9 Noise and vibration

This chapter provides a summary of the noise and vibration assessment undertaken by GHD. A full copy of the assessment report is provided as Technical Report 2 - Noise and vibration impact assessment. The report was written to address the relevant SEARs which are outlined in Appendix A.

9.1 Assessment approach

A summary of the approach to the assessment and the methodology used is provided in this section. A more detailed description of the approach and methodology is provided in Technical Report 2.

9.1.1 Methodology

9.1.1.1 Study area

The study area that informed the model for the construction noise and vibration assessment has been defined as a one kilometre buffer from the project site boundary in all directions. The construction assessment study area extends slightly to the north of Cabramatta Station and south of Warwick Farm Station.

The study area that informed the model for the operational rail noise and vibration assessment has been defined as a one kilometre buffer either side of the rail corridor between the stations of Warwick Farm and Cabramatta. The operational study area is bounded at each end by the extent of the works within the rail corridor.

The study areas have been further sub-divided into the following noise catchment areas (NCA):

- **NCA01:** The area to the north of Jacquie Osmond Reserve and west of the rail corridor. The area comprises commercial and residential land uses. Rail noise, road traffic noise along Railway Parade and noise from commercial premises along Railway Parade dominate the noise environment in NCA01.
- **NCA02:** The area to the north of Jacquie Osmond Reserve and east of the rail corridor. The area comprises residential land uses. Road traffic noise along Broomfield Street and local roads in the area dominate the noise environment. An existing noise wall along Broomfield Street shields the catchment from rail noise.
- **NCA03:** The area to the south of Jacquie Osmond Reserve and west of the rail corridor. The area comprises primarily residential land uses. Rail noise and traffic along local roads dominate the noise environment in the area.
- **NCA04:** The area to the south of Jacquie Osmond Reserve and east of the rail corridor. The area comprises primarily commercial land uses. Rail noise and noise from commercial premises dominate the noise environment.

The operational and construction noise and vibration study areas and the noise catchment areas are shown on Figure 9.1.

9.1.1.2 Key tasks

The noise and vibration assessment involved:

- identifying noise and vibration sensitive receivers
- identifying existing noise and vibration levels in the study area
- establishing noise and vibration criteria/management levels relevant to the project

- identifying existing noise and vibration levels from monitoring in the study area
- modelling operational rail noise for the agreed (year opening 2023 and design year 2033) scenarios and assessing predictions against the relevant *Rail Infrastructure Noise Guideline* (EPA, 2013) (RING) trigger levels
- assessing the potential for noise and vibration to exceed the applicable criteria and impact on the amenity of sensitive receivers
- providing related noise and vibration mitigation measures.

A detailed description of the assessment methodology is provided in section 4 and section 5 of Technical Report 2.

9.1.2 Noise and vibration criteria

The construction and operational noise and vibration criteria for the project are outlined in this section. The criteria are referenced to the relevant noise and vibration guidelines, as stipulated in the SEARs and agency comments.

The predicted noise and vibration levels (refer to section 9.3 and 9.4) are compared with the criteria outlined in this section. If the predicted construction and operational noise and vibration levels exceed the criteria, noise and vibration mitigation measures need to be considered.

9.1.2.1 Construction

Amenity impacts

The construction periods defined in the Construction Noise and Vibration Strategy (CNVS) (Transport for NSW, 2018a) are provided in Table 9.1.

Table 9.1 Construction period hours of operation

Construction hours	Monday to Friday	Saturday	Sunday/Public holiday
Standard hours	7.00 am to 6.00 pm	8.00 am to 1.00 pm	No work
Out-of-hours work - Period 1 (Day)	-	7.00 am to 8.00 am 1.00 pm to 6.00 pm	8.00 am to 6.00 pm
Out of hours work - Period 1 (Evening)	6.00 pm to 10.00 pm	6.00 pm to 10.00 pm	-
Out of hours work - Period 2 (Night)	10.00 pm to 7.00 am	10.00 pm to 7.00 am	6.00 pm to 8.00 am

The standard hours for construction periods are not mandatory and the *Interim Construction Noise Guide* (ICNG) (DECC, 2009) acknowledges that some activities can be carried out outside standard construction hours, assuming that all reasonable and feasible mitigation measures are implemented to minimise impacts on the surrounding sensitive land uses. These works would be required due to the physical location of the works within the operational rail and road corridors, safety reasons and to minimise impacts to transport, environment and adjacent properties.

The ICNG applies to the management of construction noise in NSW. The guideline provides recommendations on construction noise management levels and standard construction periods. The construction noise management levels during recommended standard hours are not intended as a noise limit but rather a level where noise management is required.

Based on the ICNG, the:

- 'noise affected' management level represents the level above which there may be some community reaction to noise (calculated by adding 10 dB to the RBL during recommended standard work hours and by adding five dB to the RBL for works outside of recommended standard work hours)
- 'highly noise affected' management level represents the level above which there may be strong community reaction to noise.

A summary of the project construction noise management levels for residential receivers from construction noise and construction traffic is provided in Table 9.2 and non-residential receivers are shown in Table 9.3(within the study area). These tables show the noise management levels for the different times of the day and night and the level used to identify the potential for sleep disturbance. A noise management level of 75 dB or above is considered 'highly noise affected'

Table 9.2 Residential construction noise management levels, dBA

Noise catchment area	Standard hours	Out of hours work - Period 1		Out of hours work - Period 2	Sleep disturbance L_{AFmax}
		Day	Evening	Night	Night
NCA01	48	43	42	36	52
NCA02	48	43	43	35	52
NCA03	47	42	42	37	52
NCA04	47	42	42	37	52

Note: The time periods for Standard hours, Out of hours work - Period 1 (Day and Evening) and Period 2 (Night) are defined in Table 9.1

Table 9.3 Non-residential construction noise management levels, dBA

Receiver type	Time of day	Management level, $L_{Aeq(15min)}$
Industrial	When in use	75 dBA (external)
Commercial	When in use	70 dBA (external)
Educational institutes	When in use	45 dBA (internal)
Hospital wards and operating theatres	When in use	45 dBA (internal)
Places of worship	When in use	45 dBA (internal)
Passive recreation areas	When in use	60 dBA (external)
Active recreation areas	When in use	65 dBA (external)

Sleep disturbance

The potential for both sleep disturbance and awakenings are considered in the assessment. The ICNG recommends that where construction works are planned to extend over two or more consecutive nights, the project should consider maximum noise levels and the extent and frequency of maximum noise level events exceeding the rating background level. The rating background level is the overall single-figure background level representing each assessment period (day/evening/night) over the whole monitoring period.

The *Noise Policy for Industry* (NPI) (EPA, 2017) provides the latest EPA guidance for the assessment of sleep disturbance. The NPI recommends a maximum noise level assessment to assess the potential for sleep disturbance impacts, which include awakenings and disturbance to sleep stages. The NPI recommends an initial screening test for the maximum noise level events with the following screening levels:

- $L_{Aeq(15\ min)}$ 40 dBA or the prevailing rating background level plus 5 dB, whichever is greater
- L_{AFmax} 52 dBA or the prevailing rating background level plus 15 dB, whichever is greater.

A detailed maximum noise level assessment should be carried out if the screening test indicates there is a potential for sleep disturbance. The detailed assessment should cover the maximum noise level, the extent to which the maximum noise level exceeds the rating background level, and the number of times this happens during the night time period.

Construction traffic

Construction traffic relates to light and heavy vehicle movements associated with travel to and from construction compounds, transporting construction materials and spoil along defined haulage routes as well as personnel travelling to and from construction sites.

Construction related traffic noise objectives are based on the *Road Noise Policy* (RNP) (DECCW, 2011). The RNP states that any increase in the total traffic noise level should be limited to 2 dB above the existing road traffic noise levels. This applies for existing residences and other sensitive land uses affected by additional traffic on existing roads generated by land use developments. The RNP has been used to identify potential impacts as a result of noise produced by construction traffic. If road traffic noise increases due to construction works, is within 2 dBA of current levels, then the RNP objectives would be met and no specific mitigation measures required.

Vibration – human comfort

Construction vibration can adversely affect the amenity of occupants inside buildings as it may affect their quality of life or working efficiency. Human comfort impacts are experienced at levels well below those that can damage or affect a structure and its contents.

Humans are capable of detecting vibration at levels which are well below those causing risk of damage to a building. For construction related vibration, it is considered appropriate to provide guidance on potential impacts in terms of a peak vibration level. The degrees of perception for humans are suggested by the vibration level categories given in *BS5228.2 – Code of Practice for noise and vibration on construction and open sites: Part 2 Vibration* (British Standard, 2009) and are shown below in Table 9.4.

Table 9.4 Guidance on effects of peak vibration levels for human comfort

Peak vibration level	Effect
0.14 mm/s	Vibration might be just perceptible in the most sensitive situations for most vibration frequencies associated with construction
0.3 mm/s	Vibration might be just perceptible in residential environments
1.0 mm/s	It is likely that vibration at this level in residential environments will cause complaints, but can be tolerated if warning and explanation has been given to residents
10 mm/s	Vibration is likely to be intolerable for any more than a very brief exposure

Table 9.5 lists the predicted safe working buffer distances calculated for typical equipment vibration values to determine indicative distances where the structural damage (standard dwelling and heritage structure) and human comfort criteria may be exceeded. The safe working buffer distances are dependent on the equipment that the construction contractor selects and would be refined prior to construction.

Vibration intensive plant such as vibratory rollers and pilling rigs may be used during road, bridge and noise wall construction.

Table 9.5 Vibration safe working buffer distances – human comfort

Equipment		Human comfort
Vibration criteria	1 mm/s	
Criteria source	BS 5228-2	
	Roller	90 m
	15 tonne vibratory roller	140 m
	7 tonne compactor	90 m
General construction activities	Dozer	60 m
	Backhoe	10 m
	Pavement breaker	90 m
	Excavator	25 m
	Piling (impact)	700 m
Piling (bridge)	Piling (vibratory)[1]	110 m
	Piling (bored)[1]	120 m

Note 1: Based on advice given in British Standard BS 7385:1993 – *Evaluation and measurement of vibration in buildings*.
Note 2: Based on levels derived from BS 5228-2. *Bored piling through stones or other obstruction*. Vibratory piling based on relationship provided in Table E.1.

Vibration impacts to buildings and infrastructure

Vibration transmission through the ground can cause a structure and structure coupled elements (walls, windows) to radiate. The transmitted vibration energy has the potential to damage and compromise the integrity of a structure as well as increase the risk of damage to building contents. Vibration intensive plant such as vibratory rollers and pilling rigs may be used during road, bridge and noise wall construction for the project.

There is no current Australian Standard that sets criteria for the assessment of damage to structures and buried pipework caused by vibrations. Guidance on limiting vibration values has been obtained with reference to:

- standard structures: British Standard BS 7385-Part 1 and Part 2
- heritage structures: German Standard DIN 4150-3:1999 *Structural Vibration Part 3: Effects of vibration on structures*.

This guidance outlines the classification for cosmetic, minor and major impacts, for both standard structures and heritage structures. This methodology is consistent with other major projects of a similar type.

Heritage structures should be considered on a case by case basis, as a heritage listed structure may not necessarily be more sensitive to vibration than a standard structure. Where a historic heritage structure is deemed to be sensitive to damage (following inspection), the more conservative criteria from DIN 4150-3 should be considered.

Predicted safe working buffer distances were calculated for typical vibration values to comply with the structural damage (standard dwelling and heritage structure) and are provided in Table 9.6. This is based on the potential vibration levels due to construction activity and the distance of those activities from the receiver.

Table 9.6 Vibration safe working buffer distances – structural damage

Equipment	Structural damage (metres)	
	Heritage structure	Standard dwellings[3]
Vibration criteria	3 mm/s	5 mm/s
Criteria source	DIN 4150-3	DIN 4150-3
General construction activities		
Roller	24 m	13 m
15 tonne vibratory roller	34 m	18 m
7 tonne compactor	24 m	13 m
Dozer	14 m	8 m
Backhoe	3 m	1 m
Pavement breaker	24 m	13 m
Excavator	6 m	3 m
Piling (bridges)		
Piling (impact)	180 m	100 m
Piling (vibratory)[1]	50 m	30 m
Piling (bored)[2]	35 m	17 m

Note 1: Based on advice given in British Standard BS 7385:1993 – *Evaluation and measurement of vibration in buildings*.
Note 2: Based on levels derived from BS 5228-2. *Bored piling through stones or other obstruction*.
Note 3: definition of standard dwelling provided in section 3.3 of Technical Report 2.

Vibration may be amplified in multi-level buildings through the structure to the upper floors. A doubling of the buffer distances provided in Table 9.6 would provide a conservative allowance for this possible effect.

The British Standard BS 7385-2:1993 notes that structures below ground are known to sustain higher levels of vibration and are very resistant to damage unless in very poor condition. Compliance with the guideline values for structural damage would result in compliance with the guideline values for buried pipework.

9.1.2.2 Operation

Amenity impacts – air-borne noise

Operational rail noise criteria are derived from the RING and relate to noise generated from rail movements along existing and proposed rail lines within the study area. The RING distinguishes between 'new' or 'redeveloped' heavy rail lines in terms of the applicable noise. In the event the predicted noise levels exceed the criteria listed below, an investigation of potential reasonable and feasible noise mitigation measures would need to be undertaken.

For this assessment, the project is considered a 'redevelopment of an existing heavy rail line' as the passing loop would generally be constructed on land within an existing operational rail corridor. As such, the 'redevelopment of existing rail line' criteria listed in Table 9.7 apply to this assessment for the total rail noise levels from both the existing (Sydney Trains and SSFL) lines and the project.

The airborne noise trigger levels for absolute levels of rail noise have two components for residential receivers, L_{Aeq} and L_{Amax}. The LAeq contribution level of rail noise is assessed over the day or night period and the maximum noise level (LAmax) from rail passby events at any time. The trigger levels and corresponding increase allowance outlined in the RING are listed in Table 9.7. These levels need to be exceeded to initiate a detailed assessment of rail noise impacts including investigation of potential mitigation measures.

Table 9.7 Airborne rail traffic noise trigger levels for residential land uses

Type of development	Noise trigger levels, dBA (external)	
	Day (7.00 am to 10.00 pm)	Night (10.00 pm to 7.00 am)
Redevelopment of existing rail line	Development increases existing $L_{Aeq(period)}$ rail noise levels by 2 dBA or more, or existing L_{Amax} rail noise levels by 3 dBA or more and	
	65 $L_{Aeq(15\ hour)}$ or 85 L_{AFmax}	60 $L_{Aeq(9\ hour)}$ or 85 L_{AFmax}

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 heavy rail redevelopments that are applicable when the facility or space is in use. Noise trigger levels for these receivers are applicable as internal or external levels depending on the land use. For internal noise criteria, the acoustic performance of the building façade affects the transmission of noise into the premises. As construction materials and the façade acoustic performance of these buildings is unknown and may vary, a conservative 10 dBA reduction in noise between the external level and internal level has been assumed[1]. The RING criteria for non-residential land uses for the redevelopment of an existing rail line are shown Table 9.8.

Table 9.8 Airborne rail traffic noise trigger levels for non-residential land uses

Sensitive land use	Noise trigger levels, dBA (when in use)
	Development increases existing $L_{Aeq(period)}$ rail noise levels by 2 dBA or more and resulting rail noise levels exceed
Schools, educational institutions and child care centres	45 $L_{Aeq(1h)}$ Internal
Places of worship	45 $L_{Aeq(1h)}$ Internal
Hospital wards	40 $L_{Aeq(1h)}$ Internal
Hospital – other uses	65 $L_{Aeq(1h)}$ External
Open space – active use	65 $L_{Aeq(15h)}$ External

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

Amenity impacts - Ground-borne noise

Ground-borne noise from can be generated inside a building by vibration generated from the pass-by of the rail vehicle. Operational ground-borne noise is assessed in accordance with the RING. The RING states that ground-borne noise level values are "*relevant only where they are higher than the airborne noise from railways (such as in the case of an underground railway) and where the ground-borne noise levels are expected to be, or are, audible within habitable rooms.*"

[1] See RING - Technical notes to tables 1, 2 and 3 – Technical note 6. Allows that a window may be opened to provide adequate ventilation.

For an existing heavy rail corridor airborne noise is expected to be the dominant noise source from the project and significantly higher than any ground-borne noise contributions. However, a situation can occur for surface rail where airborne noise is mitigated with at-residence treatments, which does not mitigate ground-borne noise.

The ground-borne noise trigger levels are provided in Table 9.9. For an existing railway the ground borne noise levels would need to increase by 3 dBA or more for the trigger levels to be exceeded. Therefore, a screening level ground-borne noise assessment has been undertaken to confirm if ground-borne noise levels are likely to increase by 3 dBA or more.

Table 9.9 Ground-borne noise trigger levels

Sensitive land use	Time of day	Internal noise trigger levels, dBA
	Development increases existing rail noise levels by 3 dBA or more ***and*** resulting rail noise level exceeds	
Residential	Day (7 am – 10 pm) Night (10 pm – 7 am)	40 L_{ASmax} 35 L_{ASmax}
Schools, educational institutes, places of worship	When in use	40-45 L_{ASmax}

Vibration impacts

The US Federal Transit Administration's 'Transit Noise and Vibration Impact Assessment' report (Department of Transportation (FTA), 2008) provides a method for estimating the ground surface vibration levels near rail lines. Vibration generation from rail traffic is generally a function of local geological conditions surrounding the project site and the following rail corridor features:

- wheel-rail interface including wheel defects, acceleration and braking
- the quality of the rail, track geometry and variations in sleepers and ballast
- axle load
- geometry and composition of the train
- speed.

For the purposes of this assessment, the track has been assumed to be in good condition and track irregularities have not been assessed.

Vibration criteria for human comfort and impacts to buildings and underground pipework are the same for construction and operational activities and are described in section 9.2.2.

9.1.3 Risks identified

The preliminary environmental risk assessment undertaken for the project included potential risks associated with noise and vibration. Potential risks were considered according to the impacts that may be generated by the construction and/or operation of the project, pre-mitigation. The purpose of the preliminary environmental risk assessment was to inform the impact assessment. Further information on the preliminary risk assessment, including the approach and methodology is provided in Appendix D.

The assessed risk level for the majority of potential noise and vibration risks was medium. Risks with an assessed level of medium or above include:

- noise impacts on local residents and sensitive receivers from construction activities, including out of hours works
- noise impacts on local residents and sensitive receivers from construction traffic
- noise impacts on local residents and sensitive receivers from the operation of trains due to the project (idling in loop, slowing down/accelerating into/out of loop) being closer to receivers
- impacts to new receivers due to change in noise wall from its existing location
- damage to structures including heritage structures from vibration caused by construction activities or operation of the project.

These potential risks and impacts were considered as part of the assessment. The assessment also considered matters identified by the SEARs and stakeholders, as described in Chapter 3 (Approval and assessment requirements) and Chapter 4 (Consultation).

9.1.4 How potential impacts have been avoided/minimised

As described in Chapters 6 (Project features and operation) and Chapter 7 (Construction), design development and construction planning has included a focus on avoiding and/or minimising the potential for environmental impacts during all key phases of the process.

Potential noise and vibration impacts have been avoided/minimised where possible by the following:

- The new noise wall will be constructed in the same locations parallel to the rail corridor as the existing noise wall to minimise the potential for changes to the existing noise environment.
- The noise wall will be progressively removed and reinstated as works progress along Broomfield Street and would provide shielding effects during construction. This is to minimise the length of time that sensitive receivers would be exposed to potential noise impacts from existing train operations.

9.2 Existing environment

9.2.1 Sensitive receivers

Noise and vibration sensitive receivers are defined by the type of occupancy within the structure and the activities performed within the property boundary. Noise and vibration sensitive receivers could include the following:

- residences (including multi-floor dwellings) - each floor of a residential dwelling is considered to be a separate residential receiver
- educational institutes (such as schools and universities eg Lawrence Hargrave School)
- hospitals and medical facilities
- places of worship
- commercial or industrial premises
- passive recreational areas
- active recreational areas such as sporting fields, golf courses. Note that recreational areas are only considered sensitive when they are in use or occupied.

For the construction noise and vibration assessment, due to the urban nature of the study area 3,604 residential receivers and 283 non-residential receivers have been identified within the construction assessment study area. For the operational noise and vibration assessment, 3321 residential receivers and 283 non-residential receivers have been identified within the operational assessment study area.

All receivers are shown in Figure 9.1. Appendix A and B of Technical Report 2 shows the receivers by type and provides an individual identification number for each receiver. A search of the NSW Government major projects online database and the Fairfield and Liverpool council online planning databases was undertaken to identify if any determined projects within 100 metres of the project site would alter the type or sensitivity of existing receivers (ie change from a commercial premises into residential). No projects were identified that would require additional consideration.

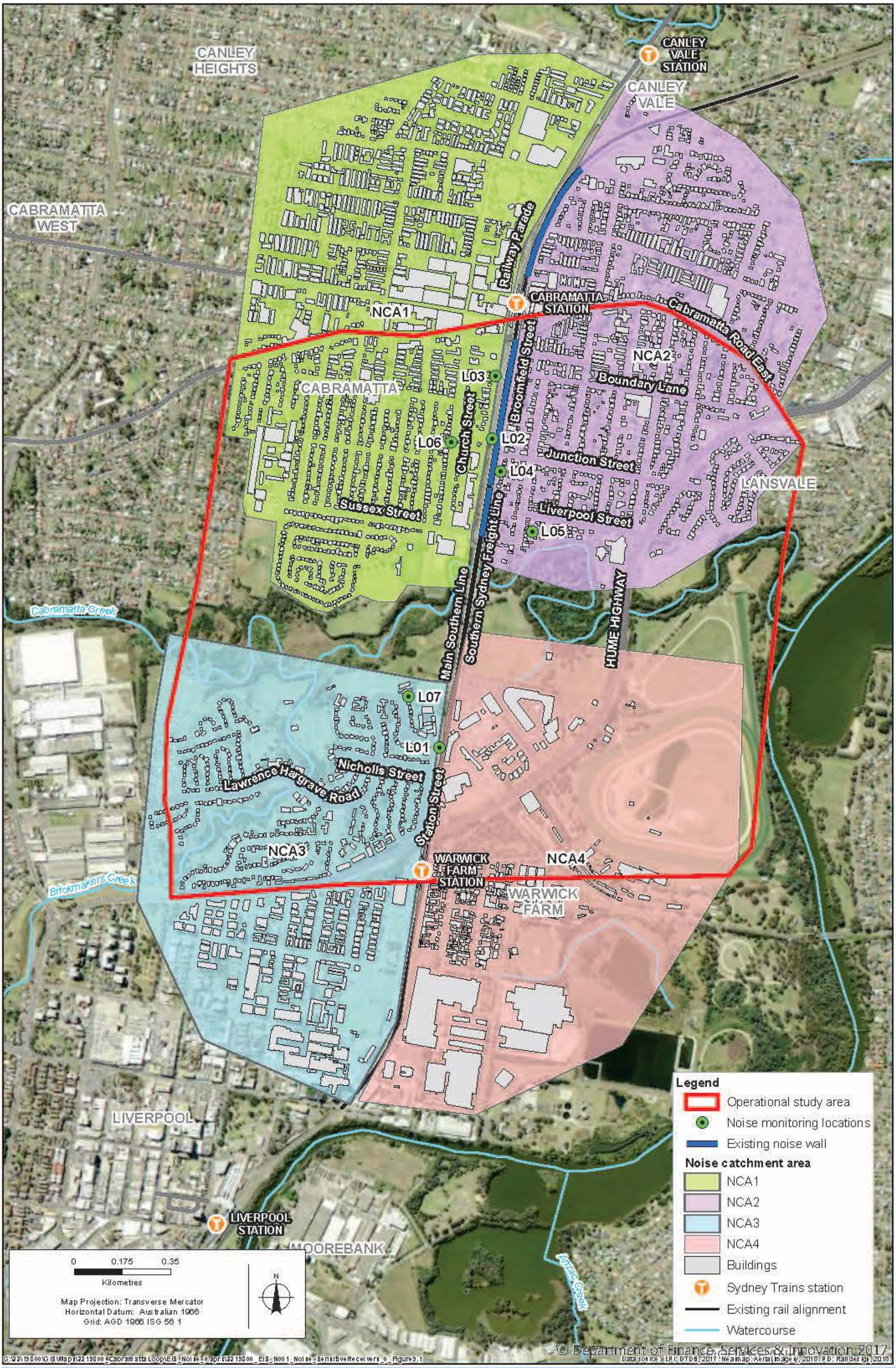

Figure 9.1 Study area, sensitive receivers and monitoring locations

9.2.2 Existing noise levels

The area surrounding the project is primarily suburban, with residential, commercial land uses and public recreation areas located directly next to the existing rail and road corridors. The sensitive receivers within the study area are discussed in section 9.1.1.

An existing noise wall exists along Broomfield Street as shown on Figure 9.1 and would be replaced as part of the project. The existing wall height (from top of rail) varies between a minimum of 3.4 metres to a maximum of around 5.5 metres.

9.2.2.1 Existing rail operations

Existing rail operations in the study area include the following:

- passenger rail operations for the Sydney South Metropolitan Network on the Sydney Trains up and down main lines. The maximum posted passenger train speeds are 80 kilometres per hour (up) and 100 kilometres per hour (down). Train speeds on the up track have been assumed based on the speed board south of Cabramatta Station as this is considered more representative of the Warwick Farm to Cabramatta section of the track
- freight rail operations on the Sydney Trains up and down main lines. These freight services share the network with the passenger trains. The maximum posted freight train speeds are 70 kilometres per hour (up) and 80 kilometres per hour (down). Train speeds on the up track have been assumed based on the speed board south of Cabramatta Station as this is considered more representative of the Warwick Farm to Cabramatta section of the track
- ARTC bi-directional freight rail operations on the SSFL. The maximum posted speed on the SSFL is 80 kilometres per hour.

9.2.2.2 Existing noise and vibration levels

Baseline ambient and background noise monitoring was undertaken at seven locations (refer to Figure 9.1) in the study area to quantify the existing railway and background noise levels. Monitoring location considerations included land topography, distance from rail activities and contribution from other noise activities, such as road noise. The logger locations were considered representative of the existing background and ambient noise environment in the study area.

Monitoring took place between 12 October 2018 and 1 November 2018. The noise loggers accumulated LAN, LAeq and LAmax noise descriptors continuously over sampling periods of 15 minutes for the entire monitoring period.

A summary of the baseline noise monitoring, including a description of the ambient noise environment at each location is provided in Table 9.10.

Vibration monitoring was also undertaken within and outside the rail corridor. The vibration environment was dominated by road traffic noise and intermittent rail passbys.

Table 9.10 Summary of baseline noise monitoring

Location	Rating background level (RBL) 90th percentile $L_{A90(15min)}$			Ambient noise levels, $L_{Aeq(period)}$			15-hour and 9-hour noise levels, $L_{Aeq(period)}$		Ambient noise observations
	Day	Evening	Night	Day	Evening	Night	Day	Night	
L01[2] - In corridor (North of Warwick Farm Station)	-	-	-	65	64	63	65	63	Rail noise dominant
L02[2] - In corridor (South of Cabramatta Station)	43	41	33	68	68	66	68	66	Rail noise dominant
L03 - 225 Railway Parade, Cabramatta	45	44	33	61	61	59	61	59	Rail noise dominant, road traffic noise along Railway Parade
L04 - 150 Broomfield Street, Cabramatta	39	38	31	56	56	52	56	52	Rail noise dominant, road traffic noise along Broomfield Street, construction works at residence along Broomfield street
L05 - 46a National Street, Cabramatta	38	37	31	53	48	46	51	46	Rail noise faintly audible, road traffic noise along National Street
L06 - 41 Church Street, Cabramatta	38	39	30	55	53	50	54	50	Road traffic noise along Church Street, rail passbys in background

Location	Rating background level (RBL) 90th percentile $L_{A90(15min)}$			Ambient noise levels, $L_{Aeq(period)}$			15-hour and 9-hour noise levels, $L_{Aeq(period)}$		Ambient noise observations
	Day	Evening	Night	Day	Evening	Night	Day	Night	
L07 - 25 Lawrence Hargrave Road, Warwick Farm	37	38	32	52	50	47	50	47	Rail noise dominant, car passbys and bird noise

Note 1: For the rating background and ambient noise levels, the periods are defined as per the NPI (EPA, 2017). For the 15 hour and nine hour noise levels, as per the Rail Infrastructure Noise Guideline (EPA, 2013).

Note 2: The absolute rail noise contributions at L01 were calculated to be 64 dB(A) $L_{Aeq,15hr}$ and 63 dB(A) $L_{Aeq,9hr}$. The absolute rail noise contributions at L02 were calculated to be 68 dB(A) $L_{Aeq,15hr}$ and 66 dB(A) $L_{Aeq,9hr}$. The absolute rail noise contributions were calculated from a detailed analysis of passby data and do not include non-rail noise sources

9.3 Assessment of construction impacts

Construction work and associated traffic movements have the potential to cause noise impacts to sensitive receivers and the community.

The assessment of noise and vibration impacts from construction within the project site has been based on 13 noise modelling scenarios and were based on the plant and equipment likely to be used. These scenarios, along with the anticipated times of the construction activities are shown in Table 9.11.

Table 9.11 Construction scenarios and anticipated construction times

Scenario	Scenario description	Construction work hours					Highly intensive works
		Standard hours	Out of hours work -	Possession works			
				Day	Evening	Night	
CS01	Compound establishment and operation of compounds	✓	✓	-	-	-	-
CS02	Vegetation removal and utility relocation	✓	✓	-	-	-	-
CS03	Road earthworks	✓	✓	✓	✓	✓	✓
CS04	Road pavement works	✓	✓	✓	✓	✓	✓
CS05	Road furniture installation	✓	✓	✓	✓	✓	-
CS06	Noise wall construction	✓	✓	✓	✓	✓	✓
CS07	Bridge construction pre-work	✓	✓	✓	✓	✓	✓
CS08	Bridge construction works	✓	-	✓	✓	✓	✓
CS09	Bridge rail installation	✓	-	✓	✓	✓	-

Scenario	Scenario description	Construction work hours					Highly intensive works
		Standard hours	Out of hours work -	Possession works			
				Day	Evening	Night	
CS10	Retaining wall installation	✓	✓	-	-	-	✓
CS11	Track construction	✓	✓	✓	✓	✓	✓
CS12	Track installation	✓	-	✓	✓	✓	✓
CS13	Finishing and rehabilitation	✓	-	-	-	-	-

Construction works for the installation of new signalling would also be required in the vicinity of Villawood Station, Liverpool Station and Casula Station and are discussed in section 9.3.3. Three compounds (C1 to C3) and four worksites (W1 to W4) are proposed for the construction phase (refer to section 7.4 for further details on the construction sites). The scale and complexity of works required means that works would need to be carried out during and outside recommended standard working hours (refer to Table 9.1 for hours). All scenarios have been assessed against the noise management levels during standard construction hours and for out of hours work.

In general, construction activities would move along the construction alignment. Impacted receivers would only experience the predicted worst case noise levels when construction works are located closest to the receiver. At other times, the receivers would experience levels below the worst case noise levels predicted as construction activities would progressively move away from the receiver as works are completed. Noise modelling undertaken as part of the construction modelling also conservatively assumed that all of the noise wall (existing and proposed) was not in place. In reality, the noise wall would be demolished and replaced in sections.

9.3.1 Predicted noise levels

Predicted noise levels from the construction scenarios were assessed by considering the number of expected exceedances and the maximum exceedance of the noise management levels. The number of receivers inside the construction study area that are predicted to experience noise levels above the construction noise management levels during standard construction hours are 161. The highly noise affected level of 75 dBA is expected to be exceeded at 102 residential receivers.

The highest construction noise impacts are expected during road earthworks, noise wall construction and track installation. This would be consistent for works during and outside standard construction hours. The receivers inside the construction study area predicted to experience noise levels above the construction noise management levels are shown in Figure 9.2, Figure 9.3, Figure 9.4 and Figure 9.5. The mitigation measures identified in section 9.5.2 should be implemented to reduce these impacts where considered feasible and reasonable.

Receivers located along Railway Parade, Broomfield Street, Station Street, Lawrence Hargrave Road, Todman Road and Sappho Road would be expected to experience the worst-case noise impacts as they are located directly adjacent the construction works. Beyond the first row of receivers located adjacent the construction works, the level of exceedance would decrease due to noise levels decreasing with distance and shielding from surrounding structures.

The predicted noise levels indicate that the removal of the existing noise wall on Broomfield Street would increase L_{Aeq} noise levels from operation of the SSFL by up to 8 to 9 dB and L_{Amax} noise levels by up to 11 to 12 dB at residences located along Broomfield Street. These noise levels would be experienced by receivers along Broomfield Street during the period when the old noise wall is demolished and the new one is in the process of being constructed. The noise wall would be progressively removed and where feasible, reinstated as works progress along Broomfield Street and would provide shielding effects during construction. This will reduce the duration that receivers would be impacted from loss of the existing noise wall.

The predicted impacts for the day, evening and night time assessment periods are discussed further below for each noise catchment area.

Figure 9.2 Receivers that exceed the construction NMLs during standard construction hours

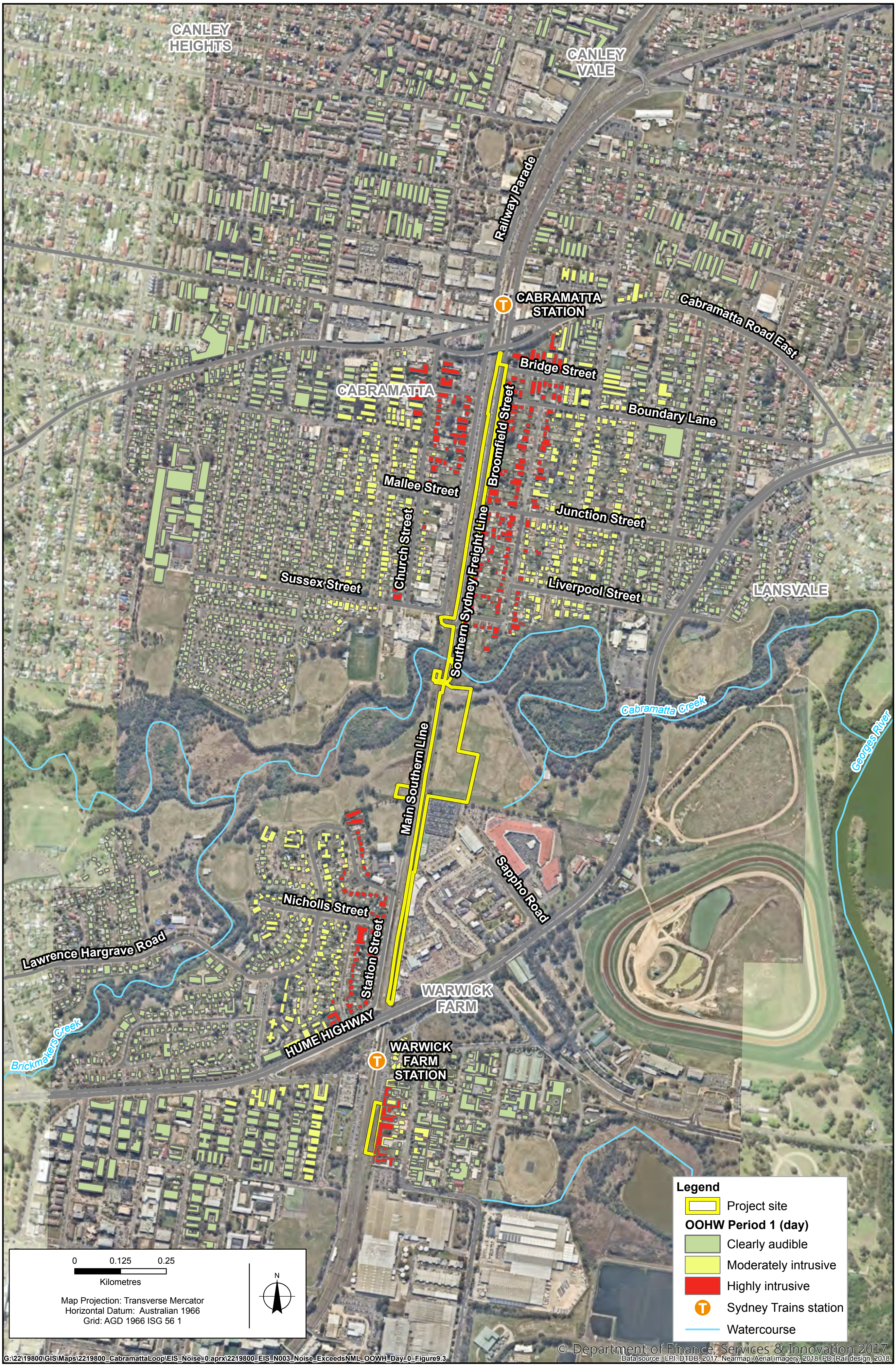

Figure 9.3 Receivers that exceed the construction NMLs outside standard construction hours - period 1 day

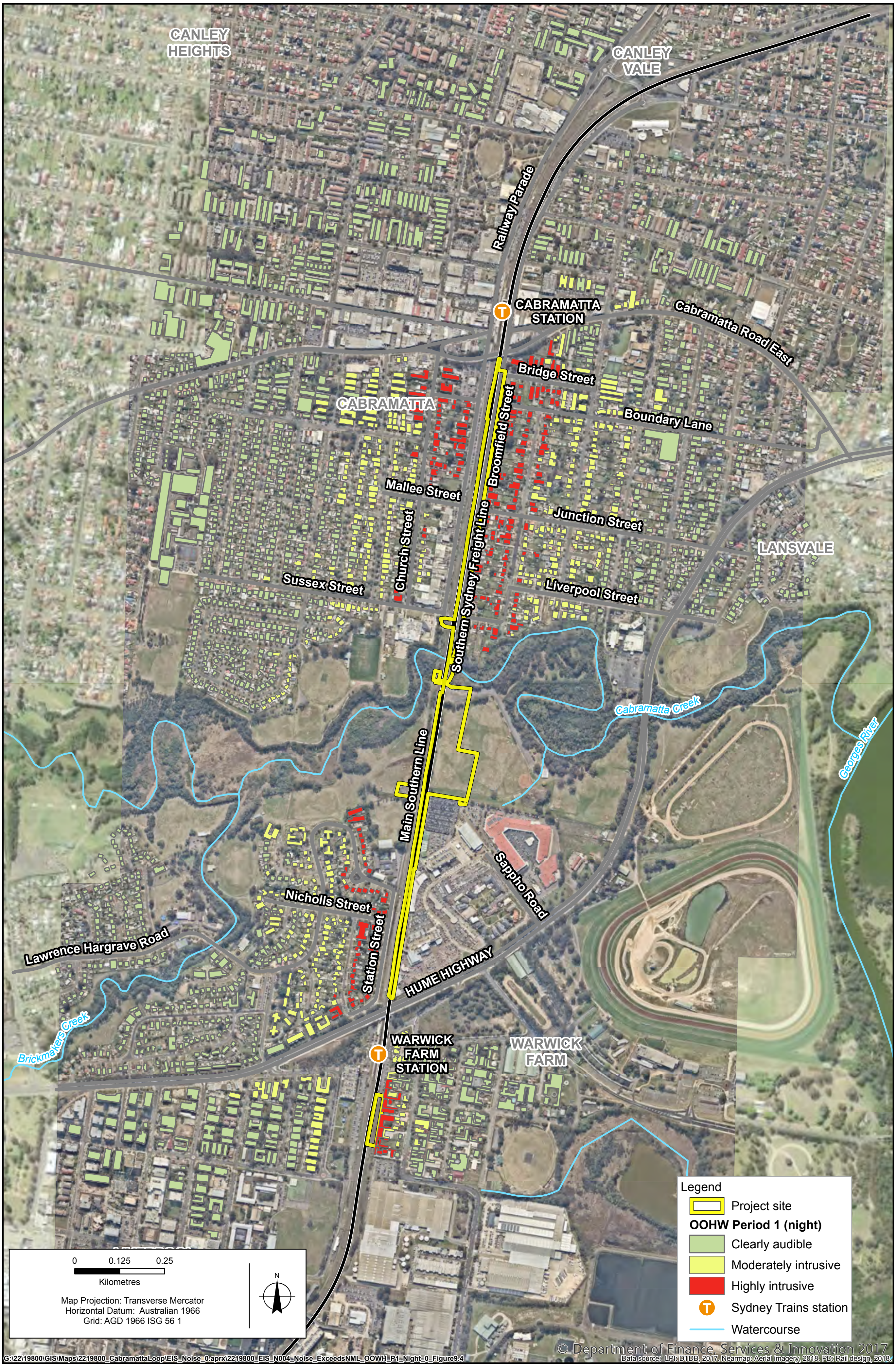

Figure 9.4 Receivers that exceed the construction NMLs outside standard construction hours - period 1 night

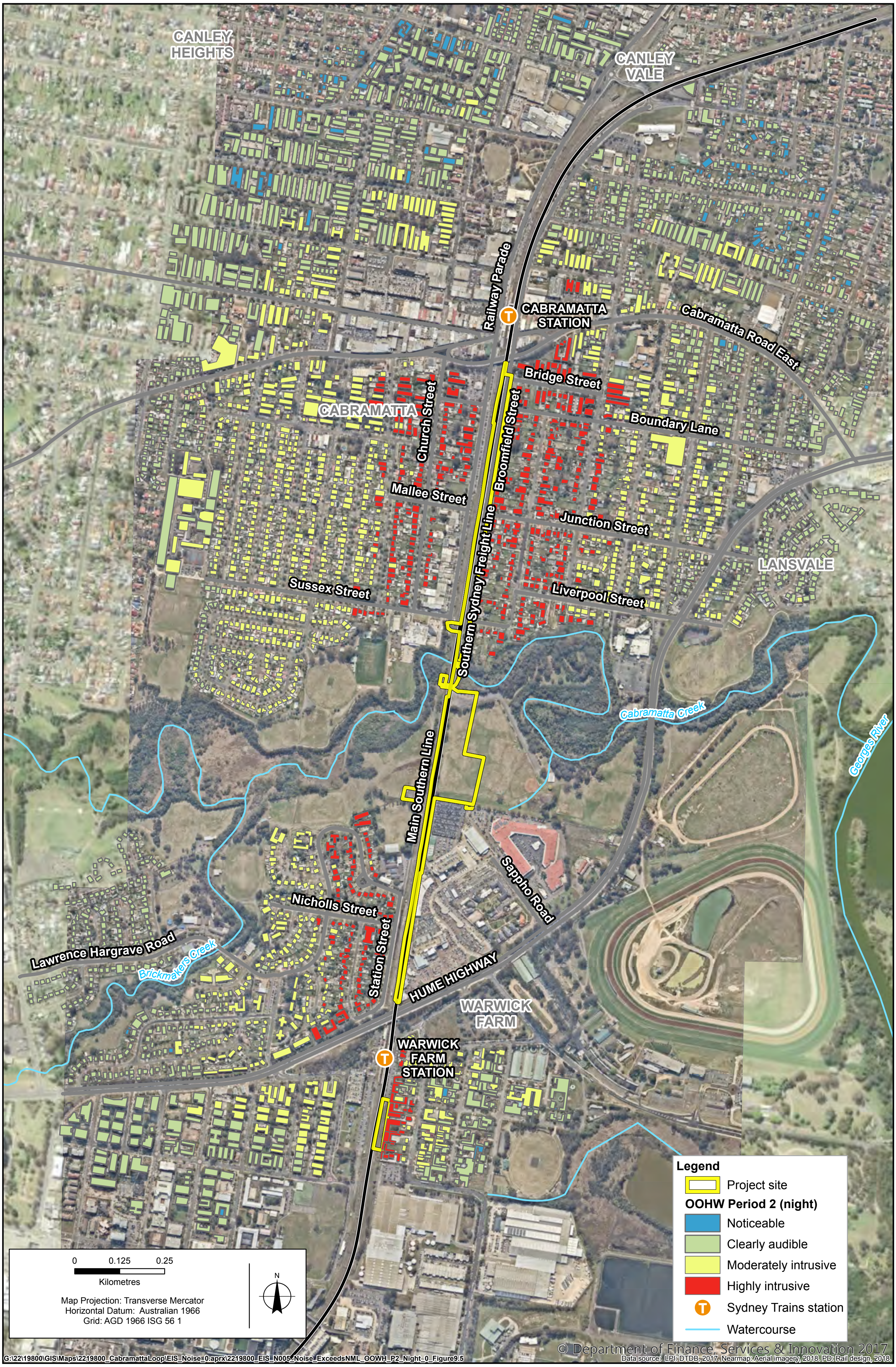

Figure 9.5 Receivers that exceed the construction NMLs outside standard construction hours - period 2 night

Results for the noise catchment area: NCA01 based on the total number of exceedances of the noise management level. This can be attributed to the high density of receivers located near the construction works. The number of total exceedances of the noise management level would be highest during the road earthworks (CS03), noise wall construction (CS06) and track installation (CS12) stages of construction.

The highest exceedances of the noise management level would occur during the noise wall construction (CS06) stage. This exceedance is due to operation of the excavator with a concrete rock breaker attachment, which is the loudest noise source for the construction scenario. The majority of noise management level exceedances during this stage of construction would be less than 10 dBA which represents a minor impact. Receivers located closer to the works would experience moderate to high impacts above 10 dBA.

Impacts outside of standard hours

Receivers located inside NCA01 are predicted to have low to moderate impacts for any works carried out outside standard hours. The highest exceedances of the noise management level would occur during the noise wall construction (CS06) stage. The majority of noise management level exceedances would be less than 15 dBA during the day and evening periods and 11 to 20 dBA during the night time period.

9.3.1.1 Results for the noise catchment area: NCA02

NCA02: The area to the north of Jacquie Osmond Reserve and east of the rail corridor. The area comprises residential land uses. Road traffic noise along Broomfield Street and local roads in the area dominate the noise environment. An existing noise wall along Broomfield Street shields the catchment from rail noise.

Impacts during standard hours

The number of total exceedances of the noise management level would be highest during the road earthworks (CS03), noise wall construction (CS06) and track installation (CS12) stages of construction. The highest exceedances of the noise management level would occur due to the use of a milling machine during road pavement works (CS04).

Approximately 200 receivers would exceed the noise management level between 1.0 and 10 dBA. The number of receivers that would exceed by more than 11 dBA are similar, illustrating that 50 per cent of the exceeding receivers experience minor noise impacts. Construction impacts during road pavement works are considered moderate as there is a high proportion of receivers that exceed the noise management level.

Impacts outside of standard hours

Receivers located inside NCA02 are predicted to have low to moderate impacts for any works carried out outside standard hours. The highest exceedances of the noise management level would occur during vegetation removal and utility relocation works (CS04). The majority of noise management level exceedances would be less than 15 dBA during the day, evening periods and night-time periods. A significant proportion of receivers located next to the works would experience high impact as the predicted exceedance of the noise management level is above 20 dBA.

9.3.1.2 Results for the noise catchment area: NCA03

NCA03: The area to the south of Jacquie Osmond Reserve and west of the rail corridor. The area comprises primarily residential land uses. Rail noise and traffic along local roads dominate the noise environment in the area.

Impacts during standard hours

The number of total exceedances of the noise management level would be highest during the retaining wall installation (CS10) and track installation (CS12) stages of construction. The highest exceedances of the noise management level would occur due to the use of a grinder and mulcher during vegetation removal and utility relocation works (CS02).

The majority of receivers that would exceed the noise management level are less than 10 dBA so construction noise impacts during CS02 are considered minor.

Impacts outside of standard hours

Receivers located inside NCA02 are predicted to have low impacts for any works carried out outside standard hours. The highest exceedances of the noise management level would occur during the road pavement works (CS04). The majority of noise management level exceedances would be less than 10 dBA during the day, evening periods and nighttime periods.

9.3.1.3 Results for the noise catchment area: NCA04

NCA04: The area to the south of Jacquie Osmond Reserve and east of the rail corridor. The area comprises primarily commercial land uses. Rail noise and noise from commercial premises dominate the noise environment.

Impacts outside of standard hours

The number of total exceedances of the noise management level would be highest during the site establishment (CS01) and track installation (CS12) stages of construction. The highest exceedances of the noise management level would occur due to the use of a crane and truck site establishment and compound operations (CS01).

The majority of receivers that would exceed the noise management level are less than 10 dBA. Construction noise impacts during site establishment and compound operations are considered minor.

Impacts during standard hours

Receivers located inside NCA02 are predicted to have low impacts for any works carried out outside standard hours. The highest exceedances of the noise management level would occur during site establishment and compound operations (CS01). The majority of noise management level exceedances would be less than 10 dBA during the day, evening periods and night time periods.

9.3.2 Sleep disturbance

Construction activities are expected outside standard construction hours to minimise the impacts on rail traffic during construction. There is the potential for maximum noise level events if the predicted maximum noise level is above the screening criteria of 52 dBA.

The screening criteria of 52 dBA is exceeded at 1284 residential receivers. Therefore a detailed maximum noise level assessment has been undertaken. The RNP states that maximum internal noise levels between 50 to 55 dBA are unlikely to awaken people from sleep. Typically a window will provide a 10 dBA reduction when partially open and a 20 dBA reduction when closed. For a conservative assessment, the windows have been assumed to be partially open to assess sleep disturbance impacts.

Based on this assessment, 102 sensitive receivers have the potential to experience sleep disturbance impacts. These receivers are shown on Figure 9.6. Potential sleep disturbance impacts near Warwick Farm Station would be due to operation of construction compound C1. This compound would be predominately used for storage and would require material deliveries during the early morning and late evening periods. Continuous impacts throughout the night-time period are considered unlikely. The relevant sleep disturbance mitigation measures provided in section 9.5.2 would be applied if the sleep disturbance criteria is anticipated to be exceeded for more than two consecutive nights and cannot be avoided due to reasonable and feasible justification.

Figure 9.6 Sleep disturbance impacted receivers

9.3.3 Predicted noise levels for construction of signalling work

Construction works for the installation of new signalling would be required in the vicinity of Villawood Station, Cabramatta Station, Liverpool Station and Casula Station. The installation works would be completed in under one week at each location, commissioning during possession periods, and cabling works for up to one month using hand tools.

A qualitative assessment has been undertaken to assess construction noise and vibration impacts of the signalling works due to the following:

- Construction works would be completed within six weeks, and may include possession periods.
- Vibration intensive equipment are used outside the minimum working distances for cosmetic damage to buildings or human disturbance.
- Construction traffic impacts are not anticipated.

The nearest residential receivers are located around 30 to 50 metres from the signalling works. The exceedance (in dBA) of the noise management level for various distances is provided in Table 9.12.

Table 9.12 Exceedance of noise management level, dBA

Period	Distance, metres							
	30	40	50	60	70	80	90	100
Standard hours	5	3	1	-	-	-	-	-
Out of hours work-Period 1 (Day)	15	13	11	9	8	7	6	5
Out of hours work- Period 1 (Evening)	15	13	11	9	8	7	6	5
Out of hours work- Period 2 (Night)	20	18	16	14	13	12	11	10

The distances within which sensitive receivers will exceed the noise management levels are:

- standard hours: 50 metres
- out of hours work - Period 1 (Day/Evening): 100 metres
- out of hours work - Period 2 (Night): 170 metres.

By implementing the mitigation measures identified in section 9.5.2, where considered feasible and reasonable, the potential for noise impacts would be minimised.

9.3.4 Construction compound operation

The compound operations have been assessed as part of construction scenario CS01. Three construction compound locations and four work sites are proposed to provide support for construction activities. A description of the access routes and activities which would take place in these sites is described in section 7.4.

Below is a description of which noise catchment areas will be impacted and the maximum level of exceedance (in decibels) above the noise management levels. Table 9.2 lists the noise management levels these exceedances relate to of each construction period.

9.3.4.1 Compound C1 – rail corridor near Warwick Farm Station

Compound C1 is located in the rail corridor next to Warwick Farm Station. Activities at compound C1 have the potential to impact receivers located inside noise catchment areas NCA03 and NCA04. The maximum exceedance of the noise management level for each time period is provided in Table 9.13. The most affected receivers are as follows:

- **NCA03:** The nearest residential receivers are located along Hart Street and are around 120 metre from the compound and have a direct line of sight. Activities towards the north of the compound have the potential to be slightly shielded by the Warwick Farm Multi-Storey Car Park.
- **NCA04:** The nearest residential receivers are located directly adjacent the compound. These receivers are separated from the railway corridor by a fence which provides a degree of shielding from compound operations.

Table 9.13 C1 Compound operations – maximum exceedances above noise management level

Noise catchment area:	Standard hours (dBA)	Out of hours work - Period 1 (dBA)		Out of hours work - Period 2 (dBA)
		Day	Evening	Night
NCA03	13	18	18	23
NCA04	47	52	52	57

Potential sleep disturbance impacts near Warwick Farm Station would be due to operation of the rail compound (C1). This compound would be predominately used for storage and may require material deliveries during the early morning and late evening periods. The sleep disturbance impacts would be limited in duration as material deliveries outside of standard construction hours would be restricted to oversized deliveries only. Continuous impacts throughout the night-time period are considered unlikely.

9.3.4.2 Compound C2 Warwick Farm Recreational Reserve and C3 Jacquie Osmond Reserve

The Warwick Farm Recreational Reserve compound C2 and the Jacquie Osmond Reserve compound C3 are located at similar locations but on opposite sides of the rail corridor. Therefore, impacts from these compounds have been assessed together.

Activities at compounds C2 and C3 would impact receivers located in all noise catchment areas. A discussion on the predicted impacts on the receivers located in each noise catchment area follows. The maximum exceedance of the noise management level for each time period is provided in Table 9.14. The most affected receivers for each noise catchment area are as follows:

- **NCA01:** The nearest residential receivers surround the reserve where the compounds will be located. The roads which would be most affected include Jasmine Crescent, Lunn Court and Sussex Street. These roads are located about 220 metres to 400 metres from the compounds. Dense vegetation along Cabramatta Creek breaks line of sight to the compound and would provide minor shielding effects.
- **NCA02:** The nearest residential receivers are located immediately north of Cabramatta Creek along Sussex Street and Liverpool Street. These roads are located about 150 metres to 270 metres from the compounds. Dense vegetation along Cabramatta Creek breaks line of sight to the compound and would provide minor shielding effects.
- **NCA03:** The nearest residential receivers are located along Lawrence Hargrave Road and include Lawrence Hargrave School. These are located about 100 metres from the C2 compound. These receivers have line of sight to the C2 and C3 compounds.

- **NCA04:** The nearest receivers are commercial and industrial and are located directly adjacent the C3 compound. Impacts on residential receivers located in noise catchment area NCA04 are considered unlikely as these receivers are located to the south of Hume Highway which is over 700 m south of the compound locations.

Table 9.14 C2/C3 Compound operations – maximum exceedances above noise management levels

Noise catchment area	Standard hours (dBA)	Out of hours work -Period 1 (dBA)		Out of hours work - Period 2 (dBA)
		Day	Evening	Night
NCA01	2	7	8	14
NCA02	9	14	14	22
NCA03	13	18	18	23

9.3.5 Construction traffic noise

Construction vehicle movements would consist of light and heavy vehicles associated with staff movements, plant delivery and material delivery and removal. This has the potential to create construction traffic noise impacts. Details on volumes and routes of construction traffic is provided in section 7.6.

Modelling undertaken to assess the impacts of construction noise indicated that construction traffic is not expected to increase existing road traffic noise levels by more than 2 dBA on arterial or sub-arterial roads. The results indicate that an increase of more than 60 per cent of existing traffic volumes would be required to increase road traffic noise levels by more than 2 dBA. Construction traffic is not anticipated to increase traffic volumes by more than 60 per cent on these roads.

On local roads, during peak construction time periods, noise levels may increase by more than 2 dBA. However, the noise levels are anticipated to be below the road traffic noise criteria and construction traffic noise impacts are not expected.

Construction traffic movements along local roads would be managed with a construction traffic management plan to limit the degree of road traffic noise impacts.

9.3.6 Vibration from construction activities

Vibration is caused by energy from equipment being transmitted into the ground. Vibration diminishes with distance and is dependent on a number of factors including on the type of equipment (ie impulsive, reciprocating, rolling or rotating equipment) and ground type and topography.

Construction and demolition works have the potential to impact on human comfort and/or cause structural damage to buildings. Potential vibration inducing activities identified during construction and demolition works may be used during road, noise wall and bridge construction, and include the following:

- piling, grinding and cutting would generate impulsive vibration emissions
- bulk earthworks, construction traffic movements and demolition works would be a source of intermittent or continuous vibration.

Equipment should be selected so that the safe working buffer distances are complied with as per those detailed in Table 9.6. This means that there is the potential for standard dwellings and heritage structures to be impacted if a backhoe is used within one metre and three metres, respectively and if impact piling is undertaken within 100 metres and 180 metres, respectively.

A building dilapidation survey should be carried out for all structures located within the safe working buffer distances to identify whether the structure is considered structurally unsound.

If the structure is found to be structurally unsound, the vibration levels of the equipment would be measured and used to confirm the buffer distances calculated as part of this assessment. If the structure is still located within the vibration safe working distances, then alternative equipment with lower vibration emissions (such as smaller compactors/rollers) would need to be considered. Construction vibration monitoring would be required if there are still structures located within the vibration safe working distances.

9.3.6.1 Vibration – human comfort impacts

Construction activities have the potential to impact on human comfort. Table 9.15 lists the number of receivers predicted to be impacted by the principle types of vibration creating equipment. Predicted safe working buffer distances were calculated for typical equipment vibration values to determine indicative distances where the human comfort criteria may be exceeded.

Table 9.15 Number of vibration affected receivers – human comfort

Equipment	Human comfort
Criteria source	BS 5228-2
General construction activities	
Roller	223
15 tonne vibratory roller	382
7 tonne compactor	223
Dozer	156
Backhoe	48
Pavement breaker	223
Excavator	64
Piling (bridges)	
Piling (impact)	2580
Piling (vibratory)[1]	272
Piling (bored)[1]	296

Impact piling has the potential to cause human comfort impacts within 700 metres of the works (2,580 sensitive receivers). Impact piling would be extremely short term in duration and may not be required. A total of 382 residential receivers within 140 metres of the vibration intensive works have the potential to experience impacts on human comfort during operation of the vibratory roller.

The assessment of potential vibration impacts is considered conservative as it considers the amount of receivers within the safe buffer distance based on property boundaries rather than the actual location of structures on each property. Additionally, construction vibration would be intermittent and these impacts would not be continuous throughout the construction period. The potential for the use of less vibratory intensive equipment and construction methods would be explored as part of detailed construction planning.

9.3.6.2 Vibration - Structural impacts

The numbers of receivers located inside the minimum working distances for vibration intensive activities are provided in Table 9.16. Predicted safe working buffer distances were calculated for typical equipment vibration values to determine indicative distances where the structural damage (standard dwelling and heritage structure) may be exceeded. However, as noted above the assessment of potential vibration impacts is considered conservative as it considers the amount of receivers within the safe buffer distance based on property boundaries rather than the actual location of standard dwellings on each property.

Table 9.16 Number of vibration affected receivers – structural damage

Equipment	Structural damage (number of receivers)	
	Heritage structure	Standard dwelling[1]
Criteria source	DIN 4150-3	DIN 4150-3
General construction activities		
Roller	2	51
15 tonne vibratory roller	2	53
7 tonne compactor	2	51
Dozer	2	41
Backhoe	2	9
Pavement breaker	2	51
Excavator	2	12
Piling (bridges and retaining wall)		
Piling (impact)	2	243
Piling (vibratory)[1]	2	69
Piling (bored)[1]	2	53

Note 1: definition of standard dwelling provided in section 3.3 of Technical Report 2.

Effects on standard structures

Receivers located along Broomfield Street and Sussex Street are set back by around 15 to 25 metres from the road. This would be inside the vibration safe working buffer distance if a 15 tonne vibratory roller is used. The size of the vibratory roller should be limited to below 15 tonnes for any works located within 25 metres of any residential structure.

Bored piling works has the potential to cause cosmetic damage impacts on residential structures along Broomfield Street and Sussex Street located within 17 metres of the works. Therefore the potential to use alternative piling methods at these locations would be considered as part of construction planning.

Effects on buried services

Compliance with the guideline values for structural damage would result in compliance with the guideline values for buried pipework. Direct contact between the vibration intensive equipment and buried pipework would be avoided.

Effects on heritage listed structures

The following heritage structures have been identified within 50 metres of the project site (refer to section 14.2 for a description of heritage items):

- Cabramatta (Cabramatta Creek), Railway Parade and Sussex Street Underbridge (I19) - piling works during bridge construction have the potential to cause cosmetic damage.

- The Federation Cottage (I10) - has the potential to experience vibration levels above the allowable limits during road construction works if a 15 tonne vibratory roller is used. It should be noted that since the Federation Cottage's listing in 2009, the structure has burnt down. As it is still a listed site however and may include archaeological potential, it remains referenced here.

In addition the proposed locations for minor works in the form of new signalling are situated close to the following heritage listed items:

- Villawood Railway Station Group (I103), 19 Villawood Road
- Liverpool Railway Station Group (72), off Bigge Street.

The signalling works would be located outside of vibration buffer distances to ensure there are no vibration impacts to these sites.

A building dilapidation survey of the heritage structures identified within the vibration safe working distance should be carried out. If the building dilapidation survey indicates that the heritage buildings are structurally unsound, then the conservative criteria of 3.0 mm/s provided by DIN 4150-3 should be used.

9.3.7 Cumulative impacts

Other projects that have the potential to occur at the same time as the project are described in Appendix E.

As the impacts from the construction of the project would be confined to an area near the boundary of the project site, the cumulative impacts would be minimal unless additional sources (to this project) of noise and vibration was generated close to receptors. There are no other known construction projects proposed in the vicinity of the project site. The potential for cumulative noise and vibration impacts from development proposals in the wider area would be negligible due to the separation distances between the construction areas for the project and other proposals. Therefore no cumulative impacts with other projects are predicted.

During scheduled possession periods there may be other rail maintenance work being conducted within the Sydney Trains rail corridor next to the SSFL. This may result in noise from construction works being exacerbated during this period. Noise from these activities would be managed within standard mitigation measures and out of hours protocols to minimise impacts to sensitive receivers.

9.4 Assessment of operation impacts

9.4.1 Rail noise impacts

Operational rail noise scenarios were developed to clearly identify noise levels resulting from existing rail operations on both the Sydney Trains and SSFL lines and the future rail operations with the inclusion of the project. The future operations of Sydney Trains were not considered as part of the assessment.

'No build' scenarios were also developed to identify the likely future operational rail noise levels without the project. This enables the effect of the project to be clearly quantified.

The RING states that noise trigger levels are to be evaluated immediately after operations start and for a design year, typically 10 years later. Consequently, the following two assessment timeframes have been evaluated within the project's operational assessment study area:

1. Opening year: No build and build scenarios for the year in which project operations are proposed to commence following construction completion, 2023.
2. Design year: No build and build scenarios 10 years after project operations are proposed to commence, 2033.

Noise modelling was also completed to examine the existing noise environment and validate predictions. For this project, the existing operations were modelled for the year 2018.

The assessment has accounted for the existing and future type of train, rolling stock, speed, idling period, stretching/bunching, which rail line they run on and track features (ie turnouts, bridges, height of rails). Individual passbys from the data were correlated with the Sydney Trains Wayside Information Management System at Warwick Farm to establish noise levels for different train types.

Predicted operational noise levels at the worst affected façade of all sensitive receivers (all floors) and figures showing the noise contours are provided in Technical Report 2.

The predicted noise levels indicate that the permanent removal of the existing noise wall on Broomfield Street would increase L_{Aeq} noise levels by up to 8 to 9 dB and L_{Amax} noise levels by up to 11 to 12 dB at residences located along Broomfield Street. Therefore, a replacement noise wall is included as part of the project. The location of the replacement noise wall would be slightly set back from the existing noise wall location due to the construction alignment of the project, as shown on Figure 6.1. A number of height options were considered for the noise wall. The final height of the noise wall has been kept the same as the current noise wall as additional increases in height did not provide substantial mitigation benefit.

Where the noise levels (L_{Aeq}) exceed the relevant day/night trigger levels and increase by 2 dB or more from the no build scenario, mitigation will be considered. Receivers can also be considered for mitigation where maximum noise levels (L_{Amax}) are predicted to exceed 85 dBA and there is a predicted increase of 3 dB or more due to the project.

The predicted noise levels would be exceeded for one sensitive receiver located in noise catchment area NCA02 with the replacement noise wall in place. This receiver (R2289 (106 Broomfield Street) – second floor only) will be considered for mitigation.

The predicted total rail noise level (L_{Aeq}) at R2289 at the second floor is exceeds the day time noise trigger level by 2 dB and the night time noise trigger level by 5.3 dB. The predicted maximum rail noise level also exceeds the trigger level by 3.2 dB.

Furthermore, rail noise levels are predicted to increase between the 'build' and 'no build' scenarios by 2.5 dB ($L_{Aeq,\ 15\ hour}$), 2.6 dB ($L_{Aeq,\ 9\ hour}$) and 3.9 dB ($L_{Amax,\ 24\ hour}$).

The increase in noise levels would be due to the following:

- increase in rolling noise contributions from the Sydney Trains lines as a result of shifting the existing noise wall location
- increase in rolling and engine/exhaust noise contributions from the SSFL as a result of the project and shifting the existing noise wall location.

A screening level ground-borne noise assessment has been undertaken to confirm if ground-borne noise levels are likely to increase by 3 dBA or more. The predicted increase in ground-borne noise based on the screening assessment would be less than 3 dBA. Therefore, there would not be an exceedance of the ground-borne criteria provided in Table 9.9.

Furthermore, as discussed in section 9.1.2, the values of ground-borne noise levels associated with railways, are relevant only where they are higher than the airborne noise from those railways and where the ground-borne noise levels are expected to be, or are, audible within habitable rooms. For an existing heavy rail corridor airborne noise is expected to be the dominant noise source from the project and significantly higher than any ground-borne noise contributions.

As the operational ground-borne noise results indicate that no residential receivers are likely to experience levels which exceed the trigger noise levels, specific operational ground-borne noise mitigation strategies are not proposed for the project.

9.4.2 Vibration impacts from operation of the project

Vibration from the operation of heavy rail infrastructure can adversely affect sensitive receivers located near a rail line. Vibration can cause buildings, windows and other fixtures to shake; contribute to annoyance and impacts on residents and other land uses; and interfere with vibration-sensitive equipment.

Vibration is caused by energy from the vibration source, the train, being transmitted into the ground. Vibration diminishes with distance and is dependent on a number of factors including the type of train, tracks and speeds and ground type and topography.

9.4.2.1 Human comfort impacts

The predicted future vibration values for day and night time along both the eastern and western sides of the rail corridor, compared to the respective residential criteria shows the criteria is met at the following distances:

- on the eastern side of the rail corridor, at 13 metres (day) and 18 metres (night)
- on the western side of the rail corridor, at 9 metres (day) and 13 metres (night).

The *Assessing Vibration: A Technical Guideline* (DEC 2006) does not specify human comfort vibration criteria for commercial sensitive receivers. This assessment conservatively adopts an intermittent vibration dose value of 0.6 $m/s^{1.75}$ for commercial spaces. This value is the midpoint of the values specified in the AVTG for offices (0.4 $m/s^{1.75}$) and workshops (0.8 $m/s^{1.75}$). The adopted commercial criteria is met at the following distances:

- on the eastern side of the rail corridor, at 4 metres (day) and 3.5 metres (night)
- on the western side of the rail corridor, 3 metres (day) and 2.5 metres (night).

The buffer distances are higher on the eastern side of the rail corridor due to the closer proximity of the SSFL and the passing loop, which carry the majority of the freight trains within the corridor.

No residential or commercial sensitive receivers have been identified within the human comfort vibration buffer distances detailed above, and therefore no receivers are predicted to be impacted. Specific operational vibration mitigation strategies are not recommended for the project.

9.4.2.2 Structural vibration impacts

The human comfort vibration criteria is more stringent than the structural damage criteria. As no residential receivers have been identified within the human comfort vibration buffer distances, structural vibration impacts at residential receivers are not anticipated as a result of the project.

The structural damage vibration criteria for commercial structures has been adopted as 20 mm/s and is significantly higher than the residential structural damage criteria. Vibration from freight trains has been measured at 4-5 mm/s at 6 metres in the study area. Therefore, vibration levels at commercial receivers would be significantly below 20 mm/s and structural impacts on commercial structures are not anticipated as a result of rail operations.

9.4.3 Cumulative impacts

The main source of noise and vibration from the operation of the project would be additional train movements on the SSFL. This future use of the rail line has been considered in the definition of the project and as part of the future scenarios (year opening 2023 and design year 2033) assessed in the noise and vibration impact assessment and are therefore not considered a cumulative impact.

9.5 Management of impacts

9.5.1 Approach and outcomes

9.5.1.1 Approach to mitigation and management

Measures to avoid impacts in the first instance have been addressed in the reference design and construction methodology (refer to section 9.1.4).

A construction noise and vibration management plan will be prepared prior to the commencement of works, with site inductions for all construction personnel undertaken to outline the requirements of the construction noise and vibration management plan. The aim of the construction noise and vibration management plan is to minimise noise and vibration impacts due to construction of the project. The construction noise and vibration management plan would include:

- application of appropriate noise and vibration criteria for each receiver type
- details of the standard and project-specific noise and vibration mitigation measures identified
- noise and vibration auditing and monitoring requirements
- additional mitigation measures to be implemented when exceedances to the noise management levels are likely to occur following detailed construction planning and confirmation of noise impacts.

Mitigation measures to be included in the construction noise and vibration management plan would be aimed at pro-active engagement with potentially affected receivers and may include provision of respite periods, and alternative accommodation for defined exceedance categories.

The additional mitigation measures will be used after the application of standard mitigation measures, where reasonable and feasible, and will be adopted from Transport for NSW CNVS. It should be noted that the mitigation measures listed in the Transport for NSW CNVS have also been adopted by the Roads and Maritime Services in the *Construction Noise and Vibration Guideline* (Roads and Maritime Services, 2016) and are considered the standard for recommending additional construction noise mitigation measures in New South Wales.

9.5.1.2 Expected effectiveness

ARTC have experience in managing potential noise and vibration impacts as a result of developments of similar scale and scope to this project.

Measures to avoid and minimise noise and vibration impacts have been included in the reference design (refer to section 9.1.4. Further pre construction impacts will be avoided by attended vibration measurements of vibration generating equipment (eg bored piling, vibratory rolling works) being undertaken prior to works near the sensitive structures located inside the vibration buffer distances identified in Figure 4.12 and Figure 4.13 of Technical Report 2. This will confirm the minimum working distances for vibration intensive activities to avoid and minimise potential impacts.

In addition to designing out noise and vibration impacts where possible, noise and vibration management measures will be included with a construction noise and vibration management plan that will be prepared for the project. The construction noise and vibration management plan will be prepared during the detailed design stage of the project and applied to all construction processes throughout the project. Noise and vibration guidelines applied by ARTC and used throughout the assessment of impacts presented in this EIS assume that a balance between the application of reasonable and feasible mitigations and a level of residual level of noise impacts would be achieved. In particular, The NSW *Construction Noise and Vibration Guideline* (Roads and Maritime Services, 2016) calls for the application of feasible and reasonable measures to mitigate construction noise and vibration.

As such, the measures to avoid impacts during development of the reference design and measures to be outlined in the construction noise and vibration management plan are considered to be proven effective in managing potential impacts from noise and vibration.

9.5.2 List of mitigation measures

The mitigation measures that would be implemented to address potential noise and vibration impacts are listed in Table 9.17.

Table 9.17 Mitigation measures

Stage	Impact	Measure
Design	Vibration impacts on heritage sites: Villawood Railway Station Group and Liverpool Railway Station Group	The signalling works near Liverpool Railway Station and Villawood Railway Station will be located outside of vibration buffer distances, where possible.
Construction	General impacts of construction activities on sensitive receivers	A construction noise and vibration management plan will be prepared by the contractor and implemented as part of the CEMP. It will include measures to minimise the potential for noise and vibration impacts on the community, including those listed in this EIS. It will also consider relevant noise mitigation measures and notification procedures outlined in ARTC's EPL #3142. The construction noise and vibration management plan will be developed in consultation with Liverpool City Council, Fairfield City Council, and the EPA.
	Noise impacts during out of hours work	An out of hours protocol will be developed as part of the construction noise and vibration management plan. It will at a minimum: • provide a process for the consideration of out of hours work against the relevant noise and vibration criteria • document procedures to manage potential impacts • identify responsibilities for implementation and management including managing complaints.
	Vibration impacts on structures including heritage items.	Strategies to minimise the vibration of construction activities will be considered during construction planning. This will include a detailed review of work methods and equipment selection with the aim of avoiding the use of equipment within the relevant vibration safe working buffer distances. Where this is not possible, attended vibration measurements of vibration generating equipment (e.g. bored piling, vibratory rolling works) will be undertaken prior to works near the sensitive structures located within the vibration buffer distances identified in Figure 4-12 and Figure 4-13 provided in Technical Report 2 – Noise and vibration impact assessment. This will confirm the project specific minimum working distances for vibration intensive activities.

Stage	Impact	Measure
	Vibration impacts on structures including heritage items.	Building dilapidation surveys will be carried out on all structures located within the vibration buffer distance prior to major project construction activities with the potential to cause property damage.
	Vibration impacts from the increase number of trains passing by Cabramatta (Cabramatta Creek), Railway Parade and Sussex Street Underbridge (I19).	If following a dilapidation survey of the heritage items the structures are found to be unsound, then a structural engineer will advise if there is a risk from increasing operational train numbers and identify strategies to avoid risks.
	Noise impacts during sensitive periods	Where feasible and reasonable, construction will be carried out during the standard daytime working hours. The use of highly intensive noise and vibration generating equipment (such as jack and rock hammering, sheet and pile driving, rock breaking and vibratory rolling) less sensitive times (e.g. the middle of the day).
	Noise impacts from continuous activities.	Highly intensive noise and vibration generating equipment (such as jack and rock hammering, sheet and pile driving, rock breaking and vibratory rolling) will only be used in continuous blocks not exceeding three hours each, with a minimum respite period of one hour between each block. 'Continuous' includes any period during which there is less than one hour respite between ceasing and recommencing any of the work. Additionally, this equipment will not be used for more than two consecutive nights over any seven day period adjacent to the same sensitive receivers.
	Noise impacts from worker activities	All employees, contractors and subcontractors are to receive an environmental induction. The induction will include at least: • all relevant project specific and standard noise and vibration mitigation measures • relevant licence and approval conditions • permissible hours of work • any limitations on noise generating activities with special audible characteristics • location of nearest sensitive receivers • construction employee parking areas • designated loading/unloading areas and procedures • site opening/closing times (including deliveries). • environmental incident procedures.
	Noise impacts from worker activities	While on site, construction workers will refrain from:

Stage	Impact	Measure
		• swearing or unnecessary shouting or loud stereos/radios on site • dropping of materials from height, throwing of metal items and slamming of doors • excessive revving of plant and vehicle engines • uncontrolled release of compressed air.
	Construction traffic noise	Traffic flow, parking and loading/unloading areas will be planned to minimise reversing movements within the site.
	Construction traffic noise	To reduce the impact of noise from construction traffic the following mitigation measures will be implemented: • Loading and unloading of materials/deliveries will occur as far as possible from sensitive receivers. • Site access points and roads will be selected as far as possible away from sensitive receivers. • Dedicated loading/unloading areas will be shielded if close to sensitive receivers, where reasonable and feasible. • Delivery vehicles will be fitted with straps rather than chains for unloading, wherever possible. • Vehicle movements will be scheduled away from sensitive receivers and during less sensitive times, where possible. • The speed of vehicles within and approaching construction compounds will be reduced • The use of engine compression brakes during night time periods will be avoided, where possible • On-site storage capacity will be maximised to reduce the need for truck movements during sensitive times. Vehicles will be fitted with a maintained original equipment manufacturer exhaust silencer that complies with the National Transport Commissions *National Stationary Exhaust Noise Test Procedures for In-service Motor Vehicles* (2006).
	Construction noise and vibration	Quieter and less vibration emitting construction methods and equipment will be used where feasible and reasonable. For example, when piling is required, bored piles rather than impact-driven piles will minimise noise and vibration impacts. Similarly, diaphragm wall construction techniques, in lieu of sheet piling, will have significant noise and vibration benefits.
	Construction noise and vibration	Where practicable, materials will be pre-fabricated and/or prepared off-site to reduce noise with special audible characteristics occurring on site. Materials can then be delivered to site for installation.
	Noise from construction equipment	The noise of plant and equipment must have operating Sound Power or Sound Pressure Levels compliant with the allowable noise levels.

Stage	Impact	Measure
	Noise from construction equipment	To reduce the impact of noise from construction equipment the following mitigation measures will be implemented: • The offset distance between noisy plant and adjacent sensitive receivers will be maximised. • Plant used intermittently will be throttled or shut down. Noise-emitting plant will be directed away from sensitive receivers
	Noise from construction equipment	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, including delivery vehicles.
	Noise from construction equipment	Noise from mobile plant will be reduced where possible, through additional fittings including: • residential grade mufflers • damped hammers such as 'City' Model Rammer Hammers • air parking brake engagement silenced.
	Noise impact from compound (C1)	Use of the construction compound (C1) near Warwick Farm Station will where practicable, be limited to standard hours only with the exception of plant storage and material delivery.
	Noise from construction compounds	Stationary noise sources on construction compounds will be enclosed or shielded where practicable, to ensure that the occupational health and safety of workers is maintained. Appendix F of AS 2436:1981 lists materials suitable for shielding.
	Noise from construction compounds	Structures will be used to shield residential receivers from noise where practicable such as site shed placement; earth bunds; fencing; erection of operational stage noise barriers (where practicable) and consideration of site topography when situating plant.
	Construction noise resulting in highly intrusive levels	A noise monitoring program will be carried out for the duration of works at sensitive receivers identified as experiencing highly intrusive noise levels and as a result of complaints received, in accordance with the CEMP.
	Vibration impacts on heritage sites: Cabramatta (Cabramatta Creek), Railway Parade and Sussex Street Underbridge	Where building dilapidation surveys indicate that the heritage listed bridges are unsound, then the conservative criteria of 3.0 mm/s provided by DIN 4150-3 will be used for construction equipment used within the vibration buffer distances, where practicable.
Operation	Impacts to second floor of 106 Broomfield Street	Receiver at 106 Broomfield Street will be consulted regarding potential noise mitigation. This may include a review of the existing internal acoustic properties of the building and identification of where improvements can be made to reduce the exceedance of the trigger level.

9.5.3 The interaction between measures

Mitigation measures to control noise to sensitive receivers may replicate mitigation measures proposed for the control of impacts associated with health and safety, visual and social impact mitigation.

As per Chapter 17 (Landscape and visual amenity) impacts resulting from the replacement of the existing noise wall to view and landscape character have been considered. This mitigation has been considered as part of the landscape and visual impact assessment.

All mitigation measures for the project would be consolidated and described in the CEMP. The plan would identify measures that are common between different aspects. Common impacts and common mitigation measures would be consolidated to ensure consistency and implementation.

9.5.4 Managing residual impacts

A residual risk analysis was undertaken following the impact assessment summarised in this chapter. The results of the residual risk analysis are provided in Appendix D and discussed further below.

The mitigation and management measures outlined in section 9.5.2 have been designed to minimise the potential impacts to people and the environment. Regardless, construction and operation of the project still involves some level of residual impact.

Residual noise impacts from the project's construction are anticipated. This this is due to some loud processes (eg saw cutting, rock breaking) that would be required to complete the project. Some construction activities would also be located close to residential receivers on Broomfield Street making screening of those works difficult. Application of project specific mitigation, including notification procedures, complaints handling process, monitoring and application of alternative methods or techniques would be implemented. While ARTC acknowledge that residual impact would exist, the application of these reasonable and feasible mitigation measures are would reduce residual impacts to an acceptable level. These residual impacts would be temporary, and in many cases, of short duration as works passes from one location to another.

Noise and vibration guidelines applied by ARTC and used throughout the assessment of impacts presented in this EIS assume that a balance between the application of reasonable and feasible mitigations and a level of residual level of noise impacts would be achieved. In particular, the *NSW Construction Noise and Vibration Guideline* (Roads and Maritime Services, 2016) calls for the application of feasible and reasonable measures to mitigate construction noise and vibration.

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