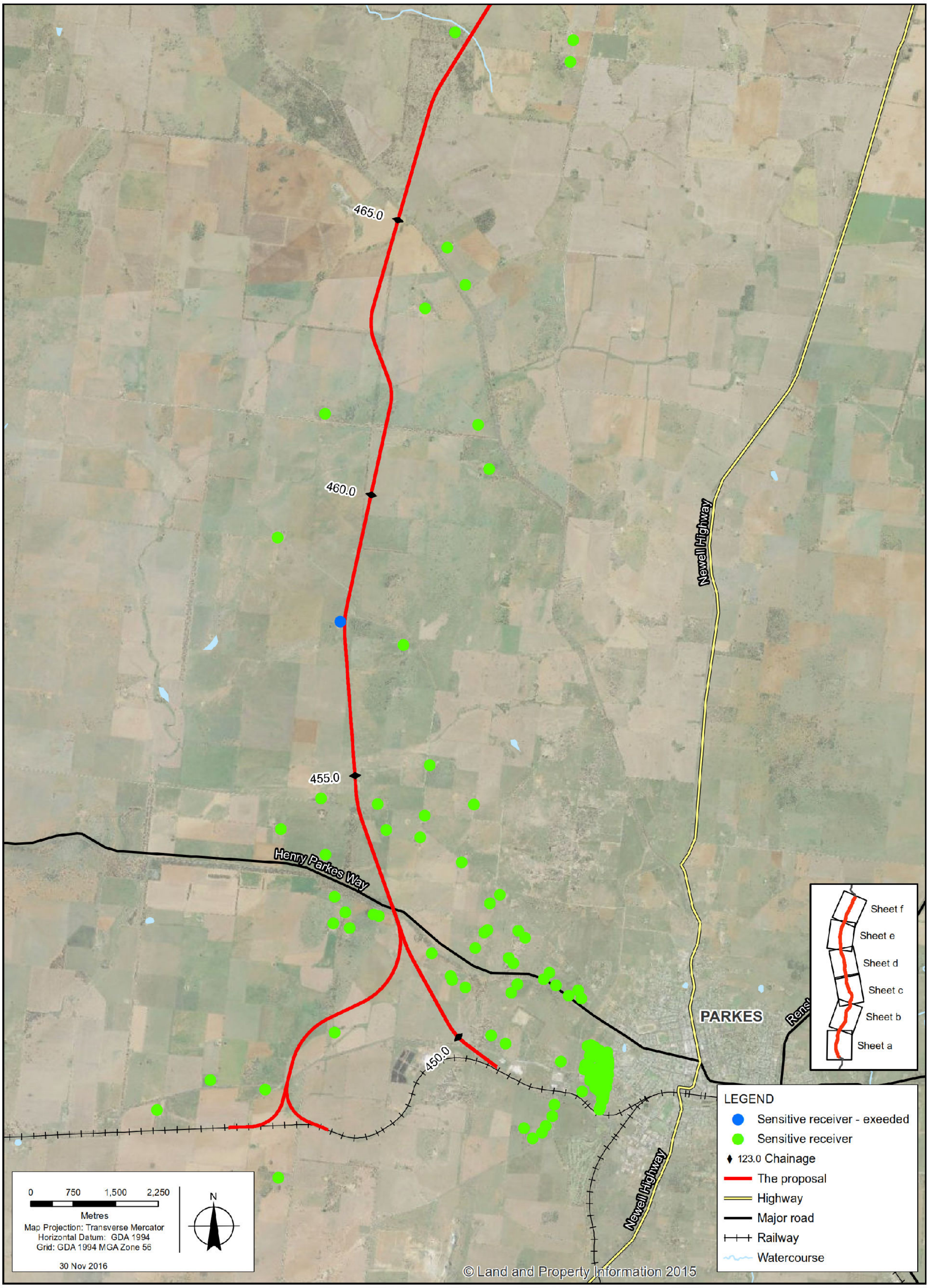
Further information on sensitive receivers and detailed noise monitoring results are provided in Technical Report 5.

### Train pass-by noise levels

Existing train pass-by noise levels recorded by the noise loggers ranged from a sound exposure level of 80 dB(A) (at a logger located 420 metres from the existing rail corridor) to a sound exposure level of 97 dB(A) (recorded by two loggers located 10 and 35 metres from the corridor). The recorded duration of train pass-by events ranged from 24 to 74 seconds.

## 11.3.2 Vibration

Vibration levels of about one to 1.3 millimetres per second were recorded at the vibration logger during train pass-by events. Between pass-by events, background vibration levels were about 0.1 millimetres per second.

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Data source: Data Custodian, Data Set Name/Title, Version/Date.

Figure 11.2a

Sensitive receiver locations

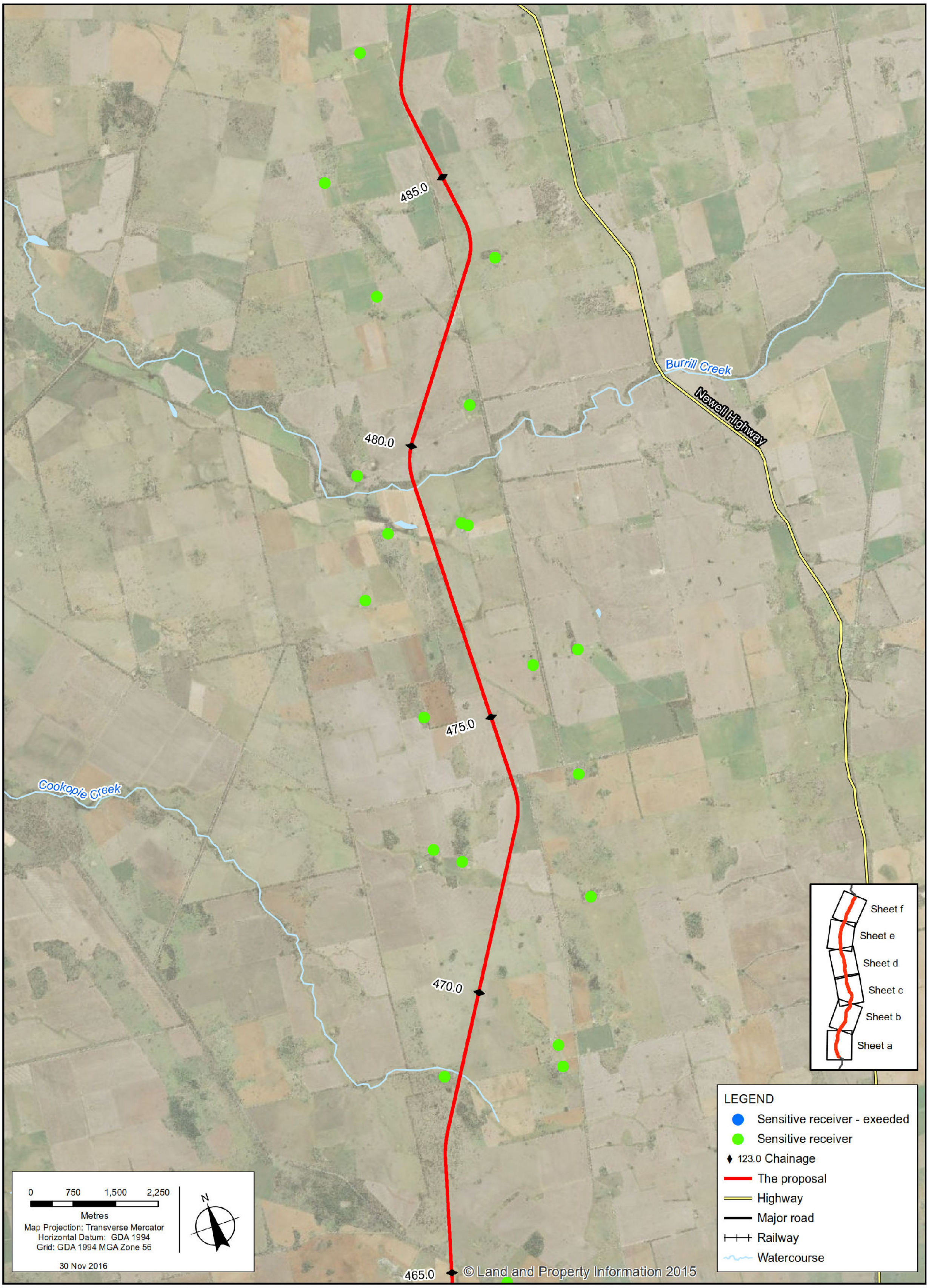


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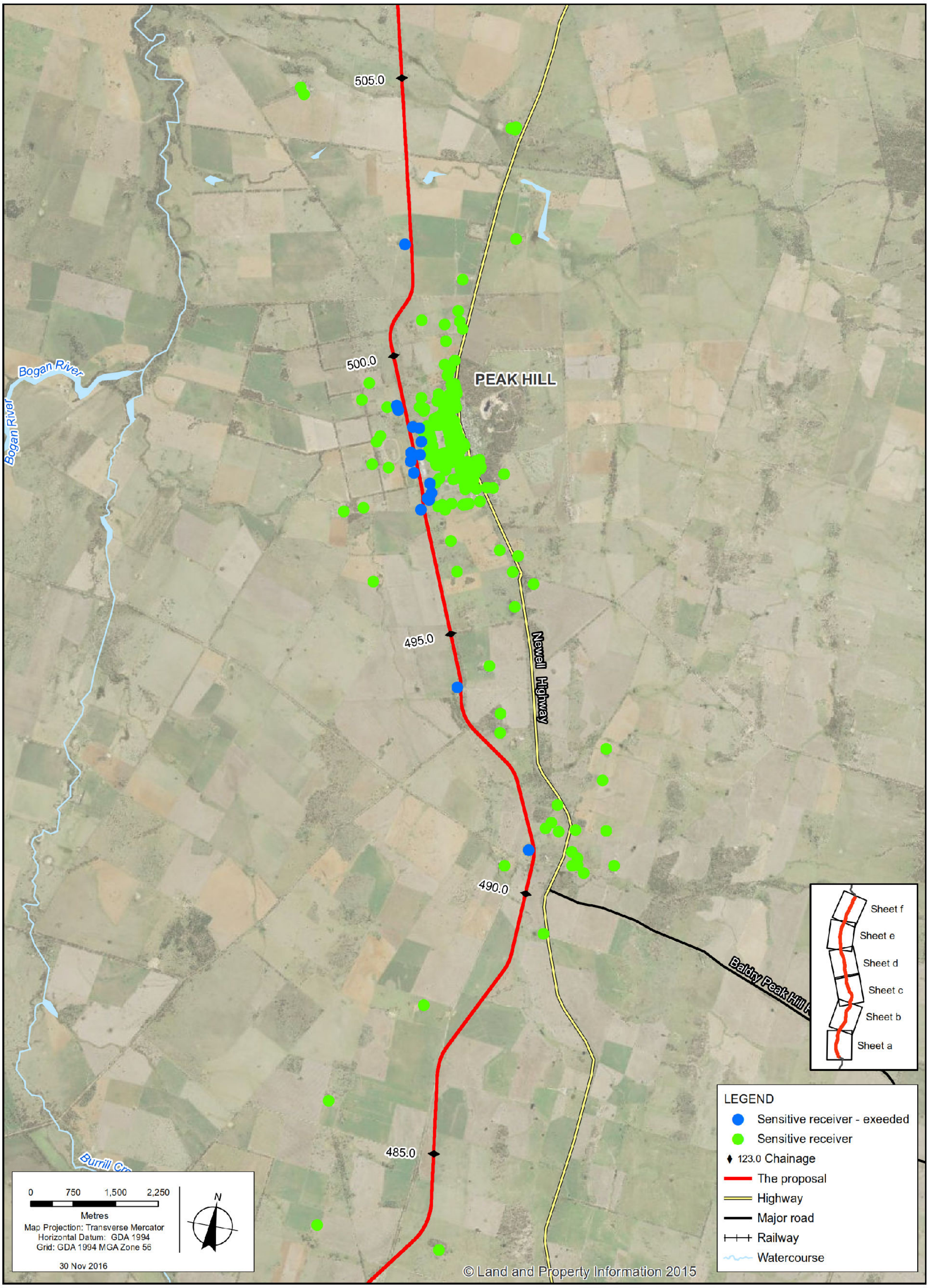
Figure 11.2b

Sensitive receiver locations



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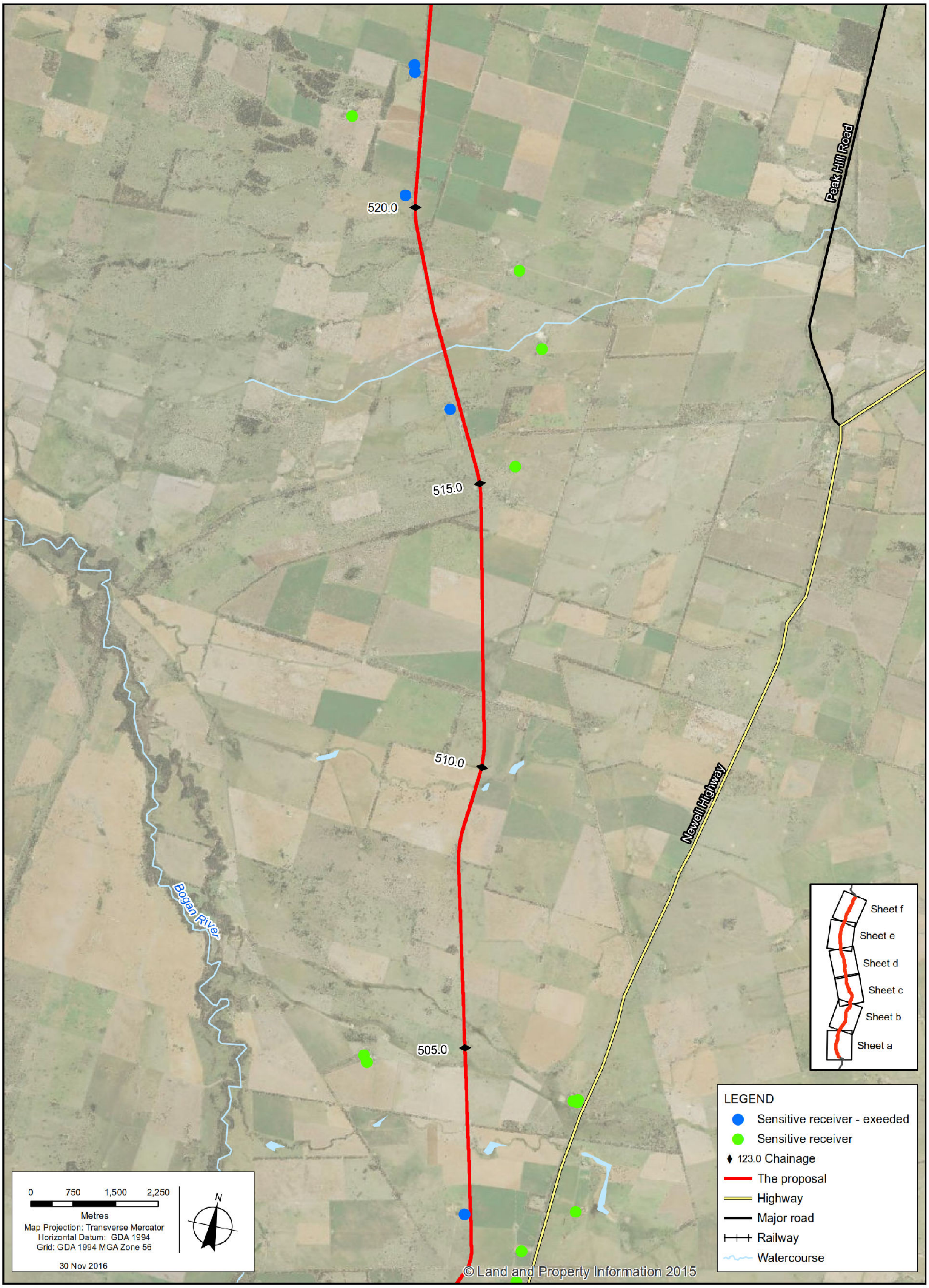
Data source: Data Custodian, Data Set Name/Title, Version/Date.

Figure 11.2c

Sensitive receiver locations

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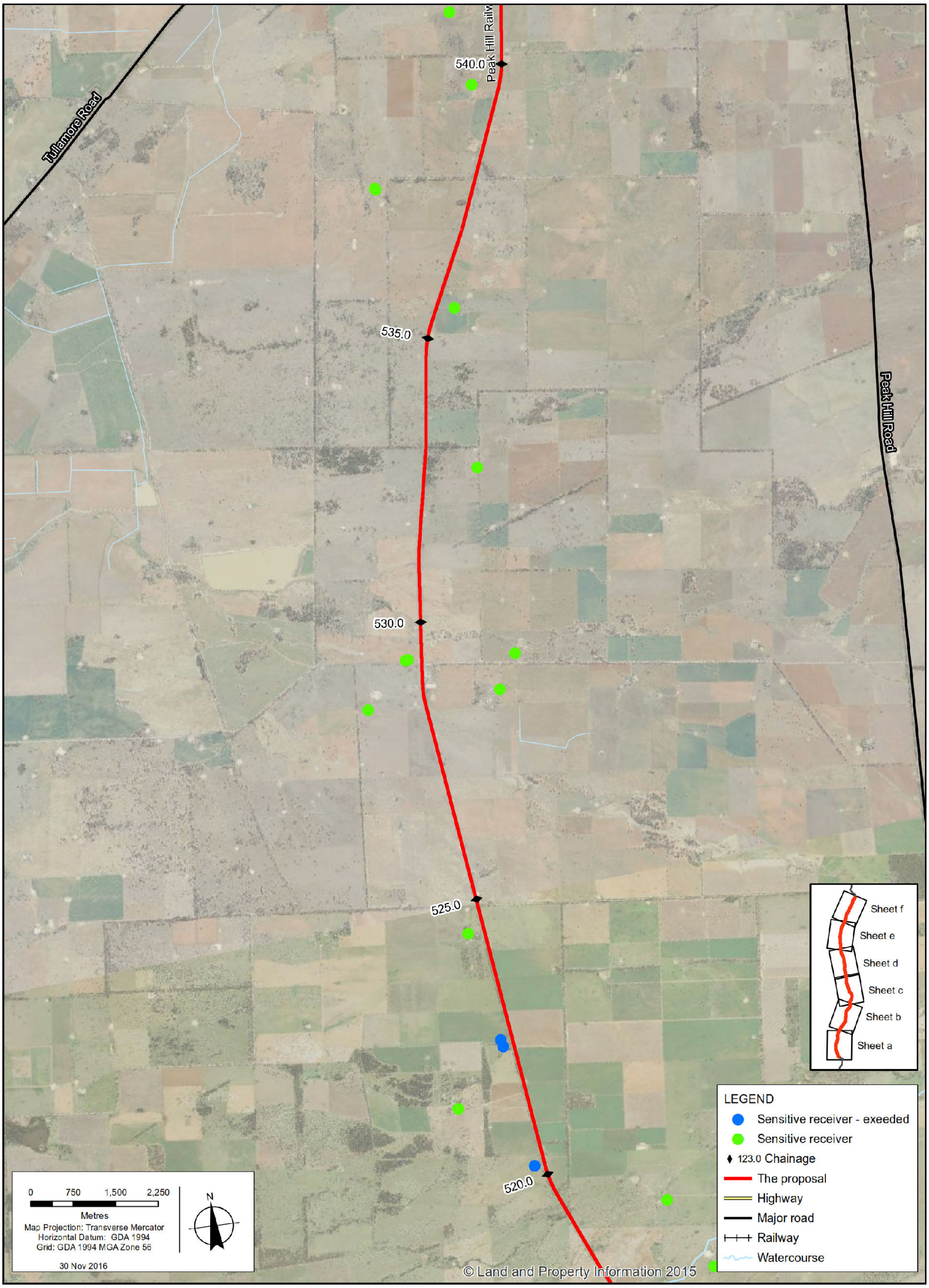
Data source: Data Custodian, Data Set Name/Title, Version/Date.

Figure 11.2d

Sensitive receiver locations

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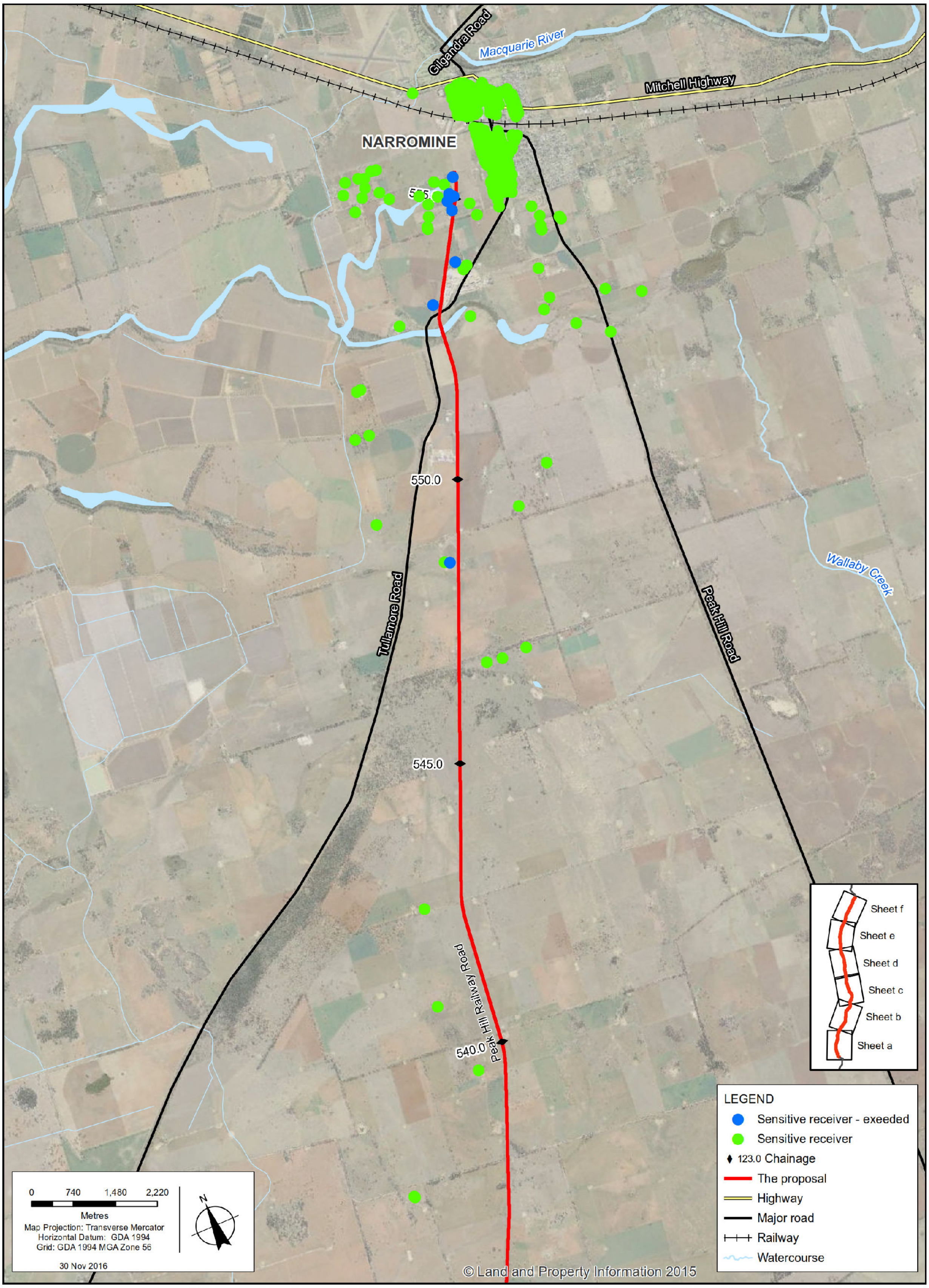
Data source: Data Custodian, Data Set Name/Title, Version/Date.

Figure 11.2e
Sensitive receiver locations

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Data source: Data Custodian, Data Set Name/Title, Version/Date.

Figure 11.2f

Sensitive receiver locations

## 11.4 Impact assessment

### 11.4.1 Risk assessment

The environmental risk assessment for the proposal (Appendix B) included an assessment of the potential amenity risks as a result of noise and vibration. Risks with an assessed level of medium or above included:

- noise impacts on local residents and sensitive receivers from construction activities, particularly during work outside recommended standard working hours
- noise impacts on local residents and sensitive receivers from construction traffic
- noise impacts on local residents and sensitive receivers from the operation of trains.

#### How potential impacts would be avoided

Potential noise and vibration (amenity) impacts would be avoided by:

- designing, constructing and operating the proposal to minimise the potential for noise and vibration (amenity) impacts
- implementing the Inland Rail Noise and Vibration Management Strategy and developing specific noise mitigation approaches in accordance with the Inland Rail NSW Construction Noise and Vibration Management Framework, described in section 11.5.1
- implementation of mitigation measures listed in section 11.5.

### 11.4.2 Construction noise

Construction typically requires the use of heavy machinery which can generate high noise and vibration levels at nearby receivers. The potential impacts may vary greatly depending on the intensity and location of construction activities, the type of equipment used, existing background noise, intervening terrain, and prevailing weather conditions.

In accordance with the assessment guidelines, potential noise impacts were predicted with a focus on those activities with the highest potential to cause noise impacts, and assuming that the loudest two items of plant for each activity operate continuously. As a result, the predictions identify worst case construction noise levels, which may not be reached, or only reached infrequently.

Potential noise emissions from construction activities were modelled for identified sensitive receivers based on various construction scenarios. The different construction scenarios represent different equipment noise levels, providing an indication of how noise levels may change across the proposal site. Waste management (excavation, handling, on-site storage and transport) has been considered in each construction scenario, where relevant to that activity. Modelling was undertaken to predict the potential impacts during the primary proposal construction hours.

As a result of the modelling, adopted activity sound power levels were determined. These range from 109 dB(A) for level crossing works, to 120 dB(A) for earthworks. It was estimated that the majority of activities would generate a sound power level of around 115 to 118 dB(A).

Table 11.7 lists the predicted exceedances of the noise management levels for each activity modelled, and the numbers of receivers where the ‘noise affected’ level may be exceeded.

Where noise is above the proposal specific construction noise management level, all feasible and reasonable work practices to minimise noise need to be implemented, and all potentially affected receivers need to be informed. If no quieter work method is feasible and reasonable, consultation with the impacted residence would be undertaken to explain the duration and noise levels of the works and any respite periods that would be provided.

*Table 11.7 Construction activity noise management level exceedances*

| Construction activity | Maximum predicted level of exceedance above 35 (dB(A)) | Number of receivers with predicted exceedances |
|---|---|---|
| Track works | 33 | 294 |
| Culvert works | 25 | 264 |
| Crossing loops | 18 | 135 |
| Level crossing – major upgrade | 24 | 59 |
| Level crossing – minor upgrade | 21 | 20 |
| Parkes north west connection – site establishment | 14 | 9 |
| Parkes north west connection – earthworks | 18 | 23 |
| Parkes north west connection – track works | 14 | 9 |
| Brolgan Road overbridge | 18 | 2 |
| Post construction | 28 | 99 |

Note: 1. As defined by DECC, 2009

The results of the construction noise assessment are summarised below.

## Impacts of construction of the key proposal features

### Track works

Activities that encompass the entire proposal site, such as site establishment (includes construction compound activities as described in section 8.4), track works, and drainage construction, are predicted to exceed the proposal specific construction management level:

- between Parkes and Peak Hill – at 29 receivers with impacts up to 27 dB
- within Peak Hill – at 123 receivers with impacts up to 30 dB
- between Peak Hill and Narromine – at 76 receivers with impacts up to 33 dB.

Construction would progress along the proposal site, and noise impacts would be experienced for a relatively short time at most locations. Construction in each work area would be completed within about eight to 10 weeks.

### Level crossing changes

Level crossing works are predicted to exceed the proposal specific construction management level:

- between Parkes and Peak Hill at nine receivers with impacts up to 13 dB
- within Peak Hill at 37 receivers with impacts up to 24 dB
- between Peak Hill and Narromine at 14 receivers with impacts up to 19 dB.

#### Culvert works

Culvert works are predicted to exceed the proposal specific construction management level:

- between Parkes and Peak Hill at 23 receivers with impacts up to 10 dB
- within Peak Hill at 119 receivers with impacts up to 18 dB
- between Peak Hill and Narromine at 67 receivers with impacts up to 25 dB.

#### Crossing loops

Construction of the crossing loops is predicted to exceed the proposal specific construction management level:

- between Parkes and Peak Hill at one receiver with impacts up to two dB
- within Peak Hill at 105 receivers with impacts up to 17 dB
- between Peak Hill and Narromine at 7 receivers with impacts up to 18 dB.

#### Parkes north west connection

Construction of the Parkes north west connection is predicted to exceed the proposal specific construction noise management levels at 18 receivers with impacts up to 18 dB.

#### Brolgan Road overbridge

Construction of the Brolgan Road overbridge is predicted to exceed the proposal noise management levels at two receivers with impacts up to 18 dB.

Feasible and reasonable mitigation measures would be required to minimise the potential impacts predicted, as described in section 11.5.

### Impacts of construction in relation to working hours

Construction working hours, and the activities that would be undertaken during each, are described in section 8.3. Where exceedances of construction management levels are predicted, reasonable and feasible mitigation measures would be implemented to reduce the significance of impacts.

#### Impacts of works

The assessment concluded that:

- rail line redevelopment construction activities are predicted to exceed the noise management level at receivers nearest to the construction footprint. Impacted receivers are within about 700 metres of the works and includes up to 228 identified noise sensitive residential receiver locations. Noise levels are predicted to exceed the proposal specific construction management level by up to 33 dB.
- new rail line construction works at the Parkes north west connection are predicted to exceed the proposal specific construction management level by up to 18 dB at 23 noise sensitive receivers.
- construction of the Brolgan road overbridge is predicted to exceed the proposal specific construction management level by about 18 dB at two residential receivers.
- construction is not predicted to exceed the noise management level for non-residential sensitive receivers.

### Sleep disturbance

The results of modelling indicate that the sleep disturbance criteria is predicted to be exceeded for:

- track works – exceedances at 13 receivers
- level crossing track works – exceedances at two receivers
- culvert works – exceedances at two receivers
- post construction works – exceedances at seven receivers.

### Construction traffic noise

The increase in noise levels due to construction traffic is estimated to be less than one dB which would not be noticeable at receivers.

Feasible and reasonable mitigation measures would be implemented to minimise the potential impacts predicted, as described in section 11.5.

## 11.4.3 Construction vibration

### Safe working buffer distances

Typical vibration levels generated by various construction plant are listed in Table 11.8.

*Table 11.8 Predicted vibration levels from construction equipment*

| Vibration source | Approximate vibration levels (mm/s) based on distances to source | | | |
|---|---|---|---|---|
| | 10 m | 20 m | 50 m | 100 m |
| Roller | 6.0 | 3.4 | 1.7 | 1.0 |
| 15 tonne vibratory roller | 8.0 | 4.6 | 2.2 | 1.3 |
| 7 tonne compactor | 6.0 | 3.4 | 1.7 | 1.0 |
| Dozer | 4.0 | 2.3 | 1.1 | 0.6 |
| Backhoe | 1.0 | 0.6 | 0.3 | 0.2 |
| Excavator | 2.1 | 1.2 | 0.6 | 0.3 |
| Piling (impact) | 30 | 17.2 | 8.3 | 4.8 |
| Piling (vibratory)[1] | 16.8 | 7.3 | 2.4 | 1.1 |
| Piling (bored)[1] | 7.4 | 4.3 | 2.1 | 1.2 |

Note 1: Based on levels derived from *BS 5228:2009. Bored piling through stones or other obstruction*. Vibratory piling based on relationship provided in Table E.1.

Based on these typical vibration levels, safe working buffer distances to comply with the human comfort vibration criteria are listed in Table 11.9. In multi-level buildings, vibration may be amplified through the structure to the upper floors. A doubling of the buffer distances provided in Table 11.9 would provide a conservative allowance for this possible effect.

*Table 11.9 Vibration safe working buffer distances*

| Activity | Human comfort buffer distance (m) (1.0mm/s)[1] |
|---|---|
| ***General construction activities*** | |
| Roller | 90 |
| 15 tonne vibratory roller | 140 |
| 7 tonne compactor | 90 |
| Dozer | 60 |
| Backhoe | 10 |
| Excavator | 25 |
| ***Piling*** | |
| Piling (impact) | 700 |
| Piling (vibratory)[2] | 110 |
| Piling (bored)[2] | 120 |

Notes 1: Based on advice given in *BS 7385:1993 – Evaluation and measurement of vibration in buildings*.

2: Based on levels derived from *BS 5228-2*.

## Works in the rail corridor and at crossing loops

During general construction works, vibration may be perceptible at certain times within 140 metres of the works. Twenty residential receivers were identified within this distance, including six near Narromine, 10 near Peak Hill, and four scattered along the proposal site.

Construction would progress along the proposal site, and vibration impacts would be experienced for relatively short times at most locations. Construction in each work area would be completed within about eight to 10 weeks.

Feasible and reasonable mitigation measures would be implemented to minimise the potential impacts predicted, as described in section 11.5.

## Works involving bridge construction

Piling would be required to construct the Brolgan Road overbridge. Vibration impacts due to boring of the piles has the potential to impact receivers located up to 120 metres from the works. The piling activities are anticipated near the bridge span, which is located more than 400 metres from the nearest vibration sensitive receiver, therefore no human comfort impacts are predicted.

## Impacts during different working hours

### Impacts of works during the primary proposal construction hours

For works during the primary proposal construction hours, the assessment concluded that vibration may be perceptible at 20 residential receiver locations. Where vibration generating activities are proposed within 140 metres of an occupied residence, mitigation would be implemented where feasible and reasonable.

### Impact of works outside proposed construction hours

Receivers are likely to have higher sensitivity to vibration experienced outside the proposed working hours compared to that experienced during proposed hours. For works outside the proposed hours, mitigation would be considered and implemented where feasible and reasonable where vibration generating activities are proposed within 140 metres of an occupied residence.

## 11.4.4 Operational noise

### Noise generated by operation of the rail vehicles

As noted in section 11.2.3, the predicted rail noise levels need to exceed the RING trigger values listed in Table 11.3 to initiate an assessment of noise impacts and mitigation measures. Modelling was undertaken to compare the existing no build (2020) noise levels with the predicted noise levels for the future build scenarios (2025 and 2040).

Modelling indicated that RING trigger values for night noise criteria would be exceeded:

- at 14 locations for the 2025 scenario
- at 28 locations for the 2040 scenario.

It is noted that the 2019 no build scenario represents the 2025 and 2040 no build scenarios, since there are no predicted changes in operational conditions/parameters without the proposal proceeding.

Most of the exceedances are predicated in and around Peak Hill. This is because there is a higher concentration of receivers located close to the proposal site at Peak Hill.

No exceedances of the RING trigger values were predicted for operation of the Parkes north west connection.

Further information in relation to exceedances at individual locations is provided in Technical Report 5.

Feasible and reasonable mitigation measures would be implemented to minimise the potential impacts predicted, as described in section 11.5.

### Horn noise

Horns are an important safety device and are a normal part of train operations. Trains are generally required to sound their horns as they pass through level crossings and at certain other times. ARTC's *Locomotive Specific Interface Requirements (WOS 01.300)* provides minimum and maximum levels for horn noise. It is acknowledged that noise emitted by train horns can be a source of annoyance for the general public. The minimum distance from the horn required to achieve the RING trigger value is listed in Table 11.10.

***Table 11.10 Estimated distance from train horn to achieve the RING $L_{Amax}$ trigger value***

| Item | High noise level horn | Low noise level horn | |
|---|---|---|---|
| Speed | Stationary | Stationary | Stationary |
| External noise limit | 88 dB(A) minimum, measured 200 m in front | 85 dB(A) minimum, measured 100 m in front | 90 dB(A) maximum, measured 100 m in front |
| Minimum distance to achieve $L_{Amax}$ 85 dB(A) | 282 m | 100 m | 180 m |

Source: *ARTC's Locomotive Specific Interface Requirements (WOS 01.300).*

During operation, an increase in the number of horn events is expected due to the projected increase in train numbers. However, a number of level crossings would be removed as part of the proposal. Therefore, the number of locations requiring horn usage would decrease along the total length of the proposal site.

## 11.4.5 Operational vibration

Ground-borne rail vibration from heavy rail infrastructure can adversely affect sensitive receivers situated close to a rail line. Vibration can contribute to annoyance and human comfort impacts at levels which are often only slightly higher than the limit of perception.

The vibration assessment predicted that daytime vibration levels for human comfort levels would be acceptable at distances of more than 11 metres from the track, while night-time levels are predicted to be acceptable at distances of more than 17 metres from the track.

The nearest receiver is located about 45 metres from the proposal site. Therefore, no receivers would be expected to experience amenity related vibration impacts during either the day or night.

# 11.5 Mitigation and management

## 11.5.1 Approach to mitigation and management

ARTC has developed the Inland Rail Noise and Vibration Management Strategy (provided in Appendix M) to guide assessment and construction of new and upgraded infrastructure and the operation of Inland Rail. The strategy:

- considers relevant legislation, licences and guidelines for NSW, Victoria and Queensland
- aims for consistency in the management of noise and vibration between states
- integrates with existing ARTC policies and guidelines.

Management of noise and vibration during construction and operation of the proposal would consider the strategy to ensure consistency with Inland Rail.

### Construction

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

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

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

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

## Operation

An operational noise and vibration review would be prepared to detail how the predicted operation impacts would be mitigated. The operational noise and vibration review would define the further design work and iterative noise modelling required during detailed design to identify feasible and reasonable mitigation measures for operational noise. This would involve consideration of the mitigation options described below. The final form of the mitigation options would be determined during detailed design.

The operational noise and vibration review would:

- confirm predicted project noise and vibration levels at sensitive receivers, which may include the results of façade testing for non-residential receivers
- assess feasible and reasonable noise and vibration measures in a hierarchical manner, consistent with RING
- identify options for controlling noise and vibration at the source and/or receiver, including location, type, and timing of implementation (as described below)
- specify noise and vibration abatement measures for all relevant sensitive receivers
- include a consultation strategy to seek feedback from directly affected stakeholders on the proposed noise and vibration abatement measures
- include a timetable for delivery of abatement prior to operation
- outline post-operational monitoring to verify noise and vibration predictions.

The proposal would be operated in accordance with the operational noise and vibration review, the conditions of approval for the proposal, and the EPL for Inland Rail.

Where exceedances of criteria for non-residential sensitive receivers have been predicted, this would be verified during detailed design, and would involve further investigation of the façade performance at these receivers.

The predicted noise and vibration levels, and the noise and vibration mitigation measures, would be confirmed during the detailed design phase.

To validate the predicted noise levels, monitoring would be undertaken after the commencement of operation of Inland Rail as a whole. Monitoring would confirm compliances with the predicted noise levels, as modified by the review of feasible and reasonable mitigation measures undertaken at the completion of detailed design.

If the results of modelling indicate that the predicted operational noise and vibration levels are being exceeded, then additional feasible and reasonable mitigation measures would be implemented in consultation with affected property owners.

### Options for operational noise impact mitigation

The assessment predicts that mitigation measures would be required for operational rail noise at affected sensitive receivers. Three main strategies are used to reduce noise and vibration impacts:

- controlling noise and vibration at the source
- controlling noise and vibration on the source to receiver transmission path
- controlling noise and vibration at the receiver.

Strategies would be assessed against a range of issues to determine whether they are feasible and reasonable, including:

- cost of construction and ongoing maintenance
- potential environmental, visual and social impacts
- consideration of feedback from relevant stakeholders and landowners.

The RING recommends that control strategies should be considered in a hierarchical manner so that all measures which reduce noise at the source are exhausted before property based measures are considered.

Preliminary information on a range of potential noise mitigation options is provided in Table 11.11. These mitigation options would be considered as part of the detailed design of the proposal. Further information on the approach to noise and vibration mitigation is provided in Technical Report 5.

*Table 11.11 Potential operational noise mitigation options*

| Mitigation option | Description |
|---|---|
| Rail dampers | Rail dampers are preformed elements made of an elastic material containing steel strips. Dampers are placed on the sides of the tracks, dampening the vibration of the rails as the train passes over them and reducing noise emissions.<br><br>Noise reduction in the order of two to five dB(A) can be achieved, depending on the rail roughness (the smoother the rail, the less attenuation). However, this is only valid when the wheel-rail interface is the main noise source.<br><br>In the context of freight train pass-bys, rail dampers would not attenuate $L_{Amax}$ levels, which are normally dominated by locomotive noise, but would reduce wagon noise. |
| Track lubrication | Trackside lubrication strategies can be implemented to improve the performance of the track and reduce noise, particularly from rail squeal and flanging on tight curves. This can result in a substantial noise reduction in $L_{Aeq}$, and $L_{Amax}$ noise levels. However, there are very few tight radius curves in the proposal, so track lubrication would have limited application. |
| Noise barriers/earth mounds | Noise barriers are typically constructed on the edge of the rail corridor to shield sensitive receivers from the noise generated by the operation of rail vehicles. Depending on the situation, noise barriers can achieve a 10 to 15 dB(A) attenuation.<br><br>Noise barriers can result in cost and visual impacts. They are generally preferable where noise attenuation at a larger number of receivers is required, and are not typically cost-effective for a small number of receivers.<br><br>Earth mounds can sometimes be used as noise barriers, and can provide effective mitigation of noise if sufficient spoil and space for the required height is available. However, earth mounds generally provide less attenuation of noise than noise barriers, and require a larger area to reach a sufficient height. During detailed design the potential to utilise the proposed spoil mounds (described in section 7.4.2) as noise barriers would be investigated. |
| Architectural treatment | Architectural treatment involves implementing measures at affected residences to reduce noise levels. Measures can include installing thicker window glazing, roof insulation, door and window acoustic seals, mechanical/forced ventilation, and/or boundary fences.<br><br>The performance of architectural treatment depends on the condition and design of the residence. Architectural treatment is often the most practical option where individual receivers require noise mitigation and other mitigation options are not considered feasible and reasonable. |

### 11.5.2 Summary of mitigation measures

To mitigate the potential for noise and vibration impacts, the following measures would be implemented.

*Table 11.12 Summary of mitigation measures*

| Stage | Impact | Mitigation measures |
|---|---|---|
| Detailed design/pre-construction | Noise and vibration control | The proposal would be designed with the aim of achieving the operational noise and vibration criteria identified by the noise and vibration assessment. |
| | | An operational noise and vibration review would be undertaken as described in section 11.5.1 to guide the approach to identifying feasible and reasonable mitigation measures to incorporate in the detailed design. |
| Pre-construction/ construction | Construction noise and vibration management | The Inland Rail NSW Construction Noise and Vibration Management Framework would be implemented, and the proposal would be constructed, with the aim of achieving the construction noise management levels and vibration criteria identified by the noise and vibration assessment.<br>All feasible and reasonable noise and vibration mitigation measures would be implemented.<br>Any activities that could exceed the construction noise management levels would be identified and managed in accordance with the Inland Rail NSW Construction Noise and Vibration Management Framework and the CEMP.<br>Notification of impacts would be undertaken in accordance with the consultation plan for the proposal. |
| Construction | Work outside proposed construction hours | An out-of-hours work protocol would be developed to guide the assessment and management of works outside the primary proposal construction hours. |
| Operation | Operational noise and vibration | The proposal would be operated with the aim of achieving the operational noise and vibration criteria identified by the noise and vibration assessment, the requirements of the conditions of approval, and the relevant environment protection licence. |
| | Monitoring | Once Inland Rail has commenced operation, operational noise and vibration compliance monitoring would be undertaken at representative locations to compare actual noise performance against that predicted by the noise and vibration assessment.<br>Compliance monitoring requirements would be defined as part of the operational noise and vibration review.<br>The results of monitoring would be included in an operational noise and vibration compliance report, prepared in accordance with the conditions of approval. |

# 12. Vibration (structural) impacts

*This chapter provides a summary of the noise and vibration assessment of the proposal as it relates to the potential for structural impacts on buildings or objects. It describes the existing environment, assesses the impacts of construction and operation, and provides recommended mitigation measures. The full noise and vibration assessment report is provided as Technical Report 5.*

*This chapter focuses on the potential for structural impacts only, mainly as a result of vibration. The potential for amenity-related noise and vibration impacts is considered in chapter 11.*

## 12.1 Assessment approach

### 12.1.1 Methodology

Vibration impacts described in this chapter are those with the potential to result in structural damage to buildings or other structures. The structural vibration assessment:

- identifies vibration sensitive receivers
- identifies the main potential vibration sources during construction and operation
- establishes structural vibration criteria/management levels to provide a basis for:
  - assessing the potential for impacts during construction
  - assessing the potential for impacts during operation
  - establishing the levels that would be used to refine the design of the proposal
  - monitoring during construction and operation.
- assesses the potential for vibration to exceed the applicable criteria
- provides vibration (structural) mitigation measures.

As there is no blasting proposed during construction, there is no risk of damage due to blast-induced vibration or overpressure.

Vibration monitoring for the assessment is described in section 11.1.1.

#### Identification of vibration sensitive receivers

Potentially sensitive receivers are those that may be affected by changes in vibration levels. Vibration sensitive receivers were identified based on the activities proposed to be undertaken and the nature of the building or structure. Sensitive receivers are summarised in section 12.3.2.

#### Construction vibration

Vibration from construction was assessed at identified sensitive receivers (buildings and heritage items). The methodology for the construction vibration assessment included the following tasks:

- Typical vibration levels for different construction equipment were sourced from the *Environmental Noise Management Manual* (RTA, 2001), *BS 5228.2 Code of Practice for noise and vibration control on construction and open sites: Part 2 Vibration* and the *Construction Noise Strategy* (Transport for NSW, 2012c).
- Vibration from construction plant and equipment was predicted and assessed, and criteria established, based on *Assessing Vibration: a technical guideline* (DEC, 2006a) and the German standard *DIN 4150-3:1999-02 Structural Vibration – Part 3: Effects of vibration on structures*.
- A quantitative assessment was undertaken of potential vibration impacts from the proposed construction equipment. Predictions of vibration impacts were made using distance attenuation calculations.
- Where vibration levels were predicted to exceed threshold levels, appropriate construction vibration mitigation measures were provided.

### Operational vibration

Operational vibration criteria were established based on *Assessing Vibration: a technical guideline* (DEC, 2006a). An assessment of operational vibration impacts was undertaken using the assessment methodology provided in the RING. The assessment was based on measured rail vibration levels and the proposed changes in operation, such as the increase in rail movements, track realignments, new track, and effect on train speeds due to the proposal.

### 12.1.2 Legislative and policy context to the assessment

Other guidelines and policies relevant to the assessment include:

- *Environmental Management System Guide: Noise and Vibration from Rail Facilities* (Sydney Trains, 2013)
- *BS 5228-2:2009 Code of practice for noise and vibration on construction and open sites – Part 2: Vibration*
- *AS 2436-2010 Guide to noise and vibration control on construction, demolition and maintenance sites*
- *Transit noise and vibration impact assessment* (Federal Transit Administration, 2006).

## 12.2 Vibration management criteria

### 12.2.1 Structural damage criteria

Minimum safe levels of short term vibration are listed in Table 12.1. In accordance with DIN 4150-3, a measured value exceeding the safe level does not necessarily lead to damage. However, further investigations are required if these values are likely to be significantly exceeded.

*Table 12.1 Guideline values for short term vibration on structures*

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

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

Notes 1: The term $v_i$ refers to vibration levels in any of the x, y or z axes.

2: In the absence of confirmation of the hertz level, the lowest guideline levels are considered (i.e. 1 to 10 Hz).

3. At frequencies above 100 Hz, the values given in this column may be used as minimum values.

# 12.3 Existing environment

## 12.3.1 Existing vibration levels

As noted in section 11.3.2, vibration levels of about one to 1.3 millimetres per second were recorded at the vibration logger during train pass-by events. Between pass-by events, background vibration levels were about 0.1 millimetres per second.

## 12.3.2 Sensitive receivers

For the purposes of the structural vibration assessment, sensitive receivers include:

- dwellings and buildings of similar design
- buildings used for commercial purposes, industrial buildings, and buildings of similar design
- activities involving use the use of vibration-sensitive equipment
- heritage listed buildings or items (including Aboriginal places and items of environmental heritage).

The most common sensitive receiver are residential dwellings.

Heritage listed items are described in chapters 17 and 18. No heritage listed items are located within or close to the proposal site. The closest listed item is the 'Peak Hill Police Station and Official Residence', which is located 750 metres to east of the proposal site. A potential heritage item, Wyanga cottage, is located about 15 metres to the west of the existing tracks. There are no Aboriginal places of heritage significance or listed items of Aboriginal heritage with the potential to be impacted by vibration located within or close to the proposal site.

# 12.4 Impact assessment

## 12.4.1 Risk assessment

### Potential impacts

The environmental risk assessment for the proposal (Appendix B) included an assessment of the potential structural risks from vibration. Potential risks were rated between low and medium, and included:

- damage to structures from vibration caused by construction activities
- damage to structures from vibration caused by the operation of trains.

### How potential impacts would be avoided

Potential vibration impacts would be avoided by:

- designing, constructing and operating the proposal to minimise the potential for vibration (structural) impacts, including the implementation of mitigation measures in section 12.5
- developing specific mitigation approaches in accordance with the strategy described in section 12.5
- implementation of mitigation measures listed in section 12.5.

### 12.4.2 Construction impacts

The operation of construction plant and equipment has the potential to generate vibration at a level that could result in structural damage to buildings located close to the proposal site.

Typical vibration levels generated by various construction plant are listed in Table 11.8. Based on these typical vibration levels, safe working buffer distances to comply with the human comfort vibration criteria are listed in Table 12.2.

***Table 12.2 Vibration safe working distances***

| Activity | Safe working distance (m) | |
|---|---|---|
| | For heritage buildings *(criteria: 3 mm/s)* | For standard dwellings *(criteria: 5 mm/s)* |
| **General construction activities** | | |
| Roller | 24 | 13 |
| 15 tonne vibratory roller | 35 | 18 |
| 7 tonne compactor | 24 | 13 |
| Dozer | 15 | 8 |
| Backhoe | 3 | 2 |
| Excavator | 7 | 4 |
| **Piling** | | |
| Piling (impact) | 180 | 100 |
| Piling (vibratory) | 50 | 30 |
| Piling (bored) | 35 | 17 |

#### General construction activities

The expected magnitude of ground vibration from general construction activities would not be sufficient to cause damage if works are undertaken at distances greater than 18 metres from standard buildings, and distances greater than 35 metres from heritage structures.

The closest residential receiver is located about 45 metres from the proposal site. This distance is beyond the safe working distances for relevant construction activities, as listed in Table 12.2. As a result, structural damage is not predicted for standard dwellings.

Heritage listed items are located a sufficient distance from the proposal site such that no impacts are predicted. The heritage assessment (described in chapter 18) notes that a potential heritage item, Wyanga cottage is in disrepair and at risk of collapse. This structure is located about 15 metres to the west of the existing tracks, within the safe working distances for heritage structures listed in Table 12.2. Vibration as a result of construction, particularly the movement of dozers, backhoes or excavators, may impact the structure. Mitigation measures would be implemented to minimise the significance of potential impacts, as described in section 12.5 and 18.4.

#### Piling

Pilling may be required to construct the Brolgan Road overbridge. There are no heritage items located in the vicinity of the proposal site for the overbridge. The nearest vibration sensitive building is located more than 400 metres from the proposed piling location, therefore no impacts are predicted.

### 12.4.3 Operational impacts

Vibration from the operation of rail infrastructure can impact sensitive structures located close to the rail line. Vibration can cause buildings, windows, and other fixtures to shake, and can interfere with vibration-sensitive equipment. The level of vibration experienced at a receiver is a function of the energy of the vibration source, the propagation through the ground, and the coupling of the ground to the receiver structure or building. Building damage is not usually likely for operation of rail projects.

The vibration level generated by trains during operation is predicted to be similar to that currently experienced at the nearest sensitive receivers. As noted in section 11.3.2, vibration levels of about one to 1.3 millimetres per second were recorded during train pass-by events at the vibration logger located 15 metres from the proposal site. This level is significantly lower than the structural damage criteria of five millimetres per second for typical dwellings, and three millimetres per second for heritage structures. The closest residential receiver is located about 45 metres from the proposal site.

Operation of the proposal would involve increasing the operational load capacity from 23 to 30 tonnes. This increase is not predicted to result in any significant increases in vibration levels at the closest receivers.

The proposal is not expected to increase operational vibration levels noticeably, and is not expected to exceed structural damage criteria. While no specific mitigation measures are considered necessary, track features such as crossovers, turnouts, and rail joints have the potential to increase vibration levels, and should be avoided near vibration sensitive structures where practicable.

## 12.5 Mitigation and management

### 12.5.1 Approach to mitigation and management

As described in section 11.5, the approach to vibration management during construction and operation would consider the overarching Inland Rail Noise and Vibration Management Strategy (provided in Appendix M). The approach to managing vibration during construction would be guided by the Inland Rail NSW Construction Noise and Vibration Management Framework (provided in Appendix H).

### 12.5.2 Summary of mitigation measures

To mitigate the potential for structural vibration impacts, the following measures would be implemented.

*Table 12.3 Summary of mitigation measures*

| Stage | Impact | Mitigation measures |
|---|---|---|
| Detailed design/pre-construction | Vibration control | The proposal would be designed with the aim of achieving the vibration criteria identified by the noise and vibration assessment.<br><br>Track features such as crossovers, turnouts, and rail joints would be avoided near vibration sensitive structures where practicable. |
| | Construction vibration | Where vibration levels are predicted to exceed the screening criteria, a more detailed assessment of the structure and vibration monitoring would be carried out in accordance with the Inland Rail NSW Construction Noise and Vibration Management Framework, to ensure vibration levels remain below appropriate limits for that structure. |

| Stage | Impact | Mitigation measures |
| --- | --- | --- |
| | Operational noise and vibration review | An operational noise and vibration review would be undertaken as described in section 11.5.1 to guide the approach to identifying feasible and reasonable mitigation measures to incorporate in the detailed design. |
| Construction | Construction vibration management | The Inland Rail NSW Construction Noise and Vibration Management Framework would be implemented, and the proposal would be constructed, with the aim of achieving the construction vibration criteria identified by the vibration assessment. |
| | | All feasible and reasonable vibration mitigation measures would be implemented.<br>Any activities that could exceed the vibration criteria would be identified and managed in accordance with the Inland Rail NSW Construction Noise and Vibration Management Framework and the CEMP.<br>Notification of impacts would be undertaken in accordance with the consultation plan for the proposal. |
| Operation | Operational vibration | The proposal would be operated with the aim of achieving the operational vibration criteria identified by the noise and vibration assessment, the requirements of any conditions of approval, and the relevant environment protection licence. |