PART B

ENVIRONMENTAL ASSESSMENT

CABRAMATTA LOOP PROJECT

ENVIRONMENTAL IMPACT STATEMENT

THIS PAGE HAS BEEN LEFT INTENTIONALLY BLANK

8 Traffic, transport and access

This chapter provides a summary of the traffic, transport and access impact assessment undertaken by GHD. A full copy of the assessment report is provided as Technical Report 1-Traffic, transport and access impact assessment. The report was written to address the relevant SEARs which are outlined in Appendix A.

8.1 Assessment approach

8.1.1 Methodology

8.1.1.1 Study area

The study area for the assessment includes all local and State roads that would be affected by the project. These include the Hume Highway and Cabramatta Road East, which act as key arterial road links that provide access and egress to local roads adjacent to works sites. Local roads within the study area that provide direct access to works sites are Broomfield Street, Junction Street and Liverpool Street, Sappho Road and Mannix Parade.

8.1.1.2 Key tasks

The assessment involved:

- reviewing the reference design for the project
- reviewing existing road features, traffic, transport services, pedestrian and cyclist facilities, parking, and available traffic survey data
- estimating the traffic that would be generated during construction
- assessing the potential impacts of construction, including impacts to the operation of the local road network, pedestrians, cyclists, parking, and public transport in accordance with *Traffic Modelling Guidelines* (RMS 2013)
- assessing the potential impacts to the local road network and parking during operation
- assessing potential operational impacts on the wider transport network, including impacts to motorists, cyclists, pedestrians, and public transport
- providing mitigation measures to manage the potential impacts identified.

In addition to the above, the Transport for NSW website was accessed for information relating to bus route and timetables (January 2019).

8.1.2 Risks identified

The preliminary environmental risk assessment undertaken for the project included potential risks associated with traffic, transport and access. 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 traffic, transport and access risks was high. Risks with an assessed level of medium or above include:

- construction traffic impacts, including temporary delays to local traffic
- construction staff parking resulting in impacts to street parking

- congestion in surrounding road networks due to diversion of road users during construction due to partial or full road closures
- reduced pedestrian and cyclist access during construction due to works on the shared path
- impacts to existing parking spaces on the western side of Broomfield Street due to the works encroaching in this area during the construction stage
- short-term impacts to land owners and occupiers due to access restrictions during services relocation work
- permanent loss of parking along Broomfield Street
- additional traffic generated by maintenance activities due to the passing loop
- impacts to emergency services through delays in access due to works.

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).

8.1.3 How potential impacts have been avoided/minimised

As described in Chapter 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 traffic, transport and access impacts have been avoided/minimised where possible by:

- maintaining existing functionality of Broomfield Street by minimising widening of rail corridor
- minimising closure of roads and active transport routes and maintaining access along Broomfield Street through staging of the construction works
- providing a temporary shared path to minimise impacts to pedestrians and cyclists
- designing the retaining walls proposed for Broomfield Street to be as narrow as possible to minimise operational impacts along Broomfield Street
- choosing a parking configuration that minimises the loss of car parking capacity in Broomfield Street.

8.2 Existing environment

8.2.1 Regional transport context

Roads in the vicinity of the project consist of the following:

- State roads – major arterial links through NSW and within major urban areas
- Regional roads – roads of secondary importance that provide the main connections between smaller towns and perform a sub arterial function in major urban areas
- Local roads – the remainder of generally council controlled roads.

The surrounding road network is shown on Figure 8.1.

Figure 8.1 Surrounding road network

8.2.2 State roads

The key arterial road that links to and from connector roads to the site is the Hume Highway. The Hume Highway allows the entry and exit of traffic to the project site at a number of locations, primarily at Cabramatta Road East and Mannix Parade. The key features of the Hume Highway within proximity to the project site are described in Table 3.1 of Technical Report 1.

8.2.3 Local road network and access arrangements

The following roads are located within the vicinity of the project:

- Broomfield Street
- Cabramatta Road East
- First Avenue
- Mannix Parade
- Liverpool Street
- Junction Street.

Some of the key features of each of the above roads are summarised below.

8.2.3.1 Broomfield Street

Broomfield Street functions as a collector road that runs adjacent to the eastern side of the T2/T5 railway line. Broomfield Street has one lane in each direction south of Cabramatta Station and a 50 kilometres per hour speed limit, reducing to 40 kilometres per hour within 200 metres of the town centre.

8.2.3.2 Cabramatta Road East

Cabramatta Road East is a sub arterial road forming part of Cabramatta Road, positioned east of the T2/T5 railway line. Cabramatta Road East provides a link between the Cabramatta town centre, Cabramatta Station and the Hume Highway. Cabramatta Road East has two lanes in each direction and a range of speed limits between 40 (in school zones) and 60 kilometres per hour.

8.2.3.3 First Avenue

First Avenue is a local no-through road providing access to Canley Vale Station and a residential area to the north of the train line. First Avenue connects to Broomfield Street via Bareena Street. First Avenue has one lane in each direction and a speed limit of between 40 (in school zone) and 50 kilometres per hour.

8.2.3.4 Mannix Parade

Mannix Parade is a local road intersecting the Hume Highway in the south and Lawrence Hargrave Road in the north. It provides access to the residential area of Warwick Farm. It has one lane in each direction and a speed limit of 50 kilometres per hour.

8.2.3.5 Liverpool Street

Liverpool Street is a local road, located about 100 metres to the east of the project. To the east, it forms a priority controlled intersection with Hume Highway. To the west, it provides connectivity to Broomfield Street via National Street and Sussex Street. It has one lane in each direction and a speed limit of 50 kilometres per hour.

8.2.3.6 Junction Street

Junction Street is a local road running in an east to west direction. It links Broomfield Street to the Hume Highway and has one lane in each direction and has a speed limit of 50 kilometres per hour.

8.2.4 Traffic volumes

Traffic survey data was collected during peak hours in October and November 2018. The location of these counts in shown on Figure 8.2. This data was analysed to determine existing intersection operational performance. The traffic survey data collected is provided in Appendix A of Technical Report 1.

The traffic surveys indicated the following network peak hour periods adjacent to the site:

- Weekday AM peak: 7.30 am to 8.30 am
- Weekday PM peak: 16.30 pm to 17.30 pm
- Saturday peak: 12.30 pm to 13.30 pm.

These peak periods were adopted for assessment of impacts on the surrounding road network for the worst case scenario. Table 8.1 summarises the peak hour traffic volumes in the study area.

Table 8.1 Mid-block traffic volumes

Location	Road classification	Direction	AM Peak Hour (vehicles per hour)	PM Peak Hour (vehicles per hour)
Hume Highway between Mannix Road and Sappho Road	Arterial road	Eastbound	2,150	1,890
		Westbound	1,650	1,885
		Total	3,800	3,775
Cabramatta Road East	Sub arterial	Northbound	390	935
		Southbound	840	800
		Total	1,230	1,735
Broomfield Street	Local road	Northbound	135	140
		Southbound	150	160
		Total	285	300
Mannix Parade	Local road	Northbound	125	120
		Southbound	165	135
		Total	290	255
Lawrence Hargrave Road	Local road	Northbound	80	80
		Southbound	65	65
		Total	145	145
Sappho Road	Local road	Northbound	205	275
		Southbound	45	200
		Total	250	475

The weekday AM and PM peak hour volumes at each location are typically similar, apart from Cabramatta Road East, where the PM peak has significantly higher volumes than the AM peak. Further, the Saturday peak total volume at Sappho Road is higher than the weekday peak, which is assumed to be as a result of the high density commercial activities accessed via Sappho Road (ie car sales yards and retail establishments, including Homemaker Warwick Farm and Peter Warren Automotive).

Figure 8.2 Intersection traffic surveys locations

8.2.4.1 Heavy and light vehicle mix

The average heavy vehicle percentage for major roads within the immediate vicinity of the project is outlined in Table 3.11 of Technical Report 1. The data indicated that heavy vehicles constitute between one and five percent of the overall traffic volumes recorded.

In proximity to the project site Hume Highway and Cabramatta Road are approved freight routes that can accommodate vehicles up to the size of a 26 metre B-Double (Roads and Maritime Services, 2019).

The Roads and Maritime Services Restricted Access Vehicle Map identifies the following approved freight routes in the vicinity of the project site to accommodate vehicles up to the size of a 26 metre B-Double.

- Hume Highway
- Cabramatta Road East.

As shown on Figure 7.5 access to the project site would utilise these approved freight routes, minimising impacts to the local road network.

8.2.5 Intersection performance

The performance of the existing road network is largely dependent on the operational performance of key intersections, which are critical capacity control points. Existing intersection performance was assessed by developing traffic models using the AM and PM weekday peak hour surveyed data (2018) and the Saturday peak hour data at the Sappho Road/Hume Highway intersection. A summary of the results including Level of Service (LoS) is outlined in Table 8.2 and Table 8.3. Detailed modelling results are provided in Appendix A of Technical Report 1.

Table 8.2 Existing intersection operations

Intersection	AM Peak				PM Peak			
	Average Delay* (s)	LoS	Control Type	Deg. of Sat.*	Average Delay* (s)	LoS	Control Type	Deg. of Sat.*
Site 1: Hume Highway/ Mannix Parade	25	B	Signal	0.882	30	C	Signal	0.929
Site 2: Lawrence Hargrave Road/ Nicholls Street	8	A	Roundabout	0.056	8	A	Roundabout	0.055
Site 3. Lawrence Hargrave Road/ Mannix Parade	7	A	Roundabout	0.098	7	A	Roundabout	0.082
Site 4: Hume Highway/ Junction Street	8	A	Priority	0.36	7	A	Priority	0.485
Site 5: Hume Highway/ Liverpool Street	150+	F	Signal	1.0+	150+	F	Priority	1.0+
Site 6: Sappho Road/ Hume Highway (Weekday)	8	A	Signal	0.534	13	A	Signal	0.523
Site 7: Broomfield Street/ Cabramatta Road East	13	A	Signal	0.222	12	A	Signal	0.242
Site 8: Hume Highway/ Cabramatta Road East	26	B	Signal	0.688	26	B	Signal	0.810

THIS PAGE HAS BEEN LEFT INTENTIONALLY BLANK

Table 8.3 Existing Saturday intersection operations

Intersection	Saturday Peak			
	Average Delay* (s)	LoS*	Control Type	Deg. of Sat.*
Site 6: Sappho Road/ Hume Highway	19	B	Signal	0.846

*Notes:

- The average delay for priority-controlled intersections is selected from the movement on the approach with the highest average delay.
- The level of service for priority-controlled intersections is based on the highest average delay per vehicle for the most critical movement.
- The degree of saturation (Degree of Saturation) is defined as the ratio of the arrival flow (demand) to the capacity of each approach.
- Average delay is given in seconds per vehicle.

Table 8.2 shows that most of the signalised intersections and roundabouts analysed currently operate with an acceptable LoS (ie better than LoS E in accordance with the *Guide to Traffic Generating Developments* (RMS, 2002)) with spare capacity in both the weekday morning and evening peak periods. The right turn movements at the Hume Highway/Liverpool Street intersection were shown to operate at LoS F both in the morning and evening peak periods, indicating that the intersection is operating at, or close to capacity. Table 8.3 shows that the Sappho Road/Hume Highway intersection operates satisfactorily for the weekend peak hour (LoS B).

8.2.6 Road safety

Crash history data was obtained for a five year period from 2013 to 2017 for roads in the study area from the Transport for NSW Centre for Road Safety. Data was used to analyse road safety to determine:

- any road safety concerns in close proximity to the main work sites
- additional construction traffic and shared road users impact on the existing situation.

Data showed that crashes typically occur at intersections along Broomfield Street, particularly at Bridge Street and Longfield Street intersections. In total there were 20 crashes on the roads assessed closest to the project. The highest number of injury related crashes recorded was at the Broomfield Street / Longfield Street intersection, which resulted in three injuries.

8.2.7 On and off street parking

There is generally a mix of both on street and off street parking available within walking distances to Cabramatta Station, Canley Vale Station and Warwick Farm Station.

Around Cabramatta Station there is designated on street parking provided on both sides of Broomfield Street. Off street parking within Cabramatta town centre (west of the station) is provided pre-dominantly for local business activity associated with the town centre. There is a multi-storey paid car park located to the east of the station accessible via Fisher Street and a smaller free car park accessible via Cumberland Street.

Warwick Farm Station is serviced by a multi-storey off street parking facility at the western side of the station. At grade parking facilities exist adjacent to the station to the east and the west. In addition, there is on street parking available on Hart Street, located to the west of the station.

A survey of existing parking use in the study area was undertaken in October 2018 and focused on Broomfield Street. The findings of the survey determined that there were approximately 379 parking spaces available on Broomfield Street (north and south of Cabramatta Station). Untimed on-street parking is located

on both sides of Broomfield Street. For the majority of street within the project site there is currently angled parking on the western side of the road and informal kerbside parallel parking on the eastern side. North of Broomfield Lane the parking consists of parallel parking on the western side only. The survey identified that parking utilisation on the western side of Broomfield Street north of Cabramatta Station typically reaches close to capacity between 8.00 am and 3.00 pm. Parking south of Cabramatta Station typically has some spare capacity during the highest utilised periods (76 spare spaces), with peak utilisation at approximately 60 per cent particularly on the eastern side south of Junction Street. Observed patterns of parking utilisation both north and south of Cabramatta Station, indicate that the majority of on street parking users are commuters, with an increase in parking demand noted prior to 9:00 am and a decrease in demand after 3:00 pm.

Parking utilisation surveys were also undertaken at Canley Vale Station and Warwick Farm Station to assess parking patterns in proximity to the compounds and work sites. First Avenue (Canley Vale Station) on the western kerb and Warwick Farm Station follow a similar trend to Broomfield Street parking demands with parking utilisation at capacity from 8:00 am to 3:00 pm.

8.2.8 Public transport

Both bus and train services operate within the study area, including four bus routes (numbers S1, 904, 823, and N50) with stops on Broomfield Street, Cabramatta Road East, Hume Highway and Mannix Parade. No bus routes operate within the project site.

Within the study area, passenger services are provided by Sydney Trains along the T2 Inner West and Leppington Line, and the T5 Cumberland Line. Two Sydney Trains stations are located in close proximity to the project site namely Cabramatta Station, located about 130 metres north of the project site and Warwick Farm Station located about 120 metres south of the project site. Train services operating on the T2 and T5 lines services the following stations near the project:

- Canley Vale Station
- Cabramatta Station
- Warwick Farm Station.

8.2.9 Pedestrians and cyclists

Footpaths are provided throughout the study area, and there are also median refuges and signalised major intersections. A pedestrian footpath and cycle path (shared path) is located on the western side of Broomfield Street and forms part of the Parramatta to Liverpool Rail Trail Cycleway, joining Canley Vale Station with Warwick Farm within the study area.

At Canley Vale Station the Parramatta to Liverpool Rail Trail Cycleway crosses the Prospect Reservoir Orphan School Creek Trail, which is one of the longest continuous off-road bike paths in Sydney. Bike racks are provide outside Canley Vale Station.

To the south of the project site, near Liverpool Station, the cycleway crosses the Mirambeena and Chipping Norton loop, which is a 27 kilometre long loop consisting mostly of off-road paths.

8.2.10 Taxi and drop off facilities

There is a taxi rank adjacent to Cabramatta Station. There is a designated taxi zone (dedicated maxi taxi) located adjacent to the Warwick Farm Station at the Remembrance Avenue/Hart Street exit.

There are two kiss and ride facilities serving Cabramatta Station. The first of these is located immediately north of the taxi rank along the western side of Broomfield Street (two car spaces). The second is located on the southern kerb of Cabramatta Road East (one car space).

There is one pick up/drop off facility at Warwick Farm Station which is a designated five minute parking zone serving ten car spaces. It is located on Remembrance Avenue just east of Hart Street.

8.3 Assessment of construction impacts

8.3.1 Construction traffic

Construction would generate additional vehicle movements, including light and heavy vehicles. Light vehicles would generally be generated by construction workers moving to and from the construction work areas and/or compounds. Heavy vehicle movements would generally be trucks delivering materials.

It is estimated that up to 60 light vehicles associated with the workforce and six heavy vehicles would use the Hume Highway per hour during peak periods to access the project site during possessions (peak construction activity period). Heavy vehicles consist of delivery vehicles, haulage trucks and oversized vehicle movements that may occur within the peak hour period. Construction vehicles would then distribute at a number of side roads to enter and leave the compound and work sites.

It is proposed that the Hume Highway would provide key access to and from the locality from the south and north, with Cabramatta Road East and Mannix Parade comprising the two major connection points from the Hume Highway. Liverpool Street and Junction Street would potentially be utilised as 'left in, left out' locations to and from Broomfield Street, while Sappho Road may be utilised in special circumstances to access the Jacqui Osmond Reserve. The preliminary haulage and access routes are shown on Figure 7.5. These routes would be reviewed during the detailed design stage and confirmed following the appointment of the construction contractor.

8.3.2 Road network performance

SIDRA modelling was undertaken using the weekday AM (morning) and PM (afternoon) peak hours and the Saturday peak hour at Sappho Road/ Hume Highway intersections based on the 2018 traffic survey data (refer Table 8.2 and Table 8.3).

The analysis indicated that most of the intersections potentially affected by the project during construction would continue to operate throughout the construction period at a level of service comparable to existing conditions. The exceptions would be:

- the Hume Highway/Mannix Parade signalised intersection where there would be a marginal decline in road network performance during the weekday morning and evening peak hour periods, however the operation of the intersection would still be considered good
- the Sappho Road/Hume Highway signalised intersection where there would be a marginal decline in road network performance during the weekday evening peak hour period, however the operation would still be considered good.

Detailed SIDRA modelling results of these intersections are provided in Appendix B of Technical Report 1.

8.3.3 Vehicular traffic

Broomfield Street realignment works would occur in stages to minimise the impact on traffic and parking. In addition, staging will occur concurrently to minimise construction time. The staged and concurrent realignment works would occur as follows:

- Stage 1A
- Stage 1B and Stage 2A
- Stage 1C and Stage 2B
- Stage 1D and Stage 2C
- Stage 2D.

These stages are shown on Figure 8.3.

Figure 8.3 Construction stages along Broomfield Street

The traffic management approach proposed during construction, along with any associated impacts, is discussed in Table 8.4.

Table 8.4 Proposed traffic management and impacts

Road	Proposed closure	Diversion/traffic management	Traffic Impact
Broomfield Street	Northbound lane closure during realignment of the eastern side road southbound lane closure during realignment of the road of the western side of the road.	One lane would be closed at a time, allowing bi-directional traffic to travel along the remaining open lane, under traffic control. No diversion would be implemented	Minor delays (estimated between 1 and 2 minutes) to vehicles on Broomfield Street. Minor delays for residents that access property driveways.
	Full road closure at night time for short periods (typically one night) for specific activities such as line marking, and when changing traffic setup to progress between stages.	Potential diversions would include the adjacent local roads such as National Street.	Minor delays (estimated between 1 and 2 minutes) to vehicles due to local road diversions from Broomfield Street to adjacent roads such as National Street. Minor delays for residents accessing property driveways.
Sussex Street	Closure of the southern lane during road alignment works and piling works associated with the Sussex Street bridge.	The northern lane would remain open with traffic management allowing bi-directional traffic	Minor delays (estimated between 1 and 2 minutes) to vehicles that travel via Sussex Street under the bridge.
	Potential full road closure (approximately 12 hours) during certain bridge construction activities (such as lifting and positioning of the girder) for safety reasons.	Road likely closed from Sussex Street bridge to Junction Street. The most likely diversion would comprise: • Western side of the railway line - Church Street (to the west) and Cabramatta Road via Railway Parade to the east • Eastern side of the railway line – Junction Street, Cumberland Street and Cabramatta Road with local access maintained.	Moderate delays (estimated between 2 and 5 minutes) to vehicles that travel via Sussex Street (bridge underpass) can be diverted to Cabramatta Road to cross the rail line. Vehicles that cross the rail line at this location would incur approximately 5 minutes of additional travel time.

Additional minor delays to travel may be experienced by drivers as a result of temporary closures within local streets around the work site and compounds due to deliveries of oversized equipment. The delivery of oversized equipment would generally be undertaken outside of standard construction hours to minimise impacts on the surrounding road network and in accordance with relevant safety considerations in consultation with Roads and Maritime.

Measures to manage the potential for impacts to traffic are provided in section 8.5.

8.3.4 Pedestrians and cycle access

Given the nature of the works on Broomfield Street, minor diversions may be required around the construction site to the opposite side of the road and temporary crossings may be provided. Access to the

shared path on the western side of Broomfield Street would be maintained while works are being undertaken on the eastern side of Broomfield Street. When the realignment works switch to the western side of Broomfield Street access to the footpath on the eastern side would be maintained, however as this is not a shared path cyclists may be directed to dismount or use the road. Works would be staged to minimise the area of impact and impact on pedestrian and cycle access. Traffic management and signage would be established which would aim to maintain existing pedestrian capacity, amenity and safety. This would be facilitated by traffic controllers where required.

There may be a need to either divert pedestrians and cyclists to adjacent local roads or manage access of pedestrians and cyclists through traffic management when Sussex Street and Broomfield Street are closed for night works. This would cause minor delays to pedestrians and cyclists however this impact is considered minor as the roads would only be closed for periods of one night at time, when pedestrian and cyclist use would be reduced.

In order to maintain pedestrian access around worksites W4 and W3 south of the Sussex Street bridge, the existing shared path would be realigned about 15 metres to the east from the corner of Broomfield and Sussex streets and would join the existing path at the northern extent of the pedestrian footbridge over Cabramatta Creek. The impact would be negligible as the diversion is generally in the same location.

During key activities of construction of the Cabramatta Creek and Sussex Street bridges, cranes will be erected in worksites W4 and W3 to facilitate lifting of bridge items into place. To maintain pedestrian and cyclist safety, the permanent and temporary shared path would be closed would be closed between Sussex Street and Jacquie Osmond Reserve during this period. This closure would be short term, with a likely duration of two weeks. Pedestrians and cyclists would likely need to be diverted to Cabramatta Road to cross to the western side of the rail corridor, which could result in significant travel time delays. In accordance with ARTC's stakeholder engagement program users of the shared path would be notified of the closure prior to works commencing to minimise any potential impacts.

Other than the temporary diversion noted above pedestrian and/or cyclist access to Jacquie Osmond Reserve from the southern end of the project site (via Warwick Farm Recreation Reserve and the Hometown Warwick Farm car park) and from the northern end of the project site (via Cabramatta Station and Cabramatta town centre) would not be impacted.

8.3.5 Parking

Parking impacts are likely during construction of the project. As Construction progresses along the western extent of Broomfield Street the area which is currently angled parking would be impacted. As works progress along the eastern extent of Broomfield Street, particularly to adjust the kerb and construct the pavement, informal kerbside parallel parking would also be impacted. It is anticipated that at the largest staged area (1B with 2A – refer Figure 8.3), about 46 parking spaces would be impacted. Impacts to parking are anticipated to be less during construction of the remaining stages.

As parking is not fully utilised along the length of Broomfield Street through to Sussex Street, it is anticipated the remaining capacity (about 14 spaces) would absorb some of the impact resulting in a reduced net loss. In order to mitigate the potential impact to parking, ARTC is proposing to lease a vacant lot in close proximity to the project site and provide a temporary at-grade parking area. As the temporary site would be subject to negotiation, and was not available at the time of writing, this section details the target criteria for potential temporary car parking site.

The proposed site would:

- aim to be located within 800 metres of Cabramatta Station
- be either an existing hard stand site or site with no existing buildings to limit the need for demolition
- provide about 40 parking spaces

- provide suitable access into and out of the site to limit impacts to the traffic network as a result.

A number of potential options have been identified and include sites in order of preference:

- within the town centre, bordered by commercial activities and a multi-story car parks
- surrounded by medium to high density residential properties which each have eight or more car spaces on site
- adjacent to low-density residential properties.

It is anticipated that construction worker parking would be kept to designated compounds and areas designated for construction workers only. Approximately 60 to 80 worker's vehicles could be accommodated within the site compounds. Therefore there should be minimal impact to on street parking from construction workers. Parking locations would be detailed in the CEMP.

Measures to manage the potential for impacts on parking are provided in section 8.5.

8.3.6 Impacts to access

8.3.6.1 Residential access

During the enabling works there may be temporary disruptions to access for properties directly fronting Broomfield Street during works to relocate or protect utilities. Additionally, there may be property access impacts if utility relocation works are undertaken in the streets directly adjoining the project site. Any temporary closures of driveways, if required, would be of short duration (up to one day). In many cases, these disruptions can be mitigated through scheduling of works in consultation with the landowner and utilising interim measures such as temporary road plates.

Vehicle access to properties located on Broomfield Street adjoining the works will be maintained during the main construction works.

There is likely to be minor impacts on vehicle travel times to and from properties due to the imposed one lane directional travel, which may cause minor delays to property access and egress.

8.3.6.2 School access

Lawrence Hargrave School is located adjacent to the western side of the railway corridor at the intersection of Lawrence Hargrave Road and Station Street. During school drop off and pick up times there may be increased traffic in proximity to the school which could be worsened as a result of construction traffic.

The movement of construction vehicles will be managed to minimise conflict between construction traffic and vehicles and pedestrians associated with the school, including construction traffic avoiding the peak period of school start and finish times to minimise potential conflicts.

Measures to manage the potential for impacts on school access are provided in section 8.5.

8.3.6.3 Jacquie Osmond Reserve

There may be potential safety impacts to vehicles, pedestrian and cyclists that use the unnamed access track during construction due to the presence of construction vehicles using this track including where it crosses underneath the rail corridor (between Jacquie Osmond Reserve and Warwick Farm Recreation Reserve). The potential for safety impacts would be minimised through implementation of a construction traffic management plan (discussed in section 8.5) which would provide measures to minimise the conflict between construction traffic, vehicles and shared path users.

Additionally, there would be no vehicle access to Jacquie Osmond via the unnamed access road on the western side of the rail corridor while some components of the Cabramatta Creek bridge are being constructed. This would impact users of Jacquie Osmond Reserve who access the park for sporting or recreational activities and use the informal parking within Jacquie Osmond Reserve. This impact is considered minor as the works would be short-term (with a likely duration of two weeks) and would likely only impact users on the weekend when sporting events are held. During this time users would still be able to park within the adjacent Hometown Warwick Farm car park and access the park from the southern entry.

Measures to manage the potential for impacts to access are provided in section 8.5.

8.3.7 Public transport

Features of the project such as the Sussex Street bridge works, Cabramatta Creek bridge and track works would need to be constructed during programmed weekend rail possession periods. Possession periods typically occur for 48 hours at a time, four times a year. During these times, it is expected that train replacement services (bus services) will be offered to the public, coordinated by Sydney Trains. This is in accordance with standard operating procedures for Sydney Trains and ARTC.

No impacts on existing bus services are expected during the proposed works as no bus routes run within the project site. Additionally, no impacts on existing taxi stands or kiss and ride locations are anticipated due to the distance of these locations from the project (the nearest kiss and ride and taxi stands are located adjacent to Warwick Farm and Cabramatta stations).

8.3.8 Emergency vehicles

In the event of an emergency during construction of the project there is the potential for impacts to emergency vehicles by way of minor to moderate delays and longer travel times as a result of road diversions and 'stop and go' traffic control arrangements. Additional construction traffic along local haulage routes may also result in minor delays to emergency vehicles.

Measures to manage the potential for impacts to emergency vehicles are provided in section 8.5.

8.3.9 Road safety

No impacts to road safety are anticipated as a result of construction of the project. The safety of road users will be managed through measures provided in the construction traffic management plan (discussed in section 8.5). Potential conflicts points between construction and school access is discussed in section 8.3.6. Other potential road hazards are discussed in Chapter 20 (Health, safety and hazards).

8.3.10 Cumulative impacts

Other projects that have the potential to occur at the same time as the project are described in Appendix E. There are no known proposed developments immediately adjacent to the project site that may be concurrently in construction with the project.

The following proposed developments within 500 metres of the project have the potential to occur at the same time as construction of the project.

- a multi-storey residential centre at the corner of Broomfield and Cabramatta Road adjacent to the station
- a carpark development in the Cabramatta town centre
- upgrade of Governor Macquarie Drive from the Hume Highway to Newbridge Road.

Potential cumulative impacts may include an exacerbation of the traffic impacts identified in this chapter including delays resulting from reduced intersection performance, additional diversions and an additional demand for parking.

The potential for cumulative impacts would be mitigated through implementation of the mitigation measures proposed in section 8.5 of this report.

8.4 Assessment of operational impacts

8.4.1 Traffic and access impacts

There are no changes expected to occur to the existing road network (including pedestrian and cyclist networks) or access arrangements to public transport as a result of the project. The project is also not expected to generate any additional traffic movements or change the current arrangements of public and active transport. Road intersections reviewed within the study area are anticipated to remain at their current level of operation following the completion of the works.

Maintenance vehicles will need to access the rail corridor to undertake routine maintenance activities on the passing loop as per existing maintenance arrangements. Maintenance works would mostly be undertaken during possessions and would be managed in accordance with ARTC's existing EPL and standard operating procedures. As a result, there are no additional traffic impacts anticipated.

There would be no changes to access arrangements for properties located along Broomfield Street.

The shared path on the western side of Broomfield Street and the footpath on the eastern side of Broomfield Street would be reinstated as part of the project. The footpath on the eastern side would be improved from the existing arrangement as it is currently not concreted along the length of the road, but would be following the completion of the project.

Opportunities to integrate cycling and pedestrian elements with surrounding networks would involve the provision of wayfinding signage, which would be explored as part of development of the urban design and landscape plan during detailed design. This is described further in Chapter 17 (Landscape and visual amenity).

8.4.2 Parking

As a result of changing the angled kerb parking along the western side of Broomfield Street to parallel parking, the project would impact parking with a loss of up to 11 parking spaces proposed. There is currently provision for 213 parking spaces along Broomfield Street between Cabramatta Station and Sussex Street, of which 135 are located on the western side of Broomfield Street.

No permanent impacts are anticipated to the parking spaces available along the eastern side of Broomfield Street and at Jacquie Osmond Reserve as a result of the project.

As discussed in section 8.2.7, it is anticipated the parking spaces are predominantly utilised by commuters of Cabramatta Station. As indicated by the parking surveys, Broomfield Street has the capacity to absorb the reduction in parking spaces within surrounding areas, particularly between Sussex Street and Junction Street. This could result in an additional distance of up to 800 metres and up to 10 minutes for commuters walking to Cabramatta Station. As parking south of Junction Street is still within 800 metres of Cabramatta Station, spare parking capacity is within an acceptable walking distance to Cabramatta Station as defined by

the NSW Planning Guidelines for Walking and Cycling (2004) which outlines a recommended walkable distance for commuters of 400 metres (desirable) to 800 metres (maximum) to public transport and other local amenities, or a cycling distance of 1.5 kilometres.

8.4.3 Cumulative impacts

There would be no anticipated cumulative traffic impacts arising from the operation of the project.

8.5 Management of impacts

8.5.1 Approach and outcomes

8.5.1.1 Approach to mitigation and management

A construction traffic 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 traffic management plan. The aim of the construction traffic management plan is to maintain the safety of workers and road users within and adjacent to the site. The primary objectives of the construction traffic management plan are to:

- minimise the impact of construction vehicle traffic on the overall operation of the road network
- provide continuous, safe and efficient movement of traffic for both the general public and construction workers. Traffic control plans will be prepared as part of the construction traffic management plan that will detail the measures to be implemented
- define the use of appropriate advance warning signs to inform users of the changed traffic condition
- provide a description of the construction vehicles and the volume of these construction vehicles accessing/egressing the construction site
- identify measures to mitigate the impacts of these vehicles (if required)
- provide information regarding changed access arrangements and also a description of the proposed external routes for vehicles including the construction vehicles accessing the site
- establish a safe pedestrian and bicycle riding environment in the vicinity of the site.

8.5.1.2 Expected effectiveness

ARTC and its contractors have experience managing potential traffic and transport impacts associated with the construction and operational phases of rail development projects.

It is expected that the recommendations in this chapter, along with relevant requirements from project approvals, and best practice guidelines would be developed into the construction traffic management plan prepared by the contractor to manage the relevant phases of the project. Routine auditing of the effectiveness of the implementation of the construction traffic management plan requirements would be routinely undertaken to ensure that management measures remain adequate, effective and fit for purpose.

While access arrangements would be outlined in the construction traffic management plan, the effectiveness of those arrangements and the requirements for any alternative and/or temporary arrangements would be agreed with the affected property managers/ owners.

Regular monitoring and inspections would be undertaken during construction to confirm the effectiveness of mitigation measures. Monitoring and inspections would include, but not be limited to Project Contractor's supervisory inspections on a daily basis and environmental representative weekly inspections.

The proposed mitigation measures are expected to be effective in providing satisfactory amenity and safety and ensuring that the road and transport network operations would be retained at an acceptable LoS.

8.5.2 List of mitigation measures

The mitigation measures that would be implemented to address potential traffic, transport and access impacts are listed in Table 8.5. Technical Report 1 provides further detail on recommended mitigation measures and provides a guide to what should be covered in the construction traffic management plan.

Table 8.5 Mitigation measures

Stage	Impact	Measure
Construction	General impacts of construction activities on traffic, transport, access, pedestrians and cyclists	A construction traffic management plan will be prepared by the contractor and implemented as part of the CEMP. It will include measures to minimise the potential for impacts on the community and the operation of the surrounding road and transport environment, including those listed in this EIS. The construction traffic management plan will be developed in consultation with relevant emergency services, Liverpool City Council, Fairfield City Council, Roads and Maritime Services, and public transport/bus operators.
	Traffic delays	Oversized vehicles will use designated heavy vehicle routes or routes approved by Roads and Maritime Services. Oversized traffic movements will be carried out, where possible, outside of peak road network periods, minimising the impacts on the road network. Should oversized vehicles be required, the contractor will be responsible for obtaining necessary permits/approvals, where required. Where possible, major road networks such as Cabramatta Road East and the Hume Highway will be used for access to the site by heavy vehicles.
	Temporary parking space loss	Where parking spaces are lost or access is impeded, particularly for extended periods, alternative parking will be provided wherever feasible and reasonable. This will include consideration of other privately owned (or vacant) land within close proximity to Cabramatta Station.
	Delays to Emergency services	A minimum lane width of about 3.5 m will be provided along Broomfield Street during construction to facilitate the access of emergency service vehicle.
	Parking space loss	The project site will be managed to minimise construction worker parking on surrounding streets. A worker car parking strategy will be developed in consultation with the relevant local council to identify measures to reduce the impact on the availability of on street and off street parking. The strategy will identify potential mitigation measures including alternative parking locations. The strategy will encourage contractor staff to: • park within compound sites • use public transport • car share.
	Traffic impacts	Where possible, heavy vehicle activity will be avoided, during school pick-up and drop-off periods (8:00 am to 9:30 am and 2:30 pm to 4:00 pm school days) in the vicinity of schools, when pedestrian and vehicle activity is generally greater.

Stage	Impact	Measure
		The extent and duration of temporary road closures along Broomfield Street and Sussex Street will be minimised to reduce the impact on local traffic, with diversions in place to the adjoining road network.
		Work areas will provide safe clearances from through traffic lanes in line with Roads and Maritime's Traffic Control at Works Sites Manual. Should road works speed zones be required, the contractor will develop necessary plans and obtain approvals by the governing authority (Roads and Maritime) in consultation with the local council.
	Residential access	Driveway and pedestrian access to properties adjoining the works is to be maintained. Where disruptions to access cannot be avoided, consultation will be undertaken with the owners and occupants of affected properties, to confirm their access requirements and to discuss alternatives. Potentially affected property owners and residents will be contacted before the commencement of works. Residents will be notified via door knocks, newsletters or letter box drops providing information on the proposed works, working hours and a contact name and number should any enquiries wish to be registered. Open trenches will be filled or covered using road plates at the end of each day to minimise impacts on vehicular access to properties, where necessary.
	Access to Jacquie Osmond Reserve	The contractor will consult with Liverpool City Council and the relevant sporting associations to minimise potential conflicts between vehicles, pedestrians and cyclists at the reserve, particularly during weekend periods when sporting activities are likely to occur.
	Informal parking within Jacquie Osmond Reserve	The contractor will consult with Liverpool City Council and the relevant sporting associations with regards to scheduling and access arrangements when works are being undertaken on Cabramatta Creek bridge, to minimise the potential impacts associated with the loss of access to informal parking in Jacquie Osmond Reserve.
	Heavy vehicles damaging local roads	A dilapidation survey will be undertaken of the Fairfield City Council and Liverpool City Council owned/managed roads within the proposed haulage routes prior to works commencing and provided to the relevant council.

8.5.3 Consideration of the interaction between measures

Mitigation measures proposed to mitigate any traffic and transport impacts during construction and operation are not considered to result in adverse interactions with other mitigation measures.

8.5.4 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.

Residual impacts are the potential impacts which may remain even after the environmental management measures outlined above have been implemented.

Due to the application of effective environmental management measures, residual adverse impacts to traffic and transport from construction activities are considered to be temporary and of an acceptable nature.

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.

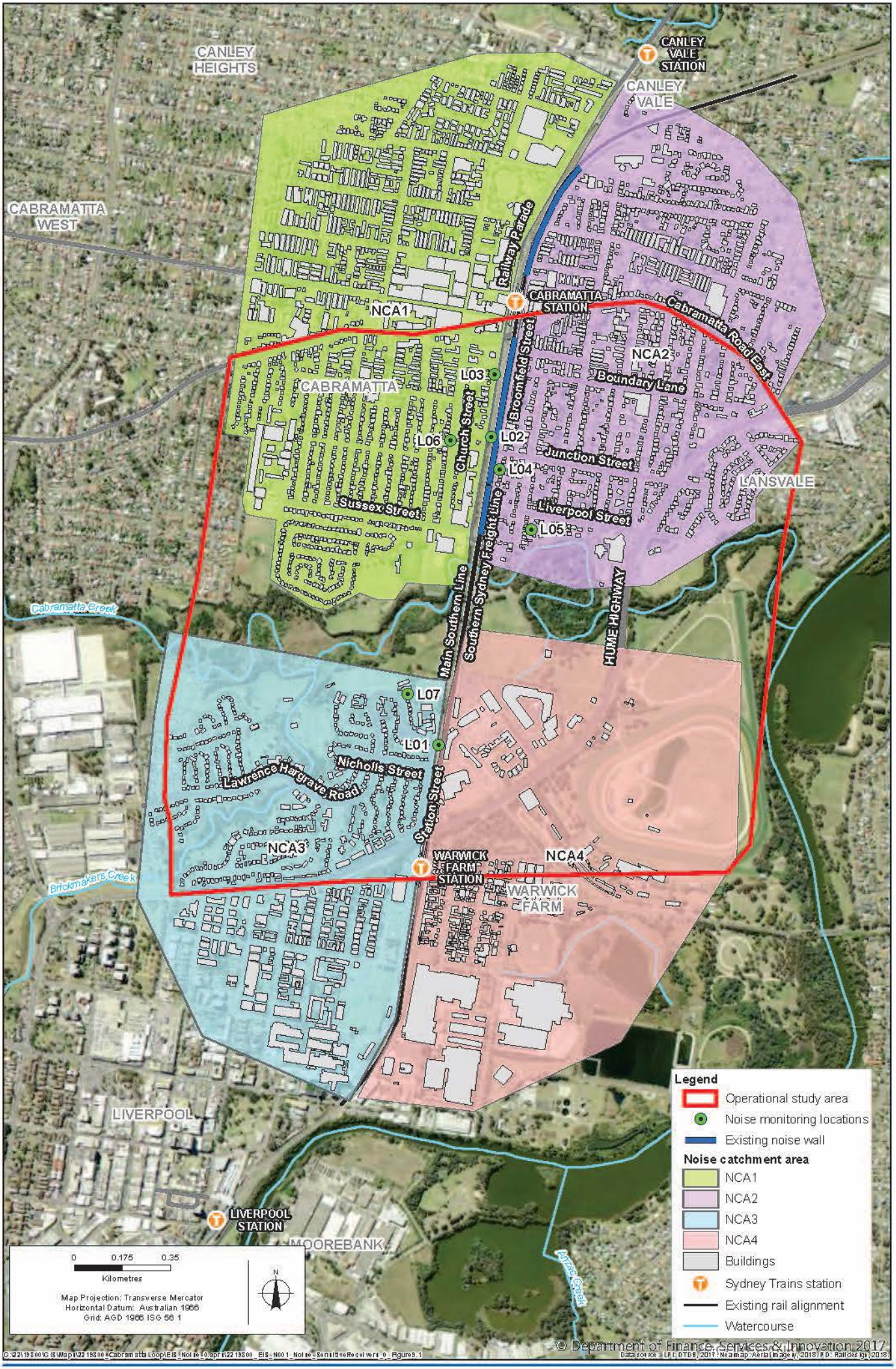

Figure 9.1 Study area, sensitive receivers and monitoring locations

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.

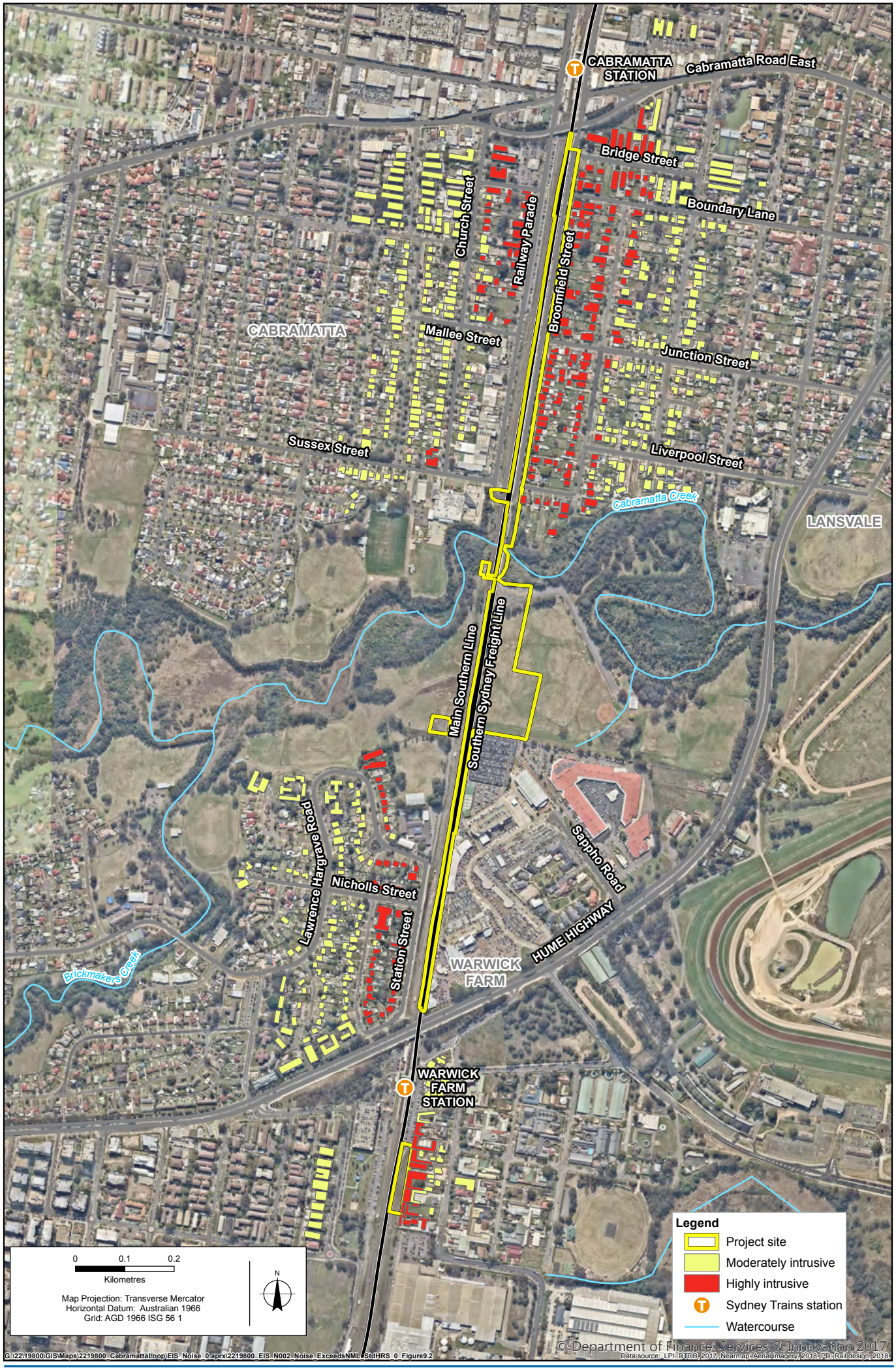

Figure 9.2 Receivers that exceed the construction NMLs during standard construction hours

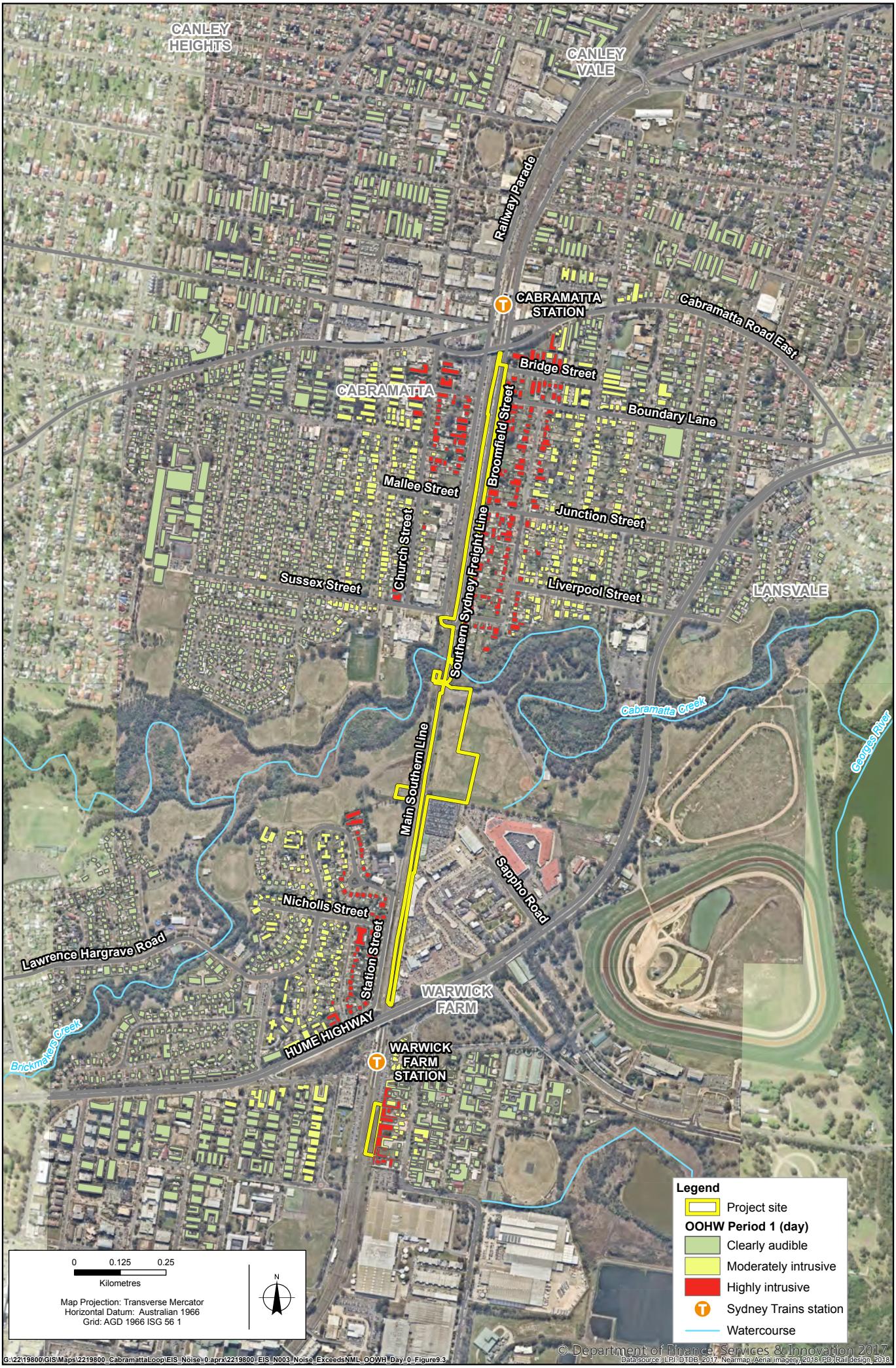

Figure 9.3 Receivers that exceed the construction NMLs outside standard construction hours - period 1 day

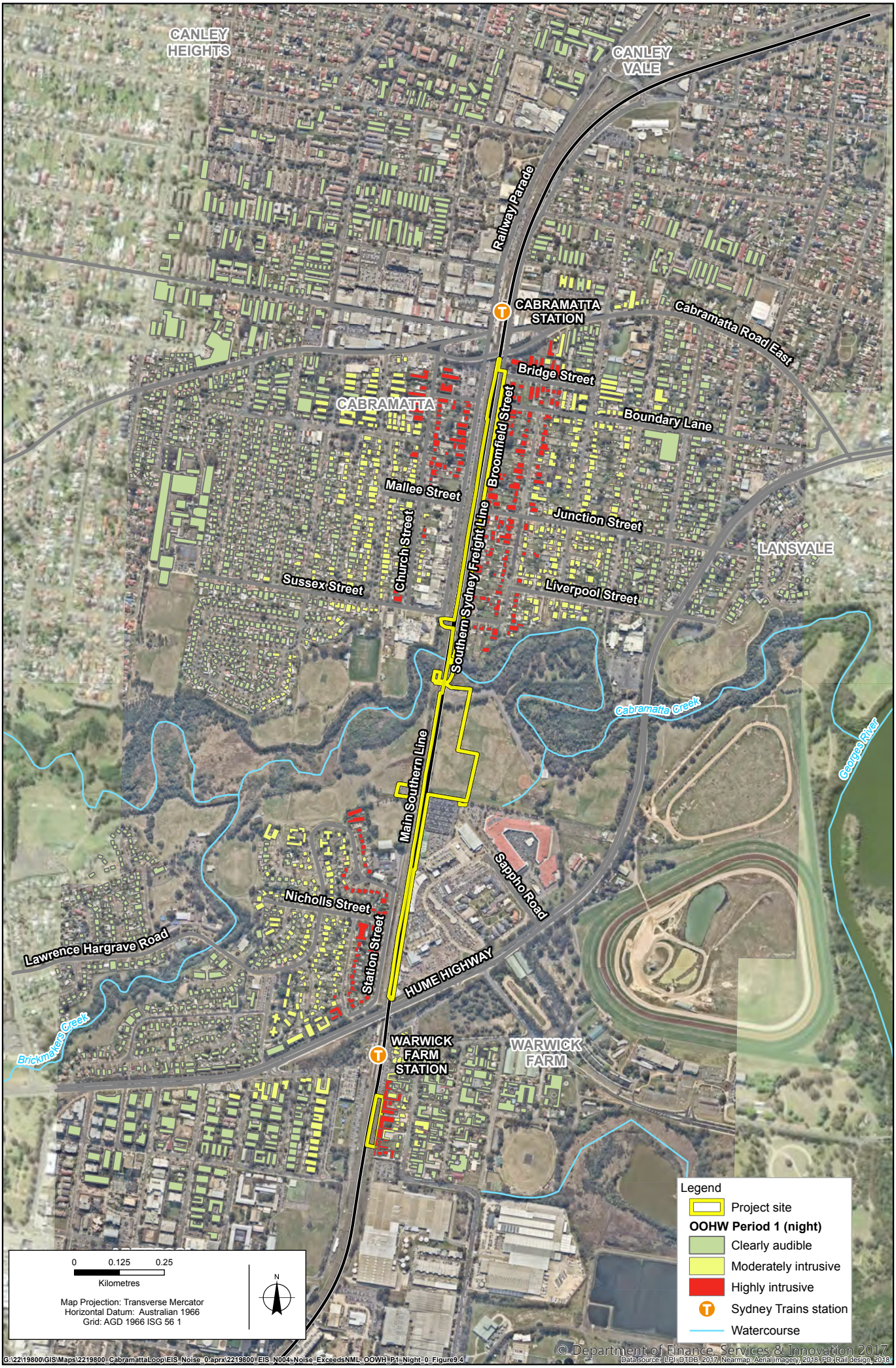

Figure 9.4 Receivers that exceed the construction NMLs outside standard construction hours - period 1 night

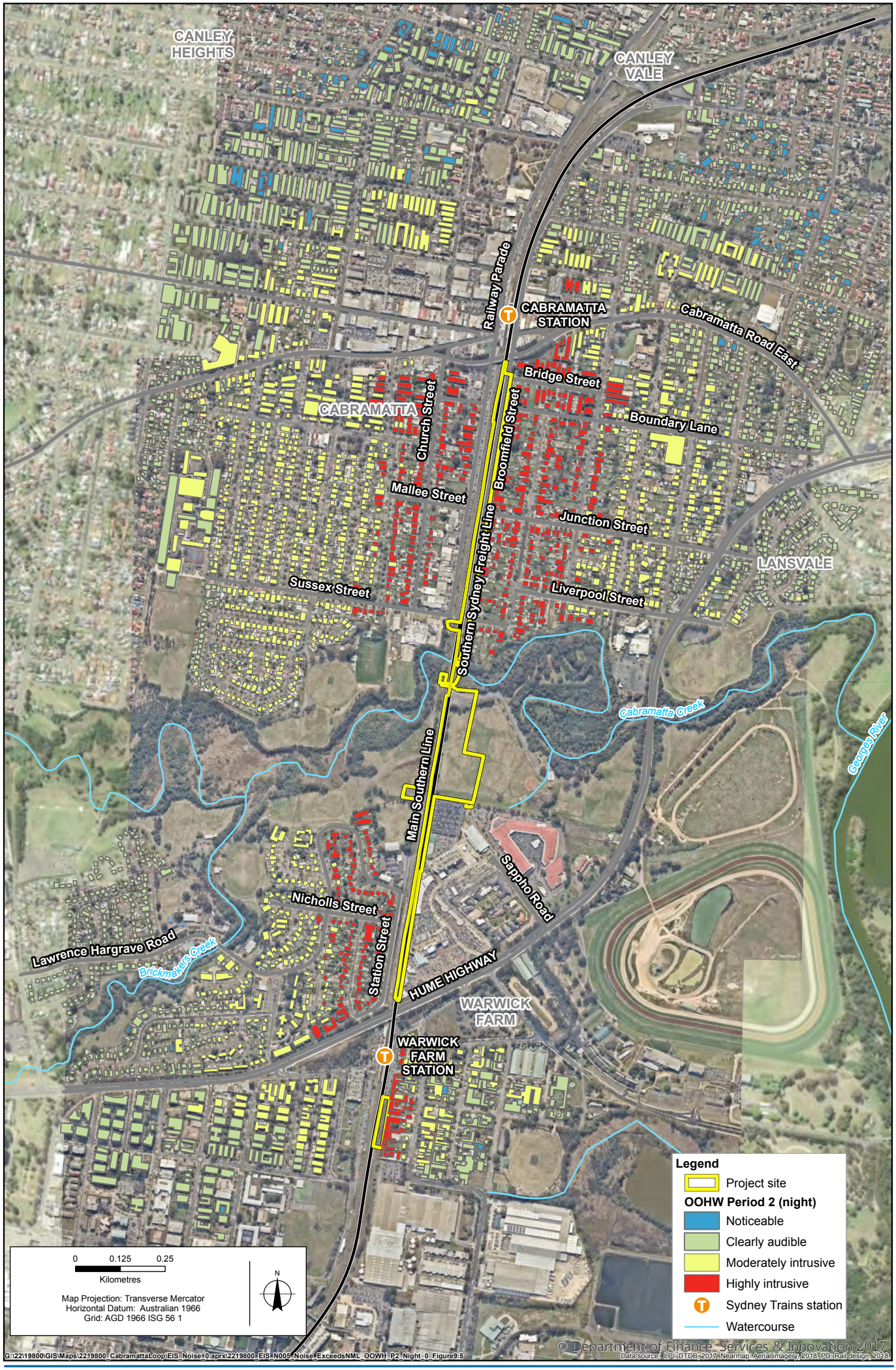

Figure 9.5 Receivers that exceed the construction NMLs outside standard construction hours - period 2 night

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.

THIS PAGE HAS BEEN LEFT INTENTIONALLY BLANK

10 Air quality

This chapter describes the existing environment in relation to air quality, assesses the potential impacts of construction and operation of the project on air quality, and provides mitigation measures to manage the impacts identified. The technical report which informs this chapter is provided in Technical Report 3 – Air quality impact assessment. The report was written to address the relevant SEARs which are outlined in Appendix A.

10.1 Assessment approach

10.1.1 Methodology

10.1.1.1 Study area

The study area encompasses a 1.5 kilometre radius from the project site. The sensitive receptors to air quality impacts from the project are discussed in section 10.2.2.

10.1.1.2 Key tasks

The air quality impact assessment involved the following tasks:

- a desktop review of site plans, aerial photographs and topographic maps to gain an understanding of the existing environment in terms of local terrain, existing and proposed operations and sensitive receptors
- the applicable air quality assessment criteria was outlined, as defined by the *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (DEC, 2005) (known as 'the Approved Methods') and the *National Environment Protection (Ambient Air Quality) Measure* ('the Air NEPM')
- a review of available background air quality in the local area using NSW Office of Environmental Heritage OEH air quality monitoring data and client provided data
- meteorological modelling for use as model input for atmospheric dispersion modelling
- a construction emissions inventory was created
- an operational emissions inventory was created to include locomotives using the report Diesel Locomotive Fuel Efficiency and Emissions Testing prepared for NSW EPA (ABMARC, 2016) and National Pollutant Inventory (NPI) emission factors
- dispersion modelling to predict construction and operational impacts at nearby receptors in the study area using regulatory approved models was undertaken as follows:
    - using AUSPLUME 6.0 for construction impacts as a 20 metre (width) by 100 metre (length) area along the length of the rail corridor. The 100 metre length is an appropriate interval to calculate the worst case air quality impacts
    - using CALPUFF version 6 for operation impacts using a 200 metre grid resolution as per the meteorological model used for the assessment.
- a screening level dust assessment for construction activities with consideration of the Approved Methods.

10.1.1.3 Project emissions

Construction emission rates were characterised using recommended emission factors for average conditions published in the *Western Regional Air Partnership Fugitive Dust Handbook* (WRAP) (Countess Environmental, 2006). These emissions factors are calculated assuming standard earth moving operations.

Combustion products from diesel locomotives predominantly comprise the following pollutants:

- nitrogen dioxide (NO_2)
- carbon monoxide (CO)
- hydrocarbons (HC)
- sulfur dioxide (SO_2)
- particulate matter with diameter less than 10 microns (PM_{10}) and less than 2.5 microns ($PM_{2.5}$).

10.1.2 Risks identified

The preliminary environmental risk assessment undertaken for the project included potential risks associated with air quality. 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 potential air quality risks during construction was low or medium. Risks with an assessed level of medium were:

- generation of dust during construction (from exposed soil/stockpiles, excavation and vehicle movements)
- emissions from vehicles or plant during construction
- generation of dust from transport of uncovered loads during operation.

The assessed risk level for potential air quality risks during operation was low.

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).

10.1.3 How potential impacts have been avoided/minimised

As described in Chapter 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 project.

Potential air quality impacts have been avoided/minimised where possible by:

- minimising the project footprint
- using areas for compounds and work sites that are already disturbed or have been previously used during the construction of SSFL.

10.2 Existing environment

10.2.1 Ambient air quality

10.2.1.1 General characteristics

Ambient air quality in Sydney is influenced by a number of factors, including topography, prevailing meteorological conditions (such as wind and temperature, which vary seasonally), and local and regional air pollution sources (such as motor vehicles, industrial facilities and bushfires). Consequently, regional air quality can be highly variable and impacted by events occurring a significant distance away.

The NSW OEH operates ambient air quality monitoring stations in selected areas around NSW. The nearest station to the project site is Liverpool, however Chullora has also been included as it contains background data for sulfur dioxide (SO_2). Ambient air pollutant concentrations recorded at Liverpool and Chullora OEH stations include emissions from all regional sources. Cumulative assessment of all regional sources of air pollution are accounted for by including the ambient air quality concentrations measured at the Liverpool and Chullora OEH stations and adding them to incremental site impacts.

Daily pollutant average and maximum ambient concentrations for the modelled year are presented in Table 10.1. This data shows that the maximum recorded PM_{10} and $PM_{2.5}$ background concentrations at the Liverpool OEH station are higher than the assessment criteria. This is consistent with air quality results noted in NSW, which experienced poorer air quality during 2013, mainly due to drier and hotter weather through the middle of the year and the impact of bushfires in September, October and November. Background concentrations of all other pollutants were below the assessment criteria.

Table 10.1 Ambient air quality daily concentrations (2013)

Pollutant concentrations		OEH monitoring site	
		Liverpool	Chullora
SO_2	Average (µg/m^3)	-	2.6
	Maximum (µg/m^3)	-	31.4
Nitrogen oxide (NO)	Average (µg/m^3)	18.4	17.2
	Maximum (µg/m^3)	290.3	413.3
Nitrogen dioxide (NO_2)	Average (µg/m^3)	20.7	24.4
	Maximum (µg/m^3)	105.3	103.4
Ozone (O_3)	Average (µg/m^3)	29.4	27.4
	Maximum (µg/m^3)	229.3	205.8
Carbon monoxide (CO)	Average (µg/m^3)	0.5	0.3
	Maximum (µg/m^3)	4.6	4.0
PM_{10}	Average (µg/m^3)	21.0	18.3
	Maximum (µg/m^3)	98.5	69.4
	70th percentile (µg/m^3)	25.2	20.6
$PM_{2.5}$	Average (µg/m^3)	9.4	8.4
	Maximum (µg/m^3)	73.8	49.1
	70th percentile (µg/m^3)	10.8	9.5

'-'denotes data not sampled at the site

10.2.1.2 Local emission sources

The main local sources of air pollution in the area include:

- vehicle emissions especially from the arterial roads such as Hume Highway, The Horsley Drive, Elizabeth Drive and Newbridge Road
- suspended dust along roadways, from pulverized pavement materials, particles from brake linings and tyres

- residential emissions such as domestic products as well as fuel combustion from domestic machinery such as lawn mowers, etc
- dust and diesel emissions from existing rail movements along the network between Warwick Farm and Cabramatta stations
- secondary particulate emissions from freight and passenger train movement (i.e. wheel and brake action, wagon turbulence in the rail corridor and windblown particulates).

10.2.2 Sensitive receptors

The project site is situated in a mixed residential and commercial area. The land adjacent to the rail corridor is predominantly residential and recreational with smaller sections of business and general industrial.

The project site is surrounded by a wide range of sensitive receptors, including residential properties, businesses, community facilities (such as schools, and sporting facilities), and recreational areas. A number of these receptors are located within or immediately adjacent to the project site. It is expected that the closest receptors will experience the worse-case air quality impacts. If potential air quality impacts from the project comply with the impact assessment criteria at the nearest receptors, then those situated at a greater distance will also likely comply.

Land uses surrounding the project site are described in Chapter 16 (Land use and property). The location of representative sensitive receptors is shown on Figure 10.1.

Figure 10.1 Site and sensitive receptor location

10.3 Assessment of construction impacts

Construction activities, including earthmoving, storage and transport of spoil and waste materials, and exhaust emissions from construction equipment and vehicles, have the potential to impact on local air quality. The main potential impact on air quality during construction is dust and this is described further below.

10.3.1 Dust generation

The processes that have the potential to generate particulate matter during construction are:

- mechanical disturbance − dust emissions as a result of earthworks/excavation and the operation/movement of construction vehicles and equipment
- wind erosion − dust emissions from disturbed soil surfaces and stockpiles in windy conditions

The project activities likely to generate dust include:

- building new rail track – providing a 1.65 kilometre long section
- realigning the track realignment – moving about 550 metres of existing track sideways
- building two new bridges next to the existing rail bridges over Sussex Street and Cabramatta Creek
- reconfiguring Broomfield Street for a distance of about 680 metres between Sussex and Bridge streets
- plant operations in compounds and work areas
- minor works in the form of new signalling installed at a number of locations within the rail corridor outside the project site
- building an embankment at Jacquie Osmond Reserve
- transport, handling, stockpiling, loading and unloading of spoil and imported materials
- temporarily relocating part of the pedestrian footbridge over Cabramatta Creek.

Given the primary air quality concern during construction is dust, a screening level dust assessment was undertaken for proposed construction activities. The modelled scenario assumes construction works occurring along the rail corridor and the results indicate the following:

- all particulate concentrations (daily and annual TSP, PM_{10} and $PM_{2.5}$) are composed of high background concentration and relatively low incremental site impacts
- daily PM_{10} and $PM_{2.5}$ criteria are met at 25 metres from and on the boundary of the project site, respectively
- annual TSP and PM_{10} are met at 2 and 30 metres from the boundary of the project site, respectively. Annual $PM_{2.5}$ results are higher than the criteria as the 9.4 $\mu g/m^3$ background concentration from the nearest station is already above the criteria.

A number of sensitive receptors within 25 metres of the project site could experience short term elevated PM_{10} concentrations. This is not anticipated to impact on the local amenity. It is expected that the location of construction works will vary as the project proceeds and consequently, no long term particulate concentration impacts are expected from construction of the project.

Construction works outside the project site boundary (eg utility relocation and protection works) have the potential to impact on nearby receptors. It is expected that these construction works will involve little or minor dust generating activities as only small trenches would be dug for conduits and cables and would therefore result in negligible additional impact. As a result of the limited scale of earthworks and nature of the works

proposed, dust emissions are expected to be manageable through the implementation of standard erosion control and dust management measures outlined in section 10.5.

Construction work will be staged through the project site so that impacts on sensitive receptors would be minor and short term.

10.3.2 Vehicle and plant emissions

The main source of emissions would be from the combustion of diesel fuel and petrol from heavy vehicles, mobile excavation machinery, and stationary combustion equipment as well as from the handling and/or on-site storage of fuel and other chemicals. The volume of emissions from construction vehicles and machinery would depend on the type of fuel used, the power output and condition of the engine, and duration of operation. Fine particle emissions associated with exhausts from vehicles and plant used during construction are accounted for in the emission factors for earthmoving and handling used in the dust assessment in section 10.3.1.

Exhaust emissions would involve periodically localised emissions of carbon monoxide, (PM_{10} and $PM_{2.5}$), nitrous oxides, sulfur dioxide, volatile organic compounds, and polycyclic aromatic hydrocarbons associated with the combustion of diesel fuel and petrol.

Exhaust emissions generated during construction would not significantly contribute to emissions in the area, given the existing levels of vehicle use. Construction vehicles are expected to travel along the alignment and resulting emissions will be discontinuous, transient, and mobile.

It is anticipated that these potential impacts could be adequately managed through the implementation of the mitigation measures provided in section 10.5.

10.3.3 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 are predicted to be transitory and confined to an area 30 metres from the boundary of the project site, the cumulative impacts would be minimal unless an additional source of dust (to this project) was generated close to receptors. There are no other known construction projects proposed for the area.

10.4 Assessment of operational impacts

10.4.1 Local impacts

10.4.1.1 Dust

Minor quantities of particulate matter would be generated, mainly due to the wear of the train brake pads, vaporisation of metals due to sparking, and wear of steel due to friction between wheels and rail. These emissions would be in very low concentrations, and are not expected to be different from the current operational rail corridor.

Similarly, maintenance activities involving minor earthworks and exhaust emissions would produce minor quantities of particulate matter and would be managed in accordance with ARTC's standard operating procedures and ARTC's EPL (EPL #3142). As a result, there is the potential for minor local air quality impacts during operation. However, no long term or adverse health impacts are expected from the project.

10.4.1.2 Locomotive Emissions

The project would increase capacity for locomotive movements from 48 to up to 72 movements within a 24 hour period. Actual volumes are highly dependent on demand, which may not always be consistent. Atmospheric dispersion modelling using the CALPUFF version 6 results show that assuming the highest frequency operation, there will be no incremental or cumulative exceedances of the relevant criteria for NO_2, CO, HC as benzene, SO_2, or PM_{10}.

The 2013 annual average $PM_{2.5}$ recorded at the Liverpool OEH station was 9.4 µg/m^3. This exceeds the annual $PM_{2.5}$ criteria supplied in the Approved Methods of 8 µg/m^3. Consequently, all predicted annual $PM_{2.5}$ concentrations exceed the assessment criteria. Incremental increases in $PM_{2.5}$ due to the project range from 0 to 0.2 µg/m^3. The predicted exceedances of the annual $PM_{2.5}$ criteria are attributable to the existing sources rather than the project. Notwithstanding, the minor increase is unlikely to be noticeable to nearby receptors.

General mitigation measures which aim to reduce any potential additional impacts as a result of operation are provided in section 10.5.

10.4.2 Regional impacts

The project would not result in any substantial regional air quality impacts as the emissions would be highly dispersed in the local area.

10.4.3 Cumulative impacts

Incremental increases in $PM_{2.5}$ from operation of the project are minor. The predicted exceedances to the annual $PM_{2.5}$ criteria are attributable to the existing sources rather than the project operations. The maximum predicted increase from the operation of the project is identified at the most affected receptor. However, most receptors would experience lower increases. As all increases are relatively minor, the cumulative impact is predicted to be minor.

10.5 Management of impacts

10.5.1 Approach

10.5.1.1 Approach to mitigation and management

Overall, the majority of potential construction related air quality impacts would be short term and temporary in nature. The potential for these impacts would be significantly reduced by:

- effective construction design and planning, including minimising the length of time excavations remain open
- implementation of the mitigation measures provided in Table 10.2.

During operation, air quality would be managed in accordance with ARTC's EPL (EPL #3142) and ARTC's standard operating procedures including those within its Environmental Management System. While it is noted that ARTC do not operate the locomotives, it is assumed these locomotives would be operated in accordance with relevant regulatory requirements to minimise air emissions.

10.5.1.2 Expected effectiveness

ARTC and its contractors have experience managing potential air quality impacts associated with the construction and operational phases of rail development projects.

Weather conditions such as wind direction, wind speed, soil moisture and rainfall or dew would substantially influence the day to day potential for dust generation and suspension. Therefore, project personnel involved in the activities need to consider the factors effecting dust generation in consultation with their environmental representatives to ensure appropriate mitigation measures are adopted.

It is expected that these recommendations, along with any relevant requirements of the project approval, best practice guidelines and applicable legislation would be developed into the CEMP prepared to manage the relevant phases of the project. Routine auditing of the effectiveness of the implementation of the CEMP requirements will be undertaken to ensure that management measures remain adequate, effective and fit for purpose.

Regular monitoring and inspections will be undertaken during construction to confirm the effectiveness of mitigation measures. Monitoring and inspections will include, but not be limited to Project Contractor's supervisory inspections on a daily basis and environmental representative weekly inspections.

10.5.2 List of mitigation measures

The mitigation measures that will be implemented to address potential air quality impacts are listed in Table 10.2.

Table 10.2 Mitigation measures

Stage	Impact	Measure
Construction	Dust deposition and decrease in receptor amenity – minor and temporary	Dust suppression will be undertaken as required using water sprays, water carts or other media on: • unpaved work areas subject to traffic or wind • sand, spoil and aggregate stockpiles • the loading and unloading of dust generating materials.
	Vehicle emissions	Plant and equipment will be maintained in good condition and in accordance with manufacturer's specifications to minimise spills and air emissions that may cause nuisance.
	Dust deposition and decrease in receptor amenity – minor and temporary	If the works are creating levels of dust which significantly impact on residential amenity, the works will be modified or stopped until the dust hazard is reduced to an acceptable level.
	Dust deposition and decrease in receptor amenity – minor and temporary	The size of stockpiles will be minimised, where possible.
	Dust deposition and decrease in receptor amenity – minor and temporary	Construction vehicles with potential for loss of loads (such as dust or litter) will be covered when using public roads
Operation	Emissions - Negligible	The project will be managed in accordance with ARTC's existing EPL (EPL #3142) and ARTC's standard operating procedures including those within the Environmental Management System.

10.5.3 Consideration of the interaction between measures

The major pollutant of concern is dust. As described in Chapter 13 (Hydrology, flooding and water quality), soil and erosion control measures will be implemented during construction in accordance with *Soils and Construction - Managing Urban Stormwater Volume 1* (Landcom, 2004) and *Volume 2A* (DECC, 2008). Implementation of these measures will be guided by a soil and water management plan to be prepared as part of the CEMP.

Chapter 12 (Soils and contamination) concludes that contaminated soils are not likely to be present at the project site. Therefore air quality mitigation measures have not included this issue. Chapter 21 (Climate Change and greenhouse gas) provides measures to be implemented to manage impacts of electricity use during construction and operation Implementation of these measures, together with the requirements of the CEMP, will minimise the potential for air quality impacts.

10.5.4 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. The mitigation and management measures proposed are expected to minimise the potential for impacts to air quality. With the implementation of these measures, residual impacts are expected to be minimal.

11 Biodiversity

This chapter describes the existing environment in relation to biodiversity and assesses the potential impacts of construction and operation of the project on biodiversity, and provides mitigation measures to manage the impacts identified. The technical report which informs this chapter is provided as Technical Report 4 - Biodiversity development assessment report. The report was written to address the relevant SEARs which are outlined in Appendix A.

11.1 Assessment approach

11.1.1 Methodology

11.1.1.1 Study area

The 'study area' refers to the area including and surrounding the project site, with the potential to be directly or indirectly affected by the project (eg by noise and vibration, visual or traffic impacts) and that was the subject of the field surveys and desktop assessment conducted for the BDAR.

The study area has been assessed in accordance with the *Biodiversity Assessment Method* (BAM) (OEH, 2017) and OEH *Biodiversity Assessment Method Operational Manual Stage* 1 (OEH, 2018) in which comprehensive vegetation mapping and habitat assessments were completed. Some field survey techniques were employed outside of the study area, including spotlighting and diurnal bird surveys and surveys targeting Powerful Owl, Bush Stone Curlew and Green and Golden Bell Frog, in order to sample better condition habitats to assist with detection of mobile fauna species that could occur in the study area from time to time. Fauna species detected by these techniques outside of the study area would also be likely to occur in similar habitats within the study area.

11.1.1.2 Key tasks

The biodiversity assessment involved:

- a desktop assessment to describe the existing environment and landscape features of the study area and to identify the suite of threatened biota potentially affected by the project, including searches of:
    - OEH *NSW BioNet* (OEH, 2018) data, including NSW Wildlife Atlas database records and Threatened Species Data Collection profiles of threatened species listed under the BC Act
    - OEH Threatened biodiversity profile search online database for threatened ecological communities listed under the BC Act (2018)
    - Department of the Environment and Energy (DEE) Protected Matters Online Search Tool for Matters of National Environmental Significance (MNES) listed under the EPBC Act and predicted to occur in the locality (DEE, 2018)
    - DEE online Species profiles and threats database (SPRAT) (DEE, 2018)
    - NSW BioNet Vegetation Classification (OEH, 2018) to identify Plant Community Types (PCTs) in the study area
    - aerial photographs and satellite imagery of the study area
    - available regional-scale vegetation mapping of the site (NPWS, 2002)
- field survey in accordance with the NSW OEH (2017) *Biodiversity Assessment Method* (BAM) to describe the biodiversity values of the project site and study area and to determine the likelihood of threatened biota and their habitats occurring in the study area or being affected by the project. The following site visits were completed:

- 12 October 2018 - preliminary investigation of biodiversity values
- 14-15 November 2018 - BAM assessment survey, including targeted surveys for candidate threatened species
- 16 January 2019 - supplementary site inspection.

- assessment of potential impacts to flora, fauna and habitats including:
  - matters of national environmental significance (MNES)
  - serious and irreversible impacts
  - prescribed impacts
  - threatened flora, fauna and ecological communities
  - determination of reasonable actions to avoid and minimise impacts to biodiversity values and assessment of residual biodiversity impacts of the project
  - completion of offset calculations using the BAM credit calculator if required to determine the ecosystem and species credits that would be required to offset these impacts.

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

11.1.2 Risks identified

The preliminary environmental risk assessment undertaken for the project included potential risks associated with biodiversity. 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 potential biodiversity risks ranged from low to medium. Risks with an assessed level of medium include:

- potential impacts from tree removal along Broomfield Street and Jacquie Osmond Reserve
- potential impacts on a limited amount of identified vegetation communities and/or threatened flora species, in particular in the vicinity of Cabramatta Creek
- potential impacts on habitat due to vegetation removal
- indirect impacts due to increased dust, sedimentation and erosion, noise, light including disturbance to flying fox habitat
- increased potential for pest plants and animals during maintenance from movement of vehicles, machinery and materials in and out of the rail corridor.

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).

11.1.3 How potential impacts have been avoided/minimised

As described in Chapter 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.

The project has adopted the following ‘avoid, minimise and offset’ approach to mitigate impacts to biodiversity values in accordance with the BAM, the *Biodiversity Conservation Act 2016* (BC Act) and

associated policy. In line with this approach, potential biodiversity impacts have been avoided or minimised where possible by:

- avoiding impacts on habitat, through the project planning and design process
- minimising impacts on habitat, through the use of a range of environmental management and impact mitigation measures
- identifying offset requirements for any residual impact that could not be avoided or mitigated.

The location of construction compounds, work sites and the construction footprint were finalised following field survey. This enabled the location of these construction sites to be located outside of areas of biodiversity value.

The most sensitive portion of the study area with respect to potential impacts on biodiversity values is the area around Cabramatta Creek. Potential impacts from bridge construction and associated construction access, crane pads and a temporary shared pathway are a potential risk to biodiversity in this location. This portion of the project will be constructed as follows to ensure that impacts to biodiversity values are avoided:

- The shared pathway temporary detour route will be located through non-native vegetation. This will include continuous use of the existing shared path bridge over Cabramatta Creek to avoid impacts associated with construction of a temporary creek crossing.
- The size of the work sites for bridge installation will be limited to ensure that the disturbance footprint is entirely limited to cleared land or non-native vegetation.
- The design of the new bridge over Cabramatta Creek will match the pier arrangement of the existing bridge to minimise hydraulic impacts on flow along the creek, and associated potential for biodiversity impacts. There would be no earthworks or other direct disturbance within the main channel. Existing flow widths will be maintained. The proposed bridge design will minimise the footprint of the project in this area. The proposed bridge will partially interrupt flow during high flow events (ie periods when water is flowing outside and above the main channel) however this interruption to flow would be in line with the existing bridge pylons and would comprise a very minor impact in the context of the existing degree of modification of the catchment.
- Cabramatta Creek is mapped as Key Fish Habitat (DPI, 2007). Mitigation measures will be implemented during construction to mitigate potential impacts to water quality. The inclusion of structures including the bridges, and the drainage design of Broomfield Street is predicted to generally not worsen existing flooding and flood velocity conditions (refer to Chapter 13 (Hydrology, flooding and water quality) for further information).
- There will be some ancillary works undertaken outside of the defined project site. These include signalling works and utility relocation/protection works. These works will be undertaken within the rail corridor and will affect only cleared land or exotic vegetation within this highly modified environment. The final location and design of the ancillary works will consider and avoid impacts to any areas of native vegetation or other biodiversity values, including specific avoidance of the *Acacia pubescens* identified in the rail corridor.

11.2 Existing environment

11.2.1 Terrestrial flora

11.2.1.1 Database search results and mapping

The Protected Matters Online Search Tool (DEE, 2018) results did not identify any World Heritage properties, National Heritage places or Wetlands of International Importance within the project site or study

area. As such, these particular MNES are not relevant to this biodiversity assessment report and are not considered further in this report.

A desktop assessment was undertaken to identify threatened flora and fauna species, populations and ecological communities (threatened biota) listed under the BC Act, *Fisheries Management Act 1994* (FM Act), and EPBC Act, that could be expected to occur at the project site, and to obtain the necessary data to perform BAM calculations.

No native vegetation was mapped in the project site. There are three non-native vegetation map units in the project site: planted native species; exotic vegetation; and cleared lands. The channel floor and banks of Cabramatta Creek where it intersects the project site have been mapped as non-native vegetation because this reach of the creek is confined by concrete or gabions and has a gravel or concrete bed.

There is native vegetation outside of the project site, within the study area, comprising Cumberland River-flat Forest and Coastal Freshwater Wetland.

Figure 11.1 shows the vegetation mapping for the study area. Table 11.1 lists the mapped habitat and their associated condition, conservation significance and the area of the habitat located within the project site.

Table 11.1 Vegetation in the study area

Vegetation m	PCT/NSW Veg. Type ID (OEH, 2016c)	Condition	Conservation significance	Area in project site (hectares)
Cumberland River-flat Forest	835 / HN526	Medium	EEC[2] listed under the BC Act (River-flat Eucalypt Forest on Coastal Floodplains of the NSW North Coast, Sydney basin and South East Corner Bioregion)	0
Coastal Freshwater Wetland	1071 / HN630	Medium	EEC listed under the BC Act (Freshwater wetlands on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions).	0
Planted native species	n/a	Cleared/non-native vegetation		0.5
Exotic vegetation	n/a	Cleared/non-native vegetation		3.0
Cleared land	n/a	Cleared/non-native vegetation		3.4
			Total	**6.9**

Searches of threatened species databases and the output from the BAM calculator were completed to determine any threatened flora species that are known or predicted to occur in the locality. A full list of species identified in the desktop study is provided in Appendix 1 of Technical Report 4.

The results from the desktop study were refined to identify flora species likely to occur in the project site based on the habitat types present, known distribution, and the knowledge and experience of the assessor. These species are listed in Table 11.2. Field surveys were conducted for each of these species in November 2018, which was an optimum survey season.

Table 11.2 Candidate threatened species and survey time – flora

Common name	Scientific name	BC Act	EPBC Act	Surveyed in optimum season
Downy Wattle	Acacia pubescens	V	V	Yes
Netted Bottle Brush	Callistemon linearifolius	V		Yes
Marsdenia viridiflora R. Br. subsp. viridiflora population	Marsdenia viridiflora subsp. viridiflora	EP		Yes
Tall Knotweed	Persicaria elatior	V	V	Yes
Spiked Rice-flower	Pimelea spicata	E	E	Yes
Rufous Pomaderris	Pomaderris brunnea	E	V	Yes
	Pultenaea parviflora	E	V	Yes
Matted Bush-pea	Pultenaea pedunculata	E		Yes

Notes: V – vulnerable species; E – endangered species; EP – endangered population

11.2.1.2 Flora survey results

A total of 94 flora species from 37 families were recorded within the study area, comprising 43 native and 51 exotic species. The Poaceae (grasses, 17 species, seven native) Fabaceae (12 species, 8 native) and Myrtaceae (10 species, all native) were the most diverse families recorded. A full list of flora species recorded within the study area is provided in Appendix B of Technical Report 4. Threatened flora species identified are discuss below.

11.2.1.3 Threatened flora species

The desktop study identified eight threatened flora species predicted to occur in the project site (see in Table 11.2).

During field survey the following flora species were recorded within the study area:

- Downy Wattle (*Acacia pubescens*)
- Narrow-leaved Black Peppermint (*Eucalyptus nicholii*)

Downy Wattle (*Acacia pubescens*) was recorded in the study area; a single stem in slashed open space in the rail corridor just north of Warwick Farm station; and a patch of six individuals in an area of exotic grassland on the outside edge of the rail corridor, south of Warwick Farm station (refer to Figure 11.1). *Acacia pubescens* is listed as a vulnerable species under the BC and EPBC Acts. This species is endemic to the Cumberland Plain (OEH, 2018c) and is possibly a naturally occurring or regenerating population within the rail corridor in the study area. No *Acacia pubescens* were recorded in the project site.

A Narrow-leaved Black Peppermint (*Eucalyptus nicholii*) was recorded in the project site. *Eucalyptus nicholii* is listed as a vulnerable species under the BC and EPBC Acts. This species naturally occurs only in the New England Tablelands from Nundle to north of Tenterfield but is widely planted as an urban street tree (OEH, 2018c). The project site is well outside the species' natural distribution and the individual at the project site and other records in the locality are clearly of planted individuals of uncertain provenance and outside of natural habitat. In this context, the *Eucalyptus nicholii* at the project site has not been treated as a threatened species requiring assessment under the BAM.

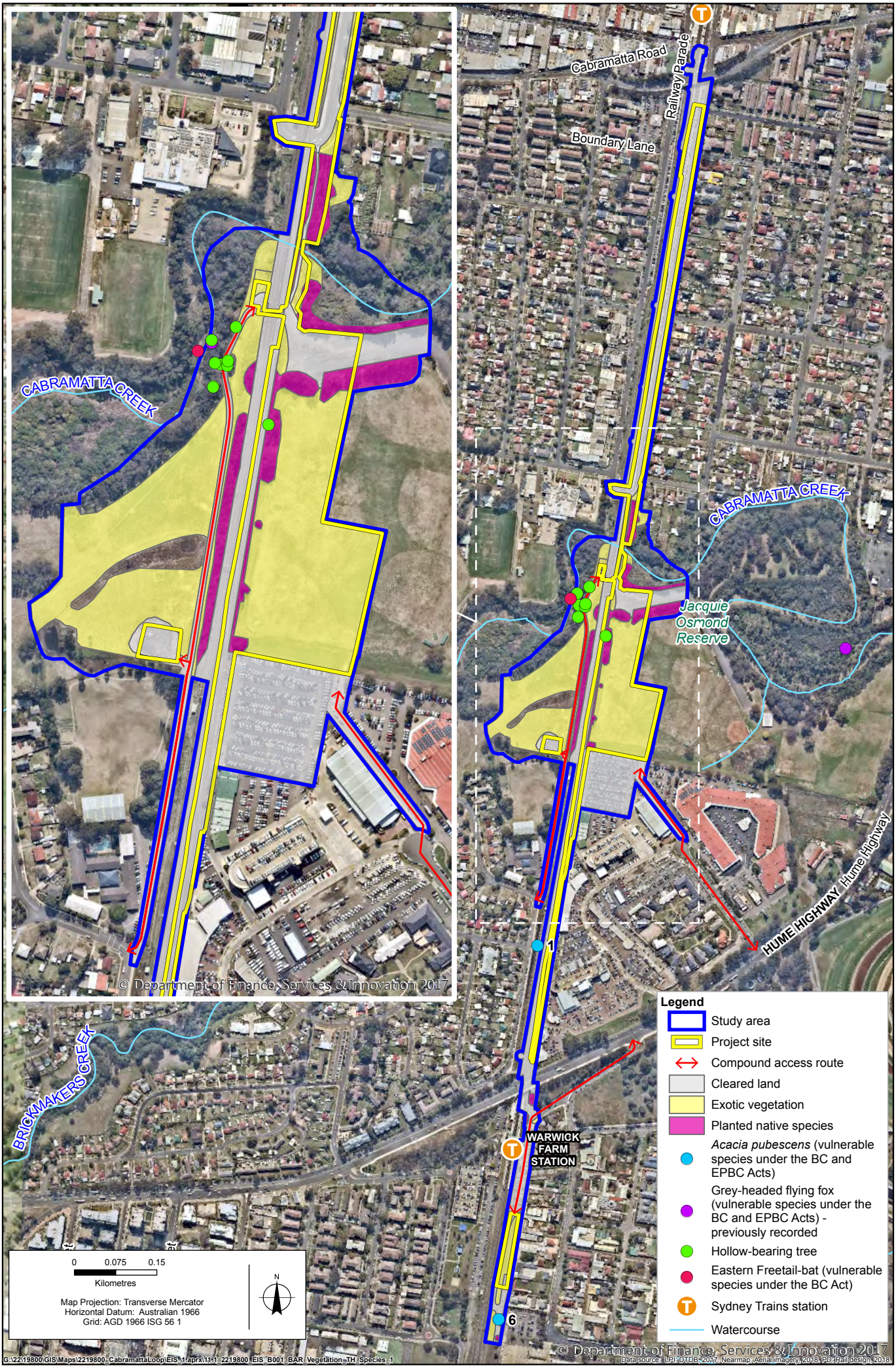

Figure 11.1 Vegetation and threatened species

11.2.1.4 Threatened ecological communities

Cumberland River-flat Forest in the riparian corridor of Cabramatta Creek comprises a local occurrence of 'River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions' (River-Flat Eucalypt Forest) which is listed as an endangered ecological community (EEC) under the BC Act and the subject of a preliminary listing as a critically endangered ecological community (CEEC) under the EPBC Act.

The boundary of the project site has been set to avoid direct impact to this habitat. Therefore there are no Threatened ecological communities listed under the EPBC Act located in the project site.

11.2.1.5 High threat weeds

High threat weeds predicted to occur in the project site from the desktop study and following site surveys are listed in Table 11.3.

Table 11.3 High threat weeds related to the study area

Vegetation	Weeds predicted from the desk study
Cumberland River-flat Forest	High threat weeds were recorded in this vegetation map unit and include Kikuyu Grass, Rhodes Grass, Green Cestrum, Moth Vine, Small-leaved Privet, Bridal Creeper (*Asparagus asparagoides*), Fireweed (*Senecio madagascariensis*), Madeira Vine (*Anredera cordifolia*), Wandering Jew, African Lovegrass and Panic Veldt Grass (*Ehrharta erecta*).
Coastal Freshwater Wetland	High threat weeds recorded in this vegetation map unit and include Alligator Weed.
Planted native species	High threat weeds were recorded in this vegetation map unit and include Kikuyu Grass, Rhodes Grass, Green Cestrum, Moth Vine (*Araujia sericifera*) and Small-leaved Privet.
Exotic vegetation	High threat weeds were recorded in this vegetation map unit, including Alligator Weed (*Alternanthera philoxeroides*), Kikuyu Grass, Rhodes Grass, Balloon Vine (*Cardiospermum grandiflorum*) and Green Cestrum.
Cleared land	N/A

11.2.2 Terrestrial fauna

11.2.2.1 Database search results

A desktop assessment was undertaken to identify threatened fauna species, populations and fauna habitat listed under the BC Act, FM Act, and EPBC Act, that could be expected to occur at the project site and to obtain the necessary data to perform BAM calculations.

Searches of threatened species databases, the Protected Matters Online Search Tool (DEE, 2018) and the output from the BAM calculator were also completed to determine any threatened fauna species that are known or predicted to occur in the locality. A full list of species identified in the desktop study is provided in Appendix A of Technical Report 4.

The results from the desktop study was refined based on the habitat types present, known distribution, and the knowledge and experience of the assessor. The refinement resulted in a list of fauna species likely to occur in the study area listed in Table 11.4.

11.2.2.2 Fauna survey results

A total of 61 species of fauna were recorded across the study area during field surveys, comprising 48 bird species, six mammals, three frogs, two fish and two reptiles. Fauna observed included common and widespread species of suburban environments as well as some small woodland birds that rely on dense

vegetation and large patch size. A full list of species identified in the field surveys is provided in Appendix B of Technical Report 4.

During field survey four threatened species were identified. These are listed in Table 11.5.

11.2.2.3 Threatened fauna species and populations

Predicted threatened species identified from the desktop study are listed in Table 11.4. Table 11.4 identifies the protected status of the species, whether the species was surveyed and what type of offset credit type the species relates to.

Table 11.4 Predicted threatened species – fauna species

Common name	Scientific name	BC Status	EPBC Status	Surveyed in optimum season	Credit type
Australasian Bittern	*Botaurus poiciloptilus*	E	E	N/A	ECS
Barking Owl	*Ninox connivens* (foraging)	V		N/A	ECS
Black Bittern	*Ixobrychus flavicollis*	V		N/A	ECS
Black-chinned Honeyeater (eastern subspecies)	*Melithreptus gularis*	V		N/A	ECS
Brown Treecreeper	*Climacteris picumnus victoriae*	V		N/A	ECS
Diamond Firetail	*Stagnopleura guttata*	V		N/A	ECS
Dusky Woodswallow	*Artamus cyanopterus*	V		N/A	ECS
Eastern Bentwing-bat	*Miniopterus schreibersii oceanensis* (foraging)	V		N/A	ECS
Eastern False Pipistrelle	*Falsistrellus tasmaniensis*	V		N/A	ECS
Eastern Freetail-bat	*Mormopterus norfolkensis*	V		N/A	ECS
Eastern Osprey	*Pandion cristatus* (foraging)	V		N/A	ECS
Flame Robin	*Petroica phoenicea*	V		N/A	ECS
Gang-gang Cockatoo	*Callocephalon fimbriatum* (foraging)	V		N/A	ECS
Greater Broad-nosed Bat	*Scoteanax rueppellii*	V		N/A	ECS
Grey-headed Flying-fox	*Pteropus poliocephalus* (foraging)	V	V	N/A	ECS
Hooded Robin	*Melanodryas cucullata*	V		N/A	ECS
Koala	*Phascolarctos cinereus* (foraging)	V	V	N/A	ECS
Little Bentwing-bat	*Miniopterus australis* (foraging)	V		N/A	ECS
Little Eagle	*Hieraaetus morphnoides* (foraging)	V		N/A	ECS
Little Lorikeet	*Glossopsitta pusilla*	V		N/A	ECS
Masked Owl	*Tyto novaehollandiae*	V		N/A	ECS
Painted Honeyeater	*Grantiella picta*	V	V	N/A	ECS
Powerful Owl	*Ninox strenua* (foraging)	V		N/A	ECS
Regent Honeyeater	*Anthochaera phrygia* (foraging)	CE	E	N/A	ECS
Scarlet Robin	*Petroica boodang*	V		N/A	ECS

Common name	Scientific name	BC Status	EPBC Status	Surveyed in optimum season	Credit type
Speckled Warbler	*Chthonicola sagittata*	V		N/A	ECS
Spotted-tailed Quoll	*Dasyurus maculatus*	V	E	N/A	ECS
Square-tailed Kite	*Lophoictinia isura* (foraging)	V		N/A	ECS
Swift Parrot	*Lathamus discolor* (foraging)	E	CE	N/A	ECS
Turquoise Parrot	*Neophema pulchella*	V		N/A	ECS
Varied Sittella	*Daphoenositta chrysoptera*	V		N/A	ECS
White-bellied Sea-Eagle	*Haliaeetus leucogaster* (foraging)	V		N/A	ECS
Yellow-bellied Sheathtail-bat	*Saccolaimus flaviventris*	V		N/A	ECS
Bush Stone-curlew	*Burhinus grallarius*	E	-	Yes	SCS
White-bellied Sea-Eagle	*Haliaeetus leucogaster* (breeding)	V	C	Yes	SCS
Little Eagle	*Hieraaetus morphnoides* (breeding)	V	-	No	SCS
Square-tailed Kite	*Lophoictinia isura* (breeding)	V	-	Yes	SCS
Eastern Osprey	*Pandion cristatus* (breeding)	V	-	Yes	SCS
Green and Golden Bell Frog	*Litoria aurea*	E	V	Yes	SCS
Cumberland Plain Land Snail	*Meridolum corneovirens*	E	-	Yes	SCS
Southern Myotis	*Myotis macropus*	V	-	Yes	SCS
Grey-headed Flying-fox	*Pteropus poliocephalus* (breeding)	V	V	Yes	SCS

Notes: V – vulnerable species; E – endangered species; C - migratory under the China-Australia migratory bird agreement; CE – critically endangered species. ECS - ecosystem-credit species; SCS - Species credit species

The November field survey was just outside of the nominated September-October field survey period for Little Eagle. As the project site contained very few potential nest trees it was considered that if the project site contained occupied Little Eagle breeding habitat then the preceding season's nest (or candidate nests of other similar sized birds such as raptors or ravens) would be detected in the field surveys.

Three migratory species were predicted by the Protected Matters Online Search Tool (DEE, 2018) to have the potential to occur within the study area on an occasional or transient basis. These are the Satin Flycatcher (*Myiagra cyanoleuca*), Rufous Fantail (*Rhipidura rufifrons*) and Yellow Wagtail (*Motacilla flava*).

During field survey four threatened fauna species were recorded on site. These species and their protected status are listed in Table 11.5.

Table 11.5 Threatened fauna species recorded in the study area

Common name	Scientific name	Observation type	BC Act status	EPBC Act status	Credit type
Grey-headed Flying-fox	*Pteropus poliocephalus*	Seen	V	V	ECS (foraging) / SCS (roosting)
Eastern Freetail-bat	*Mormopterus norfolkensis*	Probable Anabat recording	V	Not listed	ECS
Eastern False Pipistrelle	*Falsistrellus tasmaniensis*	Species group Anabat recording	V	Not listed	ECS
Southern Myotis	*Myotis macropus*	Species group Anabat recording	V	Not listed	SCS

Notes: V – vulnerable species; ECS - ecosystem-credit species; SCS - Species credit species

The Grey-headed Flying-fox is listed as a vulnerable species under the EPBC Act and the BC Act. The Grey-headed Flying-fox is a large, nomadic fruit and blossom-feeding bat. The Cabramatta Creek Grey-headed Flying-fox roost camp is located around 500 metres to the east of the rail corridor and around 350 metres to the northeast of the outer edge of the construction site boundary, with at least 250 metres of dense vegetation between the camp and the project site (refer to Figure 11.1). The camp is a roosting habitat which is critical to the survival of the species as identified in the recovery plan for the species (DECCW, 2009). A full profile of the camp is provided in section 6.7 of Technical Report 4. This colony was identified as requiring specific consideration in the project SEARs with a particular focus on potential effects of noise and lighting.

The Grey-headed Flying-fox was recorded foraging within the study area and was regularly observed flying above it, including several thousand individuals seen flying from east to west of the project site after dusk each evening. The project site contains some foraging resources for this species associated with mature fruit or blossom-bearing trees in mapped areas of planted native species and exotic vegetation.

It is not always possible to confidently identify microbat species based on Anabat call recordings because of short or poorer quality recordings or similarities between species. The Eastern Freetail-bat (*Mormopterus norfolkensis*), Eastern False Pipistrelle (*Falsistrellus tasmaniensis*) and Southern Myotis (*Myotis macropus*) may potentially be present in the study area based on identification of recorded calls to 'probable' or 'species group' level. The study area contains aerial foraging habitat and potential roost sites for these and other microbat species in hollow bearing trees, bridges and culverts.

11.2.2.4 Terrestrial fauna habitats

Vegetation within the project site is highly modified, fragmented and would have only limited value for migratory species listed under the EPBC Act. As such, potential habitat in the study area is not 'important habitat' for migratory species, as defined in DotE (2013).

Fauna habitat value within the project site is very low, reflecting the highly modified environment in the rail corridor and adjoining land. Habitat value is higher across the study area, despite its suburban context and the presence of human disturbance and edge effects. There are valuable fauna habitat resources associated with Jacquie Osmond Reserve and the riparian corridor of Cabramatta Creek, including permanent water, wetland and aquatic environments and a relatively large patch of mature, productive native vegetation. The project site is connected to a larger patch of habitat in the riparian corridor of Cabramatta Creek.

The study area contains potential habitat for a range of native animals, including threatened fauna and migratory species known or predicted to occur in the locality. In addition to the habitat types listed in Table 11.1, the following provide habitat resources for a range of native fauna, including:

- scarce woody debris and leaf litter
- mature canopy trees that provide nectar, fruits, leaves and foraging, roosting or nesting substrates
- habitat trees with hollows and/or decorticating bark
- occasional small patches of dense understorey shrubs
- a range of fruiting and flowering small trees and shrubs and grass seeds.

One hollow-bearing tree is located in the project site (refer to Figure 11.1). This is within the disturbance footprint for the proposed retaining wall located between the new rail track and sports fields in Jacquie Osmond Reserve.

11.2.3 Groundwater dependent ecosystems

Native vegetation within the study area is not mapped as vegetation with a potential for being reliant on the subsurface presence of groundwater. It is also unlikely to be an in-flow dependant ecosystem, i.e. an ecosystem that is "*accessing a water source in addition to rainfall, such as water stored in the unsaturated zone, surface water or groundwater*" (Australian Government, 2012). Based on the field observations, experience and judgement of the assessor, the vegetation in the study area is likely to be reliant on rainfall and on surface water associated with Cabramatta Creek and areas of surface water accumulation on its floodplain. Groundwater dependent ecosystems are not considered further in this assessment.

11.2.4 Aquatic ecology

Cabramatta Creek is located within the project site and study area. No endangered aquatic communities, aquatic fauna or marine vegetation listed under the FM Act or EPBC Act occur in the project site.

The channel floor and banks of Cabramatta Creek where it intersects the project site have been mapped as non-native vegetation because this reach of the creek is confined by concrete or gabions and has a gravel or concrete bed.

11.3 Assessment of construction impacts

11.3.1 Terrestrial flora

11.3.1.1 Removal of vegetation

The project will result in direct impacts on 3.5 hectares of non-native vegetation as summarised in Table 11.6 and shown on Figure 11.1. This vegetation has low biodiversity value given its context and habitat value for threatened species. The impacts on this vegetation are associated with clearing for the new rail track and associated infrastructure and for construction compounds. Residual direct impacts would be restricted to the project site. Construction access would be via existing formed roads.

Table 11.6 Extent of residual impacts in the project site

Vegetation type	Condition	Area within project site (ha)
Planted native species	Non-native vegetation	0.5
Exotic vegetation	Non-native vegetation	3.0
Total area of vegetation		**3.5**
Cleared land	Cleared land	3.4
Total direct impact		**6.9**

The clearing of non- native vegetation would involve the removal of some individual native plants, including mature planted street trees and trees in parkland. Mature trees have particular value within plant populations because they take longer to replace and are sources of pollen and seed.

An arboriculture assessment (see Appendix C of Technical Report 10 – Landscape and visual impact assessment) has assessed the number and quality of trees that would require removal as a result of the project. The project would result in the removal of 43 planted trees which are indigenous to the Fairfield and Liverpool LGAs and 77 exotic specimens. The majority of these are along Broomfield Street.

Indirect impacts on trees to be retained may include loss of or damage to roots and branches of trees located near the project site.

The project would remove a small proportion of individual plant species and associated habitat resources compared to the extent of both species and resources in the surrounding area.

11.3.1.2 Threatened flora species

The study area contains some land with biodiversity value, including around seven stems of *Acacia pubescens*. *Acacia pubescens* is listed as a vulnerable species under the BC and EPBC Acts. The project has been designed to avoid direct or indirect impacts on any *Acacia pubescens*. No *Acacia pubescens* would be removed or otherwise affected by the project.

The design and placement of any associated ancillary works such as utilities or signalling outside of the project site would purposefully avoid impacts to these *Acacia pubescens* or other biodiversity values.

A Narrow-leaved Black Peppermint (*Eucalyptus nicholii*) was recorded in the project site. *Eucalyptus nicholii* is listed as a vulnerable species under the BC and EPBC Acts. The project site is well outside the species' natural distribution and the individual at the project site and other records in the locality are clearly of planted individuals of uncertain provenance. In this context, the *Eucalyptus nicholii* at the project site has not been treated as a threatened species requiring assessment under the BAM.

Impacts to threatened ecological communities

There is an occurrence of the EEC River-flat Eucalypt Forest in the study area. The project site has been purposefully designed to avoid any vegetation removal in the area of occupancy of this ecological community and environmental management measures (refer to section 11.8) are likely to mitigate against any substantial indirect impacts to this community.

11.3.2 Terrestrial fauna

11.3.2.1 Habitat impacts

Construction of the project would remove a very small area of fauna habitat, as most of the project site is already cleared land. The vegetation that would be removed or modified would have little value for native fauna species given its structure, condition and proximity to the heavy rail corridor.

There is one hollow-bearing tree in the project site (refer to Figure 11.1). This hollow-bearing tree is within the disturbance footprint for the proposed retaining wall between the new rail track and sports fields in Jacquie Osmond Reserve. This is an essential element of the project design at this location and so there was no potential to avoid impact to this habitat resource. Given its context and surrounding land uses this hollow-bearing tree is highly unlikely to be occupied by a threatened species of owl, parrot or microbat. Individuals of these threatened species are more likely to roost or nest in larger patches of vegetation away from human disturbance than in an isolated tree adjacent to a heavy rail corridor.

Other fauna habitat resources that would be removed include foraging and shelter resources for widespread and generalist native fauna typical of urban environments. It is highly unlikely that any threatened species or any fauna populations would rely on the habitat resources within the project site for their survival. Removal of fauna habitat resources would include:

- up to 0.5 hectares of planted native species which would provide foraging habitat for the threatened Grey-headed Flying-fox, Eastern False Pipistrelle, Southern Myotis and other threatened fauna species with known or potential habitat in the study area (comprised entirely of planted native species)
- up to 3.0 hectares of exotic vegetation, including both grassland and forest and scrub structural forms, which provides nesting and foraging habitat for small birds, as well as shelter and foraging habitat for reptiles and frogs
- an additional 3.4 hectares of shelter substrate for small ground dwelling fauna such as reptiles and frogs and foraging substrate for generalist birds of open country associated with woody debris, railway ballast etc in cleared land.

11.3.2.2 Impacts on the Cabramatta Creek Grey-headed Flying-fox roost camp

The Grey-headed Flying-fox is listed as a vulnerable species under the EPBC Act and the BC Act. A description of the camp is provided in section 11.2.2.

Given the distance of the Cabramatta Creek Grey-headed Flying-fox roost camp from the project site (350 metres to the northeast of the outer edge of the construction site boundary with at least 250 metres of dense vegetation between the camp and the project site), the project would not result in any direct impacts to the roost camp. Instead, consideration has been given to the potential for indirect impacts, namely impacts associated with construction noise and lighting.

A noise and vibration assessment of construction activities associated with the project has been undertaken (see Technical Report 2 – Noise and vibration impact assessment). The likely maximum construction noise levels of up to 55 to 60 dBA at the roost camp are likely to be equivalent or less than current ambient noise levels which would include traffic noise levels of 60-65 dBA from the Hume Highway, located about 100 metres east of the camp. Individuals within the Cabramatta Creek Grey-headed Flying-fox roost camp appear to be habituated to human activity and to elevated noise levels, including traffic noise from the Hume Highway. Construction noise impacts of the project would not exceed current noise levels at the roost camp and are therefore unlikely to alter the temporal activity patterns of flying-foxes on a diurnal or seasonal basis and would not threaten the continued occupancy of the roost camp by the Grey-headed Flying-fox.

Temporary lighting would be used during night time work for brief periods during construction of the project. The roost camp is located around 350 metres to the northeast of the outer edge of the construction site boundary separated from the project site by at least 250 metres of dense vegetation in the Jacquie Osmond Reserve. Light from the project site would not reach the roost camp. Further, individuals within the Cabramatta Creek Grey-headed Flying-fox roost camp would be habituated to artificial light, including from sources associated with the Hume Highway, a hotel adjoining the roost camp and sports field lighting in the Jacquie Osmond Reserve. Construction light impacts of the project would not exceed current levels at the

roost camp and would not threaten the continued occupancy of the roost camp by the Grey-headed Flying-fox.

Given the distance of the Cabramatta Creek Grey-headed Flying-fox roost camp from the project site and the minor magnitude of noise and lighting impacts arising from the project as described above, no particular measures to further minimise impacts to the roost camp are required.

11.3.2.3 Direct impacts to fauna

The project site provides limited habitat resources for native fauna species and these resources are more likely to be utilised by common and widespread species of urban environments.

Some individual possums or native birds may nest or shelter in vegetation within the rail corridor. Groundcover vegetation, leaf litter and woody debris would provide shelter and foraging substrate for reptiles, frogs and invertebrates. Construction may result in the injury or mortality of some individuals of these less mobile fauna species and other small terrestrial fauna that may be occupying habitat within the project site during clearing or construction activities. The potential injury or mortality of individuals within a maximum of 6.9 hectares of poor quality habitat is highly unlikely to affect an ecologically significant proportion of any local populations.

The project would not create any significant or new barriers to the movement of native biota.

Impacts resulting from the project would increase gaps in habitat within the landscape by removing planted native species and exotic vegetation along the edge of a large patch of intact native vegetation in the Cabramatta Creek riparian corridor. This would comprise a very minor impact on the degree of habitat fragmentation in the local area given the limited extent and quality of habitat to be removed and because the project site is parallel to an existing significant barrier to fauna movement associated with the rail corridor and associated fencing. The design of the new bridge over Cabramatta Creek (adjacent to the existing bridge) would match the pier arrangement of the existing bridge to minimise hydraulic impacts on flow along the creek, and would maintain habitat connectivity under the bridge.

The remainder of the project site adjoins cleared and developed land that would not have any value as a fauna movement corridor.

The study area is not considered important habitat for any migratory species according to the significant impact criteria for migratory species (DotE, 2013). The project would result in very minor residual impacts on native biota and their habitats in general, and would not substantially fragment or isolate any areas of habitat Based on the above considerations the project is unlikely to impose 'a significant effect' on any of the listed migratory fauna species that may occur at the study area.

Given the scale and context of the project there are unlikely to be any substantial impacts on threatened species and their habitats beyond those associated with the removal of non-vegetation and habitat resources in the project site. There is no evidence that the non-native vegetation and other habitat resources in the project site would have any particular value to any threatened biota. The project is unlikely to result in any other significant direct or indirect impacts to threatened biota. Notably, there would be minor, if any impacts, on aquatic habitat downstream of the project site and there is no evidence that aquatic habitat in the vicinity of the project site would be occupied by any threatened biota

11.3.2.4 Indirect impacts to fauna

The following indirect impacts may also occur as a result of the project:

- edge effects
- introduction and spread of weeds, pests and pathogens such as Phytophthora (*Phytophthora cinnamomi*), Myrtle Rust (*Uredo rangelii*) and Chytrid fungus (*Batrachochytrium dendrobatidis*)

- noise and light impacts on fauna.

There is a moderate risk of construction activities increasing the degree of weed infestation in adjoining vegetation and a negligible risk of any new weeds being introduced. Management measures including the development of a weed management sub-plan as part of the project CEMP will be implemented to mitigate potential impacts.

The potential for significant or new impacts associated with pathogens is relatively low, given the suburban context and extent of human visitation across the project site.

The generation of construction noise is unlikely to reduce the value of habitat in the study area or otherwise significantly affect any fauna species that occur in the study area.

Construction activities would not substantially increase the extent or intensity of artificial lighting above current background artificial light levels associated with the rail corridor, pedestrian and bike track across Cabramatta Creek, street lighting and sports fields in Jacquie Osmond Reserve. Artificial lighting is unlikely to reduce the value of habitat in the study area or otherwise significantly affect any fauna species that occur in the study area.

11.3.3 Aquatic ecology

The potential introduction of pollutants such as vehicle fuel or mobilised sediments from the project into the surrounding environment, if uncontrolled, could potentially impact on water quality further downstream. There is minor potential for water quality impacts on Cabramatta Creek within the project site or reaches downstream. Potential water quality impacts will be managed through the implementation of mitigation measures, including the provision of sedimentation basins, silt fences and other structures to intercept runoff. Mitigation measures to minimise water quality impacts are provided in Chapter 13 (Hydrology, flooding and water quality).

No endangered aquatic communities, aquatic fauna or marine vegetation listed under the FM Act or EPBC Act occur in the project site and no significant impacts on riparian vegetation or habitats downstream of the project site are anticipated as a result of the project. There would be minor, if any impacts on Key Fish Habitat in Cabramatta Creek as a result of the project.

The project would not result in any impacts on biodiversity values not covered by the BAM (i.e. marine mammals; wandering sea birds; Lord Howe Island biodiversity; and category 1 – exempt land).

11.3.4 Cumulative impacts

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

The project would make a negligible impact to the cumulative impacts on biodiversity values arising from other developments in Western Sydney. The project would not involve the removal of any native vegetation or important habitat resources that would require the provision of biodiversity offsets. The project is unlikely to increase the extent, duration or magnitude of any of the cumulative impacts on biodiversity values occurring in the study area and region to the extent that would result in a significant negative effect on biodiversity values.

Other indirect impacts such as noise are predicted to be transitory and confined to an area near the boundary of the project, the cumulative impacts would be minimal unless additional sources (to this project) of dust, emissions or noise was generated close to receptors. There are no other known construction projects proposed in the vicinity of the project site that would result in an increase of these impacts.

11.4 Assessment of operation impacts

Impacts on biodiversity values would be largely restricted to the construction phase of the project. Some potential impacts that would occur as a result of the operation of the project include:

- generation of additional light and noise
- erosion and sedimentation as a result of runoff from hard stand areas
- introduction of weed propagules by vehicles or maintenance staff
- overshadowing of vegetation by noise walls
- fauna mortality as a result of collision with trains.

The project site is located within or immediately adjoining the existing rail corridor which is dominated by infrastructure and highly modified environments. Potential operational impacts of the project are already occurring in the project site and affecting the surrounding study area. The project is unlikely to increase the extent, duration or magnitude of any of these impacts to the extent that would result in a significant negative effect on biodiversity values.

11.4.1 Terrestrial flora

Each of the potential operational impacts listed above would already be occurring in the project site and affecting the surrounding study area. Vegetation adjoining the project site is already subject to weed infestation and other edge effects.

11.4.2 Aquatic disturbance and impacts on fish habitat

The design of the new bridge over Cabramatta Creek would match the pier arrangement of the existing bridge to minimise hydraulic impacts on flow along the creek, and would maintain habitat connectivity under the bridge. Construction work methods have been prescribed that would ensure that there are no direct impacts to the creek bed or to aquatic habitat. There would be minor, if any, impacts on Key Fish Habitat in Cabramatta Creek as a result of the project.

11.4.3 Fauna

Fauna that occupy habitats within the project site and adjacent areas are likely to be accustomed to existing noise originating from trains, road traffic and the urban environment. Additional train movements are unlikely to significantly increase the risk of fauna mortality from collisions above current levels, given the highly modified habitats present.

In this context, the project is likely to comprise only a minor increase in any of these potential negative effects. The project is unlikely to increase the extent, duration or magnitude of any of these impacts to the extent that would result in a significant negative effect on biodiversity values.

11.4.3.1 Impacts on the Cabramatta Creek Grey-headed Flying-fox roost camp

The Grey-headed Flying-fox is listed as a vulnerable species under the EPBC Act and the BC Act as described in section 11.2.2. The Cabramatta Creek Grey-headed Flying-fox roost camp is located around 500 metres to the east of the existing rail corridor and the operational project site. As per the construction impact assessment, there would be no direct impacts to the roost camp due to operation, therefore potential indirect impacts have been considered.

A noise and vibration assessment of operational activities associated with the project has been undertaken (see Technical Report 2 – Noise and vibration impact assessment). There is predicted to be a very minor increase in noise impacts arising from operation of the passing loop. The likely operational noise levels of 54 dBA at the roost camp are only marginally above the modelled 'no build' noise levels of 53 dBA. This is considered to be less than current ambient noise levels which include traffic noise from the Hume Highway. The likely maximum operation noise levels would be 74 dBA under the 'build' and 'no build' scenarios. Values of greater than 74 dBA associated with near-continuous daytime traffic noise have been recorded in monitoring of the Balgowlah camp beside the Burnt Bridge Creek deviation (DPE, 2018). This shows that Grey-headed Flying-foxes will tolerate loud and prolonged noise in the vicinity of roost camps once they have become habituated to these noise levels. Individuals within the Cabramatta Creek Grey-headed Flying-fox roost camp appear to be habituated to human activity and to

elevated noise levels, including traffic noise from the Hume Highway. Operational noise impacts of the project would not exceed current noise levels at the roost camp and are therefore unlikely to alter the temporal activity patterns of flying-foxes on a diurnal or seasonal basis and would not threaten the continued occupancy of the roost camp by the Grey-headed Flying-fox.

Trains and signals would generate light during the operational life of the project. The roost camp is separated from the rail corridor by at least 250 metres of dense vegetation in the Jacquie Osmond Reserve. Light from the rail corridor would not reach the roost camp. Further, individuals within the Cabramatta Creek Grey-headed Flying-fox roost camp would be habituated to artificial light, including from sources associated with the Hume Highway, a hotel adjoining the roost camp and sports field lighting in the Jacquie Osmond Reserve. Operational light impacts of the project would not exceed current levels at the roost camp and would not threaten the continued occupancy of the roost camp by the Grey-headed Flying-fox.

11.4.4 Cumulative impacts

Operational impacts of the project would comprise a minor addition to the existing activities in the rail corridor and extent of development in the locality. The project is unlikely to increase the extent, duration or magnitude of any of the cumulative impacts on biodiversity values occurring in the study area and region to the extent that would result in a significant negative effect on biodiversity values.

Cumulative impacts and risks connected to the project would occur in the context of human induced climate change, which is recognised as a serious threat to biodiversity values. Human induced climate change is recognised as a threat to the EEC River-Flat Eucalypt Forest, particularly if change leads to altered flood regimes (OEH, 2018c). Climate change is recognised as a threat, in the recovery plan for the Grey-headed Flying-fox due to the potential for changes in the distribution or reproduction of some Eucalyptus food tree species or the increased occurrence of extremely high temperatures (DECCW, 2009). Overall climate change is likely to have a relatively minor effect on ecosystem resilience and potential cumulative impacts on biodiversity values at the study area when compared to more immediate threats such as removal of vegetation and habitat.

11.5 Key threatening processes relevant to the project

A key threatening process is as an action, activity or project that:

- adversely affects two or more threatened species, populations or ecological communities
- could cause species, populations or ecological communities that are not currently threatened to become threatened.

Key threatening processes listed under the BC Act, FM Act and/or EPBC Act, relevant to this project are listed in Table 11.7.

Table 11.7 Key threatening process

Key threatening process	Status	Comment	Project phase
Loss of hollow-bearing trees	BC Act	The project would remove one hollow bearing tree. As a single tree, in an area of planted native species surrounded by exotic grassland and immediately adjacent to the existing rail corridor this would comprise a very minor increase in the operation of this KTP.	Construction
Removal of dead wood and dead trees	BC Act	The project site contains very little fallen timber. The project may result in the removal or disturbance of small amounts of woody debris, during construction of the project. The implementation of habitat management procedures is recommended to limit impacts on fauna and their habitats and to at least partially maintain the value of these resources by reinstating woody debris in revegetation areas	Construction
Human-caused climate change	BC Act EPBC Act	Combustion of fuels associated with construction and operation of the project would contribute to anthropogenic emissions of greenhouse gases. The project does not pass through any areas mapped as coastal corridors for climate change that provide for the latitudinal movement of species. The increase in greenhouse gases as a result of the project may impact climatic habitat elsewhere in NSW over the long-term. This contribution is likely to be minor in the context of regional and global anthropogenic emissions of greenhouse gases.	Construction and operation
Clearing of native vegetation	BC Act EPBC Act	The project does not include the clearing of any native vegetation. Concept design of the project has ensured that there is no native vegetation within the project site	N/A
Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands	BC Act	The design of the new bridge over Cabramatta Creek would match the pier arrangement of the existing bridge to minimise hydraulic impacts on flow along the creek, and would maintain habitat connectivity under the bridge. Construction work methods have been prescribed that would ensure that there are no direct impacts to the creek bed or to aquatic habitat.	N/A
The degradation of native riparian vegetation along NSW water courses	BC Act	The project does not include the clearing of any native vegetation, including riparian vegetation.	N/A

11.6 Impacts on biodiversity related matters of national environmental significance

The Protected Matters Online Search Tool (DEE, 2018) results did not identify any World Heritage properties, National Heritage places or Wetlands of International Importance within the locality. As such, these particular Matters of National Environmental Significance are not relevant to this biodiversity assessment report and are not considered further in this report.

Three migratory species were predicted by the Protected Matters Online Search Tool (DEE, 2018) and have the potential to occur within the study area on an occasional or transient basis: the Satin Flycatcher (*Myiagra*

cyanoleuca), Rufous Fantail (*Rhipidura rufifrons*) and Yellow Wagtail (*Motacilla flava*). Habitat resources for these migratory species are mainly associated with Cumberland River-flat Forest adjacent to Cabramatta Creek. They are unlikely to rely on any habitat resources associated with the planted native species and exotic vegetation in the project site.

There is no potential habitat for migratory shorebird species at the study area.

Vegetation within the project site is highly modified, fragmented and would have only limited value for migratory species listed under the EPBC Act. Habitat in the study area is not likely to support an ecologically significant proportion of the population of any of these species, be of critical importance to the species at particular life-cycle stages, is not located at the limit of any of the species' range, and/or located within an area where the species is declining. As such, potential habitat in the study area is not 'important habitat' for any of these species, as defined in DotE (2013).

11.7 Assessment of serious and irreversible impacts

Under the BC Act, a determination of whether an impact is serious and irreversible must be made in accordance with the principles set up in Section 6.7 of the Biodiversity Conservation Regulation 2017.

The principles are aimed at capturing impacts which are likely to contribute significantly to the risk of extinction of a threatened species or ecological community in New South Wales. A set of criteria have been developed and are included in the OEH Guidelines to assist a decision-maker to determine serious and irreversible impacts (OEH, 2017). Threatened biota that meet the criteria under one or more of the above principles have been identified as serious and irreversible impact entities.

There are no serious and irreversible impact entities at the project site or likely to be affected by the project.

11.8 Management of impacts

11.8.1 Approach

11.8.1.1 Approach to mitigation and management

ARTC is committed to minimising the environmental impact of the project and is investigating opportunities to reduce actual impact areas where practicable. The area that would be directly impacted by construction activities would depend on factors such as presence of significant vegetation, constructability, construction management and safety considerations, land form, slopes and anticipated sub-soil structures. Direct impacts would be reduced as far as practicable. The exact amount of clearance (within the project site) would be refined during detailed design.

The project has adopted the following 'avoid, minimise and offset' approach to mitigate impacts to biodiversity values in accordance with the BAM, the BC Act and associated policy. In line with this approach, the project has where possible:

- avoided impacts on habitat, through the project planning and design process
- minimised impacts on habitat, through the use of a range of environmental management and impact mitigation measures
- considered offset requirements.

ARTC has, where possible, altered the project to avoid and minimise ecological impacts in the project planning stage (refer to section 11.1.3), and a range of impact mitigation strategies have been included in the project to mitigate the impact on ecological values. Further refinement will be made during detailed design, where possible, to minimise ecological impacts.

11.8.1.2 Offset requirements

Under the *Environment Protection and Biodiversity Conservation Act 1999 Environmental Offsets Policy* (DSEWPaC, 2012) (the EPBC Act Environmental Offsets Policy) biodiversity offsets are required to compensate for significant residual impacts on Matters of National Environmental Significance.

There is no native vegetation in the project site. Construction of the project would remove 3.5 hectares of non-native vegetation (comprising 3.0 hectares of exotic vegetation and 0.5 hectares of planted native species) within an overall disturbance footprint of 6.9 hectares. This vegetation has low biodiversity value given its context and habitat value for threatened species. Much of the project site (3.4 hectares) is cleared land, comprising existing rail infrastructure, concrete paths, bitumen roads and other infrastructure. Impacts on non-native vegetation and cleared land do not require the provision of biodiversity offsets according to the BAM. No biodiversity offsets for impacts on MNES are therefore required in accordance with the EPBC Act Environmental Offsets Policy.

The project would not remove or otherwise impact any native vegetation or threatened species and as such would not result in any impacts requiring offsets. Impacts on non-native vegetation do not require the provision of biodiversity offsets according to the BAM. As such, no BAM credit calculations need to be completed and submitted to accompany this assessment.

The project site is located within or immediately adjoining the existing rail corridor which is dominated by infrastructure and highly modified environments. Potential operational impacts of the project are already occurring in the project site and affecting the surrounding study area. The project is unlikely to increase the extent, duration or magnitude of any of these impacts to the extent that would result in a significant negative effect on biodiversity values.

The design and placement of any associated ancillary works such as utilities or signalling outside of the project site would purposefully avoid impacts to *Acacia pubescens* or other biodiversity values. These works would be undertaken within the rail corridor and would affect only cleared land or exotic vegetation within this highly modified environment. The construction and environmental control measures proposed to mitigate impacts are considered sufficient to manage any potential indirect impacts of ancillary works.

11.8.1.3 Expected effectiveness

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

The project was design to avoid impacts arising in the first instance and has been very effective in preventing the clearance of native vegetation.

The location of construction compounds, work sites and the construction footprint were finalised following field survey. This enabled the location of these construction activities to be located outside of areas of biodiversity value. These are detailed further in section 11.1.3.

A CEMP will be prepared prior to construction. The plan will be prepared to address the requirements of the project approvals, the environmental management measures outlined in this EIS (refer to Table 11.8) and all applicable legislation.

As such, the measures to avoid impacts during development of the reference design and outlined in the CEMP are considered to be proven effective in managing potential impacts to biodiversity.

11.8.2 List of mitigation measures

The mitigation measures that would be implemented to address potential biodiversity impacts are listed in Table 11.8.

Table 11.8 Mitigation measures

Stage	Impact	Measure
Construction	Vegetation clearance	Impacts to *Acacia pubescens* will be avoided. The locations of Acacia pubescens will be marked on plans, outlined in the CEMP, fenced on site, and avoided. Signage will be placed on relevant fencing to inform of prohibited activities in that area as part of the works.
	Vegetation clearance	Disturbance of vegetation will be limited to the minimum necessary to construct works. Micro-siting of infrastructure will be undertaken during detailed design where practicable to minimise or avoid impacts on planted native species.
	Vegetation clearance	Where the project site adjoins native vegetation, the limits of clearing will be marked and temporary fencing or flagging tape installed around the vegetated area prior to the commencement of construction activities to avoid unnecessary vegetation and habitat removal or damage.
	Vegetation clearance	Equipment storage and stockpiling of resources will be restricted to designated areas within compound sites in cleared land.
	Vegetation clearance	The design and placement of any associated ancillary works such as utilities or signalling outside of the project site will avoid impacts to *Acacia pubescens* or other biodiversity values. These works will affect only cleared land or exotic vegetation.
	Revegetation	Following removal of the temporary shared path between Sussex Street and Cabramatta Creek, revegetation will be undertaken to stabilise the site. Opportunities to work with local groups such as the Fairfield Creeks and Wetlands Group will be explored where possible. Revegetation will aim to be consistent with the pre-existing vegetation and surrounding vegetation.
	Weeds	Weed management actions will be included in the CEMP to manage weeds in accordance with the *NSW Weed Control Handbook* (DPI, 2018). This will include the management and disposal of the weeds that were recorded within the project site including priority weeds in accordance with the biosecurity duties under the *Biosecurity Act 2015*.
	Weeds	Vehicles and other equipment to be used within the rail corridor will be cleaned to minimise seeds and plant material entering the project site to prevent the introduction of further exotic plant species or disease. This will include the use of vehicle wash bays or portable vehicle wash equipment such as high pressure wash units, shovels, crow bars or stiff brushes.
	Fauna habitat	The CEMP will include the locations of potential roost sites as identified in this report (eg. hollow-bearing trees, disused buildings, bridges and culverts). The CEMP will include measures to manage potential impacts to roost sites such as: • any potential roost sites that will be removed or modified will be checked for roosting bats immediately prior to work • culverts are to remain open on at least one side at all times to allow any roosting bats to fly in or out • habitat to be identified for the release of mibrobats or any fauna encountered during clearing surveys

Stage	Impact	Measure
		• habitat trees will be felled using equipment that allows the trees to be lowered wo the ground with minimal impact (eg claw extension) • animals that emerge from felled trees will be captured, inspected for injury, then relocated to pre-determined habitat identified for fauna release. Where the presence or potential presence of roosting bats is noted then management measures for managing bats will be implemented in accordance with the CEMP.
	Fauna habitat	An unexpected finds procedure will be developed specifying measures for the management of any threatened biota or habitat resources identified during construction. The unexpected finds procedure will include the requirement for work to stop immediately if any threatened fauna is encountered and the Construction Environmental Manager to be notified. Work will recommence only once relevant approvals have been obtained as required. The species will be included in subsequent toolbox talks.
	Fauna habitat	Protocols to prevent introduction or spread of chytrid fungus will be implemented following *OEH Hygiene Protocol for the Control of Disease in Frogs* (DECC, 2008b).
	Fauna habitat	A suitably qualified person will be present during the removal of potential fauna habitat (i.e. the hollow-bearing tree in Jacqui Osmond Reserve and areas of planted native species) to avoid impacts on resident fauna and to salvage habitat resources as far as is practicable. Clearing surveys will include: • inspections of vegetation for resident fauna and/or nests or other signs of fauna occupancy • capture and relocation or captive rearing of less mobile fauna (such as nestling birds) by a trained fauna handler and with assistance from Wildlife Information Rescue and Education Service (WIRES) as required • inspection and identification/marking of hollow-bearing trees or other habitat resources adjacent to the project site to help ensure against accidental impacts • salvage of habitat features such as mature tree trunks and woody debris within the project site and placement within revegetation areas as far as is practicable (e.g. if vegetated areas are not separated by fences).
Operation	Weeds	Maintenance activities within the rail corridor and weed management during operation will be undertaken in accordance with ARTC's standard operating procedures and the relevant requirements of the *Biosecurity Act 2015*.

11.8.3 Consideration of the interaction between measures

In addition to the measures for biodiversity described above, there are interactions between the mitigation measures for noise and vibration (Chapter 9), soils and contamination (Chapter 12), and hydrology and water quality (Chapter 13).

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

11.8.4 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 are summarised below.

Despite measures taken to avoid and mitigate impacts, the project would result in some unavoidable residual adverse impacts imposed upon some elements of the natural environment, including removal of a single hollow-bearing tree, other native plants and habitat resources, and imposition of edge effects on adjoining areas of native vegetation. These residual impacts are small in extent and magnitude and would comprise a minor reduction in biodiversity values in the study area.

The project would remove a very small proportion of available habitat resources for local populations of native fauna. Impacts would include the removal of 0.5 hectares foraging habitat for mobile threatened fauna species, including the Grey-headed Flying-fox, birds and microbats. The site is unlikely to contain any important breeding, roosting or nesting habitat for native fauna. No wetlands, permanent aquatic habitat, rock outcrops, woody debris or any other important habitat resources would be removed.

The impact and offset assessment has been completed in accordance with the BAM and concluded that the project would only result in 'impacts not requiring offset', comprising clearing of non-native vegetation and construction within previously cleared land. A supplementary assessment of potential direct or indirect impacts on the Cabramatta Creek Grey-headed Flying-fox roost camp has concluded that the project would have a minor effect on this roost camp.

THIS PAGE HAS BEEN LEFT INTENTIONALLY BLANK

12 Soils and contamination

This chapter describes the existing environment in relation to soils, topography, geology and contamination, and assesses the potential impacts of construction and operation of the project on these factors. Mitigation measures are provided to manage the impacts identified. The technical report which informs this chapter is provided as Technical Report 6 - Soils and contamination impact assessment. The report was written to address the relevant SEARs which are outlined in Appendix A.

12.1 Assessment approach

12.1.1 Methodology

12.1.1.1 Study area

The study area for the desktop review component of the assessment encompassed a one kilometre radius around the project site, while the study area for the field investigation encompassed the project site.

12.1.1.2 Key tasks

The assessment involved the following:

- a review of Environmental Risk and Planning Reports prepared for the project site by Lotsearch Pty Ltd (provided in Appendix A of Technical Report 6)
- a review of previous environmental assessments undertaken within the project site (Parsons and Brinckerhoff, 2006) (Parsons and Brinckerhoff, 2009)
- a review of publicly available data and web-based information searches, including:
    - the Contaminated Sites Register and Record of Notices under Section 58 of the *Contaminated Land Management Act 1997*, maintained by the NSW Environment Protection Authority
    - environment protection licences, applications, notices, audits or pollution studies and reduction programs
    - Australian Soil Resource Information System (ASRIS) (maintained by the Commonwealth Scientific and Industrial Research Organisation (CSIRO))
    - NSW Government Sharing and Enabling Environmental Data (SEED) website
    - Penrith 1: 100 000 Soil Landscape Series – Sheet 9030 (Bannerman SM and Hazelton PA, 1990)
    - Penrith 1 : 100 000 Geological Map 9030 (NSW Department of Mineral Resources, 1991)
    - Liverpool City Council LEP and Fairfield City Council LEP – acid sulphate soils maps
    - Water bore records held by NSW Office of Water
- a site inspection to identify potential sources of contamination based on existing land use
- identification of the potential for acid sulphate soils and saline soils within the project site
- a limited contamination assessment undertaken as part of a geotechnical investigation to inform design which included:
    - sampling of soils from eight boreholes and four test pits within the rail corridor, three test pits along Broomfield Street and three test pits within Jacquie Osmond Reserve

- analysis of selected soils samples for contaminants of potential concern including heavy metals (arsenic, cadmium, chromium, copper, lead, nickel zinc and mercury); benzene, toluene, ethyl-benzene and xylene (BTEX), total recoverable hydrocarbons (TRH), polycyclic aromatic hydrocarbons (PAH), phenols, pesticides and asbestos
- comparison of the analytical results to health and environmental screening criteria
- preliminary waste classification of soils within the project site.

- recommendations for additional investigations, where necessary
- identification of mitigation measures to address potential soil and contamination impacts.

A detailed description of the assessment methodology is provided in section 3 of Technical Report 6.

12.1.1.3 Assessment criteria

The assessment criteria (investigation levels) for the contamination assessment were taken from the following guideline levels provided by the National Environment Protection Council (NEPC, 1999) (Amended 2013). *National Environment Protection (Assessment of Site Contamination) Measure 1999* (NEPM, 2013) (refer to Schedule B1 of the NEPM):

- Health investigation levels:
  - to assess human health risk via all relevant pathways of exposure
  - the level adopted for this assessment was D – commercial/industrial use, based on ongoing use of the majority of the project site as a railway and road corridor.
- Health screening levels:
  - for hydrocarbon vapour intrusion under different land use scenarios
  - the level adopted for this assessment was D – commercial/industrial use.

Given that construction activities including establishment of site compounds, construction of a retaining wall and embankment and bridge construction will be undertaken in public recreation areas (Jacquie Osmond Reserve and Warwick Farm Recreation Reserve) and near Cabramatta Creek the following environmental screening levels were also adopted from the NEPM:

- Ecological investigation levels:
  - for a range of metals and organic substances to assess risk to terrestrial ecosystems
  - the levels adopted for this assessment were commercial/industrial use and urban residential/public open space.
- Ecological screening levels:
  - for selected hydrocarbon compounds and total recoverable hydrocarbons to assess risk to terrestrial ecosystems
  - the levels adopted for this assessment were commercial/industrial use and urban residential/public open space for course-grained soils.

12.1.2 Risks identified

The preliminary environmental risk assessment undertaken for the project included potential risks associated with soils and contamination. 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 soils and contamination risks was medium. Risks with an assessed level of medium or above include:

- increased erosion and sedimentation due to excavation activities and vehicle movement during construction
- impacts associated with the disturbance of contaminated, ASS or soil salinity/saline soils during construction
- contamination of soils/groundwater due to spills and leaks during construction
- increased erosion and sedimentation due to excavation activities and vehicle movement during maintenance activities
- contamination of soils/groundwater due to spills and leaks during maintenance.

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 Chapters 3 (Approval and assessment requirements) and Chapter 4 (Consultation).

12.1.3 How potential impacts have been avoided/minimised

As described in Chapter 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 soils and contamination impacts have been avoided/minimised where possible by minimising the area of disturbance.

12.2 Existing environment

12.2.1 Topography and geology

The project site gently slopes from Cabramatta Station to Cabramatta Creek. From Cabramatta Creek to Warwick Farm Station the land is fairly flat.

Surface levels across the project site vary from 13.59 metres Australian Height Datum (AHD) near Cabramatta Station to 5.02 metres AHD on the southern side of Cabramatta Creek.

The project site is underlain by Bringelly Shales consisting of shales, carbonaceous claystones, medium grained siltstone and clay in the northern end of the project site, near Cabramatta Station, and Quaternary and Tertiary alluvial deposits consisting of silts, clays, fluvial sands and gravels in the rest of the project site.

Based on the geotechnical investigations undertaken to inform the design, the site is generally underlain by variable fill material of gravel, sand and clay, typically of a depth of one metre. The fill is underlain by a deep alluvial profile that generally consists of alluvial clay, extending to a depth of over six metres below ground surface within the project site.

12.2.2 Soils

12.2.2.1 Soil types

The following soil types underlie the project site:

- Blacktown residual landscape – mapped across the majority of the project site
- South Creek alluvial landscape – located along the floodplains of Cabramatta Creek.

As discussed above there is a substantial amount of fill material within the project site, including railway ballast and fill consisting of gravel, sand and clay.

12.2.2.2 Acid sulfate soils

Acid sulfate soils are naturally occurring soils containing iron sulfides, which, on exposure to air, oxidise and create sulfuric acid. This increase in acidity can result in the mobilisation of aluminium, iron, and manganese from the soils. The release of sulfuric acid and heavy metals to the environment can have potentially adverse effects on the natural and built environment as well as human health. The majority of acid sulfate soils are formed by natural processes under specific environmental conditions. This generally limits the occurrence of acid sulfate soils to low lying sections of coastal floodplains, rivers and creeks where surface elevations are less than 5.0 metres Australian Height Datum (AHD).

A review of the NSW Government Sharing and Enabling Environmental Data (SEED) website and both the Fairfield City Council and Liverpool City Council LEP acid sulfate soils maps indicated there are no known occurrences of acid sulfate soils (ASS) within the project site. Proposed signalling works located near Liverpool Station (refer to Figure 7.2) are in an area classified as Class 5, however acid sulfate soils are not typically found within Class 5 areas.

A review of ASRIS indicated that there was a low probability of acid sulfate soils occurring within the project site. The closest mapped occurrence of acid sulfate soils to the project site is about one kilometres east where Cabramatta Creek feeds into the Georges River.

12.2.2.3 Salinity

Areas prone to salinity are usually at low positions in the landscape, such as in valley floors and along floodplains. The Salinity Potential in Western Sydney map (2002) indicates that the project site is located in an area of moderate salinity potential. However, electrical conductivity testing undertaken as part of the geotechnical assessment found that the electrical conductivity of soils in the project site were significantly less than would be expected if the area contained saline soils (between 39 – 740 µS/cm compared to 4000 µS/Cm or over (DLWC, 2002)). Therefore the presence of saline soils within the project site is considered unlikely and has not been considered further in this assessment.

12.2.3 Areas of contamination concern

12.2.3.1 Sites listed or licensed by the EPA

No sites listed on the EPA's contaminated land register are located within one kilometre of the project site. Two sites which have been notified to the EPA are located within one kilometre of the site, as listed in Table 12.1.

Table 12.1 Sites notified to the EPA

Site	Address	Activity	Contamination status	Location in relation to project site
Caltex Service Station	168 John Street Cabramatta	Service Station	Regulation under CLM Act not required	100 metres west of Cabramatta Station
Warwick Farm Public School	95 Lawrence Hargrave Road, Warwick Farm	Former landfill	Under assessment	550 metres west of Peter Warren Automotive

A number of industrial premises or activities within one kilometre of the project site are either currently licensed by the EPA through provision of an environment protection license, or have previously been. These sites and activities are listed in Table 12.2 and include ARTC's and Sydney Trains' activities within the rail corridor.

Table 12.2 Industrial sites or activities currently or previously licensed by the EPA

License number	Address	Activity	License status	Location in relation to project site
3142	Australian Rail Track Corporation Limited	Railway systems activities	Active	On site
12208	Sydney Trains	Railway systems activities	Active	On site
372	Sydney Water Corporation	Sewage treatment processing by large plants	Active	590 m southeast
12535	CPB Contractors Pty Ltd	Liverpool – Ashfield pipeline. Sewage treatment processing by small plants	Surrendered	On site
12971	Australian Rail Track Corporation	Railway systems activities	Surrendered	On site
4653	Lurhmann Environnent Management Pty Ltd	Non-Scheduled Activity – application of pesticides	Surrendered	On site
4838	Robert Orchard	Non-Scheduled Activity – application of pesticides	Surrendered	On site
5150	Fairfield City Council	Non-Scheduled Activity – application of pesticides	Surrendered	Onsite
5176	Liverpool City Council	Non-Scheduled Activity – application of pesticides	Surrendered	On site
6630	Sydney Weed and Pest Management Pty Ltd	Non-Scheduled Activity – application of pesticides	Surrendered	On site
13316	John Holland Pty Ltd	Railway System Activities	Surrendered	504 m south

12.2.3.2 Other identified areas of contamination

Based on the land uses immediately surrounding the project site, as described in Chapter 2 (Location and setting) and Chapter 17 (Landscape and visual amenity), and the findings of the desktop review and site inspection, potential sources of contamination in the vicinity of the project site are considered to include:

- imported fill and ballast within the existing rail corridor – which may be associated with asbestos, hydrocarbons, heavy metals, and polycyclic aromatic hydrocarbons
- former rail haulage activities within the rail corridor leading to potential spillages of oils and lubricants from locomotive engines, metal dust and asbestos from wheel abrasion –which may be associated with asbestos, hydrocarbons, heavy metals, and polycyclic aromatic hydrocarbons
- unknown fill and waste materials within the road corridor – which may be associated with various hazardous materials, including asbestos, heavy metals, pesticides and hydrocarbons
- weed control within the rail corridor and in recreational areas including Jacquie Osmond Reserve and Warwick Farm Recreation Reserve – which may be associated with herbicides and pesticides
- industrial activities adjacent to the rail corridor – which may be associated with hydrocarbons, oils, chemical storage, heavy metals, and hazardous building materials. However, given the proximity to the project site and/or current status of the industrial activities identified in Table 12.1 and Table 12.2, the potential for contamination from the majority of these activities is considered to be low.

The limited contamination assessment found no evidence of staining or odour that may indicate the presence of contamination in any of the test pits or boreholes.

All samples reported laboratory results either below the limit of reliability or below the relevant human health based screening criteria. Additionally, the majority of samples reported laboratory results either below the limit of reliability or below the relevant environmental screening criteria, with the exception of some samples collected at locations within the rail corridor at the southern extent and within Broomfield Street. However, soil concentrations at these locations are not deemed to have the potential to impact ecological receptors given the current land use and distance to ecological receptors. Soil samples collected from test pits within Jacquie Osmond Reserve reported concentrations below the relevant environmental criteria.

The preliminary waste classification undertaken as part of the limited contamination assessment indicated that soils within the project site would likely meet the classification of General Solid Waste, in accordance with the NSW EPA *Waste Classification Guidelines Part 1: Classifying Waste* (EPA, 2014).

The limited contamination assessment confirmed that the soils are considered suitable to remain within the project site for the uses proposed during operation (rail corridor and road corridor). Based on the findings of the desktop review, site inspection and limited contamination assessment no evidence of gross or widespread contamination was identified within soils in the project site. Therefore, the project site is not considered to meet the criteria requiring it to be notified to the EPA under Section 60 of the *Contaminated Land Management Act 1997*.

No sampling of groundwater was undertaken as part of the assessment. However, based on the results of the limited contamination assessment which did not identify any gross contamination in soils, and the type and proximity of activities which have the potential to contaminate groundwater located near the project site, the potential for groundwater within the project site to be contaminated is considered low.

12.3 Assessment of construction impacts

Excavation and ground disturbance activities would expose and disturb soils, which, if not adequately managed, could result in:

- erosion of exposed soil and stockpiled materials
- dust generation
- an increase in sediment loads entering the stormwater system and/or local runoff, and therefore nearby receiving waterways, namely Cabramatta Creek and associated drainage lines
- increase in salinity levels in soil
- acid sulfate soil conditions
- mobilisation of contaminated sediments, with resultant potential for environmental and human health impacts.

Potential impacts as they relate to soils and contamination are considered below. Potential water quality impacts, including impacts caused by increased sediment loads, are considered in Chapter 13 (Hydrology, flooding and water quality), air quality (dust) impacts are considered in Chapter 10 (Air quality), and health and safety risks, including as a result of contamination and hazardous materials, are considered in Chapter 20 (Health, safety and hazards).

12.3.1 Soils

12.3.1.1 Soil erosion

Construction of the project would temporarily expose the natural ground surface and sub-surface through the removal of vegetation and excavation and/or the removal of hardstand surfaces including roads and footpath during the following construction activities:

- earthworks associated with construction of the retaining walls and embankment, bridges, road works and ancillary infrastructure
- clearing/grubbing of trees and vegetation along Broomfield Street, near Cabramatta Creek and in Jacquie Osmond Reserve.

These activities can lead to exposure of soil to runoff and wind which can increase soil erosion potential, particularly where construction activities are undertaken in soil landscapes characterised by a high and extreme erosion hazard. Of the soil landscapes present within the project site the Blacktown residual landscape can range from low to very high erosion hazard, while the South Creek alluvial landscape has potentially a very high to extreme erosion hazard.

Soil erosion impacts are expected to be minimal for the project as a result of the relatively limited areas of excavation and earthworks, the generally flat topography of the project site, and the temporary nature of exposure.

Regardless of the amount of excavation required, the potential for erosion impacts would be minimised by implementing standard soil erosion management measures during construction, as described in section 12.5.

12.3.1.2 Acid sulfate soils

Sulfuric acid is produced when drainage or excavation brings soils to the surface that were previously located below the water table. Previous investigations undertaken as part of the SSFL EIS (Parsons Brinckerhoff, 2009), identified groundwater depths ranging from three metres below ground surface near the southern end of the project site to 0.5 metres below ground surface near Cabramatta Creek in the centre of the project site, and two metres below ground surface at the northern end. However, during the geotechnical investigation undertaken to inform the project's design, groundwater was only identified in locations in the south of the project site at depths between three and six metres below ground surface. It would be expected that groundwater levels would be shallower near Cabramatta Creek.

The majority of excavation during construction is unlikely to exceed depths of two to three metres below ground surface. Therefore, the potential to encounter water logged soils would only be likely during piling activities associated with the retaining walls and bridge construction and underboring associated with relocation of the Sydney Water gravity main.

12.3.1.3 Contamination

Excavation may disturb any contamination and hazardous materials present in soil. If inadequately managed, the disturbance of areas of contamination has the potential for:

- direct contact and/or inhalation by site workers, users, and visitors
- impacts to surrounding environmental receivers (including surrounding ecosystems and flora and fauna, where present)
- mobilisation and migration of surface and subsurface contaminants via leaching, runoff and/or subsurface flow, impacting nearby soils, surface water, and groundwater.

Based on the results of the desktop review and limited contamination assessment the potential to disturb contamination resulting in impacts to human health and the environment is considered low. Regardless, the potential for the impacts due to the potential disturbance of contamination would be minimised by implementing the mitigation measures provided in section 12.5.

Construction activities have the potential to result in the contamination of soil and groundwater due to spills and leaks of fuel, oils, and other hazardous materials. In addition, there is the potential to introduce contamination to the project site through the acceptance of imported fill that has not been properly verified. These potential impacts would be minimal with the implementation of standard mitigation measures, provided in section 12.5.

12.3.2 Site assessment and remediation

The limited contamination assessment confirmed that the soils are considered suitable to remain within the project site for the uses proposed (rail corridor and road corridor). Although it should be noted, sampling was not undertaken in accordance with the *Contaminated Sites Sampling Design Guidelines* (EPA, 1995). Therefore, the findings of the limited contamination assessment can only be used to determine the presence of gross contamination within the project site.

Based on the findings of the limited contamination assessment, the project site does not meet the criteria requiring it to be notified to the EPA under section 60 of the CLM Act and further assessment or remediation of soils within the project site is not required as part of the project.

12.3.3 Cumulative impacts

Cumulative impacts may result from the disturbance of soils and contamination from other projects occurring concurrently to the project, resulting in an increased potential for the mobilisation of contaminated sediments, and an increase in erosion and hence sediment loads entering nearby receiving waterways. Other projects that have the potential to occur at the same time as the project and in the vicinity of the project are described in Appendix E.

The potential for impacts due to erosion and sedimentation would be readily managed with the implementation of standard erosion and sedimentation control measures. As such, it is not expected that the project would have a material impact on erosion and sedimentation at the scale that cumulative impacts could occur.

The overall risk of encountering or generating contamination is low, and the project would be unlikely to generate impacts at a scale that would interact with other projects.

12.4 Assessment of operation impacts

12.4.1 Soils

Maintenance and repair activities may require excavation and ground disturbance, which could result in short-term impacts similar to those described in section 12.3.1. These impacts would be managed by implementing the mitigation measures described in section 12.5 ARTC's Environmental Management System contains processes such as the Task Based Environmental Impact Assessment (TBEIA), where the risk of contamination is considered prior to activities which would require excavation and ground disturbance. ARTC's contaminated land database and map provides information for these risks to be considered on a site specific basis. In addition, ARTC's standard operating procedures provide sufficient guidance on managing risks as they relate to maintenance activities on potentially contaminated lands.

During operation, there is a risk of accidental spillage of petroleum, chemicals or other hazardous materials as a result of leakages during maintenance activities or rail accidents. Spills could contaminate soils and pollute downstream waterways and groundwater if unmitigated. The potential for contamination is considered to be low, based on the amount of vehicles and equipment which would likely be used during maintenance related activities. This impact would be minimised by implementing existing ARTC procedures to manage spills.

12.4.2 Cumulative impacts

Given that any maintenance activities would likely be limited in nature and extent the potential for cumulative impacts due to maintenance activities during operation would be negligible.

12.5 Management of impacts

12.5.1 Approach

12.5.1.1 Approach to mitigation and management

Soil

Construction erosion and sediment control measures would be developed and implemented in accordance with *Managing Urban Stormwater: Soils and Construction Volume 1* (Landcom, 2004) and *Managing Urban Stormwater: Soils and Construction Volume 2A* (Department of Environment and Climate Change, 2008), (commonly known as 'the Blue Book').

A soil and water management plan would be prepared as one of the components of the CEMP. The soil and water management plan is required to define the management and monitoring measures that would be implemented to manage, in accordance with relevant guidelines:

- surface and groundwater impacts

- contaminated material
- erosion and sediment control.

Further information on the approach to environmental management during construction is provided in section 22.2.

Auditing and monitoring would be undertaken during construction to ensure that the CEMP and relevant sub-plans are being implemented.

Contamination

An unexpected finds protocol would be developed as part of the soil and water management sub-plan to ensure that any unexpected contamination encountered during construction does not expose workers, site users, and/or the environment to contamination in excess of regulatory guideline levels.

The unexpected finds protocol would outline the activities to be undertaken in the event that previously undetected contamination is identified, which would include making the site safe, carrying out an assessment of the finds, and managing the finds based on the results of the assessment.

A waste management procedure would also be developed as part of the CEMP, as described in Chapter 19 (Waste management).

Health and safety risks to on-site workers associated with normal construction operations are regulated by workplace health and safety legislation (including the *Work Health and Safety Act*, 2011), and are not relevant to approval of the project under Division 5.2 of the EP&A Act. In accordance with relevant workplace health and safety regulatory requirements a health and safety plan would be prepared for the project and would also include measures to help minimise the exposure of workers to potentially contaminated soil, including material containing asbestos, if encountered.

Further information on the approach to environmental management during construction is provided in Chapter 22 (Approach to environmental management).

Expected effectiveness

For impacts associated with soil the erosion and sediment control measures to be implemented would be in accordance with the requirements of the Blue Book. The measures contained in the Blue Book are based on field experience and have been previously demonstrated to be effective. In general, the implementation of measures in accordance with the Blue Book would either result in a reduced potential for the impact to be realised through either the use of engineered controls (eg hay bales, covers on stockpiles etc) or avoidance completely (eg not undertaking works during wet weather). Therefore, there is no reason the proposed mitigation measures should not be moderately to highly effective, if implemented in strict accordance with the Blue Book.

For impacts associated with contamination the implementation of management measures proposed including an unexpected finds protocol and spill procedures to manage spills would reduce the impact. However, given that the unexpected finds protocol relies on a person's ability to identify contamination and spills management would still result in some impact, these measures are considered moderately effective.

12.5.2 List of mitigation measures

The mitigation measures that will be implemented to address potential soils and water quality impacts are listed in Table 12.3.

Table 12.3 Mitigation measures

Stage	Impact	Measure
Construction	General soil and erosion management	A soil and water management plan will be prepared as part of the CEMP for the project and implemented for the duration of construction, in accordance with

Stage	Impact	Measure
		Soils and Construction - Managing Urban Stormwater Volume 1 (Landcom, 2004) and Volume 2D (DECC, 2008a) (commonly known as 'the Blue Book) The soil and water management plan will include but not be limited to: • a primary erosion and sedimentation control plan and a maintenance schedule for ongoing maintenance of temporary erosion and sediment controls. The erosion and sedimentation control plan will include site-specific details for managing sediment and erosion near Cabramatta Creek and associated drainage lines • measures and controls for the management of disturbed and stockpiled soils, including surface stabilisation of disturbed ground, covering of stockpiles where appropriate and implementation of clean-water diversions • an incident emergency spill procedure which will include measures to avoid spillages of fuels, chemicals, and fluids onto any surfaces or into any adjacent/nearby waterways.
	Acid sulfate soils	A field pH testing and field peroxide pH testing regime will be undertaken prior to piling work around Cabramatta Creek, in accordance with the *Acid Sulfate Soils Assessment Guidelines* (ASSMAC, 1998). Should ASS or potential ASS be identified during the testing, then measures to manage the potential impacts associated with encountering ASS or potential ASS will need to be developed and implemented in accordance with the *Acid Sulfate Soils Assessment Guidelines* (ASSMAC, 1998).
	Unexpected contamination	An unexpected findings protocol pertaining to contamination will be included in the soils and water management plan. The protocol will include procedures for the assessment and management of unexpected contamination encountered (if any) during construction.
	Unexpected contamination	Awareness training will be provided for all onsite staff to assist in the identification of potentially contaminated material. In the event that indicators of contamination are encountered during construction (such as odours or visually contaminated materials), work in the area will cease, and the finds will be managed in accordance with the unexpected contamination finds protocol.
	Contamination of soils	Prior to the acceptance of any imported fill onsite (regardless of volume), the following actions will be taken to reduce the risk of receiving contaminated material: • all fill used will be checked to confirm it is virgin excavated natural material (VENM) (e.g., clay, gravel, sand, soil or rock) or excavated natural material (ENM) (e.g. naturally occurring rock and soil) that is not mixed with any other waste • the supplier will provide formal certification that the fill material is clean VENM or ENM • the supplier will provide information on what activities previously occurred onsite where their fill was sourced • signs of contamination will be checked for, such as odours (chemical/petrol), staining from chemicals, and rubbish such as bricks, timber, and masonite • the delivery of the material will be supervised to check the material received matches the material ordered. • all required documents and records will be maintained.

Stage	Impact	Measure
	Contamination incident management	Spill containment kits will be present and maintained on site during all activities.
	Contamination incident management	All staff will be inducted about incident and emergency procedures in accordance with the incident emergency spill procedure and made aware of the locations of spill containment kits. Information regarding the correct and safe storage and handling of fuels and chemicals will be communicated to personnel.
Operation	Soil erosion and sedimentation	Erosion and sediment controls will be implemented during maintenance activities where soils are exposed, in accordance with ARTC's standard environmental management measures included within its Environmental Management System.
	Contamination	ARTC's existing spill response procedures will be complied with to minimise the potential for impacts on the local community and the environment as a result of any leaks and spills. Additionally, leaks and spills will be managed in accordance with ARTC's EPL #3142.

12.5.3 Consideration of the interaction between measures

There are interactions between the mitigation measures for soils and contamination (summarised in section 12.5.2) and those for water quality (Chapter 13), waste (Chapter 19), and hazardous materials (Chapter 20). Together, all these measures would ensure appropriate management of soil and potentially contaminated soils and groundwater, to minimise the potential for impacts to the community and environment.

The implementation of erosion control measures and devices during construction has the potential to result in some potential impacts on overland flow paths (as discussed in Chapter 13 (Hydrology, flooding and water quality)). Impacts on overland flow paths are considered to be manageable, as all measures would be installed in accordance with the Blue Book.

12.5.4 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. The mitigation measures provided in section 12.5.2 are expected to reduce the potential for soil and contamination impacts during construction and operation. With the implementation of these measures, residual impacts are expected to be minimal.

THIS PAGE HAS BEEN LEFT INTENTIONALLY BLANK

13 Hydrology, flooding and water quality

This chapter provides a summary of the hydrology, flooding and water quality impact assessments undertaken by GHD. A full copy of the assessment reports is provided as Technical Report 5 – Hydrology and flooding impact assessment and Technical Report 7 – Surface water and groundwater quality impact assessment, respectively. The report was written to address the relevant SEARs which are outlined in Appendix A.

13.1 Assessment approach

13.1.1 Methodology

13.1.1.1 Study area

The study area includes the entire Cabramatta Creek catchment including upstream areas and continuing downstream to the confluence with the Georges River.

13.1.1.2 Hydrology and water quality

The hydrology and water quality assessment involved:

- reviewing background information relevant to the study area to define the existing environment, including previous studies, mapping, survey data, and topography
- identifying water quality objectives for the catchment in which the project site is located, based on the NSW Water Quality and River Flow Objectives website
- identifying and assessing construction and operational activities that may impact on the surface water hydrology and water quality of watercourses within the study area
- calculating groundwater inflows for construction elements that may intercept groundwater using the analytical equations and approach outlined in Marinelli and Niccoli (2000)
- identifying potential impacts on groundwater
- identifying mitigation measures to minimise potential impacts on surface water and groundwater hydrology and water quality.

13.1.1.3 Water quality objectives and criteria

The NSW Water Quality and River Flow Objectives provide water quality objectives for the Georges River catchment (the downstream receiving waterway for flows from Cabramatta Creek), for the protection of the following (within waterways affected by urban development, or estuaries):

- aquatic ecosystems
- visual amenity
- secondary contact recreation
- primary contact recreation.

Waterways affected by urban development are defined as streams within urban areas, which are frequently substantially modified and generally carry poor quality stormwater. The majority of watercourses within the study area meet this definition.

The water quality objective for aquatic ecosystems is to 'maintain or improve the ecological condition of waterbodies and their riparian zones over the long term'. The indicators and criteria (trigger values) for this objective are listed in Table 13.1. While it is likely that watercourses within the study area would be classified as highly disturbed systems (being urban streams receiving road and stormwater runoff), the ANZECC 2000 guidelines recommend that the guideline trigger values for slightly to moderately disturbed systems should also

apply to highly disturbed ecosystems wherever possible. Therefore, the water trigger values provided in Table 13.1 are based on the ANZECC 2000 guideline default trigger values for the protection of aquatic ecosystems in slightly disturbed river ecosystems in south-eastern Australia.

A detailed list of the indicators and criteria for the other water quality objectives for the Georges River catchment is provided in Technical Paper 7.

Table 13.1 Water quality trigger values for aquatic ecosystems

Indicator	Criteria (lowland rivers)
Total phosphorus	25 ug/L
Total nitrogen	350 ug/L
Chlorophyll-a	5 g/L
Turbidity	6-50 NTU
Salinity (electrical conductivity)	125-2,200 uS/cm
Dissolved oxygen (per cent saturation)	85-110%
pH	6.5-8.5

13.1.1.4 Flooding

The project involves providing new rail and road infrastructure in an area subject to existing flooding. As a result a flooding assessment was undertaken as an input to the design of the project. The flooding assessment involved:

- a desktop review of:
  - flood studies and floodplain risk management studies, including Georges River Floodplain Risk Management Study and Plan (Bewsher Consulting Pty Ltd, 2004), Cabramatta Creek Flood Study and Basin Strategy Review (Liverpool City Council, 2011) and Georges River Floodplain Risk Management Study & Plan (Georges River Floodplain Management Committee, 2004)
  - existing and future flooding conditions
  - existing drainage infrastructure.
- hydraulic modelling to quantify flood behaviour, using ground survey undertaken during design development and the existing Cabramatta Creek flood model provided by Liverpool City Council, and updating it to reflect changes to the area as a result of the project, including the addition of structures such as the bridges and the Broomfield Street drainage infrastructure
- assessing flooding impacts and risks associated with the project which involved:
  - updating the existing TUFLOW flood model from Liverpool City Council to simulate a post development scenario for a range of different annual exceedance probability (AEP) storm events
  - comparing the flood impacts against the base case scenario to identify the extent of the flood impacts
  - identifying any potential impacts on flooding during construction stage
  - identifying any potential impacts on flooding of neighbouring properties and assets due to changes to ground levels.
- developing measures to minimise potential changes to the flood regime as a result of the project.

To assess the potential impacts associated with constructing the bridges and other structures near Cabramatta Creek a full range of flooding events, from the 0.2 per cent to the five per cent AEP event, were modelled for the existing case and the developed case (what would occur with the project in place). The AEP represents the

likelihood of occurrence of a flood of given size or larger occurring in any one year. A one per cent AEP event is a rainfall event with a one per cent chance of being exceeded in magnitude in any year. Modelling of existing and developed case flood conditions was also undertaken for the one per cent AEP event, with a ten per cent allowance for an increase in peak rainfall intensity (to account for climate change). This is referred to as the one per cent AEP climate change event. Additionally the probable maximum flood (PMF) event was modelled for the existing and developed case. The PMF is considered to be the worst case flood event for an area. The PMF represents extreme flooding conditions and defines the extent of flood prone/liable land.

In addition, the one per cent, five per cent and ten per cent AEP flooding events were modelled for the existing case and developed case for drainage in Broomfield Street (due to the road realignment works), to assess compliance with the flooding criteria adopted for the project.

The flooding criteria that has been adopted the project against which flooding impacts have been assessed, is summarised in Table 13.2. This flooding criteria has been adopted based on current practices for similar infrastructure projects in an urban setting and aims to minimise impacts on surrounding properties, taking into consideration the current flood affectation of that property.

Table 13.2 Design criteria for flooding impacts on adjoining lands

Flooding characteristics	Proposed criteria
Duration of flooding during a one per cent AEP event	Maximum increase in flood duration of on hour
Maximum increase in flood level at properties where flood levels are already exceeded during the one per cent AEP event	10 millimetres
Maximum increase in flood level at properties where flood levels are currently not exceeded during the one per cent AEP event	50 millimetres

13.1.2 Risks identified

The preliminary environmental risk assessment undertaken for the project included potential risks associated with hydrology, flooding and water quality. 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 potential hydrology, flooding and water quality risks ranged from low to high. Risks with an assessed level of medium or above include:

- presence of or change to structures associated with the project could impact upstream and downstream local flood behaviour
- blockages of flow paths affecting low flows through construction within Cabramatta Creek and through erosion and sedimentation control structures
- sedimentation and changes to geomorphology (aggradation in bed channels) in Cabramatta Creek
- impacts on upstream and downstream drainage due to the introduction of built structures such as the Jacquie Osmond embankment and bridges
- reduced water quality (increased total suspended solids and turbidity) due to earthworks and erosion and sedimentation near watercourses
- impacts on water quality from contamination from spills and leaks during construction and operation
- impacts on groundwater quality and quantity during drawdown/extraction
- impacts on water quality from discharge of excess water from dewatering
- impact to surface water quality and receiving environments due to increased runoff from increase in impervious surfaces.

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 Chapters 3 (Approval and assessment requirements) and Chapter 4 (Consultation).

13.1.3 How potential impacts have been avoided/minimised

As described in Chapter 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 hydrology, flooding and water quality impacts have been avoided/minimised where possible by:

- designing the new bridge over Cabramatta Creek so that it matches the pier arrangement of the existing bridge to minimise hydraulic impacts on flow along the creek and associated potential for water quality impacts
- designing the new bridge to minimise the footprint of the project in this area
- designing drainage infrastructure for Broomfield Street to match the existing conditions.

13.2 Existing environment

13.2.1 Catchments and watercourses

The project site is located in the Cabramatta Creek catchment, which has an area of about 74 square kilometres. Most of the catchment is located within the Liverpool LGA, however the northern side of Lower Cabramatta Creek is located with the Fairfield LGA and a small proportion of the upper catchment is also located within the Campbelltown LGA.

Major tributaries of Cabramatta Creek include:

- Hinchinbrook Creek
- Maxwells Creek
- Brickmakers Creek.

The Cabramatta Creek catchment and watercourses in the area are shown on Figure 13.1. This figure also shows the stream order of watercourses in the area (based on the Strahler stream classification system). Stream order is a measure of the relative size of the watercourse, with a first order stream being the largest and a fifth order being the smallest.

Cabramatta Creek begins in the rural/residential suburb of Denham Court, located at the southern extent of the catchment boundary. From there it flows in a northerly direction towards Hoxton Park. The Cabramatta Creek and Carnes Hill Urban Release Areas are located within the Upper Cabramatta Creek subcatchments and substantial residential development has already occurred in these areas.

Cabramatta Creek then flows in an easterly direction towards the Fairfield LGA and the creek's confluence with Georges River. Within the lower catchment, a more prominent creek corridor becomes evident (up to 200 metres wide). This area primarily consists of public open space, playing fields and golf courses.

Cabramatta Creek flows through a number of established suburbs including Miller, Cartwright, Sadler, Ashcroft, Mount Pritchard and Warwick Farm. Major transport (road and rail) routes that cross the catchment include Hoxton Park Road, Elizabeth Drive, the Cumberland Highway, the Hume Highway and the SSFL and Main Southern railway line.

Tributaries of the creek have been modified from their natural state. This includes Maxwells Creek which has been turned in to a grassed trapezoidal channel downstream of Jedda Road, continuing through to the confluence with Cabramatta Creek.

At the location where the project site crosses Cabramatta Creek, the creek is a fifth order stream.

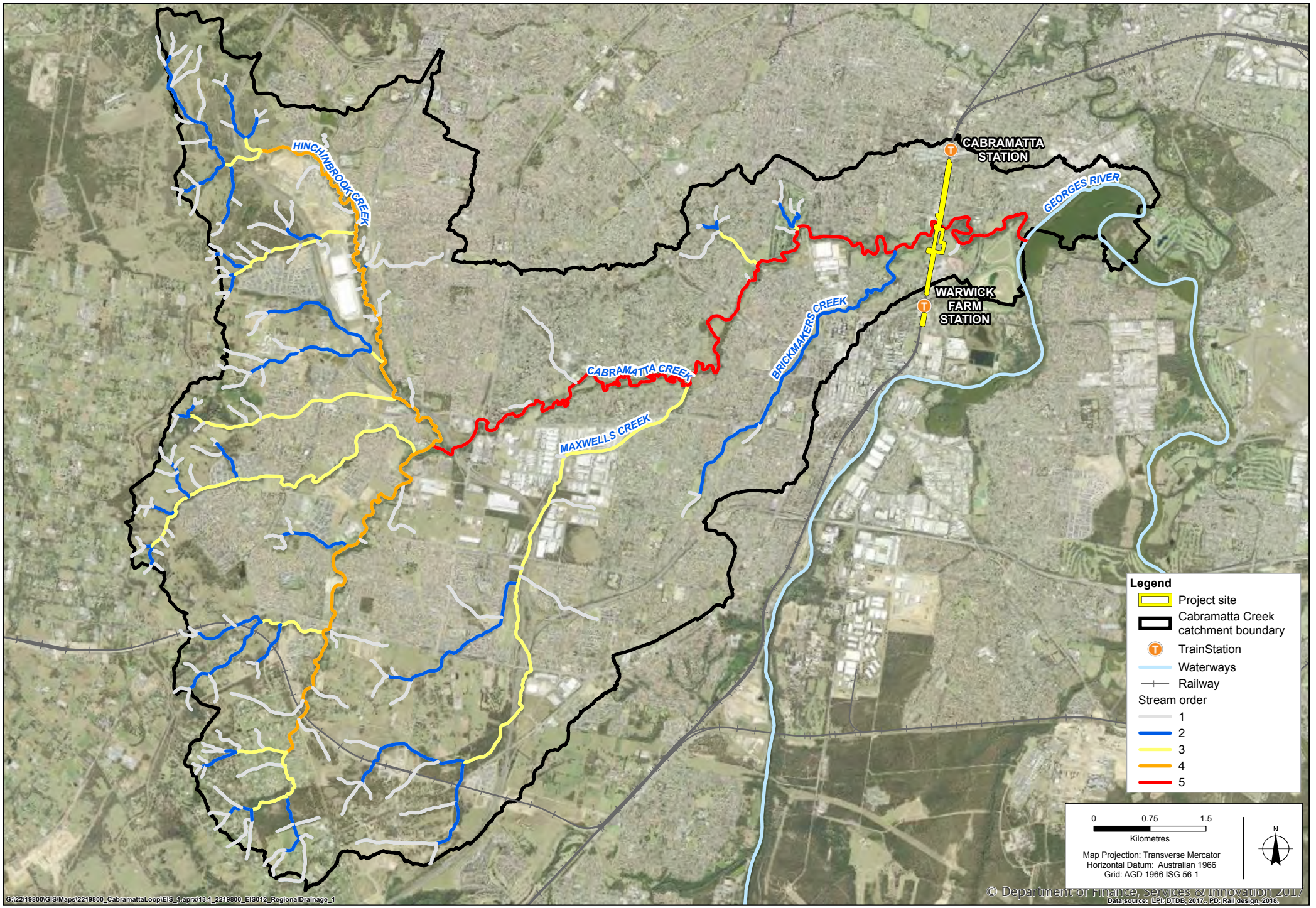

Figure 13.1 Catchment area and watercourse locations

13.2.2 Existing flooding and drainage conditions

The Cabramatta Creek catchments is typical of many urbanised catchments in that the predominance of impervious surfaces means that rainfall is quickly converted into surface water runoff. The rainfall runoff response means that floods may develop quickly following the onset of intense rainfall events. Flood waters in the main Cabramatta Creek rise within a matter of hours following the onset of intense rainfall, making advance warning difficult.

The rail corridor has a track drainage system that conveys water to the local drainage network and then to Cabramatta Creek where it drains to Georges River and Botany Bay. Drainage within the rail corridor consists of a number of open drainage channels that drain in to the track drainage network. The open channels are both earth lined and concrete open dish drain type elements. The capacity of the existing elements within the rail corridor is currently unknown but they only cater for rainfall runoff that falls within the rail corridor.

Drainage within Broomfield Street consists of a stormwater drainage line that collects and conveys stormwater runoff from the immediate surrounding area as well as runoff from the rail corridor. The drainage line discharges at the southern end of Broomfield Street to an open channel, located adjacent to 10 Sussex Street, which discharges to Cabramatta Creek.

13.2.3 Surface hydrology and identified project-specific flooding conditions

The extent and depth of existing flooding for the one per cent AEP climate change event and the PMF is shown in Figure 13.2 and Figure 13.3, respectively.

The mapping shows that the project site, from the Cabramatta Road West overbridge to the Hume Highway overbridge, is affected by flooding from Cabramatta Creek during the 0.5 per cent AEP flood event and above. The majority of the project site is located within a high flood risk precinct, and in Jacquie Osmond Reserve flood levels during the one per cent and five per cent AEP flood events are about 7.2 metres Australian Height Datum (AHD) and 6.2 metres AHD, respectively.

During the one per cent and five per cent flood events, houses on the following streets have existing flooding issues:

- Sussex Street
- Church Street
- Broomfield Street
- Railway Parade
- Lawrence Hargrave Road.

The rail corridor is largely unaffected by flooding except in rare events.

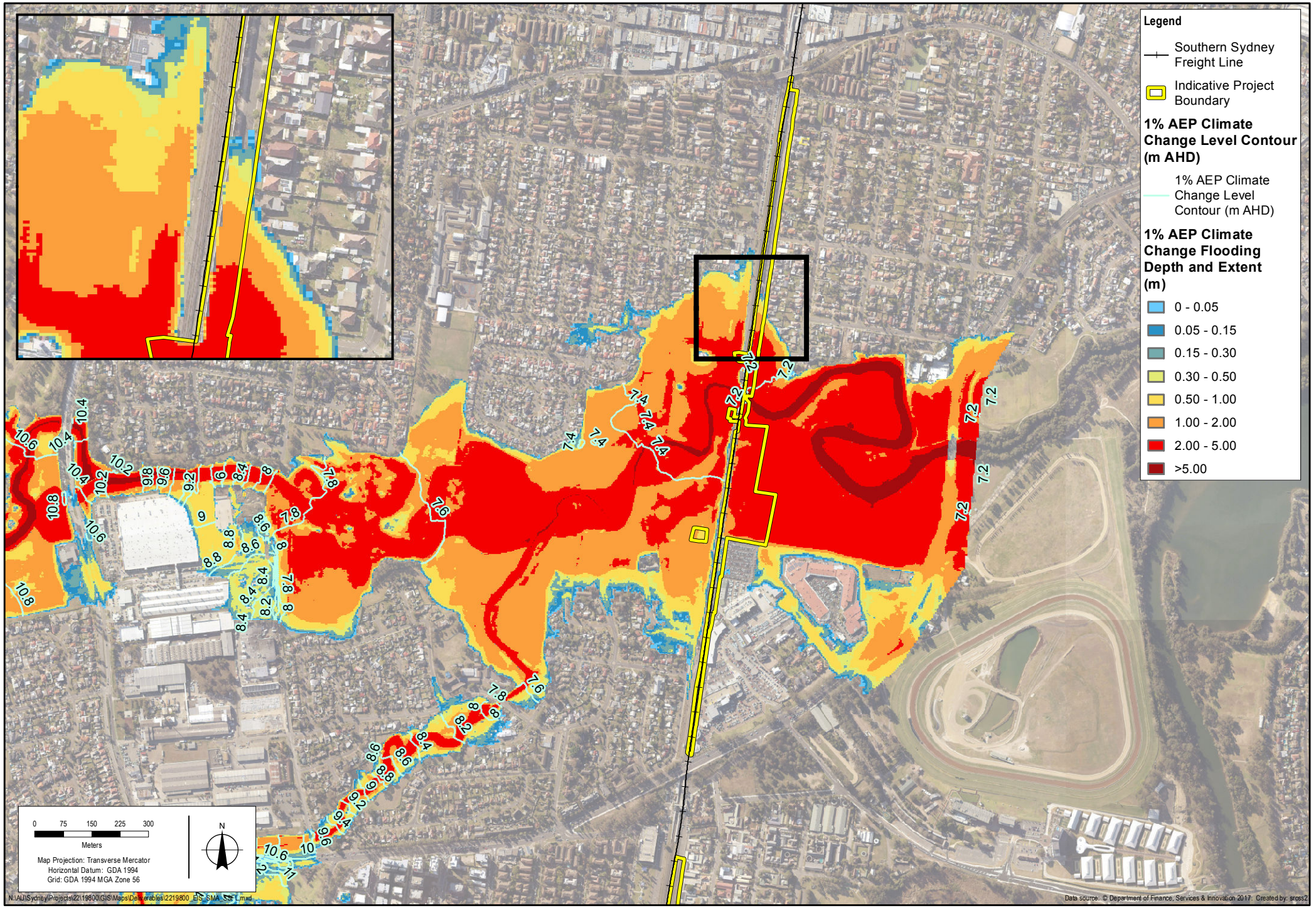

Figure 13.2 - Existing flood depth and extent – one per cent AEP plus climate change

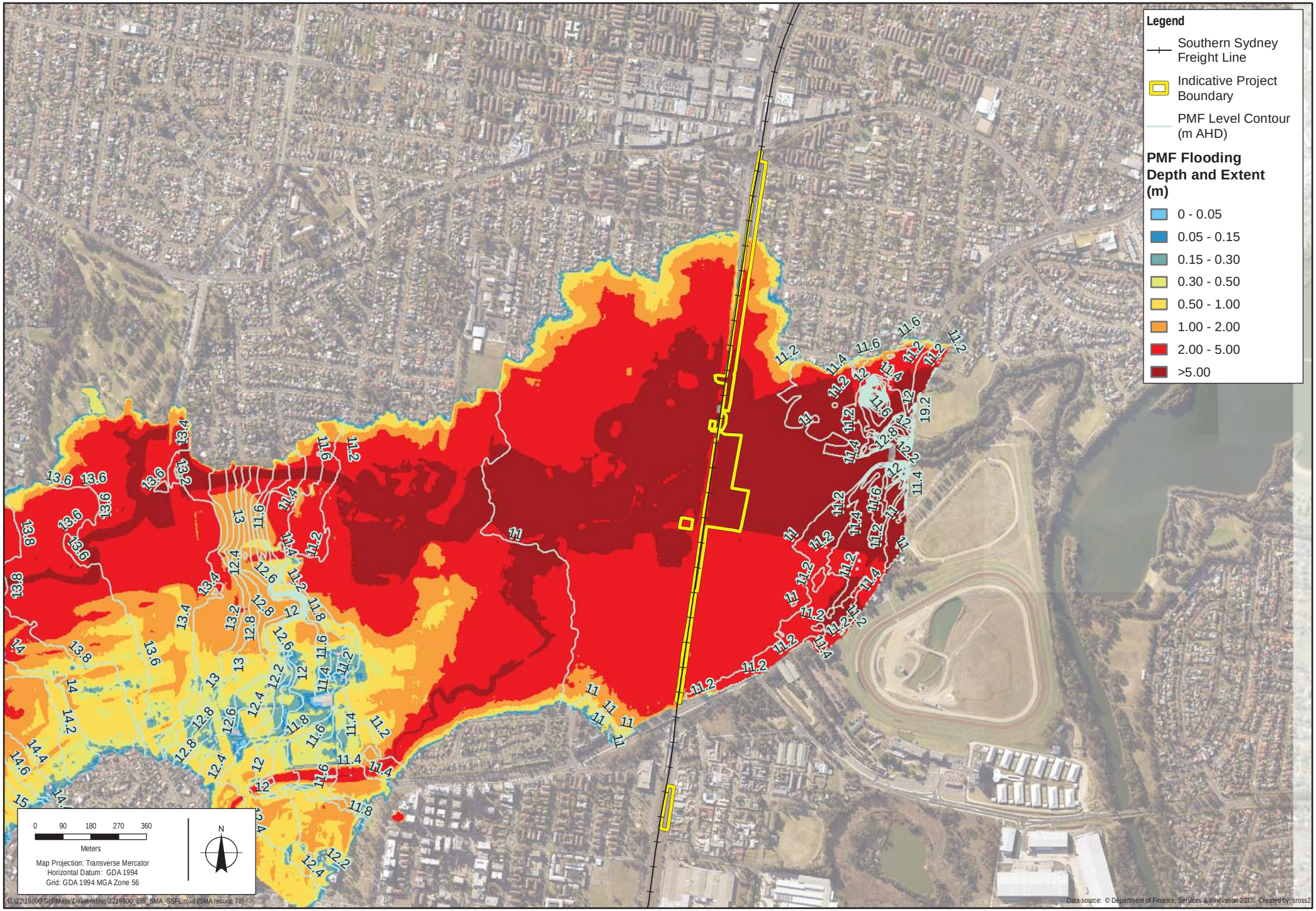

Figure 13.3 – Existing flood depth and extent – probable maximum flood

13.2.4 Water quality

According to the *Cabramatta Creek Floodplain Management Study and Plan* (Bewsher, 2004), Cabramatta Creek was noted to have the poorest water quality in the Georges River system in 2004. The major sources of pollution in Cabramatta Creek includes urban runoff and sewage effluent, most likely due to sewage overflows from the sewerage system during wet weather.

Detailed water quality monitoring data specific to the project site was not identified during the desktop review. However, the most recently available local report, the *2016-2017 River Health Report Card for the Georges River* (Georges River Combined Councils Committee (GRCCC), 2018), identified the overall water quality health of Lower Cabramatta Creek as "good" (A-) which is considered 'good' as defined by the GRCCC when assessing against environmental guidelines.

13.2.4.1 Sensitive receiving environments

A sensitive receiving environment is one that has a high conservation value, or supports human uses of water that are particularly sensitive to degraded water quality (DECC, 2008). With regard to the study area, sensitive receiving environments are considered to include:

- threatened ecological communities associated with aquatic ecosystems
- known and potential habitats for threatened fish
- Key Fish Habitats
- recreational swimming areas
- areas that contribute to drinking water catchments.

Cabramatta Creek is mapped as Key Fish Habitat, however, as described in the biodiversity development assessment report (Technical Report 4- Biodiversity development assessment report) it does not comprise habitat for any threatened species. The other watercourses in the study area are considered unlikely to contain any significant sensitive environments.

13.2.5 Groundwater

During a geotechnical investigation undertaken to inform the project design groundwater levels in boreholes drilled between Jacquie Osmond Reserve and the southern extent of the project site ranged from three metres to six metres below ground level (mbgl). Previous geotechnical investigations (Parsons Brinckerhoff, 2009) undertaken within the project site identified groundwater in the northern section at depths of between 1.5 to 2 mbgl, decreasing to 0.5 mgbl in the vicinity of Cabramatta Creek, and increasing to a depth of 3 mbgl south of the creek near Peter Warren Automotive. In the southern end of the site between Jacquie Osmond Reserve and Warwick Farm Station, alluvial groundwater flow is to the south based on monitoring of groundwater levels during the geotechnical investigation, while in the rest of the project site alluvial groundwater flow is expected to be towards Cabramatta Creek.

A search of the NSW Water Register was undertaken on 7 September 2018 to identify existing users and extraction rates. The search identified 28 registered bores within approximately 1,500 metres of the project site. The majority (22) were registered as monitoring bores. Of the remaining bores, two were identified as registered for groundwater exploration and irrigation and two for recreation. The two irrigation bores are located in Warwick Farm Racecourse to the east of the site. The two bores registered for recreation are located on the eastern side of the Georges River.

Quaternary and Tertiary alluvium underlies the Cabramatta Creek and its tributaries and forms an aquifer. Groundwater salinity within the Quaternary and Tertiary alluvium is expected to vary from lower salinity in the upper reaches of the Cabramatta Creek, to higher salinity in the lower reaches due to mixing and tidal influences.

The NSW Groundwater Quality Protection Policy outlines a number of beneficial use categories for groundwater resources. Based on the groundwater quality, the beneficial use of groundwater resources can be classified as ecosystem protection (environmental water), recreation, drinking water, agricultural water or industrial water.

While there is no groundwater quality data available as part of this assessment, a beneficial use category has been assigned based on potential groundwater receptors. Based on a review of groundwater receptors groundwater use within and surrounding the project site is expected to be limited and the primary beneficial use of groundwater in the vicinity of the site would be environmental (i.e. providing base flow to waterways).

13.3 Assessment of construction impacts

13.3.1 Flooding

13.3.1.1 Impacts on flood behaviour and overland flows during construction

The majority of construction activities and the presence of construction compounds and work sites have the potential to impact local overland flows and flood behaviour. Runoff or rainfall within the project site has the potential to cause localised flooding issues and adverse downstream impacts if not appropriately managed.

Potential impacts on flood behaviour and overland flows include:

- changed flood behaviour due to the construction of Cabramatta Creek bridge
- blocking of drainage networks through increased sedimentation of surface water
- interruption of overland flow paths by the installation of temporary construction ancillary facilities, erosion and sediment controls or construction hoarding
- changed flood behaviour as a result of changes to site topography and installation of temporary buildings/site offices and other structures within the floodplain, resulting in increased flooding of adjacent areas due to temporary loss of floodplain storage or conveyance of floodwaters
- small increase in impervious areas, including from site compounds and work sites, which would have the potential to increase the volume of water flowing to watercourses.

During construction, there may also be a need to temporarily disconnect or divert existing stormwater drainage pipes if:

- existing drainage pipes are interfering with proposed railway corridor works
- there are constructability issues with constructing new infrastructure
- possible safety concerns during construction.

This could result in localised modifications to existing flooding patterns, flow volumes, and velocities, which could also result in the scouring of downstream areas, particularly where soil has been exposed during construction.

Any flood impacts during construction are expected to be localised and relatively minor and would be effectively managed through the implementation of mitigation measures provided in section 13.5. The locations of compounds, work sites and undertaking of activities within designated flood hazard areas would not result in flood affectation of other properties, assets and infrastructure.

13.3.1.2 Impacts of flooding on construction

Works in Jacquie Osmond Reserve and near Cabramatta Creek, including the presence of compounds C2 and C3 and works W1 to W3 sites, would be undertaken where there is an existing flood hazard.

Flooding during construction could impact the following:

- safety of workers
- integrity of erosion and sediment control measures
- access to work and compound sites
- plant and equipment used during construction
- temporary drainage structures

- integrity of material stockpiles.

The layout of construction compounds and work sites would be undertaken with consideration of overland flow paths and avoid flood liable land where practicable. The location of compounds and work sites would be reviewed during construction planning to avoid, where possible, high hazard areas. Following completion of construction, no further impacts would occur.

13.3.1.3 Consistency with Council floodplain risk management plans

The *Georges River Floodplain Risk Management Study and Plan* (Bewsher, 2004) and the *Cabramatta Creek Flood Study and Plan* (Bewsher, 2004) discussed a number of potential floodplain management measures. However, no specific measures were recommended within the project site. Therefore, construction of the project would not prevent or comprise any of the works proposed in these plans. The construction works are therefore considered to be consistent with Council's floodplain risk management plans.

13.3.1.4 Impacts on existing emergency management arrangements

With the implementation of mitigation measures provided in section 13.5, no impacts on existing emergency management arrangements are expected during construction. Ongoing liaison with NSW SES and relevant stakeholders would be undertaken during detailed design and the construction period to achieve this.

13.3.2 Hydrology

13.3.2.1 Groundwater

The majority of construction activities are not expected to be greater than 3 metres in depth and are therefore not expected to intercept groundwater. The exception to this is piling as part of construction of new bridges over Sussex Street and Cabramatta Creek, the bored pile retaining wall from Bridge Street to Sussex Street Bridge and underboring as part of the relocation of the Sydney Water rising main in Jacquie Osmond Reserve. Dewatering would be undertaken during these activities to facilitate the works.

Due to the generally clayey, low yielding nature of the alluvial aquifer, the alluvial aquifer has been classified as a less productive fractured rock groundwater source under the NSW Aquifer Interference Policy. The NSW Aquifer Interference Policy requires that potential impacts on groundwater sources, be assessed against the minimal impact considerations outlined in the policy. If the predicted impacts are less than the Level 1 minimal impact considerations for less productive fractured rock groundwater sources, then the potential groundwater impacts of the project are acceptable.

Based on calculations undertaken as part of the groundwater assessment within Technical Report 7, it is predicted that the groundwater impacts from the project would be less than the Level 1 minimal impact considerations specified in the NSW Aquifer Interference Policy. The project is not predicted to result in any decline in groundwater pressure or groundwater head at any water supply work and is not predicted to alter the beneficial use of the alluvial groundwater. There are no culturally significant sites or groundwater dependant ecosystems in or immediately near the study area. Further information is provided in section 5.3 of Technical Report 7.

Piling works as part of the construction of Cabramatta Creek could result in the connection of surface water with deeper aquifers during pile shaft excavation, depending on the depth of the piles and the presence of perched water. These potential impacts are considered to be relatively minor as a result of the nature of the works and the limited excavation/piling required. Mitigation measures are provided in section 13.5.

13.3.2.2 Direct or indirect increases in erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses

The project would involve the removal of vegetation near Cabramatta Creek to facilitate building of the temporary shared path, as well as the removal of trees along Broomfield Street and in Jacquie Osmond Park, and the excavation and removal of hardstand throughout the project site, which would expose soils. Excavation would involve the disturbance of the existing ground cover and stockpiling of spoil prior to reuse or disposal off site. These and other related construction activities would result in the potential for erosion of unconsolidated material through entrainment by runoff and the subsequent transport off site. Soils transported into the local drainage network, including Cabramatta Creek, could result in the following impacts:

- reduced hydraulic capacity of Cabramatta Creek due to the deposition of material
- degraded water quality including increased nutrients, increased turbidity, lower dissolved oxygen levels and altered pH. The potential for water quality impacts is considered further in section 13.3.3
- increased sedimentation smothering aquatic life and affecting aquatic ecosystems.

Changes to surface water can occur from stream diversions and the construction of culverts and bridges. The project would involve the potential diversion of a small drainage line (through construction of a temporary culvert) adjacent to Cabramatta Creek, to facilitate the construction of the temporary shared path. Additionally a new bridge would be constructed over Cabramatta Creek and the project would install new drainage in some locations.

Changes to the natural flow of water and small increases in impervious surfaces due to construction of the project (from compounds and work sites) have the potential to increase flow velocity and the volume of stormwater runoff. This could lead to the scouring of downstream areas, and potential bank instability within Cabramatta Creek.

Water would be required for dust control, soil compaction, and vegetation establishment. The required volume of water would depend on climatic conditions during construction. It is expected that either water from dewatering of excavations (piling works and underboring) or potable or recycled water (preferably) would be used for this purpose, with the construction contractor to investigate the various sources of water available and obtain any necessary approvals.

Water usage during construction could also increase infiltration rates and surface water runoff in the project site. The impact of this additional discharge is expected to be minimal, as the additional flow and infiltration would be negligible compared to regional rainfall levels. Any impacts would be short term.

The impacts detailed above would be effectively managed through the implementation of the mitigation measures provided in section 13.5.

13.3.3 Water quality

Construction presents a risk to downstream water quality if standard construction management measures are not implemented, monitored and maintained throughout the construction period. If inadequately managed, construction activities can impact water quality if they disturb soil or watercourses, result in uncontrolled discharges of substances to watercourses, or generate contamination. The project would involve subsurface excavations, horizontal drilling works (associated with the Sydney Waters main relocation), works near watercourses and the use of water from dewatering activities for irrigation or dust control. Water from dewatering of excavations is proposed to be reused within the project site for dust suppression and/or irrigation. Therefore, potential sources of water quality impacts include:

- increased sediment loads from exposed soil transported off site to downstream watercourses during rainfall events increased sediment loads from discharge of sediment laden water from dewatering of excavations
- increased sediment loads or contaminants from uncontrolled discharges or reuse of untreated water from dewatering activities to surface water/stormwater
- increased levels of nutrients, metals, and other pollutants, transported in sediments to downstream watercourses or via discharge of water to watercourses
- chemicals, oils, grease, and petroleum hydrocarbon spills from construction machinery directly polluting downstream watercourses
- litter from construction activities polluting downstream watercourses.

The downstream effects of water quality impacts include:

- smothering aquatic life and/or inhibiting photosynthesis conditions for aquatic and riparian flora
- impacts to breeding and spawning conditions of aquatic fauna
- changes to water temperature due to reduced light penetration

- impacts to the ecosystems of downstream sensitive watercourses and floodplains.

The potential for soil and contamination impacts during construction, including the potential for contamination of surface water and groundwater due to spills and leaks, is considered in Chapter 12 (Soils and contamination). Potential water quality impacts are considered in this section.

13.3.3.1 Changes to surface water flows

Changes to surface water flows can impact water quality. An increase in flow rate and volume can lead to increased erosion and turbidity. The potential impacts of changes to surface water flows are considered in section 13.3.2.

13.3.3.2 Works in watercourses

The project would involve works in and around Cabramatta Creek. These works could disturb the bed and banks, and potentially lead to localised erosion and sediment transport downstream. The NSW Department of Primary Industries (Water) *Guidelines for controlled activities on waterfront land – Riparian corridors* (2018) would be considered when undertaking the construction of Cabramatta Creek bridge to minimise the potential for impacts to water quality.

13.3.3.3 Earthworks, demolition, stockpiling and general runoff from construction sites

Construction can impact water quality in downstream watercourses as a result of erosion. Runoff from stockpiles has the potential to impact downstream water quality during rainfall if stockpiles are not managed appropriately. Sediments from the stockpiles could wash into watercourses, increasing levels of turbidity.

Stockpiling cleared vegetation creates a risk of tannins leaching into watercourses, resulting in an increased organic load. Discharge of water high in tannins can increase the biological oxygen demand of the receiving environment, which may in turn result in a decrease in available dissolved oxygen. Once discharged to the environment, tannins may also reduce visibility, light penetration, and change the pH of receiving waters. These impacts may affect aquatic ecosystems in receiving environments.

Sediment loads in watercourses can increase in the vicinity of hard surfaces (such as roads) and compacted areas due to increased surface runoff.

Although the project has the potential to temporarily reduce water quality from pollutants and runoff, it would not be expected to cause significant impacts to the overall condition of surrounding waterways. Construction is unlikely to result in any long-term water quality impacts in the study area.

The mitigation measures provided in section 13.5 would be implemented to minimise the potential for water quality impacts during construction.

13.3.3.4 Minimising the effects of proposed stormwater and wastewater management during construction on natural hydrological attributes

Surface water at construction sites would be managed by implementing standard erosion and sediment control measures in accordance with Managing Urban Stormwater: Soils and Construction volumes 1 and 2A.

13.3.3.5 Groundwater quality

Potential risks to groundwater quality during construction include:

- contamination by hydrocarbons from accidental fuel and chemical spills
- contaminants contained in turbid runoff from impervious surfaces.

Surface water from site runoff may infiltrate and impact groundwater sources. As the infiltration process is generally effective in filtering polluting particles and sediment, the risk of contamination of groundwater from any pollutants bound in particulate form in surface water runoff, such as heavy metals, is generally low.

Soluble pollutants, such as pH altering solutes, salts and nitrates, as well as soluble hydrocarbons, can infiltrate soils and contaminate the groundwater system. Under certain pH conditions, metals may also become soluble and could infiltrate groundwater.

The mitigation measures provided in section 13.5 would be implemented to minimise the potential for groundwater quality impacts.

13.3.4 Cumulative impacts

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

There are no other substantial or major projects proposed which could potentially impact hydrology, flooding and water quality in the project site.

There is a minor development proposal current for a multi-storey residential development on the corner of Broomfield Street and Cabramatta Road East. This proposal could potentially impact on the study area given it sits upstream with part of the site within the same surface water catchment as the project. Given the existing nature of the site is urban development, this development would not be expected to have a large additional impact on flooding, hydrology and water quality in the area. The potential for cumulative impacts would be negligible with implementation of the mitigation measures provided in section 13.5.

13.4 Assessment of operation impacts

13.4.1 Flooding

13.4.1.1 Impacts on flood behaviour during operation

Based on the flooding assessment undertaken the inclusion of structures as part of the project (with the exception of the proposed drainage works) would have a minimal impact on the flooding of Cabramatta Creek for the full range of flood events. Minimal increases (of less than 11 millimetres) in flood levels are expected in the majority of the study area for the one per cent AEP and the one per cent AEP plus climate change event. Where increases of greater than this are expected (up to 16 – 17 millimetres) this would generally be in flood events up to the 0.2 per cent AEP event. However, in the PMF event, an extremely rare event, these impacts are more pronounced at around 75 mm, but occur only in areas where the rail formation is already predicted to be flooded by several metres depth.

The key outcomes in relation to flooding in Cabramatta due to the addition of bridges at Sussex Street and Cabramatta Creek are summarised in Table 13.3 and shown on Figure 13.4 to Figure 13.7.

Table 13.3 Design performance against flooding criteria (Cabramatta Creek)

Key criteria	Cabramatta Creek	Adjacent lands	Public roads
Maximum increase in time of inundation of one hour in a one per cent AEP event	Achieved	1) No increase in flooding in the majority of the study area for one per cent AEP climate change event.	No adjacent roads impacted in one per cent AEP climate change event
Maximum increase of 10 mm in flood level at properties where floor levels are already exceeded in a one per cent AEP event	Floor level survey not available. Any potential flooding above-floor will be confirmed during detailed design	2) Where there is increase in flood level, increase is 11 mm or less up to the one per cent AEP climate change event	
Maximum increase of 50 mm in flood level at properties where floor levels are not exceeded in a one per cent AEP event	Achieved	3) Floor level survey required to confirm above floor impacts at ±10 mm level.	
Increase in flood velocities – identification of mitigation measures	A number of locations benefit from flood velocity decrease. Selected locations of velocity		

Key criteria	Cabramatta Creek	Adjacent lands	Public roads
	increases are generally <0.25 m/s for flood events up to one per cent AEP plus climate change event. Events in excess of this see some wider spread velocity increases but <0.35 m/s (also noted this is in a 0.2 per cent AEP event, a very rare to extremely rare flooding event).		

Figure 13.4 - Change in flood depth and extent with the project – one per cent AEP plus climate change

Figure 13.5 - Change in flood velocity with the project - one per cent AEP plus climate change

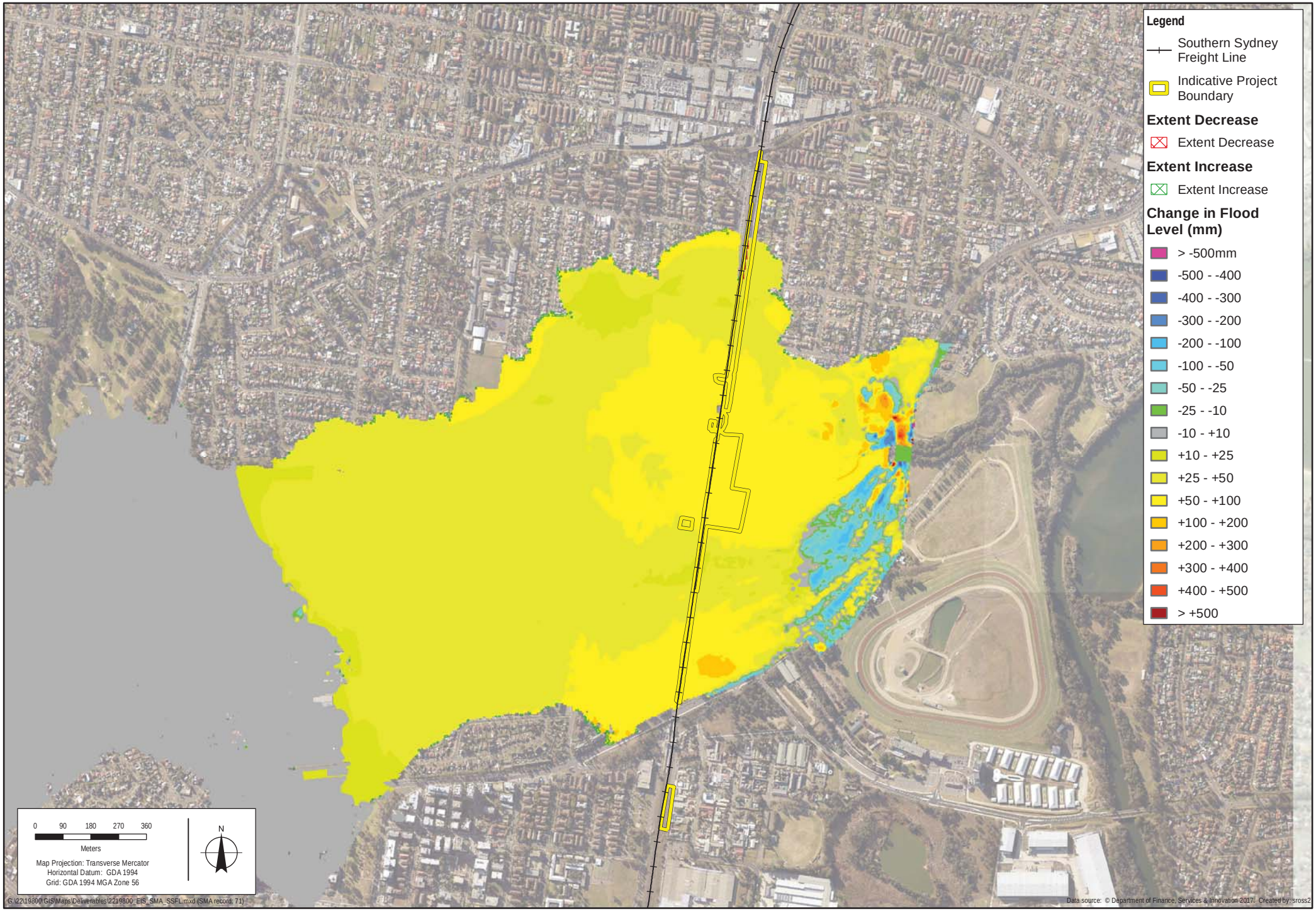

Figure 13.6 – Change in flood depth and extent– probable maximum flood

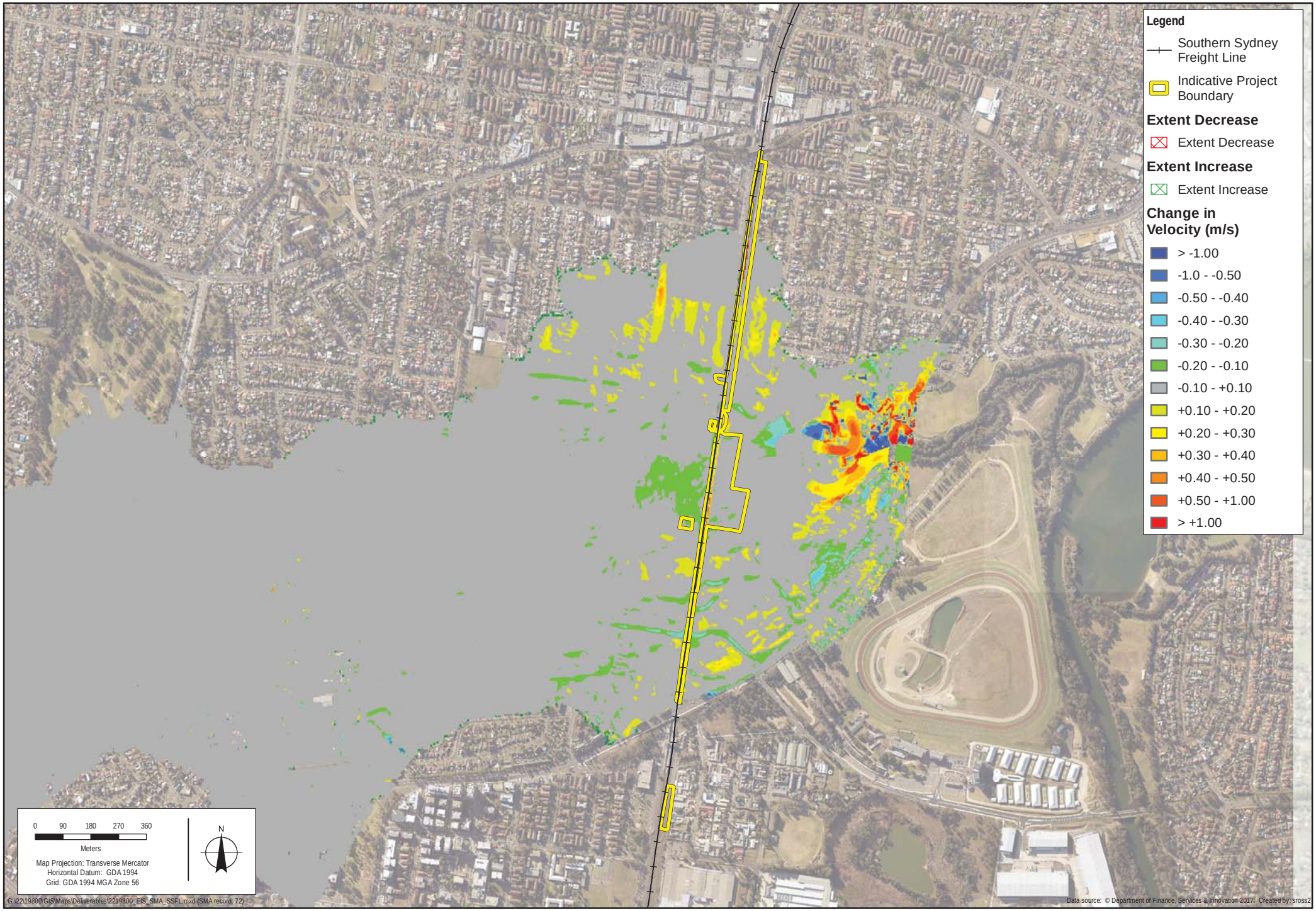

Figure 13.7 – Change in flood velocity – probable maximum flood

With regards to the proposed drainage changes along Broomfield Street the flooding assessment indicated that the project would have a minimal impact on the flooding of the majority of properties along Broomfield Street during the one per cent AEP flood event.

Eight properties that currently experience flooding along Broomfield Street would experience flooding levels beyond the criteria noted in Table 13.2. However, for the majority of these eight properties the flooding impact due to the project would be confined to the front yard of and the flood level increase would be marginal (up to 58 millimetres). That is an increase of up to eight millimetres greater than the proposed criteria. One property (168 Broomfield Street) would potentially experience an increase in flood levels of 175 millimetres (125 millimetres above the proposed criteria) however the area of this increased impact would be small and also only confined to the front yard. Two of the eight properties would experience flooding level increases closer to the front of the dwelling, however these two dwellings are high set and based on existing information would be also unlikely to experience local over floor flooding.

Further refinements of the drainage design will be undertaken during detailed design to mitigate the flood impacts noted above. These design refinements could include changing the proposed level of Broomfield Street to match the existing grading and other similar design refinements.

No adverse impacts due to the proposed drainage changes were noted during the five per cent and ten per cent AEP food events.

The key outcomes in relation to flooding in Broomfield Street due to the proposed project's drainage design and are shown on Figure 13.8 and Figure 13.9 and are summarised in Table 13.4.

Table 13.4 Design performance against flooding criteria (Broomfield Street)

Key criteria	Broomfield Street	Public roads
Maximum increase in time of inundation of one hour in a one per cent AEP event	Achieved	1) No adjacent roads impacted in one per cent AEP event
Maximum increase of 10 mm in flood level at properties where floor levels are already exceeded in a one per cent AEP event.	Detailed floor level survey not available. However based on available information, over floor flooding in a local 1 per cent AEP event is unlikely for dwellings along Broomfield Street. This is due to be confirmed during detailed design.	
Maximum increase of 50 mm in flood level at properties where floor levels are not exceeded in a one per cent AEP event	Increase beyond this criteria was noted at 8 properties along Broomfield Street. Generally the impact is up to 58 mm and within the front yard and away from the dwelling, with exception of two dwellings. However these dwellings are high set, and based on existing information, do not experience local over floor flooding.	
Increase in flood velocities – identification of mitigation measures	A number of locations would experience a decrease in flood velocity. Where increases are noted this would be generally <0.25 m/s for flood events up to the one per cent AEP event.	

13.4.1.2 Increased velocity and scouring of existing waterways

Increases in the velocity of watercourses can occur during flooding events resulting in scouring and erosion. This generally occurs when there is an increase in impermeable surfaces, resulting in additional rainwater running off into stormwater drainage and entering waterways.

The assessment concluded that increases in velocities due to the project are estimated to be generally less than 0.25 metres per second at all locations for the one per cent AEP plus climate change event (for the inclusion of structures) and for the one per cent AEP event (for the Broomfield Street drainage changes).

Existing velocities in these locations are generally less than two metres per second which is considered slow enough that any increases won't cause adverse impacts on surrounding environments.

13.4.1.3 Consistency with Council floodplain risk management plans

Drainage and structural works associated with the project are compatible with local floodplain risk management plans, and would result in generally minimal increases in existing flood extent and depth.

13.4.1.4 Compatibility with the flood hazard of the land

The project would require minimal works within high hazard areas, and would be limited to the placement of piers within Cabramatta Creek and the presence of an embankment and retaining wall in Jacquie Osmond Reserve. The piers in Cabramatta Creek would match the pier arrangement of the existing bridge to minimise hydraulic impacts on flow along the creek.

The results of flood modelling indicate that the project would not result in a change to existing flood hazard in or surrounding the rail corridor.

Further information regarding the existing flood hazard and the flood hazard post-development, including figures showing the existing and post-development provisional flood hazard mapping, is provided in Technical Report 5.

13.4.1.5 Impacts on existing emergency management arrangements

Impacts on existing emergency management arrangements are expected to be minimal during operation and would be effectively managed through the implementation of the mitigation measures provided in section 13.5.

Figure 13.8 - Change in flood depth and extent with the project (Broomfield Street drainage only)– one per cent AEP

Figure 13.9 – Change in flood velocity with the project (Broomfield Street drainage only)– one per cent AEP

13.4.2 Hydrology

13.4.2.1 Groundwater

Any excavations that may intercept groundwater will be backfilled after construction. Therefore no long term impacts from interception of groundwater are expected.

The installation of piles associated with the retaining walls and bridges are expected to have a negligible impact on groundwater flow paths, given the relatively small footprint of the proposed piling compared to the overall extent of the alluvial aquifer. Additionally, the proposed piling associated with the bridges will match the existing bridge pile layout.

Widening the rail corridor would slightly increase impervious areas in the project site, namely where there was previously permeable surfaces (Jacquie Osmond Reserve and grassed verges along Broomfield Street). The minor increase in impervious areas may result in some local changes to the rates of rainfall infiltration into the alluvial aquifer. As outlined in section 13.2.5 the main groundwater receptor is considered to be base flow to waterways. Runoff from impervious/semi-impervious areas such as Broomfield Street and the rail corridor will continue to flow to Cabramatta Creek and Georges River. Therefore a minor reduction in rainfall infiltration into the alluvial aquifer is likely to have negligible effect on the flows available to groundwater receptors such as Cabramatta Creek and Georges River.

Due to the lack of long term interaction of the project with groundwater, the project will not result in long term impact on groundwater level or quality. Therefore it is predicted that the groundwater impacts from the project would be less than the Level 1 minimal impact considerations specified in the NSW Aquifer Interference Policy.

13.4.2.2 Direct or indirect increases in erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses

Increases in the velocity of watercourses can occur during flooding events resulting in scouring and erosion and a reduction in the stability of river banks or watercourses. This generally occurs when there is an increase in impermeable surfaces, resulting in additional rainwater running off into stormwater drainage and entering waterways.

As discussed above the project would result in minimal increases in impermeable surfaces. Hydraulic modelling undertaken for the project determined that increases in velocities are estimated to be generally less than 0.25 metres per second at all locations for the one per cent AEP plus climate change event. Existing velocities in these locations are generally less than two metres per second which is considered slow enough that any increases won't cause adverse impacts on surrounding environments.

Appropriate scour protection measures would be incorporated into the design of the project, particularly at the new Cabramatta Creek bridge structures, to protect the piers and abutments, and at new stormwater outlets.

13.4.3 Water quality

During operation, the project has the potential to result in water quality impacts mainly from changes in hydrology leading to an increase in erosion and sedimentation, and the mobilisation of pollutants from the rail corridor. Widening the rail corridor would slightly increase the impervious areas of the rail corridor (and potentially surrounding areas as well). This could result in increased generation of surface runoff, litter and other pollutants being conveyed to receiving waterways. The increase in impervious area due to the proposed rail corridor widening is very small relative to the total catchment area and therefore the overall impact on surface water quality would be minimal.

13.4.3.1 Change in pollutants entering watercourses

Contamination of watercourses could occur through increased stormwater runoff containing typical pollutants, such as oils and greases, petrochemicals, and heavy metals, as a result of the operation of rolling stock, track operational wear, and any uncontrolled spills during maintenance activities. Any contamination of watercourses could result in a reduction in water quality, which could impact biodiversity in downstream areas. However, as the proposed use of the railway corridor would be similar to the existing, the potential increase in contamination from

these types of pollutants is expected to be very small. Maintenance activities would be undertaken in accordance with ARTC's standard operating procedures.

13.4.3.2 Erosion and sedimentation

An increase in impervious areas could also result in increased flow volumes and velocities, which have the potential to result in erosion and sedimentation at discharge locations if not adequately mitigated.

The change in impervious areas resulting from the project would be very small compared with the level of urbanisation which already exists in the catchment as a whole. Additionally, the design would provide necessary flow retardation structures, including scour protection, to minimise the erosion potential of stormwater flows. As such, potential impacts would be limited and localised in nature.

13.4.3.3 Minimising the effects of proposed stormwater and wastewater management during operation

Increases in impervious surfaces could result in the build-up of contaminants in dry weather, which during rainfall events would be mobilised to surrounding watercourses as stormwater and wastewater. The generation of additional pollutants are directly attributable to the increased impervious surface area. As discussed above the increases in impervious areas are very small, compared with the level of urbanisation which already exists in the catchment as a whole. Therefore any changes to stormwater and wastewater within and surrounding the project site are likely to be insignificant.

13.4.3.4 Achieving water quality objectives

The main pollutants of concern relating to surface runoff include:

- sediments from impervious surfaces from atmospheric deposition
- oils, greases, petrochemicals and heavy metals as a result of the operation of rolling stock, track operational wear and any uncontrolled spills during maintenance activities
- litter from the rail corridor including wind-blown litter
- nutrients such as nitrogen and phosphorus (organic compounds) from biological matter and from natural atmospheric deposition of fine soil particles.

The emphasis in stormwater quality management for surface runoff includes managing the export of suspended solids and associated contaminants (heavy metals, nutrients, hydrocarbons and organic compounds) as well as litter and oils and grease where necessary. Stormwater quality management for Broomfield Street and the rail corridor would be incorporated at detailed design, with the aim of replacing existing management devises with like for like.

It is noted that the water quality outcomes have not yet been assessed against the ANZECC 2000 guideline criteria. An assessment against these criteria would be undertaken during the detailed design.

Provision of water quality treatment measures as per the existing situation is expected to contribute to improved water quality overall, although further analysis would be required during detailed design to confirm this. Implementation of effective water quality treatment measures would mean that the project would not impact on the ability of the catchment to meet the water quality objectives over time.

13.4.4 Cumulative impacts

A number of other projects are either currently occurring within the Liverpool and Fairfield LGAs or are scheduled to occur at the same time as the project (refer to Appendix E). Of these the following two projects are located within 500 metres of the project site and have the potential to occur at the same time as the project:

- a multistorey residential centre at the corner of Broomfield Street and Cabramatta Road adjacent to Cabramatta Station which would be developed by Moon Investments. The site is zoned B4 Mixed Use and consists of 22 privately owned lots and a section of public laneway owned by Fairfield City Council and has a total area of approximately 12,487 square metres. The site is currently being rezoned to mixed use high density for up to 600 residential/commercial units.

- a new car park is proposed in the Cabramatta town centre by Fairfield City Council, on the corner of Hughes Street and Dutton Lane. Work on the new car park is expected to start in mid-2019 and take around nine months to complete. The 220 space car park connects to the existing multi-deck car park with access to a new lift and pedestrian connection to the existing Dutton Plaza lifts.

It is assumed that all buildings and/or infrastructure would be designed in accordance with relevant council standards and guidelines with respect to flooding.

Considering that the study area is already highly urbanised, it is expected that redevelopment near the project site would not have any significant impacts in terms of increased runoff and flow velocities. On this basis, no adverse cumulative impacts are expected.

13.5 Management of impacts

13.5.1 Approach

13.5.1.1 Approach to mitigation and management

The detailed design of the project would continue to take into account necessary measures to minimise the potential for hydrology, flooding, and water quality impacts. This would include further refinements of the drainage design to mitigate the flood impacts noted above. These design refinements could include changing the proposed level of Broomfield Street to match the existing grading, changing the gutter invert levels to increase capacity, installation of berms to divert local flows or duplicating the proposed drainage pipes.

Mitigation measures are provided in this section to mitigate the potential impacts that have not been avoided by the project design to date.

The main water quality risks are associated with erosion and sedimentation, and works within or near Cabramatta Creek. A soil and water management plan would be prepared as part of the CEMP, as discussed in Chapter 12 (Soils and contamination). This would define the management and monitoring measures that would be implemented to manage water quality impacts, erosion, and sediment control in accordance with relevant guidelines. Soil and water management measures would be developed and implemented in accordance with the Blue Book. In accordance with these guidelines, management measures would be designed to manage a 10 per cent AEP rainfall event.

A monitoring program would be implemented prior to and during construction to establish baseline water quality conditions in Cabramatta Creek and monitor water quality outcomes during construction against the water quality objectives for Cabramatta Creek and Georges River. Indicative requirements for the monitoring program would include monitoring at Cabramatta Creek at points both upstream and downstream of the project site for the duration of construction or as otherwise determined, at monthly intervals. Monitoring parameters would be as per the water quality objectives defined in section 13.2.4.

During operation, water quality would be managed to comply with ARTC's EPL (EPL #3142).

13.5.1.2 Expected effectiveness

ARTC has experience in managing potential hydrology, flooding and water quality impacts as a result of rail developments of a similar scale and scope to this project. Project-specific mitigation measures provided in section 13.5 have been developed with the aim of minimising or mitigating, as far as practical, construction and operational impacts to water quality or from changes to the existing hydrological regime of the project site.

The potential impacts to flooding of the project site and of flooding on the project as a result of the project have been modelled. As outlined in section 13.3 and section 13.4 the project structure design, drainage design and flood mitigation strategy for construction and operation is effective at mitigating the potential flooding and hydrological impacts of the project as well as generally providing a one per cent AEP plus climate change level of flood immunity to the project. Where potential flooding impacts were noted due to the proposed drainage changes along Broomfield Street, the design of the project would be further refined to minimise these impacts.

Construction of the project may result in minor and temporary impacts that would be effectively managed through the implementation of standard construction techniques and protection measures.

Audits and reporting of the effectiveness of environmental management measures employed during construction is generally carried out to show compliance with management plans and other relevant approvals and would be outlined in detail in the CEMP prepared for the project.

13.5.2 List of mitigation measures

The mitigation measures that would be implemented to address potential hydrology, flooding and water quality impacts are listed in Table 13.5.

Table 13.5 Mitigation measures

Stage	Impact	Measure
Design	Stormwater runoff	Where feasible and reasonable, detailed design will result in no net increase in stormwater runoff rates in all storm events, unless it can be demonstrated that increased runoff rates as a result of the project would not increase downstream flood risk.
	Scour potential	Any existing rip rap that is impacted or removed during construction would be reinstated. This would include the provision of rip rap around the piers and abutments of Cabramatta Creek bridge. The design of the rip rap will take into consideration the size, quantity and type of rip rap with the aim of not causing additional impacts to water quality.
	Water quality	The project will be designed to ensure there is minimal potential for water quality impacts, including incorporating water sensitive urban design elements.
	Groundwater	A water license will be obtained as necessary in accordance with Part 5 of the *Water Act 1912* if dewatering of excavations is required.
	Flooding	Further assessment and design refinement will be undertaken during detailed design with the objective of not exceeding the following flooding characteristics during the one per cent AEP event: • a maximum increase in time of inundation of one hour in a one per cent AEP event • a maximum increase in 50 mm in inundation at properties where floor levels are currently not exceeded • a maximum increase in 10 mm in inundation at properties where floor levels are currently exceeded. In the event this cannot be met further mitigation would be proposed in consultation with the relevant councils.

Stage	Impact	Measure
Construction	Flooding, changes to surface water and water quality	A flood management procedure will be prepared as part of the soil and water management plan. It will include specific controls to be implemented during wet weather or forecasts of heavy rainfall for works undertaken near Cabramatta Creek and Jacquie Osmond Reserve and appropriate monitoring strategies following the flood to verify design performance and impact predictions It will also include a flood warning and evacuation procedure for emergency management of flooding up to the PMF event. Development of a flood warning and evacuation procedure for the project will be undertaken in consultation with stakeholders including Liverpool City Council and Fairfield City Council and the NSW SES.
	Flooding	The site layout and staging of construction activities will: • avoid or minimise obstruction of overland flow paths and limit the extent of flow diversion required • consider how the works will affect the existing stormwater network such that alternatives are in place prior to any disconnection or diversion of stormwater infrastructure.
	Flooding	Detailed construction planning will consider flood risk for compounds and worksites near Jacquie Osmond Reserve and Cabramatta Creek. This will include identification of measures to not worsen existing flooding characteristics. Not worsen is defined as: • a maximum increase in flood levels of 50 mm in a one per cent AEP event • a maximum increase in time of inundation of one hour in a one per cent AEP event • no increase in the potential for soil erosion and scouring from any increase in flow velocity in a one per cent AEP flood event.
	Watercourse impacts	Works within or near Cabramatta Creek will be undertaken with consideration given to the NSW Department of Primary Industries (Water) *Guidelines for controlled activities on waterfront land – Riparian corridors* (2018).
	Water quality	Dewatered groundwater will be stored and reused on site for wetting down and reducing dust in disturbed areas (within existing erosion and sediment controls), or for irrigation in grassed areas. Requirements for testing will be included in the soils and water management plan and will include the following at a minimum: • No visible sheen or odour is noted. • Water pH is between 6.5 and 8.5. • Total suspended solids are less than 60 mg/L (approximately equivalent to a turbidity level of 50 NTU). Water may be dosed with gypsum, alum or a similar product to reduce sediment levels if required. • All litter and debris must be filtered out and removed prior to reuse.

Stage	Impact	Measure
		• Pump-out events are supervised at all times, and the pump is positioned to prevent reuse of sediment-laden water settled at the bottom of the trench or tank. • Sludge from the bottom of the trench or tank can be placed in a shallow pit lined with heavy duty plastic sheeting to dry out (evaporation pit). Once the sludge has dried out sufficiently to allow it to be spaded this waste can be stored with excess excavated spoil and disposed in accordance with the findings of the preliminary waste classification assessment (refer to Technical Report 6 – Soils and contamination impact assessment).
	Water quality	A water quality monitoring program will be developed and implemented, to monitor water quality due to the proximity of construction activities to surface water receiving environments. The program will include relevant water quality objectives, parameters, and criteria and specific monitoring locations identified in consultation with DPI (Water) and the EPA.

13.5.3 Consideration of the interaction between measures

In addition to the measures for water quality measures described above, there are interactions between the mitigation measures for soils and contamination (Chapter 12 (Soils and contamination), waste (Chapter 19 (Waste management)), and hazardous materials (Chapter 20 (Health, safety, and hazards)). Together, all these measures would ensure appropriate management of water quality, to minimise the potential for impacts to the community and environment.

13.5.4 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 summarised below.

It is expected that with the appropriate mitigation measures in place, residual impacts during construction are likely to be negligible.

Residual operational impacts of the project could include increases in flood level in rare to extreme flood events. This could include impacts to surrounding properties, including increased flood depth, potential flood damages during a flood event, and emergency access during times of flooding. Further consultation with relevant stakeholders and consideration of these potential impacts during the detailed design phase will reduce any residual impacts to an acceptable level.

THIS PAGE HAS BEEN LEFT INTENTIONALLY BLANK

14 Non-Aboriginal heritage

This chapter provides a summary of the non-Aboriginal heritage impact assessment undertaken by Biosis. A full copy of the assessment report is provided as Technical Report 8 – Historical heritage assessment and statement of heritage impact. The report was written to address the relevant SEARs which are outlined in Appendix A.

14.1 Assessment approach

14.1.1 Methodology

14.1.1.1 Study area

The study area considered heritage features and areas of archaeology within around 500 metres from the project site and the proposed location of signalling upgrades.

14.1.1.2 Key tasks

The assessment involved:

- a review of existing literature such as previously prepared heritage studies
- a review of statutory framework, guidance and implications to the project, including:
    - EPBC Act
    - *NSW Heritage Act 1977*
    - Fairfield City Wide Development Control Plan 2013 and Cabramatta Town Centre Development Control Plan 2014
    - Liverpool Development Control Plan 2008
    - Assessing Heritage Significance (Heritage Office, 2001)
    - Australia ICOMOS Charter for Places of Cultural Significance, (Burra Charter, 2013).
- a review of Heritage Schedules:
    - Fairfield Local Environmental Plan 2013, Liverpool Local Environmental Plan 2008 and other relevant planning instruments
    - Section 170 Register
    - State Heritage Register
    - National Heritage Register
    - Commonwealth Heritage Register.
- developing a photographic inventory and historical context of the project site
- carrying out a field inspection
- assessing the archaeological potential and significance of heritage features
- assessing the potential impacts of the project, and preparing the Statement of Heritage Impact, in accordance with the guidelines listed above.

A detailed description of the assessment methodology is provided in section 3 of Technical Report 8.

14.1.2 Risks identified

The preliminary environmental risk assessment undertaken for the project included potential risks associated with non-Aboriginal heritage. 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 non-Aboriginal heritage risks was medium. Risks with an assessed level of medium or above included:

- impacts to listed heritage items or items with heritage values due to demolition, altered historical arrangements and access, visual amenity, landscape and vistas, curtilage, subsidence and architectural noise treatment
- damage to heritage items from vibration during construction and operation
- disturbance of known or unidentified items or places of non-Aboriginal heritage significance
- design that detracts from the heritage significance of a nearby items.

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).

14.1.3 How potential impacts have been avoided/minimised

As described in Chapter 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 non-Aboriginal heritage impacts have been avoided/minimised where possible by:

- developing a construction methodology that avoided demolition of heritage structures, altering historical arrangements and access, landscape and vistas, curtilage, or activities which could result in subsidence
- preventing vibration impacts on heritage sites from the proposed signalling works (Villawood Railway Station Group and Liverpool Railway Station Group). Works will be located outside of vibration buffer distances.

The new bridge structures have been designed to minimise impacts on heritage through the following:

- the form, abutment and pier locations of bridges will match the existing SSFL bridges.
- the height will not exceed the height of the heritage listed bridges in order to minimise visually dominating the bridges.
- they will be built on the eastern side of the SSFL, as not to further block the view of the heritage listed bridges.

14.2 Existing environment

14.2.1 Historical context

The timing for the human occupation of the Sydney Basin is still uncertain. Archaeological evidence of Aboriginal occupation of the Cumberland Plains indicates that the area was intensively occupied from approximately 4,000 years before present. Aboriginal land ownership in the area is not clearly recorded within early historical references and would have changed through time, particularly after the arrival of Europeans in Sydney Cove in 1788.

The earliest settlements in the colony were generally located in areas such as rivers and coastal areas which could be easily accessed by boat. The earliest land grants in the Liverpool region were made in 1798, and in the Fairfield area from 1803, focusing around the Georges River as agricultural plots. The project site is located within the township of Cabramatta, part of a 300 acre grant originally purchased by Andrew White in 1818 and then acquired by John Bloomfield in 1884. The area of Fairfield was first developed around 1789–1806 and Liverpool 1799–1810.

In 1857, the single-track railway line from Granville to Liverpool, which formed part of the Main South railway line to Goulburn, was completed, with the Liverpool station opening in 1856. The timber beam bridge across Cabramatta Creek was replaced with brick arch bridges in 1891, using locally made bricks. These bridges were the first instances of the major use of brick arch bridges by the Railways network. With 17 spans, the Cabramatta Creek viaduct was the longest of these brick arch bridges. Around 2012, an additional bridge was constructed adjacent to the brick arch bridge to support a new track and associated infrastructure built for the South Sydney Freight Line.

14.2.2 Heritage listed items

There are multiple items within and adjacent to the project site which are listed either on the State Heritage Register created under the *Heritage Act 1977*, Section 170 New South Wales (NSW) State Agency Heritage Register or LEPs. A description of the items is provided in and below Table 14.1 and their locations are shown on Figure 14.1.

Table 14.1 Heritage items

Site number	Site name	Address / Property description	Listings - Individual item	Significance	Location
I10	Federation cottage	132 Broomfield Street, Lot 11, section 6, DP 1656	Fairfield LEP 2013	Local (Fairfield LEP)	On the boundary of the project site
I19	Cabramatta (Cabramatta Creek), Railway Parade & Sussex Street Underbridge	Railway Parade and Sussex Street (Cabramatta Creek)	Fairfield LEP 2013 RailCorp Section 170 Register	Local (Fairfield LEP, Section 170 register)	Within project site
I103	Villawood Railway Station Group	19 Villawood Road	Fairfield LEP 2013	Local (Fairfield LEP)	Near to project site
72	Liverpool Railway Station Group	Bigge Street (off), Lot 31, DP 859887; Part Lot 5, DP 226933	State Heritage Register Liverpool LEP 2008	State and local (Liverpool LEP)	State items near the project site, local items within project site

Federation cottage - The house has burned down since the heritage listing was updated in 2009. However the site of this heritage item is directly adjacent to the development and is listed as having local significance as a very good example of a Federation period, weatherboard farm or workers cottage. It was one of the oldest houses at Cabramatta. It is situated where the rail corridor is to be widened along Broomfield Street. As there has been no development on the lot there is a high potential for archaeological remains associated with the Federation cottage such as structural foundations and occupation deposits.

Cabramatta (Cabramatta Creek), Railway Parade and Sussex Street Underbridge - These two heritage items are listed together on RailCorp's Section 170 Register. The Cabramatta (Cabramatta Creek) Underbridge and the Railway Parade and Sussex Street Underbridge represent the earliest examples of brick arched underbridges built by NSW Railways from the 1890s using local building materials. With their original structure and fabric intact they are significant as fine examples of their type constructed by the NSW Railways.

Villawood Railway Station Group - This heritage item is listed as having local significance. Villawood is a typical roadside 1920s standard lineside island platform building without many subsequent changes. It is typical of many suburban buildings until 1924, after which the style was modified as on the East Hills line.

Liverpool Railway Station Group, - The Liverpool Railway Station Group consists of a locally listed area, and adjacent to the state listed group of buildings which includes the station building, goods shed and jib crane. Liverpool station building is a good example of a third class station building in the centre of a large scale redevelopment of the site. It indicates the change in technology and approach to railway construction. Liverpool goods shed is a rare brick structure on the State system which is substantially intact with platforms and jib crane. It is located in an historic town and is the last remnant of the early station and yard complex at the site. It is rare as one of the last two surviving brick goods sheds in the State.

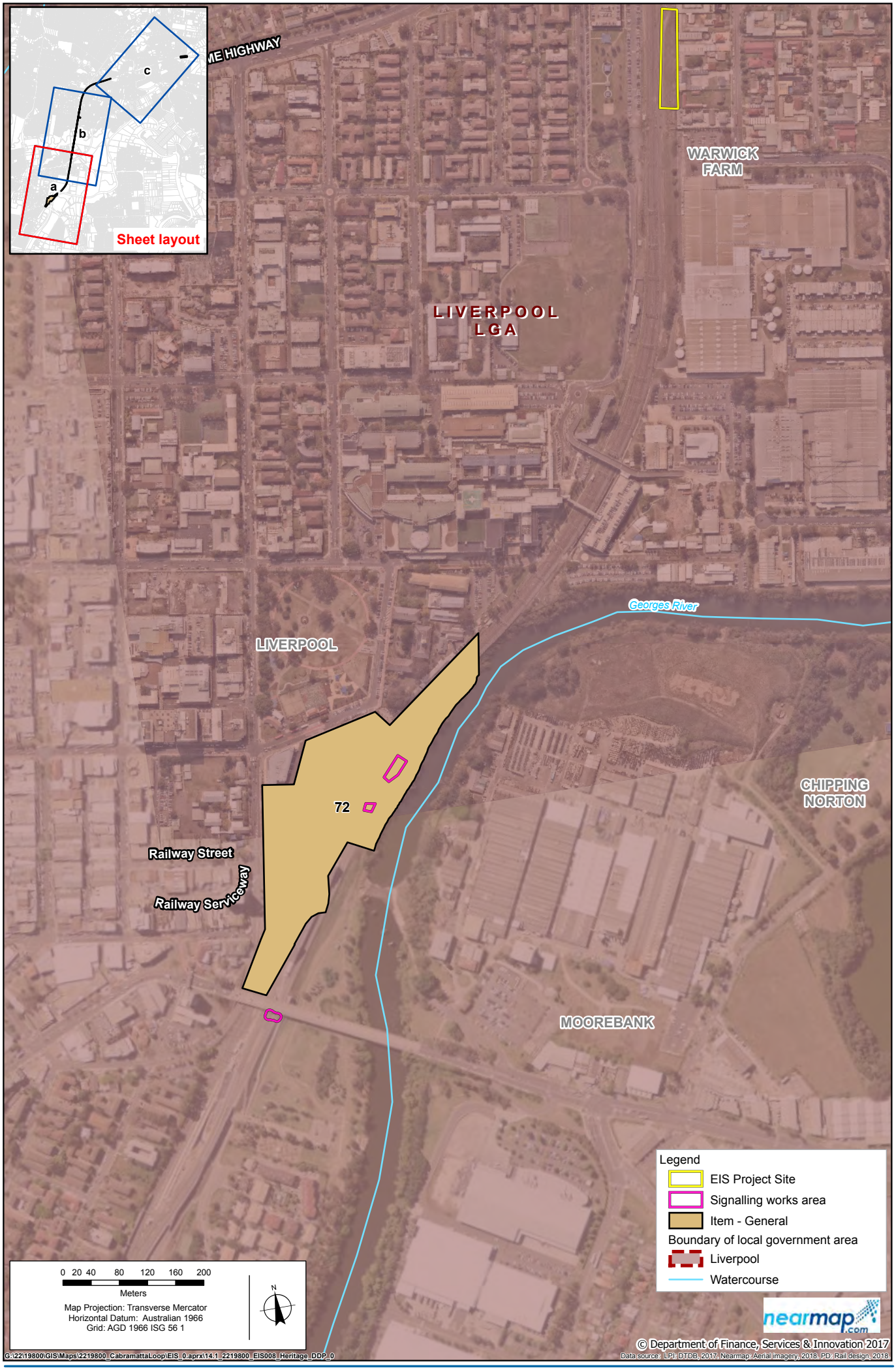

Figure 14.1a Listed heritage items

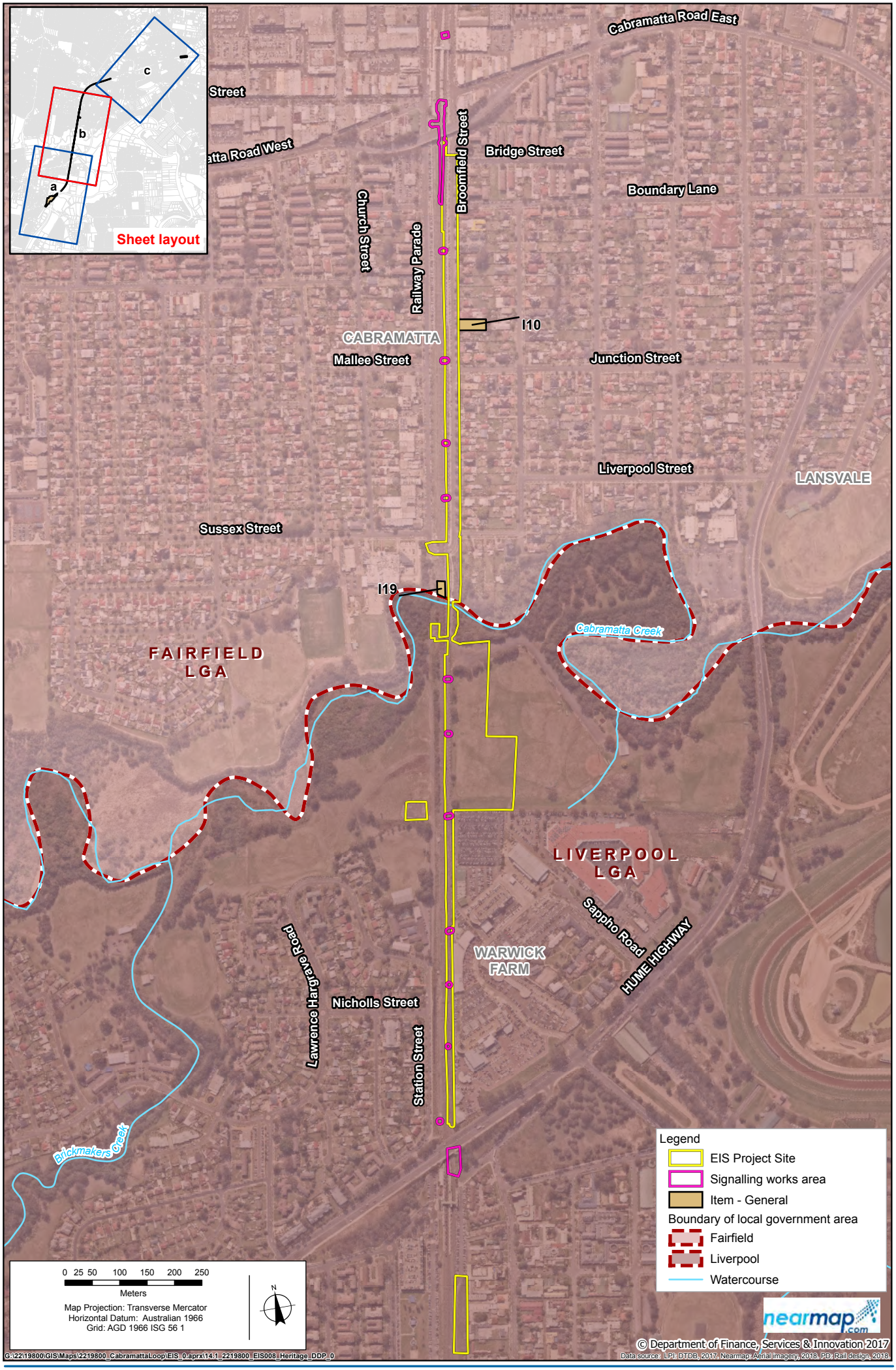

Figure 14.1b Listed heritage items

Figure 14.1c Listed heritage items

14.2.3 Archaeological sites and potential

The project site has been utilised for a range of different uses. These vary from agriculture and animal husbandry to more modern uses such as rail tracks and large areas of vacant public spaces. This assessment has identified that there may be archaeological material present within the project site related to the early ownership and use of the land for agricultural and animal husbandry purposes. This could include evidence of land clearance, plough lines, agricultural marks, post holes from fence lines and rubbish pits. Evidence of later use as a railway corridor could include evidence of crossings such as gate and fence post holes, impressions or post holes of the foundations of a timber bridge, post holes of gates and sandstone or sandstock bridge drain structures and infrastructure related to the 1857 railway line.

Due to the ephemeral nature of the early remains and the subsequent upgrade of the rail line, the archaeological potential has been assessed as low. The archaeological materials have also been assessed as not holding heritage significance.

The project site has been continually updated and the installation of the infrastructure for electrifying the track in 1929 and construction of the SSFL would have also disturbed any subsurface remains which were present. While there may be disturbed and undisturbed archaeological material associated with these activities within the project site, it is unlikely that any remains would provide further information regarding to agriculture, pastoralism and transport that could not be derived from any other source and which contributes to the archaeological significance of the site.

The assessment of archaeological potential for the project site has been categorised as having low archaeological potential for all site features as summarised in Table 14.2.

Table 14.2 Assessment of archaeological potential

Designation	Description	Probable feature(s)	Possible construction date	Archaeological potential
1	Crossing	Gate or fence post holes	1884	Low
2	Crossing	Gate or fence post holes	1884	Low
3	Railway line	Trenches for tracks or track bedding	1857	Low
4	Timber bridge	Impressions or post holes of the foundations	1867	Low
5	Gates	Post holes	1867	Low
6	Drains	Sandstone or brick structural remains	1867	Low
7	Cabramatta Creek Underbridge	n/a	1891	Still present
8	Railway Parade and Sussex Street Underbridge	n/a	1891	Still present
9	Southern Sydney Freight Line	n/a	2012	Still present

14.2.4 Significance assessment

An assessment of heritage significance encompasses a range of heritage criteria and values. The heritage values of a site or place are broadly defined as the 'aesthetic, historic, scientific or social values for past, present or future generations'. This assessment is based on seven criteria outlined in the guidance document *Assessing Heritage Significance* (Heritage Office, 2001).

Much of the possible potential archaeological resource relating to the agriculture and animal husbandry period described in section 14.2.3, is ephemeral in nature, likely to be disturbed and unlikely that any remains would provide further information.

Remains relating to the construction of the railway would have likewise been disturbed by the constant upgrading of the tracks and the SSFL which was constructed in 2012. The possible archaeological remains relating to construction of the railway within the project site, would have no significance and do not satisfy any of the significance assessment criteria. The archaeological potential for this is also low.

The Cabramatta (Cabramatta Creek), Railway Parade & Sussex Street Underbridge satisfies two of the seven criteria outlined in the guidance document Assessing Heritage Significance (Heritage Office, 2001).

Criteria C: An item is important in demonstrating aesthetic characteristics and/or a high degree of creative or technical achievement in NSW (or the local area) - The bridges have aesthetic and technical significance at a local level as they exemplify the particular brick arch viaduct design employed by the NSW Railways during the period from the 1890s to the 1920s. The bridges are aesthetically distinctive and have landmark qualities because of their size and setting. The viaduct over Cabramatta Creek is especially significant due to the large number of spans and the use of sandstone in the arch imposts. The new adjacent bridges partially obstruct views to the bridges on one side impacting their aesthetic and landscape values. The Cabramatta (Cabramatta Creek), Railway Parade & Sussex Street Underbridge satisfies this criterion at a local level.

Criterion G: An item is important in demonstrating the principal characteristics of a class of NSW's cultural or natural places, or cultural or natural environments. (or a class of the local area's cultural or natural places, or cultural or natural environments) - The two bridges at Cabramatta have a high level of integrity and are good representatives of this type of arched brick viaduct which were constructed by NSW Railways from the 1890s to the 1920s and which were the first examples of their type. The bridge over Cabramatta Creek has significance as it utilises sandstone in the arch impost in place of the brick which has been used in much of the other viaducts. This bridge particularly is an outstanding example because of its picturesque natural setting over Cabramatta Creek and the number of arches and long length of the structure, making it the longest of 1890s brick viaducts on this section of the line. The Cabramatta (Cabramatta Creek), Railway Parade & Sussex Street Underbridge satisfies this criterion at a local level.

This assessment has not identified any information which would lead to an alteration in the assessment of significance for this item, and its statement of significance is as it appears on the State Heritage Inventory.

14.3 Assessment of construction impacts

14.3.1 Impact on archaeological potential

Construction works have the potential to directly impact archaeological potential through ground works such as piling, excavations for relocating services and activities relating to establishing compound sites such as temporary drainage works. This can result in the direct destruction or damage to an item.

Archaeology could also be impacted by vibration or compaction of the ground surface from heavy plant and construction vehicles. This could result in shifting or compaction of soils damaging or destroying buried artefacts.

This assessment has identified that there may be archaeological material present within the project site related to the early ownership and use of the land for agricultural and animal husbandry purposes and evidence of later use as a railway corridor.

Due to the ephemeral nature of the early remains and the subsequent disturbance during upgrades of the rail line, the archaeological potential has been assessed as low. The archaeological materials have also been assessed as not holding heritage significance.

Therefore impacts to archaeological material present or archaeological potential is considered to be low.

14.3.1.1 Liverpool Railway Station Group (72) and Villawood Railway Station Group (I103)

The signalling work has the potential to be either within or adjacent to these heritage items or their curtilage. Vibration impacts and earthworks from the signalling works could affect archaeological resource within the locally listed area of these items. The signalling works involve minor earth works and the construction of signalling equipment and associated infrastructure which may disturb buried archaeological resources. Vibration could also cause shifting or compaction of soils which may damage buried artefacts The works are proposed within the existing rail corridor and there is the potential to move the new signalling locations to areas outside of vibration buffer distances or areas with archaeological potential, to avoid impacts.

14.3.1.2 Federation cottage (I10)

The heritage listed Federation Cottage has burnt down. There is the potential for archaeological remains to still exist within the Federation Cottage (110) heritage site, therefore the project may indirectly impact the heritage site through vibrations from the construction works, disturbing buried artefacts. However, the potential for these impacts is likely to be low. Additionally, while this item is located outside the project site the project has the potential to directly impact archaeological remains within the heritage site if utilities relocation works are undertaken at this location.

Impacts to archaeological remains would be adequately managed through the mitigation measures provided in Table 14.3. Vibration impacts to archaeological remains would be adequately managed through the mitigation measures provided in Table 9.17.

14.3.2 Impacts on heritage items

No heritage items would be removed, altered or demolished as a result of the project therefore there would be no direct impacts to heritage items within the project site.

Heritage listed items within or adjacent to the project could be indirectly impacted due to alterations to the environment or setting of a heritage item which will result in a loss of heritage value. This may include permanent or temporary visual, noise or vibration impacts caused during construction and after the completion of works.

The following sites have the potential to be indirectly impacted during the construction phase:

- Cabramatta (Cabramatta Creek), Railway Parade and Sussex Street Underbridge (I19)
- Federation cottage (I10).

Minor works in the form of new signalling works would be installed at a number of locations within the rail corridor. Indicative locations for the signalling works are shown in Figure 14.1 however the exact locations would be determined during detailed design. This signalling work has the potential to be either within or adjacent to two heritage items or their curtilage. There is the potential however, to move the location of the signalling work to avoid any potential indirect impacts to heritage features. These items are:

- Liverpool Railway Station Group (72)
- Villawood Railway Station Group (I103).

14.3.2.1 Cabramatta (Cabramatta Creek), Railway Parade and Sussex Street Underbridge (I19)

The project would include new bridges being built near to the existing heritage rail bridges (with the SSFL situated between the proposed bridge and the heritage listed item). The design of the new bridges would match the existing SSFL bridges and the new bridges would be structurally independent from, and would not be connected to the existing bridges (refer to section 6.2 for further detail).

Vibration from equipment, groundworks and construction activities could result in vibration compromising the structural integrity of the bridge structure. This could result in cosmetic damage detracting from the visual appeal of the structure. The development may also effect the technical significance of the item, if damage prevented or changed the original use of the item, where that use is part of the heritage value.

Bridge works and road alignment works at Sussex Street will be undertaken near this heritage item and would include the use of excavators, piling (bored) and other equipment that has the potential to cause impact to this

heritage item if used within their relative vibration safe working distances (refer to section 9.3.6). Therefore, a detailed review of work methods and equipment selection would be undertaken. A dilapidation survey would also be required to confirm whether the structure is considered structurally unsound. If this heritage item is still located inside the vibration safe working buffer distances after review of the construction methodology, equipment with lower vibration emissions should be considered. If this is deemed unfeasible, then a long term monitoring and alarm system may be required to warn operators in real time when vibration levels are approaching the allowable limits.

14.3.2.2 Federation cottage (I10)

The proposed works along Broomfield Street would include groundworks, construction of new structures, roadworks and removal of a number of trees. It would also include a number of utilities and services to be adjusted.

These works would result in a change to the existing setting of the area adjacent to the heritage listed Federation Cottage. The aesthetic significance of the house is no longer present as it has burnt down.

14.3.2.3 Liverpool Railway Station Group (72) and Villawood Railway Station Group (I103)

The signalling works have the potential to impact on the local and State listed Liverpool Railway Station Group and the locally listed Villawood Railway Station Group. The proposed works may be located within the local listings and near the State listed items.

The signalling works would involve ground disturbance and use of equipment which may cause vibration. This could indirectly impact structures within the station group, through cosmetic damage detracting from the visual appeal of structures. Vibration may also effect the technical significance of the items, if damage prevents or changes the original use of the items, where that use is part of the heritage value. The equipment proposed for this work includes the use of excavators, handheld equipment and light and heavy vehicles. The conservative vibration safe working distance for an excavator is six metres, therefore use of an excavator within this distance has the potential to cause vibration impacts.

Where possible, the proposed signalling work would be located outside of the heritage items. If following detailed design, the proposed works are located inside the vibration safe working buffer distances (refer to section 9.3.6) of the heritage items, equipment with lower vibration emissions should be considered. If this is not possible a dilapidation survey should be undertaken to confirm the structural integrity of the items and monitoring may be required.

Construction impacts to heritage items would be adequately managed through the mitigation measures provided in Table 14.3. Vibration impacts to heritage items during construction would be adequately managed through the mitigation measures provided in Table 9.17.

14.3.3 Cumulative impacts

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

There are no other known construction projects proposed in the vicinity of the project site. 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, including in the vicinity of the Cabramatta (Cabramatta Creek), Railway Parade & Sussex Street Underbridge. This may result in vibration from construction works being exacerbated during this period. Vibration from these activities would be managed with standard mitigation measures to avoid where possible and minimise impacts to heritage structures.

14.4 Assessment of operation impacts

14.4.1 Impact on archaeological potential

No impacts on archaeological potential are predicted during operation of the project.

14.4.2 Impacts on heritage items

The following sites have the potential to impacted during the operational phase:

- Cabramatta (Cabramatta Creek), Railway Parade and Sussex Street Underbridge (I19)
- Liverpool Railway Station Group (72)
- Villawood Railway Station Group (I103).

14.4.2.1 Cabramatta (Cabramatta Creek), Railway Parade and Sussex Street Underbridge (I19)

The presence of the proposed bridges near the heritage listed Cabramatta Creek and Sussex Street underbridges could alter the setting of this listed item. This could include the existing aesthetic and technical significance and the characteristics of local cultural places that give this item its heritage value. However, given that the bridges would be located on the eastern side of the existing SSFL bridges and the design of the proposed bridges would match the SSFL bridges this impact is considered minor.

There is the potential for vibration impacts during operation due to an increase in train volumes. However, given the existing use of the heritage bridges by Sydney Trains and the use of the adjacent SSFL this impact is difficult to quantify. A dilapidation survey would be undertaken during construction to assess the structural integrity of the heritage listed bridges. If this survey notes there is structural damage to the bridges then there may be a need for a structural assessment to be undertaken to assess potential impacts due to vibration from trains.

14.4.2.2 Liverpool Railway Station Group (72) and Villawood Railway Station Group (I103)

The Liverpool Railway Station Group consists of a state listed group of buildings which includes the station building, goods shed and jib crane within a locally listed area. The Villawood Railway Station Group is a item of local significance consisting of a typical roadside 1920s standard lineside island platform building. The project in these location would entail new signalling equipment, including a signalling location hut and axle counter at Liverpool Station and an axel counter at Villawood Station.

The aesthetic significance of these listings are unlikely to be impacted by the proposed infrastructure. The signalling location hut at Liverpool is located on the eastern side of the rail line, and will not block or impede views to the Liverpool Railway Station Group. To its east, it is visually screened by plantings along the banks of the Nepean River. From the surrounding Moore and Bigge Streets, works within the rail corridor are visually screened by extant structures and fencing. The hut will be located at a lower elevation than the station buildings to ensure that it does not visually dominate the landscape.

Smaller infrastructure consisting of axle counters and other items of a similar scale will also have a negligible visual impact at both Liverpool Station and Villawood Station and the proposed infrastructure is generally consistent with the existing rail infrastructure in the rail corridor.

Potential operational impacts to heritage items would be adequately managed through the mitigation measures provided in Table 14.3. Vibration impacts to heritage items during operation would be adequately managed through the mitigation measures provided in Table 9.17.

14.4.2.3 Federation cottage (I10)

The project would result in changes to the existing setting of the area adjacent to the heritage listed Federation Cottage due to the removal of street trees and the introduction of new structures. However, the aesthetic significance of the house is no longer present as it has burnt down. ARTC would consult with Council to request a revision to the heritage significance of this item given that there is no above ground structure present.

Potential operational impacts to heritage items would be adequately managed through the mitigation measures provided in Table 14.3. Vibration impacts to heritage items during operation would be adequately managed through the mitigation measures provided in Table 9.17.

14.4.3 Cumulative impacts

Operational impacts to heritage structures is predicted to be localised and relate to aesthetic and technical significance and principal characteristics of local cultural places. There are no other known construction projects

proposed in the vicinity of the heritage items or archaeological sites that would result in additional impacts. As such, no cumulative impacts are expected to occur.

14.5 Management of impacts

14.5.1 Approach

14.5.1.1 Approach to mitigation and management

ARTC is committed to minimising the environmental impact of the project and is investigating opportunities to reduce actual impact areas where practicable.

Measures to avoid impacts in the first instance have been addressed in the reference design and construction methodology (refer to section 14.1.3). The mitigation measures proposed have been formulated to respond to the heritage requirements of the SEARS and the significance of the site. They are guided by the ICOMOS Burra Charter with the aim of minimising impacts to the heritage significance of sites and to retain their cultural significance. Standard construction mitigation measures will be included in the project CEMP.

14.5.1.2 Expected effectiveness

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

Measures to avoid and minimise vibration impacts have been included in the reference design (refer to section 14.1.3). Further pre construction impacts will be avoided by attended vibration measurements of vibration generating equipment (e.g. bored piling, vibratory rolling works) being undertaken prior to works near heritage structures located inside the vibration impact zones (refer to details provided in section 9.6). This will confirm the minimum working distances or suitable equipment for vibration intensive activities to avoid and minimise potential impacts.

In addition vibration management measures will be included with the CEMP. The CEMP will be prepared during the detailed design stage of the project and applied to all construction processes throughout the project.

As such, the measures to avoid impacts during development of the reference design and measures to be outlined in the CEMP are considered to be proven effective in managing potential impacts heritage and archaeological features.

14.5.2 List of mitigation measures

The mitigation measures that would be implemented to address potential non-Aboriginal heritage impacts are listed in Table 14.3. Additionally, mitigation measures to mitigate vibration impacts to non-Aboriginal heritage items are listed in Table 9.17.

Table 14.3 Mitigation measures

Stage	Impact	Measure
Design	Changes to aesthetic significance and views to/from Cabramatta (Cabramatta Creek), Railway Parade and Sussex Street Underbridge (I19)	As per the current reference design, detailed design of the bridges will ensure the height, form, abutment and pier locations of both bridges matches the existing SSFL bridges.
	Changes to the aesthetic significance by the size and placement of the project. obscuring or blocking views to/from: • Liverpool Railway Station Group (72) • Villawood Railway Station Group (I103)	The visible infrastructure will be as small as possible to not obscure views to/from the item and not to visually dominate the landscape.

Stage	Impact	Measure
	Changes to the aesthetic significance of the Federation cottage (I10).	ARTC will consult with Council to request the heritage significance of this item is updated to reflect the fact that the cottage has burnt down.
Construction	Disturbance to possible archaeological remains within the curtilage of the Federation cottage (I10)	Works in the road corridor including utility works that need to be adjusted will not encroach on the curtilage of this heritage item so as not to disturb any possible archaeological remains.
	Impact to archaeological heritage	The CEMP will contain measures to protect non-Aboriginal archaeological relics. This will include an unexpected finds protocol and heritage induction materials to ensure all onsite staff can identify items with potential archaeological heritage significance. During pre-work briefings, onsite staff will be made aware of the unexpected finds procedure and obligations under the *Heritage Act 1977*.
	Impact to archaeological heritage	The unexpected finds protocol will include the following at a minimum: • In the event that unexpected archaeological remains, relics, or potential heritage items are discovered during construction, all works in the immediate area would cease, and the remains and potential items would be assessed by a qualified archaeologist or heritage consultant. If necessary, the Heritage Division of OEH would be notified in accordance with the requirements of section 146 of the Heritage Act 1977.

14.5.3 Consideration of the interaction between measures

Mitigation measures to control impacts to the heritage items and archaeology from the project may replicate mitigation measures proposed for the control of impacts associated noise and vibration.

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.

14.5.4 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 summarised below.

Minor residual impacts have the potential to occur during construction. These would relate predominantly to visual intrusion to the setting of heritage features from construction equipment and activities and from vibration. Impact from visual intrusion and vibration would be temporary and will be minimised through the implementation of relevant mitigation measures. Therefore these are not expected to be significant.

Residual impacts during operation relate to aesthetic and technical significance and principal characteristics of local cultural places to the Cabramatta (Cabramatta Creek), Railway Parade and Sussex Street Underbridge (I19). This impact would be minor and arises from the new bridge structures and additional rail infrastructure. Opportunities to reduce these impacts through refinement of the design during detailed design, would continue to be investigated.

15 Aboriginal heritage

This chapter provides a summary of the Aboriginal heritage assessment undertaken by Biosis. A full copy of the assessment report is provided as Technical Report 9 – Aboriginal and cultural heritage impact assessment. The report was written to address the relevant SEARs which are outlined in Appendix A.

15.1 Assessment approach

15.1.1 Methodology

15.1.1.1 Study area

A search of the AHIMS database was undertaken for a five by five kilometre search area, centred on the project site, in order to characterise the nature of recorded Aboriginal sites within the local area surrounding the project site.

The site inspection covered a study area targeting all areas with the potential for Aboriginal heritage in the vicinity of the project site. The focus of this was Warwick Farm Recreation Reserve, Jacquie Osmond Reserve and Cabramatta Creek.

15.1.1.2 Key tasks

The assessment involved:

- identifying the existing environment with respect to the history of the project site through a desk top study reviewing:
    - public databases
    - previous heritage assessments from the area
    - geotechnical studies.
- consultation with Registered Aboriginal Parties (RAPs)
- a field investigation of the project site, undertaken on 6 December 2018
- assessing the impacts of constructing and operating the project on Aboriginal cultural values in accordance with the *Guide to investigating, assessing and reporting on Aboriginal Cultural Heritage in NSW* (OEH, 2011)
- recommending measures to mitigate the impacts identified.

The field investigation was restricted to the portions of the project site located outside of the heavily disturbed rail line. The overall effectiveness of the survey for examining the ground for Aboriginal sites was deemed low due to ground surface visibility combined with a low amount of exposures; however, ground disturbances were identified across much of the project site.

15.1.1.3 Consultation

Consultation with the Aboriginal community was undertaken in accordance with the *Aboriginal cultural heritage consultation requirements for proponents* (DECCW, 2010). Known Aboriginal stakeholders in the Fairfield and Liverpool areas were contacted. A public notification was also placed in local newspapers. There were zero registered native title claims, unregistered claimant applications or registered indigenous land use agreements within the project site. A total of 22 groups registered interest in the project.

Details about the project were provided to the RAPs as well as the proposed test excavation methodology (provided in Appendix 3 of Technical Report 9) and Gandangarra Local Aboriginal Land Council (LALC) were invited to attend the field investigation of the study area. The RAPs were also provided with a copy of the draft Aboriginal cultural heritage assessment report on 17 April 2019 for review and comment. Eight responses were received within the 28 day review period. The majority of responses agreed with the recommendations. Other

responses were administrative around requesting a hard copy or a notice of receipt. A copy of the comments are provided in Appendix 4 of Technical Report 9.

15.1.2 Risks identified

The preliminary environmental risk assessment undertaken for the project included potential risks associated with Aboriginal heritage. 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.

One risk with an assessed level of high was identified:

- disturbance of known or unidentified items or places of Aboriginal heritage significance.

This potential risk was 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).

15.1.3 How potential impacts have been avoided/minimised

As described in Chapter 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 Aboriginal heritage impacts have been avoided/minimised, where possible by:

- designing the project site to minimise the amount of ground disturbance required. The location of compound sites have been proposed to:
    - avoid areas of high archaeological potential
    - minimise areas of moderate potential
    - where possible, locate compounds in previously disturbed areas.
- selecting locations for compounds that would avoid impacts on two previously recorded AHIMS sites.

15.2 Existing environment

15.2.1 Aboriginal historical and landscape context

The timing for the human occupation of the Sydney Basin is uncertain. While there is some possible evidence for occupation of the region around 40,000 years ago, the earliest known radiocarbon date for the Aboriginal occupation of the Sydney Basin is associated with an archaeological deposit at Parramatta, which was dated to around 30,000 years before the present day.

The historical landscape resources around the project site are likely to have provided an abundance of natural resources able to be utilised by Aboriginal people.

The project site consists of gently undulating slopes forming in the north that flow south from two crest landforms towards Cabramatta Creek, forming flood plains on either side of the creek line. These flood plains are gently inclined and feature low lying crests which range in elevation from 6 to 10 metres. Areas along Cabramatta creek range from steeply incised to gently inclined flood plains.

Potential archaeological deposits (PADs) have been previously recorded within the region upon well drained topographies within the vicinity of permanent sources of fresh water, and therefore have the potential to occur upon low lying crests within the lower floodplains.

The study area contains portions of the railway corridor installed in the late 1880s, and as such the surrounding areas have likely been heavily disturbed by the construction, maintenance and upgrades of the rail line.

15.2.2 Registered Aboriginal sites

A simple analysis of the Aboriginal cultural heritage sites registered within a five by five kilometre area around the project site indicates that artefact scatters are the most common site type identified. A search of the AHIMS database identified the following within the search radius:

- 109 Aboriginal archaeological sites
- Collingwood Precinct Aboriginal Place.

Two previously recorded AHIMS sites were identified within 50 metres of the project site:

- AHIMS 45-5-3271(CC1)
- AHIMS 45-5-3428/CC1.

The archaeological significance assessment for these sites is provided in section 15.2.4.

15.2.3 Archaeological survey

Disturbances identified within the project area included a previously cleared laydown area, a modified drainage line, access tracks adjacent to the rail line, the rail line and bridge crossing, and a large asphalted area on the eastern side of the rail line. The creek line immediately around the bridge crossing is highly disturbed from bridge and rail construction. These areas of disturbance have been assessed as having low archaeological potential.

Due to the high levels of previous ground disturbance and the level of urban development within the majority of the project site, the field investigation undertaken on 12 December 2018 focused on Warwick Farm Recreation Reserve and Jacquie Osmond Reserve. One random meander transect targeting areas of exposure within Warwick Farm Recreation Reserve and Jacquie Osmond Reserve was undertaken. The location of the two previously recorded AHIMS sites were inspected during the field investigation. Generally the survey was hampered by grass cover and ground disturbances reducing surface visibility of the underlying ground profile.

No Aboriginal objects were identified during the survey. The previously recorded AHIMS sites could not be located during the survey due to low surface visibility across the project area.

The area to the west of the rail line within Warwick Farm Recreation Reserve was assessed as having high archaeological potential due to the presence of previously recorded AHIMS sites with demonstrated archaeological deposits, and low levels of previous ground disturbance observed. Further subsurface archaeological deposits are likely to exist within the undisturbed areas within Warwick Farm Recreation Reserve.

The area to the east of the existing rail line within Jacquie Osmond Reserve displayed higher levels of disturbance and was assessed as having moderate archaeological potential. While Jacquie Osmond Reserve displayed evidence of some ground disturbance associated with the establishment of baseball playing fields, the field investigation and the background research conducted for the project area does not suggest that activities such as bulk earth works have occurred in this area.

Previous archaeological investigations in the region demonstrate that alluvial flats within close proximity to higher order waterways have high potential to contain subsurface archaeological deposits. It is therefore likely that Aboriginal objects exist within this area, however they are likely to be in a partially disturbed context.

15.2.4 Archaeological potential and significance

No previously unrecorded Aboriginal cultural heritage sites were identified during the field investigation.

The area to the west of the rail line within Warwick Farm Recreation Reserve was assessed as having high archaeological potential due to the presence of previously recorded AHIMS sites with demonstrated archaeological deposits, and low levels of previous ground disturbances observed. The area to the east of the existing rail line within Jacquie Osmond Reserve displayed higher levels of disturbance and was assessed with moderate archaeological potential. Areas of moderate and high Archaeological potential are shown on Figure 15.1. All remaining areas of the project site are assessed as disturbed areas only.

Figure 15.1 Areas of archaeological potential

In the event that archaeological remains did in fact exist in this area, the site types likely to be encountered, based predominantly on the location, land type and known history, are described in Table 15.1. All other sites types are considered to have a low potential for being within the project site.

Table 15.1 Aboriginal site prediction statements

Site type	Site description	Potential
Flaked stone artefact scatters and isolated artefacts	Artefact scatter sites can range from high-density concentrations of flaked stone and ground stone artefacts to sparse, low-density 'background' scatters and isolated finds.	High: Stone artefact sites have been previously recorded in the region across a wide range of landforms including alluvial flats, and also within 50 metres of the project area; they have the high potential to be present in undisturbed areas within the project area.
Potential archaeological deposits (PADs)	Potential sub surface deposits of cultural material.	Moderate: PADs have been previously recorded in the region across a wide range of landforms including alluvial flats. PAD sites have been previously recorded within 50 metres of the project area. They have the potential to be present in undisturbed landforms.
Modified trees	Trees with cultural modifications	Moderate: Scarred trees are the second most common site type within the vicinity of the project area. Due to extensive vegetation clearance only a small number of mature native trees have survived within the project area.

The following archaeological significance assessment is based on Requirement 11 of the *Code of practice for archaeological investigation of Aboriginal objects in NSW* (DECCW, 2010) (the Code). Using the assessment criteria detailed in Scientific Values and Significance Assessment, an assessment of significance was determined and a rating for each site was determined. The results of the archaeological significance assessment are given in Table 15.2.

Table 15.2 Statements of scientific significance for archaeological sites recorded within the project area

Site Name	Statement of Significance	Scientific significance
AHIMS 45-5-3271/CC1	AHIMS 45-5-3271/CC1 is recorded as an isolated artefact, and PAD. No further information about this site is available but a review of AHIMS 45-5-3428 suggests it has been tested as part of an assessment undertaken in 2007. An inspection of the site during this assessment found that the site is in good condition. This site type occurs frequently throughout the Cumberland Plans region. The archaeological significance of this site has therefore been assessed as moderate.	4 - Moderate
AHIMS 45-5-3428/CC1	AHIMS 45-5-3428 /CC1 was recorded in 2007. A copy of this site card was obtained from the AHIMS database. The information contained within this site card indicates that Aboriginal archaeological test excavations were undertaken by Therin in 2007 within PAD site AHIMS 45-5-3271, and the surrounding area. Excavations within the area identified 27 subsurface Aboriginal artefacts across four test pits. Therin therefore registered AHIMS 45-5-3428 as an extension of AHIMS 45-5-3271. An inspection of the site during this assessment found that the site is in good condition. This site type occurs frequently throughout the Cumberland Plans region. The archaeological significance of this site has therefore been assessed as moderate.	4 - Moderate

15.3 Assessment of construction impacts

15.3.1 Impacts on listed and identified sites

The location of compound sites were selected to avoid impacts to known archaeological sites. Table 15.3 summarised the significance of the two known sites and the potential impacts identified.

Table 15.3 Summary of potential archaeological impacts

AHIMS site no.	Site name	Significance	Type of harm	Degree of harm	Consequence of harm
45-5-3271	CC1	Low	No harm	None	No loss of value
45-5-3428	CC1	Low	No harm	None	No loss of value

15.3.2 Impacts on Aboriginal archaeology

During construction the following activities could result in impacts to the ground surface from excavations and compaction:

- piling
- ground works
- heavy vehicles and plant driving across the surface and therefore compacting the ground surface
- utility works comprising new or moving existing underground infrastructure such as sewer and stormwater pipes.

The majority of works to construct the project have been confined to areas of existing disturbance.

Proposed compound sites and work sites within Warwick Farm Recreation Reserve have been sited to avoid impacts to areas of high archaeological potential and placed in areas previously disturbed.

Impacts to the area of moderate archaeological potential within Jacquie Osmond Reserve cannot be avoided as the utility works to move existing sewer and stormwater pipes are required. In addition access to the rail corridor would be required from this location to build a retaining wall alongside the existing rail corridor.

The establishment of a site compound (C3) is also proposed within Jacquie Osmond Reserve and as it lies on an area identified as moderate potential for archaeological items, it could result in impacts to potential Aboriginal sites. These works involve use of the area for storage of plant, equipment and site offices and facilities, as well as staff parking areas. Some minor utility adjustments may also be required to service the compound facilities to the various utilities. These uses will result in shallow disturbances to soils and disturbances as a result of compaction, therefore further assessment is required to confirm the potential for archaeological deposits.

Further assessment would be undertaken in the form of test excavations at this location. The aim of the test excavations would be to identify and understand the nature, extent and significance of any areas of potential archaeological deposit within Jacquie Osmond Reserve by exposing, processing and recording potential archaeological remains. A systematic approach would be undertaken involving excavating test pits in a grid pattern across the area of interest. Further detail regarding the methodology for the proposed test excavations is provided in Appendix 3 of Technical Report 9. Test excavations proposed in the area of moderate potential will further contribute to the understanding of Aboriginal archaeology in the area which can be accessed by future generations, thereby complying with the principles of intergenerational equity.

15.3.3 Cumulative impacts

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

Direct impacts from ground disturbance or compaction from vehicles and equipment would be restricted to the project site. There are no other known construction projects proposed in the direct vicinity of the project site. Therefore no cumulative impacts with other projects are predicted.

15.4 Assessment of operation impacts

No significant operational impacts have been identified. Maintenance activities would take place within the rail corridor and would not therefore impact new areas.

15.4.1 Cumulative impacts

No significant operational impacts have been identified. There are no other known construction projects proposed within the project site or immediately adjacent to the site. Therefore no cumulative impacts with other projects are predicted.

15.5 Management of impacts

15.5.1 Approach

15.5.1.1 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 15.1.3).

Strategies to minimise impacts further have been developed based on the archaeological significance of cultural heritage relevant to the project site and influenced by:

- predicted impacts to Aboriginal cultural heritage
- the planning approvals framework including the National Parks and Wildlife Act 1974 and EPBC Act
- current best conservation practise
- ethos of the *The Burra Charter: the Australia ICOMOS Charter for Places of Cultural Significance*, (Australia ICOMOS, 2013)
- the Code.

Where impacts are unable to be avoided, standard construction mitigation measures are outlined in Table 15.4 and will be included in the CEMP.

Expected effectiveness

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

Measures to avoid and minimise impacts have been included in the reference design (refer to section 15.1.3). The project site has been designed to minimise the amount of ground disturbance required. The location of compound sites have been proposed to avoid areas of high archaeological potential and minimise areas of moderate potential.

Mitigation measures are recommended where ground disturbance would be unavoidable in areas of moderate archaeological potential.

As such, the measures to avoid impacts during development of the reference design and measures to be outlined in the CEMP are considered to be proven effective in managing potential impacts heritage and archaeological features.

15.5.2 List of mitigation measures

The mitigation measures that would be implemented to address potential Aboriginal heritage impacts are listed in Table 15.4.

Table 15.4 Mitigation measures

Stage	Impact	Measure
Design	Potential impacts to areas of high archaeological potential	If works are proposed outside the current project footprint (such as utility relocations) and impacts could occur within areas of high archaeological potential, further assessment in the form of subsurface investigations (test excavations) prior to impacts will be required (refer to methodology provided in Appendix 3 of Technical Report 9 – Aboriginal and cultural heritage impact assessment)..
	Impacts to archaeological heritage with the area of moderate potential in Jacquie Osmond Reserve.	Further assessment will be carried out in Jacquie Osmond Reserve in the form of subsurface investigations (test excavations) prior to construction commencing (refer to methodology provided in Appendix 3 of Technical Report 9 – Aboriginal and cultural heritage impact assessment). Should any Aboriginal objects be encountered during investigation a long term care agreement setting out the obligations and methods of long term safekeeping will be developed in consultation with the RAPs.
Construction	Impact to archaeological heritage	The CEMP will contain measures to protect Aboriginal heritage. This will include an unexpected finds protocol and heritage induction materials to ensure all onsite staff can identify items with potential archaeological Aboriginal heritage significance. During pre-work briefings, onsite staff will be made aware of the unexpected finds procedure and obligations under the *National Parks and Wildlife Act 1974*. The unexpected finds protocol will be prepared and provided to all staff and contractors as part of a site induction.
	Impact to archaeological heritage	The unexpected finds protocol will include the following at a minimum: • If potential Aboriginal items are uncovered, works within 10 metres of the item will cease and the find should not be moved. The item would then be assessed and managed by qualified archaeologist. If the find is determined to be an Aboriginal object the archaeologist will provide further recommendations which may include notifying the OEH and Aboriginal stakeholders.
	Damage to artefact found	A long term care agreement for any artefacts found as part of the works will be developed in consultation with the RAPs.
	Impacts to archaeological heritage with the area of high potential in Warwick Farm Recreational Reserve.	Areas of high archaeological potential will be clearly marked and fenced off as exclusion zones to ensure these areas are not impacted on by the proposed works. If changes to the proposed works occur which will result in impacts to these areas, subsurface investigations (test excavations) will be required.
	Impacts to unexpected finds	Consistent with the *NSW Skeletal Remains: Guidelines for Management of Human Remains* (Heritage Office, 1998), if any suspected human remains are discovered during any activity the following will occur: 1. Immediately cease all work at that location and not further move or disturb the remains. 2. Notify the NSW Police and OEH's Environmental Line on 131 555 as soon as practicable and provide details of the remains and their location. 3. Not recommence work at that location unless authorised in writing by OEH.

15.5.3 Consideration of the interaction between measures

Mitigation measures to control impacts to the Aboriginal heritage items and archaeology may replicate mitigation measures associated with non-Aboriginal heritage items, noise and vibration impacts and soils and contamination.

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.

15.5.4 Managing residual impacts

Residual impacts are defined as those impacts that remain following the implementation of mitigation measures.

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 summarised below.

It is expected that some limited residual impact will exist following completion of the proposed mitigation measures, which include archaeological investigation.

The scientific value of archaeological sites is linked to the physical information the sites contain. Although the loss of intrinsic Aboriginal cultural value of impacted sites cannot be offset through the proposed program of investigation, the information obtained would increase an understanding, strengthen the interpretations and improve ongoing and future management of Aboriginal heritage in the surrounding area. Moreover, the information recovered during the mitigation program would allow for informed management of the partially impacted sites, thereby achieving a positive result for Aboriginal heritage.

However while the proposed mitigation for impacted sites will contribute to our understanding, strengthen the interpretations and improve ongoing and future management of Aboriginal heritage in the surrounding area, the investigations would have a residual impact to the heritage value of sites by physically removing artefacts.

THIS PAGE HAS BEEN LEFT INTENTIONALLY BLANK

15 Aboriginal heritage

This chapter provides a summary of the Aboriginal heritage assessment undertaken by Biosis. A full copy of the assessment report is provided as Technical Report 9 – Aboriginal and cultural heritage impact assessment. The report was written to address the relevant SEARs which are outlined in Appendix A.

15.1 Assessment approach

15.1.1 Methodology

15.1.1.1 Study area

A search of the AHIMS database was undertaken for a five by five kilometre search area, centred on the project site, in order to characterise the nature of recorded Aboriginal sites within the local area surrounding the project site.

The site inspection covered a study area targeting all areas with the potential for Aboriginal heritage in the vicinity of the project site. The focus of this was Warwick Farm Recreation Reserve, Jacquie Osmond Reserve and Cabramatta Creek.

15.1.1.2 Key tasks

The assessment involved:

- identifying the existing environment with respect to the history of the project site through a desk top study reviewing:
    - public databases
    - previous heritage assessments from the area
    - geotechnical studies.
- consultation with Registered Aboriginal Parties (RAPs)
- a field investigation of the project site, undertaken on 6 December 2018
- assessing the impacts of constructing and operating the project on Aboriginal cultural values in accordance with the *Guide to investigating, assessing and reporting on Aboriginal Cultural Heritage in NSW* (OEH, 2011)
- recommending measures to mitigate the impacts identified.

The field investigation was restricted to the portions of the project site located outside of the heavily disturbed rail line. The overall effectiveness of the survey for examining the ground for Aboriginal sites was deemed low due to ground surface visibility combined with a low amount of exposures; however, ground disturbances were identified across much of the project site.

15.1.1.3 Consultation

Consultation with the Aboriginal community was undertaken in accordance with the *Aboriginal cultural heritage consultation requirements for proponents* (DECCW, 2010). Known Aboriginal stakeholders in the Fairfield and Liverpool areas were contacted. A public notification was also placed in local newspapers. There were zero registered native title claims, unregistered claimant applications or registered indigenous land use agreements within the project site. A total of 22 groups registered interest in the project.

Details about the project were provided to the RAPs as well as the proposed test excavation methodology (provided in Appendix 3 of Technical Report 9) and Gandangarra Local Aboriginal Land Council (LALC) were invited to attend the field investigation of the study area. The RAPs were also provided with a copy of the draft Aboriginal cultural heritage assessment report on 17 April 2019 for review and comment. Eight responses were received within the 28 day review period. The majority of responses agreed with the recommendations. Other

responses were administrative around requesting a hard copy or a notice of receipt. A copy of the comments are provided in Appendix 4 of Technical Report 9.

15.1.2 Risks identified

The preliminary environmental risk assessment undertaken for the project included potential risks associated with Aboriginal heritage. 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.

One risk with an assessed level of high was identified:

- disturbance of known or unidentified items or places of Aboriginal heritage significance.

This potential risk was 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).

15.1.3 How potential impacts have been avoided/minimised

As described in Chapter 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 Aboriginal heritage impacts have been avoided/minimised, where possible by:

- designing the project site to minimise the amount of ground disturbance required. The location of compound sites have been proposed to:
    - avoid areas of high archaeological potential
    - minimise areas of moderate potential
    - where possible, locate compounds in previously disturbed areas.
- selecting locations for compounds that would avoid impacts on two previously recorded AHIMS sites.

15.2 Existing environment

15.2.1 Aboriginal historical and landscape context

The timing for the human occupation of the Sydney Basin is uncertain. While there is some possible evidence for occupation of the region around 40,000 years ago, the earliest known radiocarbon date for the Aboriginal occupation of the Sydney Basin is associated with an archaeological deposit at Parramatta, which was dated to around 30,000 years before the present day.

The historical landscape resources around the project site are likely to have provided an abundance of natural resources able to be utilised by Aboriginal people.

The project site consists of gently undulating slopes forming in the north that flow south from two crest landforms towards Cabramatta Creek, forming flood plains on either side of the creek line. These flood plains are gently inclined and feature low lying crests which range in elevation from 6 to 10 metres. Areas along Cabramatta creek range from steeply incised to gently inclined flood plains.

Potential archaeological deposits (PADs) have been previously recorded within the region upon well drained topographies within the vicinity of permanent sources of fresh water, and therefore have the potential to occur upon low lying crests within the lower floodplains.

The study area contains portions of the railway corridor installed in the late 1880s, and as such the surrounding areas have likely been heavily disturbed by the construction, maintenance and upgrades of the rail line.

15.2.2 Registered Aboriginal sites

A simple analysis of the Aboriginal cultural heritage sites registered within a five by five kilometre area around the project site indicates that artefact scatters are the most common site type identified. A search of the AHIMS database identified the following within the search radius:

- 109 Aboriginal archaeological sites
- Collingwood Precinct Aboriginal Place.

Two previously recorded AHIMS sites were identified within 50 metres of the project site:

- AHIMS 45-5-3271(CC1)
- AHIMS 45-5-3428/CC1.

The archaeological significance assessment for these sites is provided in section 15.2.4.

15.2.3 Archaeological survey

Disturbances identified within the project area included a previously cleared laydown area, a modified drainage line, access tracks adjacent to the rail line, the rail line and bridge crossing, and a large asphalted area on the eastern side of the rail line. The creek line immediately around the bridge crossing is highly disturbed from bridge and rail construction. These areas of disturbance have been assessed as having low archaeological potential.

Due to the high levels of previous ground disturbance and the level of urban development within the majority of the project site, the field investigation undertaken on 12 December 2018 focused on Warwick Farm Recreation Reserve and Jacquie Osmond Reserve. One random meander transect targeting areas of exposure within Warwick Farm Recreation Reserve and Jacquie Osmond Reserve was undertaken. The location of the two previously recorded AHIMS sites were inspected during the field investigation. Generally the survey was hampered by grass cover and ground disturbances reducing surface visibility of the underlying ground profile.

No Aboriginal objects were identified during the survey. The previously recorded AHIMS sites could not be located during the survey due to low surface visibility across the project area.

The area to the west of the rail line within Warwick Farm Recreation Reserve was assessed as having high archaeological potential due to the presence of previously recorded AHIMS sites with demonstrated archaeological deposits, and low levels of previous ground disturbance observed. Further subsurface archaeological deposits are likely to exist within the undisturbed areas within Warwick Farm Recreation Reserve.

The area to the east of the existing rail line within Jacquie Osmond Reserve displayed higher levels of disturbance and was assessed as having moderate archaeological potential. While Jacquie Osmond Reserve displayed evidence of some ground disturbance associated with the establishment of baseball playing fields, the field investigation and the background research conducted for the project area does not suggest that activities such as bulk earth works have occurred in this area.

Previous archaeological investigations in the region demonstrate that alluvial flats within close proximity to higher order waterways have high potential to contain subsurface archaeological deposits. It is therefore likely that Aboriginal objects exist within this area, however they are likely to be in a partially disturbed context.

15.2.4 Archaeological potential and significance

No previously unrecorded Aboriginal cultural heritage sites were identified during the field investigation.

The area to the west of the rail line within Warwick Farm Recreation Reserve was assessed as having high archaeological potential due to the presence of previously recorded AHIMS sites with demonstrated archaeological deposits, and low levels of previous ground disturbances observed. The area to the east of the existing rail line within Jacquie Osmond Reserve displayed higher levels of disturbance and was assessed with moderate archaeological potential. Areas of moderate and high Archaeological potential are shown on Figure 15.1. All remaining areas of the project site are assessed as disturbed areas only.

Figure 15.1 Areas of archaeological potential

In the event that archaeological remains did in fact exist in this area, the site types likely to be encountered, based predominantly on the location, land type and known history, are described in Table 15.1. All other sites types are considered to have a low potential for being within the project site.

Table 15.1 Aboriginal site prediction statements

Site type	Site description	Potential
Flaked stone artefact scatters and isolated artefacts	Artefact scatter sites can range from high-density concentrations of flaked stone and ground stone artefacts to sparse, low-density 'background' scatters and isolated finds.	High: Stone artefact sites have been previously recorded in the region across a wide range of landforms including alluvial flats, and also within 50 metres of the project area; they have the high potential to be present in undisturbed areas within the project area.
Potential archaeological deposits (PADs)	Potential sub surface deposits of cultural material.	Moderate: PADs have been previously recorded in the region across a wide range of landforms including alluvial flats. PAD sites have been previously recorded within 50 metres of the project area. They have the potential to be present in undisturbed landforms.
Modified trees	Trees with cultural modifications	Moderate: Scarred trees are the second most common site type within the vicinity of the project area. Due to extensive vegetation clearance only a small number of mature native trees have survived within the project area.

The following archaeological significance assessment is based on Requirement 11 of the *Code of practice for archaeological investigation of Aboriginal objects in NSW* (DECCW, 2010) (the Code). Using the assessment criteria detailed in Scientific Values and Significance Assessment, an assessment of significance was determined and a rating for each site was determined. The results of the archaeological significance assessment are given in Table 15.2.

Table 15.2 Statements of scientific significance for archaeological sites recorded within the project area

Site Name	Statement of Significance	Scientific significance
AHIMS 45-5-3271/CC1	AHIMS 45-5-3271/CC1 is recorded as an isolated artefact, and PAD. No further information about this site is available but a review of AHIMS 45-5-3428 suggests it has been tested as part of an assessment undertaken in 2007. An inspection of the site during this assessment found that the site is in good condition. This site type occurs frequently throughout the Cumberland Plans region. The archaeological significance of this site has therefore been assessed as moderate.	4 - Moderate
AHIMS 45-5-3428/CC1	AHIMS 45-5-3428 /CC1 was recorded in 2007. A copy of this site card was obtained from the AHIMS database. The information contained within this site card indicates that Aboriginal archaeological test excavations were undertaken by Therin in 2007 within PAD site AHIMS 45-5-3271, and the surrounding area. Excavations within the area identified 27 subsurface Aboriginal artefacts across four test pits. Therin therefore registered AHIMS 45-5-3428 as an extension of AHIMS 45-5-3271. An inspection of the site during this assessment found that the site is in good condition. This site type occurs frequently throughout the Cumberland Plans region. The archaeological significance of this site has therefore been assessed as moderate.	4 - Moderate

15.3 Assessment of construction impacts

15.3.1 Impacts on listed and identified sites

The location of compound sites were selected to avoid impacts to known archaeological sites. Table 15.3 summarised the significance of the two known sites and the potential impacts identified.

Table 15.3 Summary of potential archaeological impacts

AHIMS site no.	Site name	Significance	Type of harm	Degree of harm	Consequence of harm
45-5-3271	CC1	Low	No harm	None	No loss of value
45-5-3428	CC1	Low	No harm	None	No loss of value

15.3.2 Impacts on Aboriginal archaeology

During construction the following activities could result in impacts to the ground surface from excavations and compaction:

- piling
- ground works
- heavy vehicles and plant driving across the surface and therefore compacting the ground surface
- utility works comprising new or moving existing underground infrastructure such as sewer and stormwater pipes.

The majority of works to construct the project have been confined to areas of existing disturbance.

Proposed compound sites and work sites within Warwick Farm Recreation Reserve have been sited to avoid impacts to areas of high archaeological potential and placed in areas previously disturbed.

Impacts to the area of moderate archaeological potential within Jacquie Osmond Reserve cannot be avoided as the utility works to move existing sewer and stormwater pipes are required. In addition access to the rail corridor would be required from this location to build a retaining wall alongside the existing rail corridor.

The establishment of a site compound (C3) is also proposed within Jacquie Osmond Reserve and as it lies on an area identified as moderate potential for archaeological items, it could result in impacts to potential Aboriginal sites. These works involve use of the area for storage of plant, equipment and site offices and facilities, as well as staff parking areas. Some minor utility adjustments may also be required to service the compound facilities to the various utilities. These uses will result in shallow disturbances to soils and disturbances as a result of compaction, therefore further assessment is required to confirm the potential for archaeological deposits.

Further assessment would be undertaken in the form of test excavations at this location. The aim of the test excavations would be to identify and understand the nature, extent and significance of any areas of potential archaeological deposit within Jacquie Osmond Reserve by exposing, processing and recording potential archaeological remains. A systematic approach would be undertaken involving excavating test pits in a grid pattern across the area of interest. Further detail regarding the methodology for the proposed test excavations is provided in Appendix 3 of Technical Report 9. Test excavations proposed in the area of moderate potential will further contribute to the understanding of Aboriginal archaeology in the area which can be accessed by future generations, thereby complying with the principles of intergenerational equity.

15.3.3 Cumulative impacts

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

Direct impacts from ground disturbance or compaction from vehicles and equipment would be restricted to the project site. There are no other known construction projects proposed in the direct vicinity of the project site. Therefore no cumulative impacts with other projects are predicted.

15.4 Assessment of operation impacts

No significant operational impacts have been identified. Maintenance activities would take place within the rail corridor and would not therefore impact new areas.

15.4.1 Cumulative impacts

No significant operational impacts have been identified. There are no other known construction projects proposed within the project site or immediately adjacent to the site. Therefore no cumulative impacts with other projects are predicted.

15.5 Management of impacts

15.5.1 Approach

15.5.1.1 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 15.1.3).

Strategies to minimise impacts further have been developed based on the archaeological significance of cultural heritage relevant to the project site and influenced by:

- predicted impacts to Aboriginal cultural heritage
- the planning approvals framework including the National Parks and Wildlife Act 1974 and EPBC Act
- current best conservation practise
- ethos of the *The Burra Charter: the Australia ICOMOS Charter for Places of Cultural Significance*, (Australia ICOMOS, 2013)
- the Code.

Where impacts are unable to be avoided, standard construction mitigation measures are outlined in Table 15.4 and will be included in the CEMP.

Expected effectiveness

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

Measures to avoid and minimise impacts have been included in the reference design (refer to section 15.1.3). The project site has been designed to minimise the amount of ground disturbance required. The location of compound sites have been proposed to avoid areas of high archaeological potential and minimise areas of moderate potential.

Mitigation measures are recommended where ground disturbance would be unavoidable in areas of moderate archaeological potential.

As such, the measures to avoid impacts during development of the reference design and measures to be outlined in the CEMP are considered to be proven effective in managing potential impacts heritage and archaeological features.

15.5.2 List of mitigation measures

The mitigation measures that would be implemented to address potential Aboriginal heritage impacts are listed in Table 15.4.

Table 15.4 Mitigation measures

Stage	Impact	Measure
Design	Potential impacts to areas of high archaeological potential	If works are proposed outside the current project footprint (such as utility relocations) and impacts could occur within areas of high archaeological potential, further assessment in the form of subsurface investigations (test excavations) prior to impacts will be required (refer to methodology provided in Appendix 3 of Technical Report 9 – Aboriginal and cultural heritage impact assessment)..
	Impacts to archaeological heritage with the area of moderate potential in Jacquie Osmond Reserve.	Further assessment will be carried out in Jacquie Osmond Reserve in the form of subsurface investigations (test excavations) prior to construction commencing (refer to methodology provided in Appendix 3 of Technical Report 9 – Aboriginal and cultural heritage impact assessment). Should any Aboriginal objects be encountered during investigation a long term care agreement setting out the obligations and methods of long term safekeeping will be developed in consultation with the RAPs.
Construction	Impact to archaeological heritage	The CEMP will contain measures to protect Aboriginal heritage. This will include an unexpected finds protocol and heritage induction materials to ensure all onsite staff can identify items with potential archaeological Aboriginal heritage significance. During pre-work briefings, onsite staff will be made aware of the unexpected finds procedure and obligations under the *National Parks and Wildlife Act 1974*. The unexpected finds protocol will be prepared and provided to all staff and contractors as part of a site induction.
	Impact to archaeological heritage	The unexpected finds protocol will include the following at a minimum: • If potential Aboriginal items are uncovered, works within 10 metres of the item will cease and the find should not be moved. The item would then be assessed and managed by qualified archaeologist. If the find is determined to be an Aboriginal object the archaeologist will provide further recommendations which may include notifying the OEH and Aboriginal stakeholders.
	Damage to artefact found	A long term care agreement for any artefacts found as part of the works will be developed in consultation with the RAPs.
	Impacts to archaeological heritage with the area of high potential in Warwick Farm Recreational Reserve.	Areas of high archaeological potential will be clearly marked and fenced off as exclusion zones to ensure these areas are not impacted on by the proposed works. If changes to the proposed works occur which will result in impacts to these areas, subsurface investigations (test excavations) will be required.
	Impacts to unexpected finds	Consistent with the *NSW Skeletal Remains: Guidelines for Management of Human Remains* (Heritage Office, 1998), if any suspected human remains are discovered during any activity the following will occur: 1. Immediately cease all work at that location and not further move or disturb the remains. 2. Notify the NSW Police and OEH's Environmental Line on 131 555 as soon as practicable and provide details of the remains and their location. 3. Not recommence work at that location unless authorised in writing by OEH.

15.5.3 Consideration of the interaction between measures

Mitigation measures to control impacts to the Aboriginal heritage items and archaeology may replicate mitigation measures associated with non-Aboriginal heritage items, noise and vibration impacts and soils and contamination.

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.

15.5.4 Managing residual impacts

Residual impacts are defined as those impacts that remain following the implementation of mitigation measures.

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 summarised below.

It is expected that some limited residual impact will exist following completion of the proposed mitigation measures, which include archaeological investigation.

The scientific value of archaeological sites is linked to the physical information the sites contain. Although the loss of intrinsic Aboriginal cultural value of impacted sites cannot be offset through the proposed program of investigation, the information obtained would increase an understanding, strengthen the interpretations and improve ongoing and future management of Aboriginal heritage in the surrounding area. Moreover, the information recovered during the mitigation program would allow for informed management of the partially impacted sites, thereby achieving a positive result for Aboriginal heritage.

However while the proposed mitigation for impacted sites will contribute to our understanding, strengthen the interpretations and improve ongoing and future management of Aboriginal heritage in the surrounding area, the investigations would have a residual impact to the heritage value of sites by physically removing artefacts.

THIS PAGE HAS BEEN LEFT INTENTIONALLY BLANK

16 Land use and property

This chapter provides the land use and property impact assessment of the project. It describes the existing environment, assesses the impacts of construction and operation on land use, and provides mitigation measures.

16.1 Assessment approach

16.1.1 Methodology

The assessment involved:

- describing the existing environment with reference to existing land uses and planning controls, based on a review of aerial photography, land use zones specified by applicable local environmental plans, and a site visit
- reviewing key strategic planning policies and documents relevant to the study area, to identify planned future priorities, including land uses and developments
- assessing the potential impacts of construction and operation on existing and likely future land uses, and properties within and around the project site
- identifying mitigation measures to avoid, minimise or manage potential impacts.

16.1.2 Risks identified

The preliminary environmental risk assessment undertaken for the project included potential risks associated with land use and property. 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 potential land use and property risks ranged from medium to high. Risks with an assessed level of medium or above include:

- establishment of compound sites and relocation of utilities impacting access to properties
- establishment of compound sites within public recreation areas
- impacts on land use as a result of property acquisition
- severance of properties (Peter Warren Automotive) resulting in smaller lot sizes that may impact on use
- impacts to local amenity due to increased frequency of trains.

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).

16.1.3 How potential impacts have been avoided/minimised

As described in Chapter 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 land use and property impacts have been avoided/minimised where possible by:

- designing the project to ensure project infrastructure is located within the existing rail corridor as far as practicable, to minimise the potential for impact to other land use and private property
- designing the project to maintain the existing functionality of Broomfield Street
- siting compounds in the same locations as those previously used for the SSFL project
- minimising the footprint of compound C3 in Jacquie Osmond Reserve to minimise potential impacts on use of the sports field and reserve.

16.2 Existing environment

A description of the project site for the purpose of the EIS is provided in Chapter 2 (Location and setting). Section 16.2.1 describes existing land uses and properties within and immediately surrounding the project site. Future land uses are described in section 16.2.2.

16.2.1 Existing land use and zoning

The project lies within the suburbs of Cabramatta and Warwick Farm within the City of Fairfield and City of Liverpool local government areas.

Land uses within the project site include:

- the existing rail corridor which is used for transport – rail and supporting infrastructure purposes
- the existing road corridor which is used for transport and parking (Broomfield Street and Sussex Street)
- open space recreational (Jacquie Osmond Reserve and Warwick Farm Recreation Reserve)
- commercial/industrial (southern end of the project site).

Land use zoning within and in the vicinity of the project site is set by the following environmental planning instruments:

- Liverpool LEP 2008
- Fairfield LEP 2013.

The majority of the rail corridor is zoned SP2 Infrastructure. Some sections of the rail corridor are also zoned as follows:

- B4 Mixed Use - at Cabramatta Station
- SP2 Infrastructure (Classified Road) – at Cabramatta Station
- IN1 General Industrial- north of Warwick Farm Station.

The areas located outside of the rail corridor consist of the following land zoning:

- Broomfield Street and Sussex Street and the shared path between Broomfield Street and Jacquie Osmond Reserve:
  - Land zoned R3- Medium Density Residential
  - Land zoned R2- Low Density Residential
  - Land zoned E2- Environmental Conservation.
- Warwick Farm Reserve and Jacquie Osmond Reserve:
  - Land zoned RE1- Public Recreation.

- Commercial/industrial land use adjacent to the eastern boundary of SSFL at the southern extent of the project site:
    - Land zoned IN1- General Industrial.

Land use zones in and around the project site are shown in Figure 16.1

The existing environment is distinctly urban in its setting with residential areas bordered by major roads. The Hume Highway runs to the east and south of the project site, Cabramatta Road runs through the north of the study area and the SSFL runs north-south through the centre of the project site. The project site is surrounded by a mix of land uses, including residential, commercial, industrial, and recreation/open space, with pockets of education and community uses. Further information on the location of key community facilities is provided in Chapter 18 (Socio-economic impacts).

To the north of the project site is Cabramatta Station and Cabramatta's commercial centre, with retail and food businesses located on both sides of the station and rail corridor.

The northern end of the project site is characterised by low density residential land use. On the eastern side of the rail corridor, within the project site lies Broomfield Street. The wide residential street includes a shared path that is part of the Liverpool to Parramatta Rail Trail and angled parking on the west and a grassed and tree lined verge on the east, beyond which is low to medium density residential housing, a Buddhist temple and cultural centre. Railway Parade is located on the western side of the rail corridor, beyond which are a mixture of residential and industrial properties.

The centre of the project site is characterised by recreational land, nature reserves and open space either side of the rail corridor. The shared path (part of the Liverpool to Parramatta Rail Trail) extends from Broomfield Street, across Cabramatta Creek (which runs east-west through the centre of the project site) to Jacquie Osmond Reserve on the eastern side of the project site. The main feature of the reserve is 12 baseball diamonds which are used for local, district and State competitions and local weekly training sessions by the Southern Districts Softball Association (SDSA).

On the western side of the rail corridor is Warwick Farm Recreation Reserve which is a large area of environmental conservation and public recreation, including parks and a number of sporting ovals. These include Stroud Park, which abuts the rail corridor to the west; Cabramatta Sportsground; Don Dawson Oval and Durrant Oval.

The southern end of the project site is characterised by industrial and commercial land uses on the eastern side of the rail corridor including Peter Warren Automotive and Warwick Farm Hometown which contains a number of businesses and fast food outlets. On the eastern side of the rail corridor is Lawrence Hargrave Special Education School and residential properties.

To the south of the project site is Hume Highway and Warwick Farm Station as well as a mixture of residential, commercial and industrial uses.

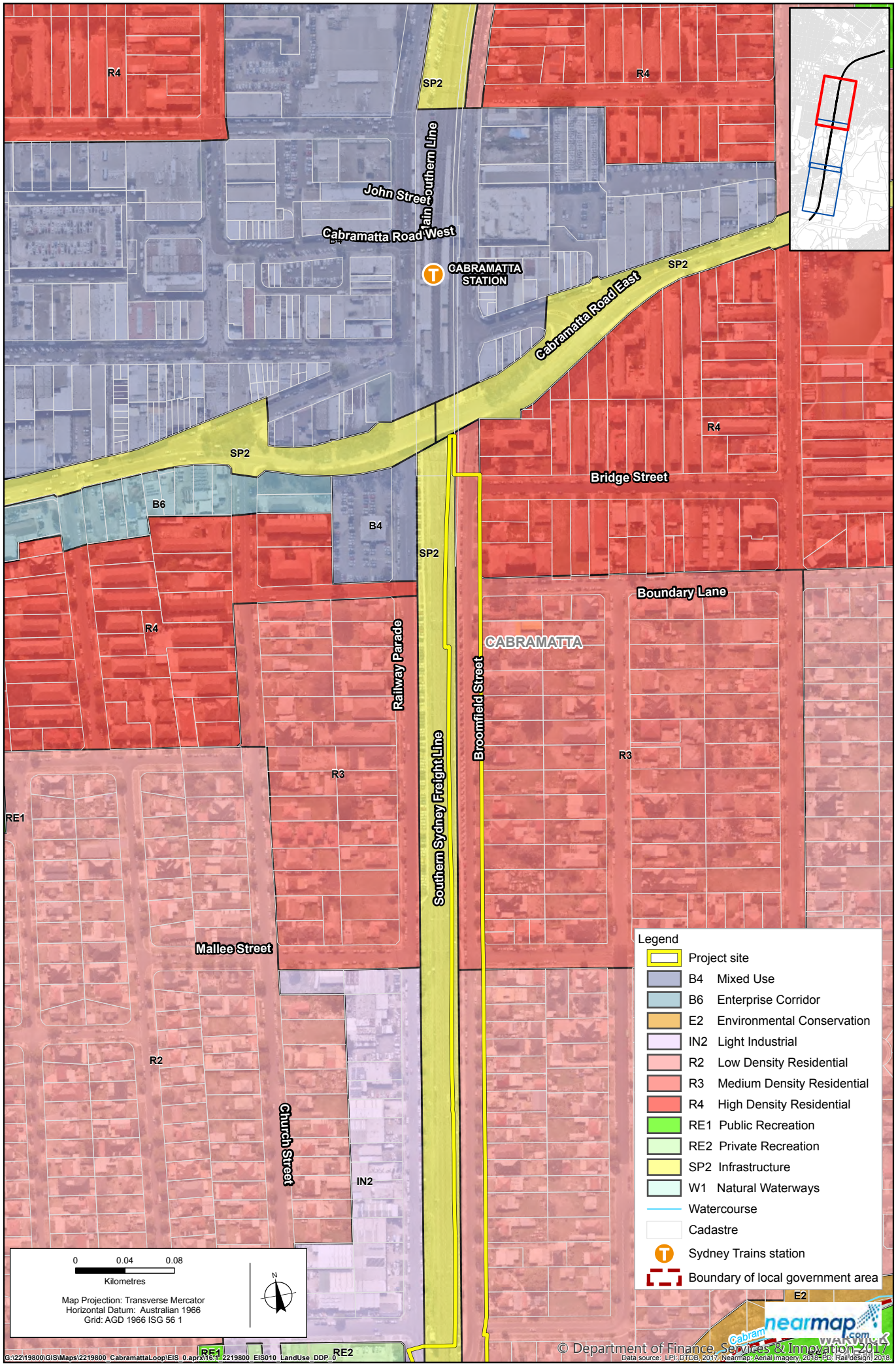

Figure 16.1a Land uses

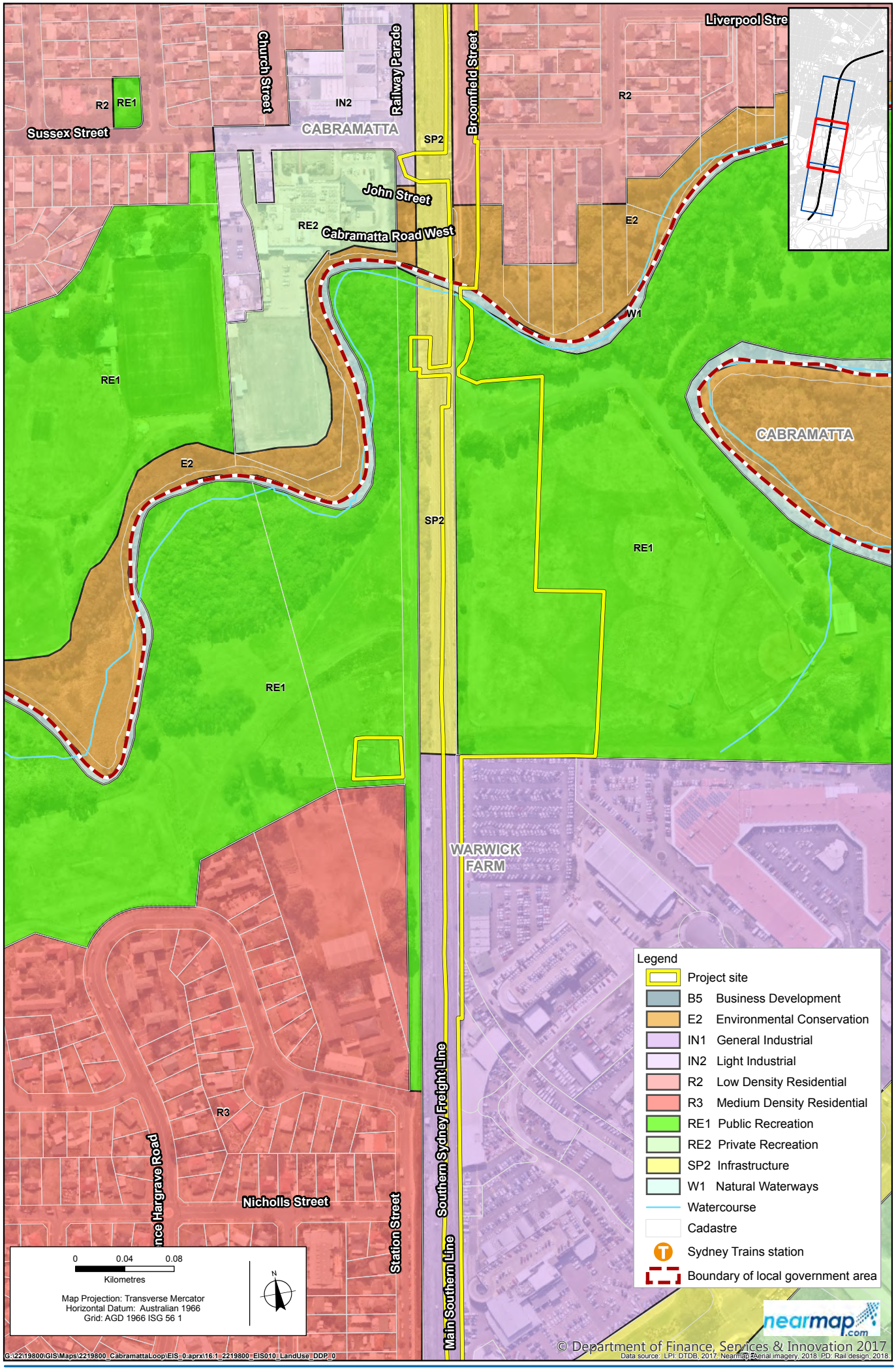

Figure 16.1b Land uses

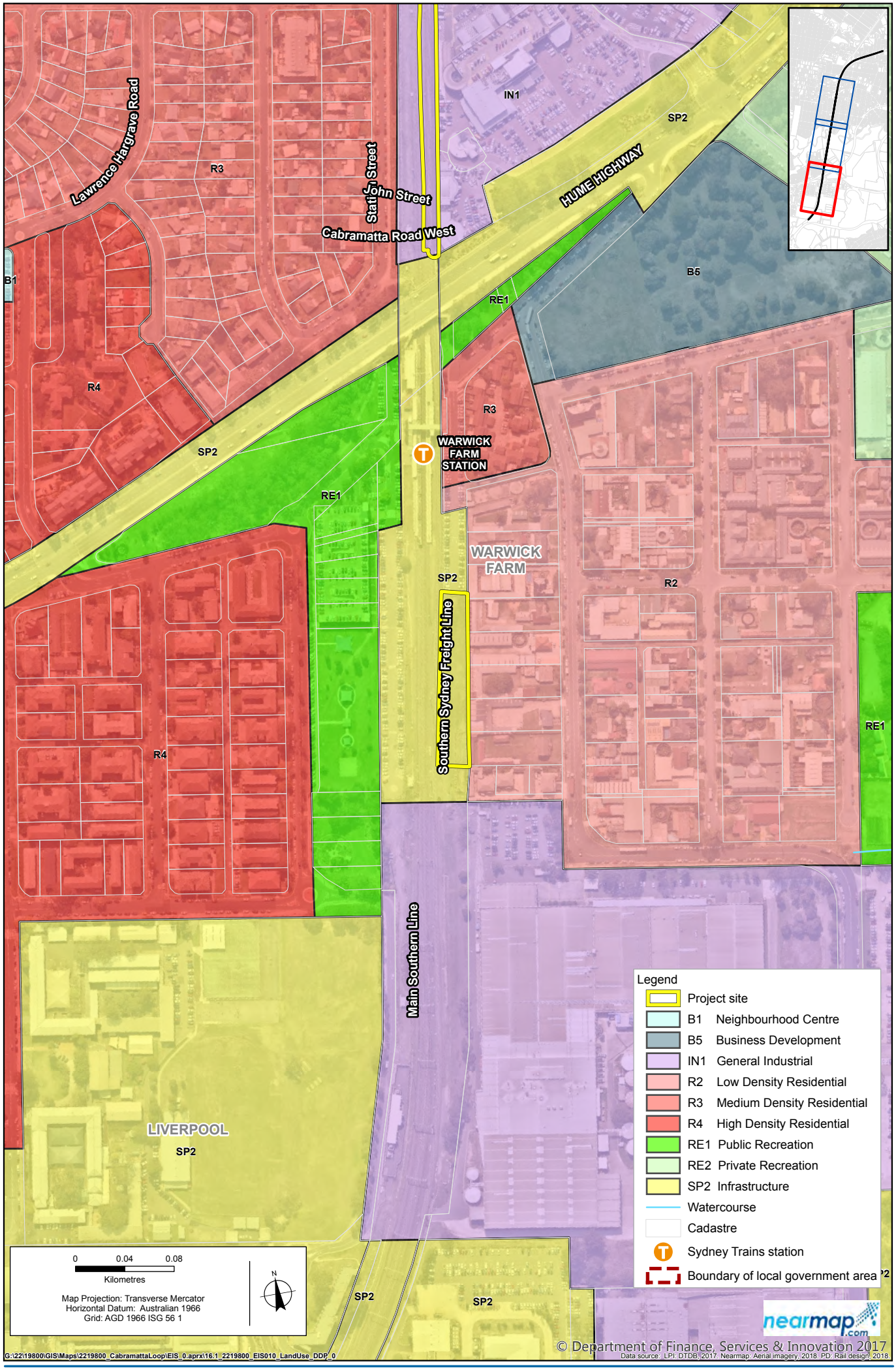

Figure 16.1c Land uses

16.2.2 Future land uses

16.2.2.1 Strategic Planning

Strategic planning for the region, including the study area has and is being undertaken by a number of agencies, including the Greater Sydney Commission and relevant councils. This strategic planning is separate to the planning and approval process for the project, however the project has been informed by the broader strategic planning context.

The main strategies relevant to future land use planning for the study area are summarised below.

A Metropolis of Three Cities – the Greater Sydney Region Plan

A Metropolis of Three Cities – the Greater Sydney Region Plan (Greater Sydney Commission, 2018a) sets a 40 year vision (to 2056) and establishes a 20 year plan to manage Greater Sydney's growth and change. The plan recognises that to have a well-connected and productive city, there is a need to co-locate jobs and services, improve transport efficiency and create more efficient freight networks.

The plan is built on a vision of three cities, where most residents live within 30 minutes of jobs, education, health facilities, and other services comprised of:

- Western Parkland City
- Central River City
- Eastern Harbour City.

The project is located in the Western Parkland City. The Western Parkland City is referred to as one of the key trade gateways for the City of Sydney with plans for dedicated road and rail trade networks to increase interconnectivity. Major new infrastructure will be required for the Westland Parkland City, where the focus will be on planning growth and sequencing new infrastructure and services to support shaping a new connected city. The Western Sydney Airport will be the economic catalyst to transform the Westland Parkland City as it will attract globally significant defence and aerospace activities and have significant freight and logistics strengths.

To support the economic growth of the Western Parkland City Objective 16 of the plan commits to providing a freight and logistics network that is competitive and efficient. Major improvements are being planned, including a dedicated freight rail connection from Port Botany to the Western Parkland City to increase the proportion of freight moved by rail. This will boost the economic potential of surrounding industrial precincts in Western Sydney. With this investment comes the need to maintain buffers to nearby residential areas and restrict further encroachment by residential uses. To optimise the efficiency and effectiveness of the freight handling network the following strategy is proposed which is of relevance to land use planning in the study area (Strategy 16.2):

- protect current and future freight corridors and shared freight corridors
- balance the need to minimise negative impacts of freight movement on urban amenity with the need to support efficient freight movements and deliveries
- identify and protect key freight routes
- limit incompatible uses in areas expected to have intense freight activity.

Western City District Plan – connecting communities

The Greater Sydney Commission's five district plans are a guide for implementing the *A Metropolis of Three Cities – the Greater Sydney Region Plan* at a district level. These 20 year plans are a bridge between regional and local planning. Their purpose is to inform local environmental plans, community strategic plans and the assessment of planning proposals.

The project is located in an area subject to the *Western City District Plan* (Greater Sydney Commission, 2018b), within the suburbs of Cabramatta and Warwick Farm.

The *Western City District Plan* (Greater Sydney Commission, 2018b) identifies the need to increase economic productivity and the critical role that new infrastructure plays in achieving this. It emphasises the importance of the

trade gateways – such as Western Sydney Airport and Port Botany for the economic corridor of the Western region, as well as Greater Sydney and NSW. A key action of relevance to the project is for councils and government agencies is to support and facilitate internationally competitive freight and logistics sectors.

With regards to future land use planning within the study area the plan recognises Cabramatta as an area of diversity and richness, also noting that street life is particularly evident in this suburb. Cabramatta is also recognised as a distinctive dining and night-time precinct. To achieve Objective 12 (Great places that bring people together) the plan notes that planning for places like Cabramatta needs to integrate site-specific planning proposals with precinct-wide place and public domain outcomes through place-based planning. Additionally the plan notes that street environments will need to allocate road space between footpaths, cycleways, public transport and vehicles that considers people's safety needs and balances movement and place functions in response to the type of street and local conditions.

The plan also identifies Collaboration Areas, which will be the main focus for access to goods and services, entertainment, leisure and recreational activities as well as cultural and arts experiences. One of these Collaboration Areas incorporates the Warwick Farm Precinct and the under construction Moorebank Intermodal Terminal. The Warwick Farm Precinct is directly south of the project site and the aim in this area is to undertake urban renewal and retain a social housing mix.

16.2.2.2 Adjacent to the project site

Other future development opportunities relevant to land in the vicinity of the project site include a proposed amendment to the Fairfield LEP which has been submitted to facilitate the future re-development of a 1.285 hectare precinct of land on the eastern side of Cabramatta Station (on the corner of Broomfield Street and Cabramatta Road East).

The precinct in question is currently zoned B4 Mixed Use and consists of 22 privately owned lots and a section of public laneway owned by Fairfield City Council. The purpose of the planning proposal is to increase the maximum building heights and floor space ratios for the subject site to facilitate the future development of the precinct for a mix of commercial and residential apartment development (up to 19 storeys and 582 dwelling) including basement car parking, overhead pedestrian bridge to Cabramatta Station, activated street frontages and reinvigorated public spaces to activate the commercial area east of the rail line. The amendment has been submitted to the Department of Planning, Industry and Environment for gateway determination. There would be no change in the existing zoning of the precinct.

No other proposed development opportunities or strategies were identified that may influence the future land use in the vicinity of the project site.

16.3 Assessment of construction impacts

16.3.1 Property impacts

16.3.1.1 Property and land requirements

As described in Chapter 7 (Construction), permanent land acquisition would involve acquisition of an approximately five metre strip of land to the east of the existing rail corridor to accommodate the passing loop, including:

- partial acquisition of the road corridor owned by Fairfield City Council (Broomfield Street and an area that currently accommodates the shared path between Sussex Street and Cabramatta Creek) in the northern end of the project site
- partial acquisition of one lot owned by the Department of Planning, Industry and Environment and operated by Liverpool City Council (Jacquie Osmond Reserve) in the centre of the project site
- partial acquisition of two privately owned commercial lots at the southern end of the project site on which a car dealership is located (Peter Warren Automotive)

- full acquisition of one lot and partial acquisition of another lot owned by Liverpool City Council at the southern end of the project site. Property and land acquisition requirements are summarised in Table 6.4. The location of these properties and the existing land uses/zoning is shown in Figure 6.8.

RailCorp would acquire the land on behalf of ARTC with ARTC leasing the land off RailCorp as per the SSFL rail corridor. RailCorp is bound by NSW Government legislation to act according to specific procedures when acquiring property. The acquisition of privately owned land would be managed in accordance with the *Land Acquisition (Just Terms Compensation) Act 1991*. This legislation encourages the acquisition of land by agreement rather than by compulsory acquisition wherever possible.

Independent valuers assess the current market value for each property being acquired. In addition to the market value of the property, assessment can be made of any additional costs that can reasonably be incurred as a result of an acquisition, such as stamp duty, professional costs (eg legal fees, valuation fees, etc.), relocation costs, losses resulting from severance, and losses relating to disturbance.

The valuation informs the offer made to the property owner. ARTC would work collaboratively with property owners to ensure that the acquisition process is fair, reasonable and as easy as possible.

16.3.1.2 Temporary acquisition or lease of property

As described in section 7.4, a number of compound areas and work sites would be required for temporary use during construction. These include sites within the rail corridor and outside it. Some areas of land would need to be temporarily leased or occupied to locate some of these compounds and work sites.

Additionally, as described in section 7.5.5, the temporary acquisition of land within three lots of a privately owned commercial property at the southern extent of the project site would also be required to facilitate the relocation of Sydney Water's assets currently running parallel to the rail corridor. As discussed in section 8.3.5, ARTC is also proposing to lease a vacant lot in close proximity to the project site and provide a temporary at-grade parking area during construction. There are four potential options available, all subject to negotiation.

16.3.2 Land use

Direct impacts on land use during construction would include temporary land take and the short term presence of construction equipment, plant, vehicles, compounds, and work sites within the project site. During construction, the use of the land would change from a shared path and public recreation space to a partial and temporary construction site.

Between the existing Sussex Street bridge and Jacquie Osmond Reserve, the project would have a temporary impact on use of the shared path and footbridge which crosses Cabramatta Creek as the existing land use would temporarily change due to the presence of work sites to facilitate construction of the new bridges.

Within Jacquie Osmond Reserve and Warwick Farm Recreation Reserve use of the land for public recreation purposes would be temporarily restricted due to the presence of construction compounds. At Jacquie Osmond Reserve this would impact on the usability of three of the existing twelve softball diamonds.

Along Broomfield Street the use of some existing on-street parking areas and access to residential properties would be temporarily restricted during construction. Impacts on parking and property access during construction are considered in Chapter 8 (Traffic, transport and access).

Table 16.1 provides a summary of the potential impacts of temporary construction sites on land uses. These impacts would be predominantly minor and short term and following construction these areas would be returned to their pre-existing condition and land use.

During construction, land subject to acquisition would also change from its existing use (commercial, public road and reserves) to a temporary construction site. Public access would be restricted.

Typically, the temporary use of land would be secured through a lease or a memorandum of understanding with the relevant land owner or manager which in this case would be the government (Fairfield City Council or Liverpool City Council).

Table 16.1 Impacts of temporary construction sites on land use

Site	Location	Temporary proposed use	Owner	Potential temporary impact on land use
C2	Warwick Farm Recreation Reserve	Construction compound	Public	Change from existing use (recreation) to construction compound
C3	Jacquie Osmond Reserve	Construction compound	Public	Change from existing use (recreation) to construction compound
W1	Access to compound site C3	Truck turning circle	Public	Change from existing use (recreation and shared path) to work site. Temporary alterations to pedestrian/cyclist access between Broomfield Street and Warwick Farm Recreation Reserve.
W2	Southern side of Cabramatta Creek bridge	Crane pads	Public	Change from existing use (shared path) to work site. Temporary alterations to pedestrian/cyclist access between Broomfield Street and Jacquie Osmond Reserve.
W3	Northern side of Cabramatta Creek bridge	Construction compound	Public	Change from existing use (shared path) to work site. Temporary alterations to pedestrian/cyclist access between Broomfield Street and Jacquie Osmond Reserve.
W3	Sussex Street bridge	Construction compound	Public	Change from existing use (shared path) to work site. Temporary alterations to pedestrian/cyclist access between Broomfield Street and Jacquie Osmond Reserve.

16.3.3 Impacts to utilities

As identified in Chapter 7 (Construction), it is likely that a number of utilities and services located within the project site, including power, water, wastewater and telecommunications would require protection, relocation or realignment as part of the construction of the project. This is particularly the case around areas of surface or shallow soil disturbance.

A preliminary assessment of impacts to major utilities identified the following key areas of interest:

- road works along Broomfield Street
- construction of the passing loop in Jacquie Osmond Reserve and Peter Warren Automotive.

The potential land use impacts in these areas are outlined in the following section.

16.3.3.1 Road works along Broomfield Street

It is proposed that all existing services located in both of the verges and the roadway of Broomfield Street, including overhead power lines, be relocated to the new Broomfield Street verges and roadway. This would have a negligible impact on land use given the existing services would be relocated to the same land use in a different location.

16.3.3.2 Construction of the passing loop in Jacquie Osmond Reserve and Peter Warren Automotive

The existing sewer rising main and gravity main located parallel to the rail corridor in Jacquie Osmond Reserve and Peter Warren Automotive would require relocation during construction of the passing loop. It is proposed to relocate this service about five metres to the east of its existing location. This relocation would not preclude use of the land within Jacquie Osmond Reserve however it would preclude planting of trees and any sort of building

development above it. Given the current use of the land within Jacquie Osmond Reserve as open space recreational, utility related land use impacts at this location are considered to be low.

Peter Warren Automotive would be temporarily impacted due to the relocation of Sydney Water assets. This would involve temporary acquisition for a period of up to six months of land within three lots of the car dealership (refer to section 7.5.5) for the purposes of a temporary Sydney Water easement. While the land to be temporarily acquired appears to currently be either vacant or used for car parking and does not contain any buildings, the land is located directly adjacent to buildings therefore the construction of the easement may limit access to and from these buildings.

There may be the need for utility relocations to be undertaken in areas directly adjacent to the project site. Utility relocation activities outside of the project site may result in the following potential impacts:

- traffic impacts, eg impacts associated with the presence of works within the road corridor and additional traffic movements
- property access impacts, eg impacts due to works restricting access
- noise and vibration impacts, eg from the use of construction equipment
- soil and waste management impacts, including the potential exposure and disposal of contaminated soils
- impacts to vegetation if clearance/pruning is required to undertake works
- air quality impacts due to the dust generation
- potential Aboriginal heritage impacts due to sub-surface disturbance
- hazard and risk impacts, eg impacts associated with welding or abrasive blasting
- potential non-Aboriginal impacts where heritage items are located in proximity to works.

The potential for the above impacts has been considered within this EIS and the specialist assessments appended to this EIS, within the context of the study areas defined by the specialist assessments. Where there is potential for impacts based on the assessments undertaken, or where the relocations would occur outside the assessed study area then the approach to design refinements described in section 22.5.2 would be adopted.

16.3.4 Cumulative impacts

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

There may be the potential for cumulative impacts to utilities along Broomfield Street during construction, if the proposed development identified in section 16.2.2 is constructed at the same time as the project. The potential for cumulative impacts would be minimised through ongoing consultation with utility providers.

Any other impacts on land use would be short term and within the project site only, therefore they would not contribute to cumulative land use changes in the surrounding area.

16.4 Assessment of operation impacts

16.4.1 Property impacts

Property acquisition would occur during the project planning and pre-construction phases. Direct impacts to properties are not expected during operation.

16.4.2 Land use

16.4.2.1 Direct impacts to land use

Operation of the project would result in minimal direct impacts to land use. The rail corridor would continue to operate as a rail corridor, Jacquie Osmond Reserve and the shared path near Cabramatta Creek would continue to be accessed as public recreation space and Peter Warren Automotive would continue existing commercial

operations. Construction of the project would mean that the western edge of Broomfield Street (an average of five metres width) would change from the existing use of a road corridor, to a rail corridor. However, with the realignment of Broomfield Street, it would continue to operate as a road corridor with parking, a shared path and footpath, as per the existing situation, albeit elements of the road corridor would be narrower. The project including the proposed realignment of Broomfield Street would not change the existing functionality of Broomfield Street.

Direct operational impacts on land use related to the acquisition described in section 16.3.1 and occur at the construction stage of the project.

Land uses within the road corridor and shared path would not be impacted by the partial acquisition, as these areas would continue to be used for transport purposes and would be consistent with the current zoning. The project would affect parking along Broomfield Street, as the partial acquisition and reconfiguration of Broomfield Street would result in the permanent loss of up to 11 parking spots out of a total of 213 available parking spots (between Cabramatta Station and Sussex Street). The potential impacts on the availability of parking are considered in Chapter 8 (Traffic, transport and access).

The partial acquisition of Jacquie Osmond Reserve may require the movement of up to three of the existing softball diamonds up to ten metres to the east. However, based on a review of aerial images, this is considered unlikely to impact on the operation of the softball fields. The need to move the softball diamonds, would be further refined during detailed design and where there is the potential to impact on the existing operation of the softball fields ARTC would consult with Liverpool City Council and the Southern Districts Softball Association.

Some of the land proposed to be acquired from Liverpool City Council (Lot 10 DP 776165) and the private owner of Peter Warren Automotive (Lot 12 578199) in the southern end of the project site is currently used for overflow car parking of commercial vehicles. The council land is vacant and where Peter Warren Automotive use this land for parking there is no formal agreement in place. Acquisition of the privately owned land would reduce the amount of land available to Peter Warren for car parking.

With regards to the partial acquisition of Lot 3 DP 1013680 within Peter Warren Automotive this land consists of hardstand surfaces located adjacent to buildings including the machinery sheds and main dealership building. It is unknown what this land is currently used for. Acquisition of the land may also impact on the businesses ability to access the buildings adjacent to this land.

Consultation with the private owner of Peter Warren Automotive is currently underway to understand and manage any potential impacts associated with acquisition of this land.

16.4.2.2 Impacts on future land use

The acquisition of land for the project would potentially result in the reconfiguration of land owned by Peter Warren Automotive. This would be subject to consultation during the acquisition process.

The project would not directly impact any local urban release areas identified for future residential or employment land. Instead, the project would enable the increase in economic productivity and economic growth for the Western Parkland City by contributing to a freight and logistics network that is competitive and efficient. Further information regarding the project's consistency with future strategic planning is provided in Appendix C.

16.4.3 Cumulative impacts

The project would result in limited changes in land use in the long term and therefore would not contribute to any cumulative land use changes in the region.

16.5 Management of impacts

16.5.1 Approach

16.5.1.1 Approach to mitigation and management

Overall, the majority of potential construction related impacts on land use and property would be short term and temporary in nature. The potential for these impacts would be significantly reduced by:

- effective construction design and planning
- implementation of the mitigation measures provided in Table 16.2
- consultation with individual property owners and managers to identify individual concerns, and develop and document strategies (including actions and timeframes) to address these concerns
- ongoing communication with the broader community.

16.5.1.2 Expected effectiveness

ARTC have experience in managing potential impacts on local communities and businesses as a result of rail developments of a similar scale and scope to this project. Many of the mitigation measures outlined involve effective and ongoing communications with the community and affected land owners and managers.

The CEMP prepared prior to construction would also address the requirements of the project approvals, the environmental management measures outlined in the EIS and all applicable legislation. With regard to land use impacts, mitigation measures are expected to minimise and manage impacts on land use throughout the construction phase. The local and broader community would be notified in advance of construction activities, temporary arrangements, traffic management and pedestrian/cyclist access arrangements and any special construction activities of short duration. As such, impacts to land use during construction are expected to be relatively minor and temporary, and would be effectively managed through the mitigation measures proposed.

With regards to property impacts, any acquisition would be undertaken in accordance with relevant NSW regulatory requirements, including the *Land Acquisition (Just Terms Compensation) Act 1991,* ensuring a fair, reasonable and as easy as possible acquisition process.

It is expected that these recommendations, along with any relevant requirements of the project approval, best practice guidelines and applicable legislation would be developed into the CEMP prepared to manage the relevant phases of the project. Routine auditing of the effectiveness of the implementation of the CEMP requirements will be undertaken to ensure that management measures remain adequate, effective and fit for purpose.

16.5.2 List of mitigation measures

The mitigation measures that would be implemented to address potential land use and property impacts are listed in Table 16.2.

Table 16.2 Mitigation measures

Stage	Impact	Measure
Design	Property acquisition	All acquisitions/adjustments will be undertaken in consultation with landowners and relevant acts.
	Impacts to services and utilities	Utility and service providers will continue to be consulted during detailed design to identify possible interactions and develop procedures to minimise the potential for service interruptions and impacts on existing land uses.
	Temporary land use impacts on Council and privately owned land	Individual property agreements/licenses will be developed in consultation with the relevant council and land owners. These will detail any restoration requirements and relocation of impacted infrastructure as required.
	Temporary land use impacts on Council and privately owned land	The overall disturbance footprint will be refined during detailed design to identify areas where the footprint could be minimised to reduce impacts on existing public recreation land uses and privately owned land. Detailed construction staging of the project will also be considered further during detailed design and will aim to minimise the time that affected land uses are impacted during construction.

Stage	Impact	Measure
Construction	Temporary use	Temporary use areas, including public open space, will be restored to their pre-existing condition (as a minimum) as soon as practicable following completion of construction. This will be undertaken in consultation with the relevant council.

16.5.3 Consideration of the interaction between measures

Mitigation measures in other chapters that are relevant to the management of potential land use and property impacts include:

- Chapter 8 (Traffic, transport and access), particularly with respect to the management of traffic and property access during construction
- Chapter 18 (Socio-economic impacts) with respect to management of impacts to the community during construction.

Together, all these measures would minimise the potential land use and property impacts of the project.

16.5.4 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 summarised below.

Residual land use and property impacts following implementation of the mitigation measures described in Section 16.5.2 are predicted to include the partial acquisition of five lots and a section of the road corridor, including two commercial lots, and subsequent change in land use to transport from commercial, road, and open space/recreation uses.

On balance, the residual impacts described above would result in minimal direct impacts to land use.

17 Landscape and visual amenity

This chapter provides a summary of the landscape and visual impact assessment undertaken by GHD. A full copy of this report is provided as Technical Report 10 – Landscape and visual impact assessment. The report was written to address the relevant SEARs which are outlined in Appendix A.

17.1 Assessment approach

17.1.1 Methodology

17.1.1.1 Study area

The study area for the landscape and visual impact assessment (LVIA) has been defined as land within one kilometre of the project site. This has been determined based on considering both landform and land cover, relevant guidelines and an analysis of the Zone of Theoretical Visibility mapping which considers how visible the project is from surrounding areas.

17.1.1.2 Key tasks

The LVIA involved the following initial tasks:

- preliminary analysis of the potential landscape and visual impacts of the project which involved:
    - a desktop analysis of relevant publically available data on landscape character and visual impact at a national, regional and local level for the study area
    - a site inspection on the 23 November 2018 to verify the desktop study, allow characterisation of the landscape, identify sensitive visual receivers and observe how receivers might view the landscape.
- developing urban design principles and objectives for the project based on the preliminary landscape and visual analysis, the existing urban environment for the project and a review of relevant policies and guidelines
- undertaking an arboricultural assessment of trees that have the potential to be impacted by the project (refer to Appendix B of Technical Report 10 for further information regarding the arboricultural assessment methodology).

Following completion of the above initial tasks a detailed LVIA commenced in conjunction with an iterative design process that was undertaken by the project's urban design team. This involved further refining the reference design to produce a landscape concept that addressed impacts identified as part of the preliminary landscape and visual analysis as well as the outcomes of ongoing consultation with the relevant councils. This landscape concept is described in section 17.3 and informed the project description which the detailed landscape and visual impact assessment was based on.

The detailed LVIA involved the following key tasks:

- identifying potentially sensitive visual receptors and representative viewpoints
- undertaking a landscape character assessment (see further information below)
- visual impact assessment (see further information below)
- developing mitigation measures to minimise the potential for negative impacts and enhance the potential for positive impacts.

Technical Report 10 provides further information on how the impact, sensitivity, and level of significance were assigned.

17.1.1.3 Landscape impact assessment

Landscape refers to the overall character and function of a place. It includes all elements within the public realm and the interrelationship between these elements and the people who use it.

Landscape character considers common landscape character zones defined by typical features and characteristics identified during the desktop assessment and site inspection. Defining landscape character zones identifies areas sharing the same homogenous environmental or cultural qualities or pattern such as topography, vegetation, hydrology, land use and settlement, built form scale and character, cultural and recreational characteristics.

Landscape character impacts refer to the relative capacity of the landscape to accommodate changes to the physical landscape through the introduction of new features or loss/modification of existing features. This is assessed through defining the sensitivity of the landscape and the magnitude of impact on that landscape. The sensitivity and magnitude of landscape effects address the following specific criteria:

- sensitivity of landscape to proposed change (high to negligible), based on the susceptibility to change, and the value of landscape
- magnitude of landscape effect (high to negligible), based on the size or scale of change, the geographical extent of effects, and the duration and reversibility of effects.

17.1.1.4 Visual impact assessment

This visual impact assessment considers visual amenity as experienced by the users of the site and surrounds. It aims to identify the range of views to the site which may be impacted, including views from residential areas, commercial areas, parks and streets.

The potential sensitivity of receivers to change was determined and rated (from negligible to high). Sensitivity depends on the location of receivers, the importance of their view, land uses, the extent of existing screening and if viewing durations are prolonged (ie from a residence) or transient (from a vehicle passing by).

Sensitive visual receivers and the sensitivity criteria include:

- **High** - Occupiers of residential properties within close proximity to the project, communities that place value upon the urban landscape and enjoyment of views of their setting
- **Moderate** - Outdoor workers, viewers at schools, occupiers of residential properties at a distance from or screened from the study area
- **Low** - Road users in motor vehicles, trains or on transport routes that are passing through or adjacent to the study area and therefore have short term views; Viewers indoor at their place of work, schools or similar.
- **Negligible** - Viewers from locations where there is screening by vegetation or structures.

The magnitude of change to views and visual amenity (from high to negligible) depends on the nature, scale and duration of the change that is expected to occur.

The significance of potential visual impacts was determined by assessing the magnitude of impacts in combination with the sensitivity of the receiver.

Impacts were assessed from representative viewpoints and rated (from negligible to high).

17.1.2 Risks identified

The preliminary environmental risk assessment undertaken for the project included potential risks associated with landscape and visual amenity. 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 landscape and visual risks was low. Risks with an assessed level of medium or above include:

- adverse impacts on landscape character during construction, particularly in Jacquie Osmond Reserve
- impacts on visual amenity due to the introduction of built elements, including the noise wall, retaining wall and embankments.

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).

17.1.3 How potential impacts have been avoided/minimised

As described in Chapter 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 landscape and visual impacts have been avoided/minimised where possible by:

- minimising clearance of trees and vegetation where possible through the selection of construction compounds in locations already cleared
- undertaking an iterative design process whereby the landscape concept for the project, as described in section 17.3, was informed by the preliminary landscape and visual impact analysis and consultation with relevant councils.

17.2 Existing environment

17.2.1 Existing urban condition

The urban landscape of the project site consists of several discreet areas. These areas are generally consistent with the landscape character zones described in section 17.2.2 and are described further below.

17.2.1.1 Broomfield Street

This urban landscape consists of a rail corridor that sits at elevation above the adjoining roads and is delineated from the adjacent road corridors by a vegetated batter on the western side and a retaining wall and noise wall on the eastern side. On the eastern side of the rail corridor car parking is present as is a line of street trees which occur along the southern end of Broomfield Street towards Cabramatta Creek.

This area is used by road users, shared path users (cyclists and pedestrians), residents and people who park in this area from either the Cabramatta Town Centre or Cabramatta Station, and is consistent with the description of landscape character zone 1 and landscape character zone 2.

17.2.1.2 Commercial/industrial

This area is defined by the commercial and light industrial areas adjacent to the rail corridor, including Peter Warren Automotive and Hometown Warwick Farm located between the rail corridor and Hume Highway. Currently a chain link fence runs south from Jacquie Osmond Reserve on the eastern boundary for approximately 210 metres. This then transitions to the outer shells of industrial buildings.

Users of this area include workers within the commercial and industrial facilities, and people who visit those locations for retail purposes and is consistent with the description of landscape character zone 3.

17.2.1.3 Passive recreation

This area directly interfaces with Cabramatta Creek and the wetland area to the western side of the rail corridor. The rail corridor continues to run north-south and is suspended over dense riparian vegetation. In

parallel and at a lower grade, a shared path makes provision for pedestrians and cyclists to connect from Cabramatta to Jacquie Osmond Reserve, crossing over Cabramatta Creek via a small footbridge.

This area is used predominantly by users of the shared path and is consistent with landscape character zone 4.

17.2.1.4 Active recreation

This area is largely defined by active recreation, facilitated by Jacquie Osmond Reserve which is an oval that is located to the east of the rail corridor. Currently the oval's functions are buffered from the rail corridor by a number of trees, a chain link fence, a landscape setback zone and retaining wall with railing.

This area is used by people who use the parks for recreational purposes on a casual basis as well as sporting organisations, and is consistent with the description of landscape character zone 5.

As described in section 17.1.1 the preliminary landscape and visual impact analysis and the existing urban landscape described in this section informed the urban design principles and objectives for the project. These are provided in section 6.4.

17.2.2 Landscape character

The existing environment is distinctly urban in its setting with residential areas bordered by major roads. The Hume Highway runs to the east and south of the study area, Cabramatta Road runs through the north of the study area and the SSFL runs north-south through the centre of the study area.

The existing landform is gently undulating with a high point in the north of the study area along Cabramatta Road. The landform slopes gently down to Cabramatta Creek which runs east-west through the centre of the study area, with the parklands and commercial area to the south of Jacquie Osmond Reserve on low lying land.

The vegetation cover consists of established street trees within the surrounding residential areas. Vegetation in the vicinity of the Cabramatta Creek corridor comprises of a combination of Cumberland Riverflat Forest ecological community adjacent to the watercourse, with areas of planted native species adjacent and along the rail corridor edges.

Five Landscape Character Zones (LCZs) were identified in the study area and are described below and shown on Figure 17.1.

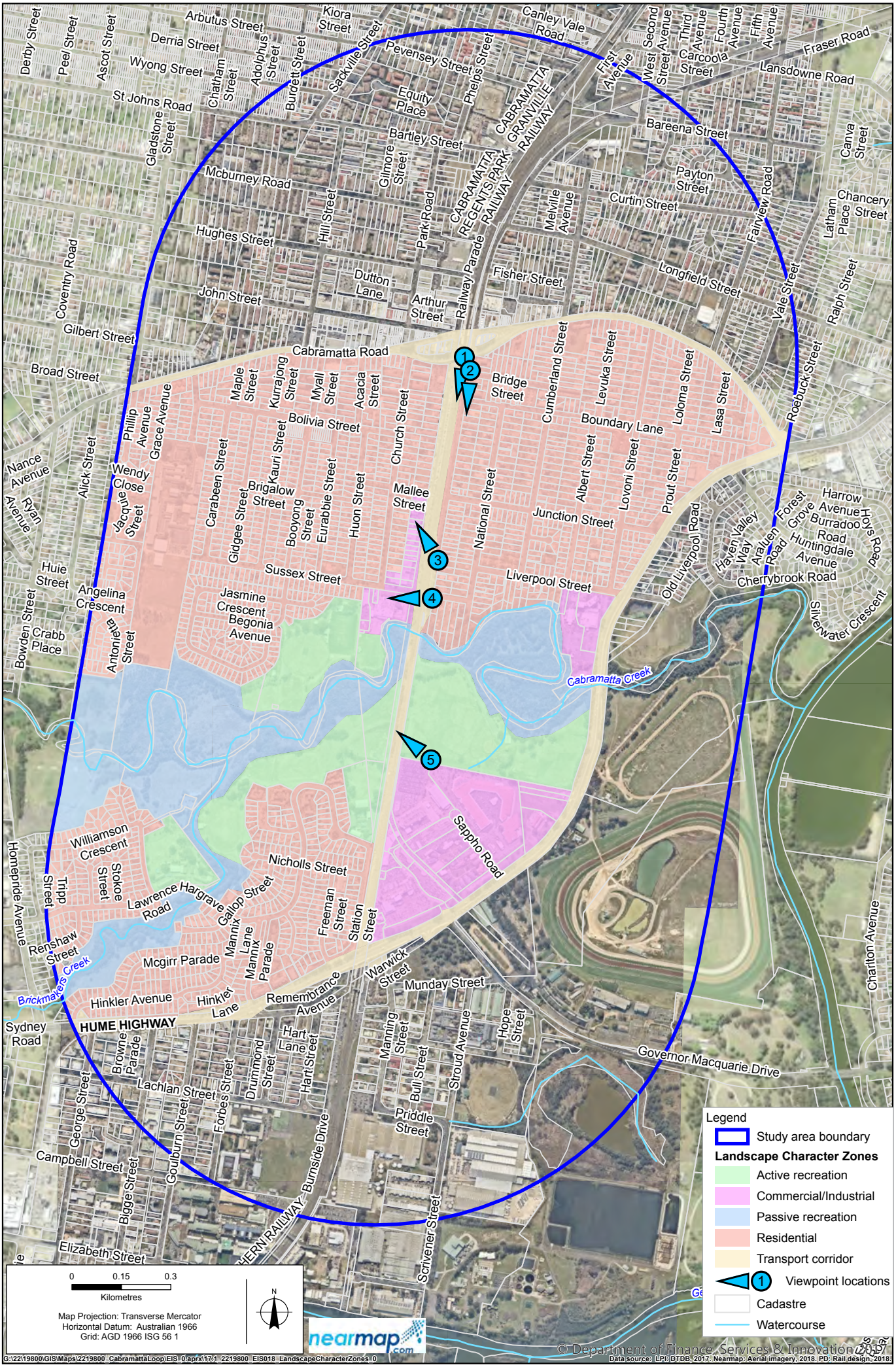

Figure 17.1 Landscape character zones and viewpoints

17.2.2.1 Landscape character zone 1 (LCZ1) – Transport corridor

LCZ1 is defined by linear transport infrastructure including the rail corridor, and major roads including the Hume Highway and Cabramatta Road. The existing conditions are shown in Photo 17.1 and Photo 17.2.

Photo 17.1 Rail corridor

Photo 17.2 Cabramatta Road

17.2.2.2 Landscape character zone 2 (LCZ2) – Residential

LCZ2 is defined by the residential areas on either side of the rail corridor, including to the north of the study area in Cabramatta, and an area to the south west in Warwick Farm, including Lawrence Hargrave School. The existing conditions are shown in Photo 17.3 and Photo 17.4.

Photo 17.3 Residential properties

Photo 17.4 Residential properties

17.2.2.3 Landscape character zone 3 (LCZ3) – Commercial/light industrial

LCZ3 is defined by the commercial and light industrial areas adjacent to the rail corridor. This includes the cluster of auto sales caryards and Warwick Farm shopping area between the rail corridor and the Hume

Highway; the row of smaller scale auto services on Railway Parade with adjacent Rugby League Club to the west of the rail line; and The Warwick and Holiday Inn.

The existing conditions are shown in Photo 17.5 and Photo 17.6.

Photo 17.5 Railway Parade

Photo 17.6 Sappho Road

17.2.2.4 Landscape character zone 4 (LCZ4) – Passive recreation

LCZ4 is defined by the passive recreation and riparian areas within the Cabramatta Creek corridor. The existing conditions are shown in Photo 17.7 and Photo 17.8.

Photo 17.7 Shared use path along Cabramatta Creek

Photo 17.8 Shared use path adjacent to Cabramatta Creek

17.2.2.5 Landscape character zone 5 (LCZ5) – Active recreation

LCZ5 is defined by the active recreation areas on either side of the rail corridor adjacent to Cabramatta Creek. This includes Jacquie Osmond Reserve, Warwick Farm Recreation Reserve, Cabramatta Sportsground, Don Dawson Oval, and the Cabramatta Rugby League Club fields.

The existing conditions are shown in Photo 17.9 and Photo 17.10.

Photo 17.9 Jacquie Osmond Reserve

Photo 17.10 Warwick Farm Recreation Reserve

17.2.3 Visual environment and sensitive viewpoints

17.2.3.1 Existing visual environment

The existing visual environment consists of an urban setting with residential areas to the east and west of the SSFL, the densely vegetated Cabramatta Creek and sporting fields running east-west through the centre of the study area. The southern portion of the study area is defined by a light industrial/commercial area in the east and a suburban residential areas to the west.

Due to the topography within the study area the visual environment varies, with long views from Cabramatta Road East overbridge to vegetated ridgelines in the distance and Cabramatta Creek forming the backdrop to the rail corridor and suburban residential setting. Within the residential areas and low lying sporting fields surrounding Cabramatta Creek, short enclosed views to the SSFL and surrounding built form and vegetation are available.

17.2.3.2 Representative viewpoints

Sensitive visual receivers within the study area include residents of the residential properties surrounding the SSFL, users of the Cabramatta Creek corridor and surrounding sporting fields, pedestrians and cyclists within the streets surrounding the SSFL and workers within Peter Warren Automotive and Hometown Warwick Farm shopping centre. Residential visual receivers would generally have long viewing periods and visual receivers such as cyclists and pedestrians would have short term transient viewing periods.

The following viewpoints (shown on Figure 17.1) were identified as representative viewpoints for sensitive receivers in the study area:

- Viewpoint 1 – Cabramatta Road East (looks south from Cabramatta Road East overbridge). This view is representative of views from pedestrians, cyclists and road users using the Cabramatta Road East overpass.

- Viewpoint 2 – Corner of Broomfield Street and Bridge Street. This view is representative of views from residents in adjacent residential properties as well as pedestrians and cyclists along Broomfield Street.
- Viewpoint 3 – Broomfield Street. This view is representative of views from residents in adjacent residential properties as well as pedestrians and cyclists along Broomfield Street.
- Viewpoint 4 – Corner Broomfield Street and Sussex Street. This view is representative of views from residents in adjacent residential properties as well as pedestrians and cyclists along Broomfield Street.
- Viewpoint 5 – Jacquie Osmond Reserve. This view is representative of views from users of Jacquie Osmond Reserve such as softball players, spectators and people using the reserve for other recreational purposes.

17.2.4 Trees in and adjacent to the project site

Appendix B of Technical Report 10 provides an arboricultural assessment of trees within and adjacent to the project site.

The trees assessed comprise a mixture of native species indigenous to the locality, non-indigenous native species and exotic ornamental specimens. Trees within or adjoining the project site are most likely all planted, occurring within school grounds, private gardens, parkland and roadside nature strips. No remnant trees occur within the project site, although there are several specimens which are most likely greater than 80 years old. The older specimens appear, however, to have been planted, based on their locations in the context of proximity to fences, paths and other trees or tree groups.

17.3 Landscape concept

As described in section 17.1.1 a landscape concept was prepared as part of the reference design through an iterative design process that considered the urban landscape as well as the findings of the preliminary landscape and visual impact analysis.

The landscape concept for the project considers landscaping along Broomfield Street, adjacent to Cabramatta Creek and within Jacquie Osmond Reserve and is described in further detail below. A schematic of the landscape concept is shown in Figure 17.2.

17.3.1 Broomfield Street

Replacement street trees would be provided on the eastern side of Broomfield Street. To the north of the intersection with Junction Street the street trees would be planted in-lane, in alignment with the car parking bays. While to the south of the Junction Street intersection the street trees would be planted within the grassed verge.

On the western side of Broomfield Street compact native grasses would be planted within a narrow garden bed located between the noise wall and shared path. To the south of the intersection with Boundary Lane a catenary system with climbers would be attached to the noise wall and retaining wall. The retaining wall would be constructed to match the colour and look of the noise wall, where possible. Panels from the existing wall would be reused where practicable, particularly those with art work, the design of which the local community had input into (refer to Chapter 18 (Socio-economic impacts)). This catenary system would only be affixed to the blank noise wall panels, with the panels with art work to be left uncovered.

17.3.2 Cabramatta Creek

The shared path would be reinstated in a similar position to the existing shared path. Areas of Cabramatta Creek disturbed during construction would be revegetated.

17.3.3 Jacquie Osmond Reserve

The form of the embankment is described in section 6.3. As per consultation with Liverpool City Council, the embankment would be grassed, as the provision of trees or other plantings on the embankment would potentially cause safety issues (branches in the rail corridor and hard distances near the softball field) and/or require additional maintenance.

.

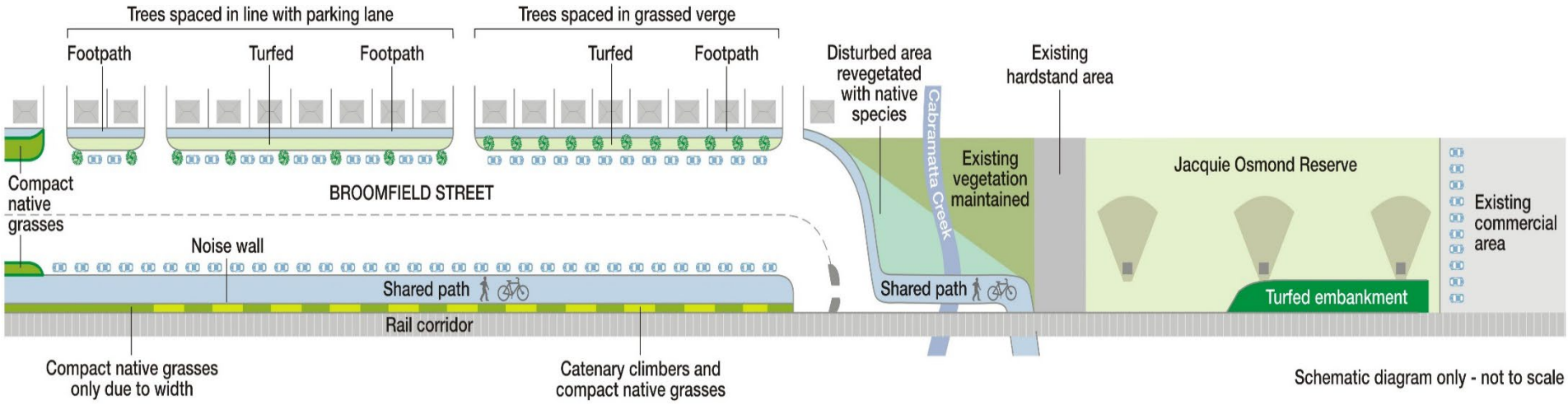

Figure 17.2 Indicative landscape concept for project site (not to scale)

17.4 Assessment of construction impacts

17.4.1 Landscape impacts

The significance of the impact of the project during construction is predicted to be moderate to low for residential areas and areas of active recreation and low to negligible to other areas.

The sensitivity of a landscape to change and the magnitude of that potential change are categorised from negligible to high. The condition of existing structures is also assessed as being in poor, average or in good condition.

The predicted impacts for all areas are summarised in Table 17.1 and discussed further below.

Table 17.1 Summary of construction impacts

Landscape character area	Sensitivity to change	Magnitude of change	Significance of impact
LCZ1 – Transport corridor	Negligible	Low	Low to negligible
LCZ2 – Residential	Low	Moderate	Moderate to low
LCZ3 – Commercial/light industrial	Low	Negligible	Low to negligible
LCZ4 – Passive recreation	Moderate	Moderate	Moderate
LCZ5 – Active recreation	Moderate	Moderate	Moderate

17.4.1.1 Landscape character zone 1– Transport corridor

The predicted impacts to LCZ1 during construction are assessed in Table 17.2.

Table 17.2 LCZ1 - Transport corridor description and impact assessment

Landscape character zone 1	
Anticipated change to LCZ	During construction works areas would be located to the east of the existing tracks.
Sensitivity to change	The sensitivity of the landscape represented by LCZ1 is considered to be **negligible** due to the existing elements being in below average condition and not particularly distinctive local features.
Magnitude of change	During construction the magnitude of change to LCZ1 during construction is considered to be **low.** This is due to the proposed works areas not being out of character with the existing landscape.
Significance of impact	During construction the significance of impact for LCZ1 during construction is therefore **low to negligible** as the works areas and machinery associated with the proposed works may be new but are in keeping with the existing landscape character and are temporary in nature.

17.4.1.2 Landscape character zone 2 – Residential

The predicted impacts to LCZ2 during construction are assessed in Table 17.3.

Table 17.3 LCZ2 - Residential description and impact assessment

Landscape character zone 2	
Anticipated change to LCZ	During construction the reconfiguration of Broomfield Street would affect traffic, cyclist and pedestrian access and use of the street. The existing vegetation would be removed and there would be partial closure of the street. Partial access would be maintained for the period of works but would be restricted to the eastern or western side of the street depending on the stage of works. Machinery, site fencing, construction lighting and increased activity from vehicles would be present during the construction period.
Sensitivity to change	The sensitivity of the landscape represented by LCZ2 is considered to be **low**. This is due to the landscape character elements being in average condition and a development of this type would be unlikely to have an adverse effect on the landscape character that could not be mitigated.
Magnitude of change	During construction the magnitude of change is considered to be **moderate**. This is due to there being discernible change in the landscape character due to the removal of existing vegetation and the partial closure of Broomfield Street during the reconfiguration works.
Significance of impact	During construction the significance of impact for LCZ2 is therefore **moderate to low** due to the removal of vegetation and partial closure of the street.

17.4.1.3 Landscape character zone 3 – Commercial/light industrial

The predicted impacts to LCZ3 during construction are assessed in Table 17.4.

Table 17.4 LCZ3 - commercial/light industrial description and impact assessment

Landscape character zone 3	
Anticipated change to LCZ	During construction the proposed works would be limited to the track duplication, realignment, and retaining wall works between Peter Warren Automotive and the existing rail corridor. This would comprise acquisition of a strip of land around five metres in width. There would be no works within a majority of this LCZ.
Sensitivity to change	The sensitivity of receivers represented by LCZ3 is considered to be **low**. This is due to the landscape character elements being in average condition and a development of this type would be unlikely to have an adverse effect on the landscape character that could not be mitigated.
Magnitude of change	The magnitude of change to LCZ3 is considered to be **negligible** during construction. This is due to the imperceptible change to the existing landscape elements.
Significance of impact	The significance of impact for LCZ3 is therefore **low** to **negligible** during construction as the proposed new track and retaining wall would be in keeping with the existing landscape character.

17.4.1.4 Landscape character zone 4 – Passive recreation

The predicted impacts to LCZ4 during construction are assessed in Table 17.5.

Table 17.5 LCZ4 Passive recreation description and impact assessment

Landscape character zone 4	
Anticipated change to LCZ	During construction, the changes to LCZ4 would include the diversion of the shared path from between Sussex Street and the Cabramatta Creek footbridge and the addition of works areas to the east and west of the existing rail corridor for the proposed new bridge over Cabramatta Creek. There would be some vegetation removal within the proposed works area. The existing embankment and chain mesh fence adjacent to the shared use path would be removed and replaced with a retaining wall around three metres high.
Sensitivity to change	The sensitivity of LCZ4 is considered to be **moderate**. This is due to the extent of vegetation cover and passive recreation opportunities the character area provides to the surrounding urban environment.
Magnitude of change	The magnitude of change to LCZ4 is considered to be **moderate** during construction. This is due to the introduction of machinery, site fencing, lighting and removal of vegetation being out of character with the existing landscape. These changes would be temporary.
Significance of impact	The significance of impact for LCZ4 is therefore **moderate** during construction. This is due to the introduction of new elements which are out of character with the existing landscape.

17.4.1.5 Landscape character zone 5 – Active recreation

The predicted impacts to LCZ5 during construction are assessed in Table 17.6.

Table 17.6 LCZ5 Active recreation description and impact assessment

Landscape character zone 5	
Anticipated change to LCZ	During construction there would be construction works associated with the additional track, new retaining wall and embankment and the removal of the existing trees in front of the railway corridor on the east side of the SSFL rail corridor. There would be site fencing to the rail corridor boundary along the western edge of Jacquie Osmond Reserve. A portion of Jacquie Osmond Reserve would be occupied during construction for use as a construction compound. Machinery, site fencing, construction lighting and increased activity from vehicles would be present during the construction period.
Sensitivity to change	The sensitivity of LCZ5 is considered to be **moderate**. This is due to the active recreation opportunities the character area provides to the surrounding urban environment.
Magnitude of change	During construction the magnitude of change to LCZ5 is considered to be **moderate**. This is due to the removal of vegetation and softball nets on the east side of the SSFL rail corridor, addition site fencing and machinery which would result in a discernible change within LCZ5.
Significance of impact	During construction the significance of impact for LCZ5 is therefore **moderate**.

17.4.2 Visual impacts

The significance of the impact on principal viewpoints during construction is predicted to be high to moderate for the residential areas around Broomfield Street and moderate to low for other areas.

The predicted impacts for all areas are summarised in Table 17.7 and discussed further below.

Table 17.7 Summary of construction impacts

Landscape character area	Sensitivity to change	Magnitude of change	Significance of impact
View point 1 – Cabramatta Road	Low	Low	Low
View point 2 – Corner Broomfield Street and Bridge Street	High	Moderate	High to moderate
View point 3 – Broomfield Street	High	Moderate	High to moderate
View point 4 – Corner Sussex Street and Broomfield Street	High	Moderate	High to moderate
View point 5 – Jacquie Osmond Reserve	Moderate	Moderate	Moderate

17.4.2.1 Viewpoint location 1 – Cabramatta Road East

The predicted impacts to VP1 during construction are assessed in Table 17.8.

Table 17.8 VP1 description and visual assessment

Viewpoint location 1 (VP1)	
	
Photograph of existing view south along the SSFL	
Anticipated change to view	During construction, the view would be of the construction works associated with the removal of the existing retaining wall, noise wall and street trees along Broomfield Street, the addition of new track and signalling and the reconfiguration of Broomfield Street. There would be construction machinery, fencing and site compounds.
Sensitivity to change	The sensitivity of receivers represented by VP1 is considered to be **low**. This is due to the type of sensitive receivers and their experience of this view, which includes pedestrians, cyclists and road users along Cabramatta Road.
Magnitude of change	During construction the magnitude of change to VP1 is considered to be **low**. This is due to the construction works introducing new elements into the view but these would be contained to the rail corridor and Broomfield street and would be temporary.
Significance of impact	During construction the significance of impact for VP1 is therefore **low** due to the widening of the rail corridor and loss of vegetation along Broomfield Street introducing new infrastructure into the existing view where the SSFL rail corridor is a key feature.

17.4.2.2 Viewpoint location 2 - Corner Broomfield Street and Bridge Street

The predicted impacts to VP2 during construction are assessed in Table 17.9.

Table 17.9 VP2 description and visual assessment

Viewpoint location 2 (VP2)	
	
Photograph of existing view south along Broomfield Street	
Anticipated change to view	During construction, the existing noise wall would be removed and the rail corridor would have construction works for the new track and noise wall. Broomfield Street would be temporarily closed in stages with one lane of access always available. The existing vegetation along Broomfield Street would be removed. The overhead power lines would be relocated east within the verge. The removal of the existing noise wall during construction would temporarily open up views to the rail corridor. Machinery, site fencing, construction lighting and increased activity from vehicles would be present during the construction period.
Sensitivity to change	The sensitivity of receivers represented by VP2 is considered to be **high**. This is due to the type of sensitive receivers and their experience of this view, which includes residents of the adjacent residential properties and pedestrians (who would have a moderate sensitivity) along Broomfield Street. Both types of visual receiver would be in close proximity to the project.

Viewpoint location 2 (VP2)	
Magnitude of change	During construction the magnitude of change to VP2 is considered to be **moderate**. This is due to proposed construction works with machinery, construction fencing and the removal of vegetation being out of scale with the existing view which currently consists of a residential street with the built form elements consisting of a concrete noise wall and residential properties. The removal of the existing noise wall temporarily opening up views to the rail corridor.
Significance of impact	During construction the significance of impact for VP2 is therefore **high to moderate**. This is due to the amount of construction activity that would be occurring in close proximity to the residents along Broomfield Street.

17.4.2.3 Viewpoint location 3 - Broomfield Street

The predicted impacts to VP3 during construction are assessed in Table 17.10.

Table 17.10 VP3 description and visual assessment

Viewpoint location 3 (VP3)	
	
Photograph of existing view north along Broomfield Street	
Anticipated change to view	During construction the existing noise wall would be removed and the rail corridor would have construction works for the additional track, noise wall and retaining wall. The existing vegetation along Broomfield Street would be removed. The overhead power lines would be relocated east within the verge. Broomfield Street would be temporarily closed in stages with one lane of access always available. During construction there would be site fencing, machinery and increased activity within and surrounding the project site. The removal of the existing noise wall during construction would open up views to the rail corridor. Machinery, site fencing, construction lighting and increased activity from vehicles would be present during the construction period.

Viewpoint location 3 (VP3)	
Sensitivity to change	The sensitivity of receivers represented by VP3 is considered to be **high**. This is due to the type of sensitive receivers and their experience of this view, which includes residents of the adjacent residential properties and pedestrians along Broomfield Street. Both types of visual receiver would be in close proximity to the project and the residential receivers would have long uninterrupted viewing periods.
Magnitude of change	During construction the magnitude of change to VP3 is considered to be **moderate**. This is due to proposed construction works with machinery, construction fencing and the removal of vegetation being out of scale with the existing view and the removal of the existing noise wall temporarily opening up views to the rail corridor.
Significance of impact	During construction the significance of impact for VP3 is therefore **high to moderate**. This is due to the presence of construction works along Broomfield Street creating discernible changes in the view in close proximity to residents, although these changes would be temporary.

17.4.2.4 Viewpoint location 4 – Corner Sussex Street and Broomfield Street

The predicted impacts to VP4 during construction are assessed in Table 17.11.

Table 17.11 VP4 description and visual assessment

Viewpoint location 4 (VP4)	
	
Photograph of existing view south-west towards SSFL	
Anticipated change to view	During construction the view would be to the construction of the new rail bridge over Cabramatta Creek, temporarily realigned shared use path between Sussex Street and Cabramatta Creek and the removal of some of the creek vegetation. The existing embankment and chain mesh fence adjacent to the shared use path would be removed and replaced with a retaining wall around three metres high.
Sensitivity to change	The sensitivity of receivers represented by VP4 is considered to be **high**. This is due to the type of sensitive receivers and their experience of this view, which includes residents of the adjacent residential properties and pedestrians along Broomfield Street. Both types of visual receiver would be in close proximity to the project.
Magnitude of change	During construction the magnitude of change to VP4 is considered to be **moderate**. This is due to the introduction of construction works including machinery, fencing and removal of vegetation being discernible changes to the existing view. These would be temporary changes to the view.

Viewpoint location 4 (VP4)	
Significance of impact	During construction the significance of impact for VP4 is therefore **high to moderate** as the construction works would result in a discernible change to the existing view for visual receivers in close proximity to the works, although the changes would be temporary.

17.4.2.5 Viewpoint location 5 – Jacquie Osmond Reserve

The predicted impacts to VP5 during construction are assessed in Table 17.12.

Table 17.12 VP5 description and visual assessment

Viewpoint location 5 (VP5)	
Anticipated change to view	During construction the view would be towards the construction works associated with the additional track, new retaining wall and the removal of the existing trees in front of the railway corridor. There would be site fencing to the rail corridor boundary along the western edge of Jacquie Osmond Reserve.
Sensitivity to change	The sensitivity of receivers represented by VP5 is considered to be **moderate**. This is due to the type of sensitive receivers and their experience of this view, which includes users of Jacquie Osmond Reserve who are in close proximity but would have limited viewing periods with their attention on the game or sport and not the setting.
Magnitude of change	During construction, the magnitude of change to VP5 is considered to be **moderate**. This is due to the construction works associated with the additional track, retaining wall and batter resulting in the removal of existing trees and softball nets and the location of a construction compound within the reserve resulting in a noticeable change to the view.
Significance of impact	During construction the significance of impact for VP5 is therefore **moderate** as the construction works would result in a noticeable change to the existing view for visual receivers in close proximity to the works, although the change would be temporary.

17.4.3 Construction lighting impacts

Construction activities would not substantially increase the extent or intensity of artificial lighting above current background artificial light levels associated with the rail corridor, pedestrian and bike track across Cabramatta Creek, street lighting and sports fields in Jacquie Osmond reserve.

Lighting for construction works undertaken at night has the potential to cause light spill into residential properties. The use of lighting towers during any night work may result in light spill impacting adjoining properties and residents. Impacts can be minimised through appropriate siting and use of directional lights to avoid light spill (refer to section 17.6.2).

17.4.4 Tree removal

Construction would result in the unavoidable removal of a number of trees. The majority of these comprise street trees along Broomfield Street and trees adjacent to the rail corridor in Jacquie Osmond Reserve. An arboricultural assessment (Appendix C of Technical Report 10) has assessed the number and quality of trees that would require removal as a result of the project. The project would result in the removal of 43 planted trees which are indigenous to the Fairfield and Liverpool LGAs and 77 exotic specimens.

The landscape concept described in this chapter has been developed to minimise the impacts associated with tree removal. In addition, mitigation measures to minimise impacts to trees within or adjacent to the project site that will be retained are provided in Appendix C of Technical Report 10.

17.4.5 Cumulative impacts

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

The majority of landscape changes and visual impacts from the project during construction relate to work activities such as lighting, construction of the project and the compounds sites. There are no other known construction projects proposed in the vicinity of the project site that would result in additional changes to the views or landscape character identified for this project.

17.5 Assessment of operation impacts

17.5.1 Overview of operational impacts

The project would comprise a widened rail corridor with the addition of new track, fences, retaining walls, two new bridges over Sussex Street and Cabramatta Creek and replacement of the Broomfield Street noise wall. Outside of the rail corridor would be new planting, an embankment in Jacquie Osmond Reserve and minor changes to the configuration of Broomfield Street including parking and the shared path. These new structures and planting would change the existing landscape and views around the project site.

17.5.2 Landscape character impacts

The significance of the impact of the project during operation is predicted to be moderate to low for residential areas and areas of active recreation and low to negligible to other areas. The predicted impacts for each area is summarised in Table 17.13 and discussed further below.

Table 17.13 Summary of construction impacts

Landscape character area	Sensitivity to change	Magnitude of change	Significance of impact
LCZ1 – Transport corridor	Negligible	Negligible	Negligible
LCZ2 – Residential	Low	Low	Low
LCZ3 – Commercial/light industrial	Low	Negligible	Low to negligible
LCZ4 – Passive recreation	Moderate	Low	Moderate to low
LCZ5 – Active recreation	Moderate	Low	Moderate to low

17.5.2.1 Landscape character zone 1– Transport corridor

The predicted impacts to LCZ1 during operation are assessed in Table 17.14.

Table 17.14 LCZ1 - Transport corridor description and impact assessment

Landscape character zone 1	
Anticipated change to LCZ	During operation the LCZ would see the addition of a new portion of track and realignment of 450 metres of existing track between Cabramatta Station and the Hume Highway along the existing SSFL. The rail corridor would be widened by about five metres to the east with a new replacement fence and/or retaining wall and a relocated noise wall along Broomfield Street. Two new bridges would be added over Sussex Street and Cabramatta Creek to the east of the existing concrete bridges. The new bridges would be similar in size and materiality to the existing concrete bridges. Modifications and upgrades to signalling and overhead wires would occur for the length of the SSFL between Warwick Farm Station and Cabramatta Station.
Sensitivity to change	The sensitivity of the landscape represented by LCZ1 is considered to be **negligible** this is due to the existing elements being in below average condition and not particularly distinctive local features.

Landscape character zone 1	
Magnitude of change	During operation the magnitude of change to LCZ1 is considered to be **negligible**. This is due to the addition of new rail track and bridges but these elements are in keeping with the existing landscape character elements.
Significance of impact	During operation the significance of impact for LCZ1 is therefore **negligible** as although the existing rail corridor would be widened and there would be the addition of new track and two new bridges, these elements are in keeping with the existing landscape character.

17.5.2.2 Landscape character zone 2 – Residential

The predicted impacts to LCZ2 during operation are assessed in Table 17.15.

Table 17.15 LCZ2 - Residential description and impact assessment

Landscape character zone 2	
Anticipated change to LCZ	During operation, changes to LCZ2 would occur along Broomfield Street to the east of the SSFL. The expansion of the rail corridor would result in the removal of the existing street trees and reconfiguration of the street. The reconfiguration of Broomfield Street would include parallel parking on both sides of the street between Bridge Street and Sussex Street, the realignment of the shared path and the relocation of the existing noise walls. The street trees would be replaced along the eastern edge with in-lane trees to the north of Junction Street and within the grassed verge to the south of Junction Street. Compact native grasses would be planted between the shared path and realigned noise wall. Climbers on a catenary system would be grown where room allows on the blank noise wall panels,
Sensitivity to change	The sensitivity of the landscape represented by LCZ2 is considered to be **low**. This is due to the landscape character elements being in average condition and a development of this type would be unlikely to have an adverse effect on the landscape character that could not be mitigated.
Magnitude of change	During operation the magnitude of change to LCZ2 is considered to be **low**. This is due to the reconfiguration of Broomfield Street being in keeping with the local character.
Significance of impact	During operation, although a portion of the LCZ2 along the western edge of the rail corridor would become part of LCZ1, the significance of impact for LCZ2 would be **low**. This is due to the reconfiguration of Broomfield Street being in keeping with the local character and the loss of a portion of the LCZ2 along the western edge would not result in a change to the LCZ's key characteristics. The edge of LCZ2 would remain similar to existing, with key features such as the noise wall and street trees replaced. The addition of the catenary climbers would be a positive new element within the LCZ.

17.5.2.3 Landscape character zone 3 – Commercial/light industrial

The predicted impacts to LCZ3 during operation are assessed in Table 17.16.

Table 17.16 LCZ3 - commercial/light industrial description and impact assessment

Landscape character zone 3	
Anticipated change to LCZ	During operation, a strip of land around five metres in width along the eastern boundary of Peter Warren Automotive would be required to accommodate the additional track. There would be a new retaining wall to the boundary of the Peter Warren Automotive and the rail corridor.

Landscape character zone 3	
Sensitivity to change	The sensitivity of receivers represented by LCZ3 is considered to be **low**. This is due to the landscape character elements being in average condition and a development of this type would be unlikely to have an adverse effect on the landscape character that could not be mitigated.
Magnitude of change	The magnitude of change to LCZ3 is considered to be **negligible** during operation. This is due to the imperceptible change to the existing landscape elements.
Significance of impact	The significance of impact for LCZ3 is therefore **low** to **negligible** during operation as the proposed new track and retaining wall would be in keeping with the existing landscape character.

17.5.2.4 Landscape character zone 4 – Passive recreation

The predicted impacts to LCZ4 during operation are assessed in Table 17.17.

Table 17.17 LCZ4 Passive recreation description and impact assessment

Landscape character zone 4	
Anticipated change to LCZ	During operation the project would see the addition of a new rail bridge over Cabramatta Creek adjacent to the existing bridge and the reinstatement of the existing shared use path in its current location. There would be a retaining wall around three metre high adjacent to the eastern edge of the shared path. There would be revegetation of the creek corridor where vegetation was removed
Sensitivity to change	The sensitivity of LCZ4 is considered to be **moderate**. This is due to the extent of vegetation cover and passive recreation opportunities the character area provides to the surrounding urban environment.
Magnitude of change	The magnitude of change to LCZ4 is considered to be **low** during operation. This is due to the minor loss of vegetation and although the addition of the new rail bridge would introduce a new element into the landscape, it would be on the edge of the LCZ adjacent to the existing rail bridge and would be in keeping with the existing landscape character. The vegetation would be replaced where practicable and a majority of the vegetation within the LCZ4 would be retained. The proposed three metre high retaining wall would introduce a new element but this would be softened over time with the reestablishment of vegetation.
Significance of impact	The significance of impact for LCZ4 is therefore is **moderate to low** as the project would be in keeping with the existing landscape character and the vegetation loss would be minor. Although the three metre high retaining wall would be a new element, it would be softened over time as the vegetation re-establishes.

17.5.2.5 Landscape character zone 5 – Active recreation

The predicted impacts to LCZ5 during operation are assessed in Table 17.18.

Table 17.18 LCZ5 Active recreation description and impact assessment

Landscape character zone 5	
Anticipated change to LCZ	During operation the change would include an additional track and new retaining wall with chain mesh fencing on top and a grassed embankment in front on the east side of the SSFL rail corridor. The existing trees on the east side of the track would be removed. The softball nets would be reinstalled. Proposed changes would be limited to Jacquie Osmond Reserve with the rest of LCZ5 remaining untouched.

Landscape character zone 5	
Sensitivity to change	The sensitivity of LCZ5 is considered to be **moderate**. This is due to the active recreation opportunities the character area provides to the surrounding urban environment.
Magnitude of change	During operation the magnitude of change to LCZ5 is considered to be **low**. This is due to the removal of existing trees and taken down and re-installed of the softball nets on the east side of the SSFL rail corridor which would result in a minor loss of key landscape character elements in LCZ5.
Significance of impact	During operation the significance of impact for LCZ5 is therefore **moderate to low**. The removal of the existing trees within Jacquie Osmond Reserve would be a minor change and the general landscape character would be maintained.

17.5.3 Visual impacts

The significance of the impact on principle viewpoints is predicted during operation to be high to moderate for the residential areas around Broomfield Street and moderate to low to other areas. The predicted impacts for all areas are summarised in Table 17.19 and discussed further in the following sections.

Table 17.19 Summary of construction impacts

Landscape character area	Sensitivity to change	Magnitude of change	Significance of impact
View point 1 – Cabramatta Road	Low	Low	Low
View point 2 – Corner Broomfield Street and Bridge Street	High	Low	Moderate
View point 3 – Broomfield Street	High	Moderate	Moderate
View point 4 – Corner Sussex Street and Broomfield Street	High	Moderate	High to moderate
View point 5 – Jacquie Osmond Reserve	Moderate	Low	Moderate to low

17.5.3.1 Viewpoint location 1 – Cabramatta Road East

The predicted impacts to VP1 during operation are assessed in Table 17.20.

Table 17.20 VP1 description and visual assessment

Viewpoint location 1 (VP1)	
	
Photograph of existing view south along the SSFL	
Anticipated change to view	During operation the view would be to a widened rail corridor with an additional track to the east and associated overhead signalling wires. The retaining wall and noise wall would be moved a few metres to the east. There would be a new concrete noise wall to the eastern edge of the rail corridor and Broomfield Street would be reconfigured with the street trees removed.
Sensitivity to change	The sensitivity of receivers represented by VP1 is considered to be **low**. This is due to the type of sensitive receivers and their experience of this view, which includes pedestrians, cyclists and road users along Cabramatta Road.
Magnitude of change	During operation the magnitude of change to VP1 is considered to be **low** as the widening of the rail corridor and removal of vegetation within Broomfield Street would be visible but not uncharacteristic within the existing view.
Significance of impact	During operation the significance of impact for VP1 is therefore **low** due to the widening of the rail corridor and loss of vegetation Broomfield Street introducing new infrastructure into the existing view where the SSFL rail corridor is a key feature.

17.5.3.2 Viewpoint location 2 - Corner Broomfield Street and Bridge Street

The predicted impacts to VP2 during operation are assessed in Table 17.21.

Table 17.21 VP2 description and visual assessment

Viewpoint location 2 (VP2)	
	
Photograph of existing view south along Broomfield Street	
Anticipated change to view	During operation the view would be towards the relocated noise wall around five metres closer to the viewpoint and similar height to the existing. This would include the retaining of noise wall panels with artwork, the design of which the community had an input into. The view would also include parallel car parking on both sides of the street and a reduced verge on the east side of the street. The street trees would be replaced along the eastern edge and would be planted in-lane. Along the western edge compact native grasses would be planted between the shared path and noise wall. To the south of Boundary Lane climbing plants on a catenary system would be installed on the blank noise wall panels,
Sensitivity to change	The sensitivity of receivers represented by VP2 is considered to be **high**. This is due to the type of sensitive receivers and their experience of this view, which includes residents of the adjacent residential properties and pedestrians (who would have a moderate sensitivity) along Broomfield Street. Both types of visual receiver would be in close proximity to the project.
Magnitude of change	During operation the magnitude of change to VP2 is considered to be **low**. This is due to the relocated noise wall and car parking being visible new elements but not out of scale with the existing view and the climbers on the catenary system being a positive new element.
Significance of impact	During operation the significance of impact for VP2 is therefore **moderate**. This is due to the close proximity to the residents to the project along Broomfield Street.

17.5.3.3 Viewpoint location 3 - Broomfield Street

The predicted impacts to VP3 during operation are assessed in Table 17.22.

Table 17.22 VP3 description and visual assessment

Viewpoint location 3 (VP3)	
	
Photograph of existing view north along Broomfield Street	
	
Photomontage of Broomfield Street showing landscape concept	
Anticipated change to view	During operation the view would be towards the new retaining wall and relocated noise wall along the rail corridor edge. The noise wall would be approximately five metres closer to the view point with the realigned shared path in front. Parallel parking would be on both sides of the street and the verge on the eastern side of the street would be reduced. The street trees along the eastern edge would be replaced within the grassed verge. Along the western edge compact native grasses would be planted between the noise wall and shared path. Where there are blank panels on the noise wall there would be climbers on a catenary system. The panels with art work would be left uncovered.
Sensitivity to change	The sensitivity of receivers represented by VP3 is considered to be **high**. This is due to the type of sensitive receivers and their experience of this view, which includes residents of the adjacent residential properties and pedestrians along Broomfield Street. Both types of visual receiver would be in close proximity to the project and the residential receivers would have long uninterrupted viewing periods.

Viewpoint location 3 (VP3)	
Magnitude of change	During operation the magnitude of change to VP3 is considered to be **low**. This is due to the relocated noise wall and car parking being visible new elements but not out of scale with the existing view. Although the trees have been removed, the climbers and compact native grasses would be a positive new element.
Significance of impact	During operation the significance of impact for VP3 is considered to be **moderate.** This is due to the close proximity to the residents to the project along Broomfield Street

17.5.3.4 Viewpoint location 4 – Corner Sussex Street and Broomfield Street

The predicted impacts to VP1 during construction are assessed in Table 17.23.

Table 17.23 VP4 description and visual assessment

Viewpoint location 4 (VP4)	
 **Photograph of existing view south-west towards SSFL**	
Anticipated change to view	During operation the view would be to the new concrete rail bridge to the east of the existing concrete bridge, the shared use path over Cabramatta Creek reinstated in its current location and re-established vegetation. There would be a retaining wall around three metres high next to the eastern edge of the shared use path.
Sensitivity to change	The sensitivity of receivers represented by VP4 is considered to be **high**. This is due to the type of sensitive receivers and their experience of this view, which includes residents of the adjacent residential properties and pedestrians along Broomfield Street. Both types of visual receiver would be in close proximity to the project and have uninterrupted views to the project.
Magnitude of change	During operation the magnitude of change to VP4 is considered to be **moderate**. This is due to the removal of vegetation and the addition of the proposed three metre high retaining wall adjacent to the shared use path. The new bridge would be in keeping with the existing view.
Significance of impact	During operation the significance of impact for VP4 is therefore **high** to **moderate** as although the new bridge would be in keeping with the existing view and the vegetation would be re-established where possible, the proposed three metre high retaining wall would be a dominant visual element until the vegetation re-establishes.

17.5.3.5 Viewpoint location 5 – Jacquie Osmond Reserve

The predicted impacts to VP5 during operation are assessed in Table 17.24.

Table 17.24 VP5 description and visual assessment

Viewpoint location 5 (VP5)	
	
Photograph of existing view north-west towards SSFL	
	
Photomontage of Jacquie Osmond Reserve showing proposed landscape concept	
Anticipated change to view	During operation the view would be towards the new track and retaining wall with chain mesh fencing on top and a grassed batter in front. The softball nets on the east side of the track would be reinstated along with planting of trees where practicable.
Sensitivity to change	The sensitivity of receivers represented by VP5 is considered to be **moderate**. This is due to the type of sensitive receivers and their experience of this view, which includes users of Jacquie Osmond Reserve who are in close proximity but would have limited viewing periods with their attention on the game or sport and not the setting.
Magnitude of change	During operation the magnitude of change to VP5 is considered to be **low**. This is due to the addition of the track and new retaining wall with chain mesh fence being in keeping with the existing view, although, the removal of the existing trees and softball nets would be a minor change, some of the trees would be replaced.

Viewpoint location 5 (VP5)	
Significance of impact	During operation, the significance of impact for VP5 is therefore **moderate to low** as the additional track, new retaining wall, chain mesh fence and grassed batter would be generally consistent with the existing view whilst some of the removed vegetation and softball nets would be reinstated.

17.5.4 Cumulative impacts

Given the low profile and horizontal form of most of the project, the level of visual modification would be confined to a distance relatively close to the area subject to change. There are no other known projects currently proposed in the vicinity of the project site that would result in additional vegetation clearance or changes to the views or landscape character identified for this project.

17.6 Management of impacts

17.6.1 Approach

17.6.1.1 Approach to mitigation and management

Overall, the majority of potential construction related landscape and visual impacts would be short term and temporary in nature. The potential for these impacts would be significantly reduced by:

- effective construction design and planning
- implementation of the mitigation measures provided in Table 17.25
- ongoing communication with the relevant councils and the broader community.

As part of the detailed design an urban design and landscape plan would be developed, which would build on the existing landscape concept, be informed by the urban design principles and objectives and would consider the mitigation measures provided in Table 17.25.

17.6.1.2 Expected effectiveness

ARTC have experience in managing potential urban design, landscape character and visual impacts as a result of developments of a similar scale and scope to this project.

ARTC has in the first instance, aimed to avoid impacts where possible through design of the project and selection of location of compounds sites and work sites where possible (refer to section 17.1.3).

Secondly, urban design outcomes have been incorporated into the reference design and would be further refined during detailed design of the project as part of the urban design and landscape plan development. The urban design outcomes have been guided by existing policies and procedures (such as *Beyond the Pavement*), which commit to providing excellent outcomes for the people of NSW, governed by over-arching urban design principles that include both physical outcomes and performance based principles. The object is to produce a design outcome that will maintain the existing quality of the urban environment in the long term (once vegetation has established) and identifies improvements where possible, in line with SEARs requirements.

In addition, a range of mitigation measures are recommended for incorporation into the project to minimise construction impacts which are unable to be designed out of the project.

As such, the measures to avoid impacts during development of the design and measures outlined in the CEMP are considered to be proven effective in managing potential impacts to visual amenity and landscape character.

17.6.2 List of mitigation measures

The mitigation measures that would be implemented to address potential landscape and visual impacts are listed in Table 17.25.

Table 17.25 Mitigation measures

Stage	Impact	Measure
Design	Visual impacts due to addition of new structures and removal of vegetation	An urban design and landscape plan will be developed as part of the detailed design with the objective of maintaining and improving pedestrian and cycling connectivity, reinstating vegetation where possible and, ensuring constructed elements improve on existing design and materiality. It will build on the existing landscape concept and consider the urban design principles and objectives and the mitigation measures provided in this table. The urban design and landscape plan will be developed in consultation with Fairfield and Liverpool City Councils.
	Vegetation clearance	The urban design and landscape plan will include a planting pallet consistent with the existing area. Native species selected will be of local significance, from the relevant ecological vegetation community and will be sourced from nurseries in the local area, where possible.
	Vegetation clearance	Where revegetation of riparian areas and bank stabilisation is required, the design will be prepared in consultation with an experienced waterway rehabilitation consultant and Fairfield and Liverpool City Councils.
	Visual impact from new bridges	The design and materiality of the bridges will integrate with the existing built form in accordance with *Bridge Aesthetics: Design guidelines to improve the appearance of bridges in NSW* (RMS, 2012*).* The bridge design will minimise visual clutter where possible, through incorporating cabling and barriers into a single bridge façade. The bridge design will be in accordance with ARTC's requirements to ensure bridge structures can be visually monitored as part of ongoing maintenance.
	Visual impacts from noise wall	The noise walls along Broomfield Street will be reused in the project due to the existing value placed on them by the local community. Where vegetation screening is implemented views to the artwork panels will be retained. Along Broomfield Street where retaining walls are to be replaced, colour is to match existing noise wall. High quality materials, textured and graffiti resistant surfaces will be used, where possible, on retaining walls along Broomfield Street and Jacquie Osmond Reserve to deter graffiti, particularly at lower levels of the walls. The design will be finalised following consultation with maintenance stakeholders.
	Light spill	Permanent lighting will be designed in accordance with AS 4282-1997 Control of obtrusive effects of outdoor lighting. This will avoid light spill into residential properties along Broomfield Street and surrounding residential streets and ecologically sensitive areas along Cabramatta Creek.

Stage	Impact	Measure
Construction	Visual impact from construction compounds and worksites	Construction compounds located within Jacquie Osmond Reserve, Warwick Farm Recreation Reserve and within the rail corridor should, where possible, have screening measures implemented such as hoarding or temporary vegetation. Where equipment or stockpiles are to be located in a visually prominent location for any reasonable period of time, screening measures and practices will be incorporated to ensure sites are kept tidy.
	Temporary light spill	Temporary lighting required during the construction period will be sited and designed to avoid light spill into residential properties along Broomfield Street and surrounding residential streets and ecologically sensitive areas along Cabramatta Creek.
	Vegetation to be retained	Existing vegetation will be protected and retained where possible, particularly mature canopy trees. Tree removal and protection measures for trees to be retained, will be carried out as stated in the Arboricultural assessment provided in Appendix B of Technical Report 10 – Landscape and visual impact assessment.

17.6.3 Consideration of the interaction between measures

Mitigation measures to control impacts to the landscape character of the project sites and visual impacts may replicate mitigation measures proposed for the control of impacts associated with biodiversity in relation to tree and vegetation clearance (Chapter 11 (Biodiversity)).

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.

As per Chapter 9 (Noise and vibration) noise operational impacts would be mitigated through the replacement of the existing noise wall. This mitigation has been considered as part of the landscape and visual impact assessment (refer section 17.5.3 of this chapter).

17.6.4 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 summarised below.

Residual impacts during construction of the project are expected to be minor, with the exception of vegetation removal. Minor short-term residual impacts would be associated with the establishment and operation of construction sites and ancillary facilities which would be visible from by surrounding land users and residents. For the most part the proposed temporary compounds during construction would be established in areas without trees, and where tree removal is already required for the project. Areas would be progressively restored on completion of construction works where practicable. Therefore residual impacts during construction (with the exception of vegetation removal) are expected to be minor and short-term.

Despite measures taken to avoid and mitigate impacts, the project would result in some unavoidable residual adverse impacts on some elements of the landscape and views from surrounding areas. The proposed new structures would be visible from surrounding areas. There would be a loss of some trees within Jacquie Osmond Reserve and street trees along Broomfield Street.

The potential for residual impacts would be minimised as far as possible during detailed design, with further consideration of landscaping opportunities.

THIS PAGE HAS BEEN LEFT INTENTIONALLY BLANK

18 Socio-economic impacts

This chapter assesses the potential socio-economic impacts associated with the project. It has been informed by the social impact assessment undertaken by GHD. A full copy of the social impact assessment report is provided as Technical Report 11 – Social impact assessment.

18.1 Assessment approach

18.1.1 Methodology

18.1.1.1 Study area

Data from the 2016 Census of Population and Housing (ABS, 2016) is available at the Statistical Areas Level 2 (SA2) level. The SA2 is the smallest area for the release of ABSA statistics. The study area for the assessment covers two SA2 areas within the Fairfield and Liverpool LGAs.

The two SA2 areas of relevance to this assessment are:

- Cabramatta-Lansvale – which encompasses the suburb of Cabramatta in which the project site is located
- Warwick Farm – which encompasses the suburb of Warwick Farm in which the project site is located.

18.1.1.2 Key tasks

The assessment involved:

- confirming the study area for the purposes of the assessment (see above)
- describing the existing social environment of the study area, including developing a demographic profile for communities in the study area with the potential to be affected by the project
- identifying and mapping community infrastructure and facilities with the potential to be affected by the project
- reviewing information on the project, including the indicative construction methodology, and the proposed operational features and details
- reviewing other technical papers prepared for the EIS to understand the nature, scale and significance of potential impacts, and identify resultant social impacts
- assessing the potential social impacts and benefits of the project, in accordance with relevant principles and guidelines such as:
    - *Social Impact Assessment Guideline* (Department of Planning, Industry and Environment, 2017)
    - *Social Impact Assessment: Guidance for Assessing and Managing the Social Impacts of Projects* (Vanclay et al, 2015)
    - *Environmental Impact Assessment Practice Note: Socio-economic assessment* (Roads and Maritime, 2013)
    - *International Principles for Social Impact Assessment 2003* (Vanclay, 2003)
- taking into account issues raised by the community and relevant stakeholders (described in Chapter 4 (Consultation))
- identifying measures to mitigate the potential impacts.

A detailed description of the assessment methodology is provided in section 2 of Technical Report 11.

18.1.2 Risks identified

The preliminary environmental risk assessment undertaken for the project included potential risks associated with socio- economics. 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 socio-economic risks was high. Risks with an assessed level of high include:

- impacts on the use and functionality of community facilities, including Jacquie Osmond Reserve and Warwick Farm Recreation Reserve
- amenity impacts (noise, air, traffic, visual) to nearby residential receivers and users of recreational grounds
- impacts to local amenity due to increased frequency of trains.

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).

18.1.3 How potential impacts have been avoided/minimised

As described in Chapter 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 social impacts have been avoided/minimised where possible by:

- maintaining the existing functionality of Broomfield Street
- making retaining walls as narrow as possible to minimise operational impacts on Broomfield Street
- assessing the options to identify a parking configuration that would minimise the loss of car parking capacity in Broomfield Street
- reducing the footprint of compound C3 in Jacquie Osmond Reserve to minimise potential impacts on the sports field and use of the reserve.

18.2 Existing environment

A general description of the project site and study area is provided in Chapter 2 (Location and setting). Key socio-economic indicators (mainly from 2016 ABS census data) are summarised below.

The LGAs have a combined population of 403,143 (ABS, 2016), with about 50 per cent living in each LGA. The study area is characterised by socially and culturally diverse communities.

18.2.1 Demographic characteristics

The LGAs have a combined population of 403,143 (ABS, 2016), with about 50 per cent living in each LGA. The study area is characterised by socially and culturally diverse communities.

Cabramatta-Lansvale has a population of 24,708 and Warwick Farm 5,799 (ABS, 2016).

About 80 per cent of the population in Cabramatta-Lansvale speak a language other than English at home compared to 58 per cent in Warwick Farm and 36 per cent in Greater Sydney.

There are also higher levels of disadvantage in Cabramatta-Lansvale and Warwick Farm compared to the LGAs which they are within and the Greater Sydney. These measures include lower income, educational attainment,

English language skills, unemployment, dwellings without motor vehicles, and higher need for assistance with self-care, communication or mobility services, due to illness, age or disability.

The key demographic characteristics of Cabramatta-Lansvale and Warwick Farm compared to the LGAs they are within and Greater Sydney include:

- higher proportions of people born overseas and people who speak a language other than English
- lower median household weekly income
- higher unemployment (about 14 per cent in Cabramatta-Lansvale and Warwick Farm which is over double that for Greater Sydney)
- higher levels of disadvantage with a lower household income and educational attainment compared to Greater Sydney
- generally fewer children and smaller households than the LGAs although Greater Sydney has a smaller average household size compared to the LGAs and Cabramatta-Lansvale
- higher levels of public transport use, with lower usage of cars and higher rates of walking to work.

18.2.2 Community infrastructure and facilities

Cabramatta and Warwick Farm both contain a large range of community facilities and services, including educational facilities, places of worship, sport and recreational areas, health and community services. Community infrastructure is located throughout the study area. Concentrations of facilities are located in the Cabramatta town centre and in the centre of the study are where land uses are dominated by public recreation space.

Community infrastructure and facilities within 500 metres of the project site is shown in Figure 18.1 and listed in Table 18.1. Further information on community infrastructure in the study area is provided in section 18.2.2 and Technical Report 11.

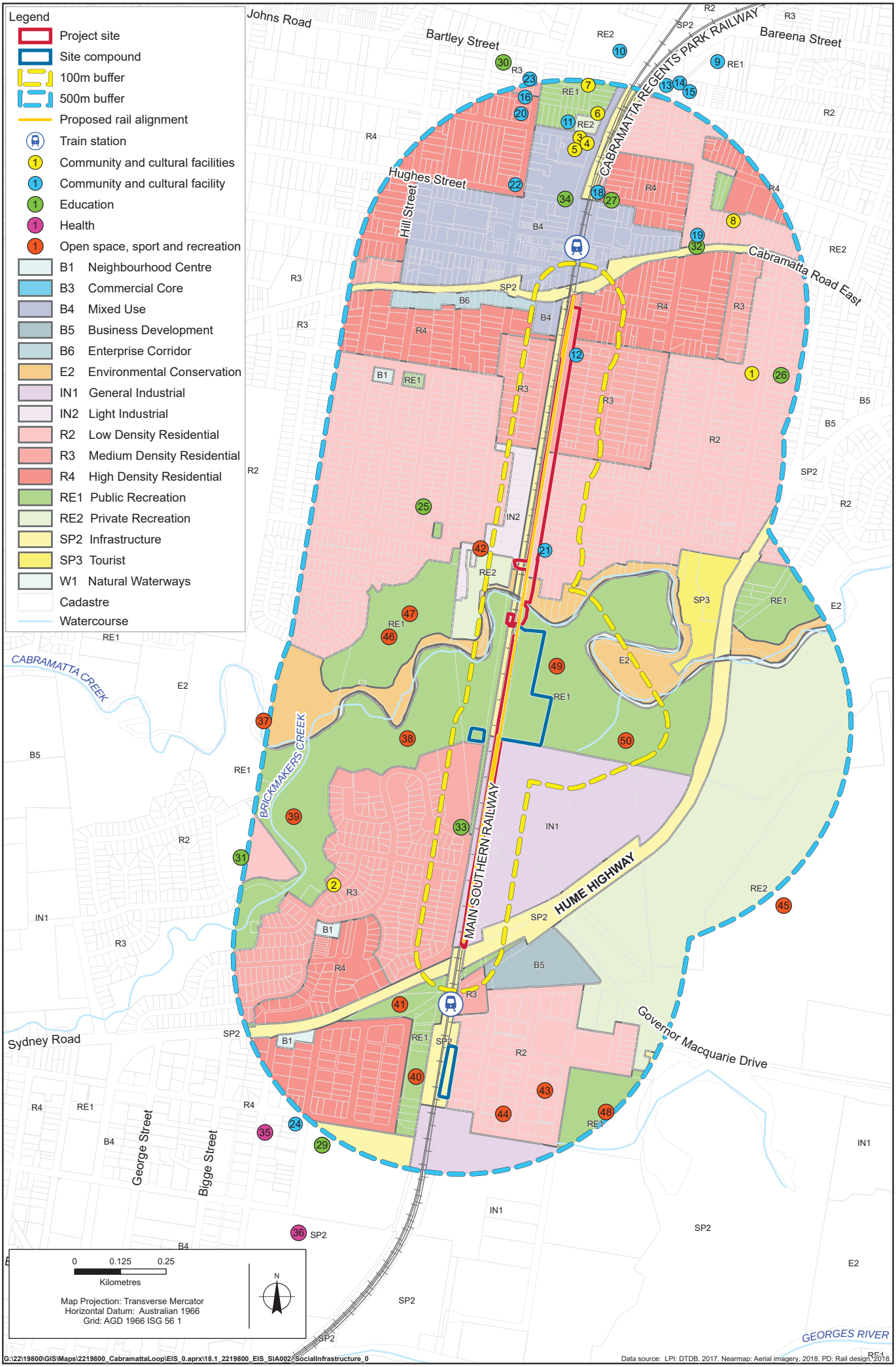

Figure 18.1 Community infrastructure

Table 18.1 Community infrastructure within 500 metres of project site

ID	Type	Name	Description
Community and cultural facilities			
1	Aged care	Lansdowne Nursing Home	Large aged care facility with 161 beds. It is located at 25 Lovoni Street, around 300 m east of the project.
2	Community centre	Liverpool Neighbourhood Connections	Community facility supporting accessible services and community development, around 400 m west of the rail corridor.
3	Community centre	Cabra-Vale (Cabramatta) Senior Citizens Centre	Public community facility operated by Fairfield City Council with 80 person capacity, around 230 m northwest of Cabramatta Station.
4	Community centre	CORE Community Services	Community facility providing Children's Services, Youth Services, Multicultural Communities, Aged and Disability Care and Community Engagement, around 240 m northeast of Cabramatta Station.
5	Community library	Whitlam Library	Public library around 230 m northeast of Cabramatta Station.
6	Cultural facility	PCYC Fairfield-Cabramatta	Community facility around 270 m northwest of Cabramatta Station.
7	Open space/park	Cabra-Vale Memorial Park and Bandstand	First World War memorial and park close to the main Cabramatta retail area and next to the project. It is located around 350 m northwest of Cabramatta Station.
8	Places of worship	Macedonian Orthodox Church	Place of worship around 400 m east of Cabramatta Station.
9	Community centre	Cabravale Leisure Centre	Cabravale Leisure Centre's facilities include a modern gymnasium, swimming pool, sauna and a multipurpose indoor aerobics/program room; community function room, meeting and training facilities with computer access. Located around 600 m north east of Cabramatta Station.
10	Community centre	Cabra-Vale Diggers Club	Cabra-Vale Diggers Club is an entertainment and restaurant venue with full-service function rooms available for hire, around 470 m north of Cabramatta Station
11	Community centre	Arthur West Memorial Hall	Arthur West Memorial Hall is a community hall available for hire located around 280 m northwest of Cabramatta Station
12	Cultural facility	Kampuchea Krom Cultural Centre of NSW	Public place of worship on Broomfield Street adjacent to the existing SSFL.
13	Cultural facility	Ukrainian Hall and Shaolin Temple	Ukrainian Hall and Shaolin Temple is a cultural facility located around 430 north of Cabramatta Station
14	Cultural facility	The German-Austrian Society	The German-Austrian Society is a cultural facility located around 430 north of Cabramatta Station
15	Cultural facility	Kin Fu Ma Zu Association	Kin Fu Ma Zu Association is a cultural facility located around 430 m north of Cabramatta Station

ID	Type	Name	Description
16	Cultural facility	Australian Chinese Teo Chew Association Inc.	Australian Chinese Teo Chew Association Inc. is a cultural facility located around 400 m northwest of Cabramatta Station
17	Education	Seven day Adventist English Language School	Seven day Adventist English Language School is a cultural facility that holds English language classes, located around 80 m northeast of Cabramatta Station
18	Places of worship	Seven Day Adventist Church	Public place of worship around 80 m northeast of Cabramatta Station.
19	Places of worship	Cabramatta Anglican Church	Public place of worship around 260 m east of Cabramatta Station.
20	Places of worship	Baptist Union of NSW	Public place of worship around 350 m northwest of Cabramatta Station.
21	Places of worship	Buddhist Temple	Public place of worship on Broomfield Street adjacent to the existing SSFL.
22	Places of worship	Cabramatta Multi-Centre Uniting Church	Public place of worship around 420 m northwest of Cabramatta Station.
23	Places of worship	Sacred Heart Catholic Church	Public place of worship around 430 m northwest of Cabramatta Station.
24	Places of worship	Saint Raphael Nicholas And Irene Greek Orthodox Church	Public place of worship around 2.5 km south of Cabramatta Station.
Education			
25	Child care	Cabramatta Early Learning Centre	Cabramatta Early Learning Centre is a public centre operated by Fairfield City Council, about 200 m west of the rail corridor.
26	Child care	Vattana Early Learning Centre	Vattana Early Learning Centre is a private centre open from 7.00 am to 6.00 pm, about 500 m east of the rail corridor.
27	Combined school	Khmer Adventist Language School	Khmer Adventist Language School is a community service about 120 m north east of Cabramatta Station.
28	High school	Liverpool Boys High School	Boys secondary public school catering for years 7-12, with around 563 students enrolled. Located at 18 Forbes Street, about 550 m southwest of Warwick Farm Station.
29	High school	Liverpool Girls High School	Girls secondary public high school with around 940 students. Also located on Forbes Street next to Liverpool boys High School.
30	Primary school	Sacred Heart Catholic Primary School	Catholic primary school located around 460 m northwest of Cabramatta Station.
31	Primary school	Warwick Farm Public School	Small, culturally diverse public school with around 230 pupils. It is located 500 m northwest of Warwick Farm Station.
32	Primary school	Cabramatta Public School	A large school with around 730 students 96% of those are from a non-English speaking background. It is located 350 m east of Cabramatta Station.

ID	Type	Name	Description
33	Specialist school (e.g. SSP)	Lawrence Hargrave	Lawrence Hargrave Special Education School supports 63 students with mild intellectual disability, emotional disturbance and a range of behaviour difficulties, located adjacent to the western side of the rail corridor.
34	Tertiary institution	Navitas English Language School	Navitas English Language School is a government supported English learning school, about 100 m northwest of Cabramatta Station.
Health facilities			
35	Hospital	Sydney South West	Private hospital located about 500 m southwest of Warwick Farm Station.
36	Hospital	Liverpool Hospital	Public hospital about 700 m southwest of Warwick Farm Station.
Open space, sports and recreation			
37	Open space/park	Warwick Farm Recreation Reserve	Public open space next to the rail corridor, opposite Jacquie Osmond Reserve.
38	Open space/park	Stroud	Public multi-purpose sport field around 100 m west of rail corridor.
39	Open space/park	Durrant Oval	Sport field located in Warwick Farm Reserve around 420 m west of the rail corridor.
40	Open space/park	Hart Park	Park and playground located adjacent to the Warwick Farm Station parking facility.
41	Open space/park	Berryman Reserve	Nature reserve located adjacent to Warwick Farm Station.
42	Sport facility	Cabramatta Rugby League Club	Private sport club adjacent to the western side of the rail corridor.
43	Sport facility	Warwick Farm Equine Centre	24/7 equine veterinary service and hospital. About 300 m southwest of Warwick Farm Station and close to Warwick Farm Racecourse.
44	Sport facility	Matthew C Smith Stable	Private horse stables and training around 420 m southeast of Warwick Farm Station.
45	Sport facility	Warwick Farm Race Course	Racecourse for thoroughbred horse racing owned by the Australian Turf Club. Located around 700 m east of Warwick Farm Station.
46	Sport facility	Cabramatta Sports Ground	Public multi-purpose sport fields around 200 m west of rail corridor.
47	Sport facility	Don Dawson Oval	Public cricket grounds around 200 m west of rail corridor.
48	Sport facility	Rosedale Oval	Australian Football League (AFL) sporting field around 200 m southeast of Warwick Farm Station.
49	Open space/park	Jacquie Osmond Reserve	Jacquie Osmond Reserve consists of 12 baseball pitches used for local, district and State competitions and weekly training sessions. The Reserve is next to the rail alignment. Vehicular access is via Railway Parade access road which runs along the western side of the rail corridor and connects to the Reserve via an underpass.

ID	Type	Name	Description
50	Sport facility	Jacquie Osmond Softball Centre	Administration office for the Southern Districts Softball Association (SDSA) and facilities for softball training and team play. Located at Jacquie Osmond Reserve.

18.2.3 Community values

Community values refer to tangible and intangible characteristics and aspects of a community, such as amenity, character, lifestyle, access, connectivity, community cohesion, and community health and safety. A project may affect these aspects by changing noise levels, visual amenity, traffic conditions and access, movement across the community, the use and enjoyment of community spaces, and by requiring relocation as a result of property acquisition.

The values held by communities in the study area were identified by analysing community feedback received to date (refer to Chapter 4 (Consultation)), and reviewing relevant State and local government strategic and community planning documents such as the following documents:

- Liverpool City Council, *Our Home, Liverpool 2017 - 2027: Community Strategic Plan*
- Liverpool City Council, *Draft Liverpool Community Safety and Crime Prevention Strategy 2019 – 2022*
- Fairfield City Council, *Fairfield City Plan 2016 – 2026*.

18.2.3.1 Liverpool LGA

Community cohesion, access and connectivity

Liverpool's communities value opportunities to create connections between each other. They aspire for more community events and activities, and community facilities for social cohesion. Celebrating diversity, promoting participation and recognising people's history are all recognised as key values.

The communities also aspire to have an improved transport network to increase accessibility while also facilitating economic growth. Equitable access is also a key value, with communities aspiring for more inclusive urban environments.

The community are concerned about existing issues affecting access and connectivity. These include poor wayfinding signage in the local area, particularly near Jacqui Osmond Reserve. It was also noted that an access road to Jacquie Osmond Reserve was lost during the SSFL works and was not reinstated.

The area currently has a deficit of sport and recreation facilities. Loss of open space at Jacquie Osmond Reserve could be perceived to be a considerable impact to the local community.

Local amenity and character

Liverpool's communities aspire to have well planned, attractive people-friendly urban environments and more green spaces. These should be clean and well managed, with an emphasis on improved access and safety in public areas.

The safety of public areas is a key community concern, which is supported by Liverpool City Council's recently released draft *Liverpool Community Safety and Crime Prevention Strategy 2019–2022*. Developed in consultation with the communities, the strategy aims to encourage social inclusion and build community capacity as a means to increase community safety.

Community members are also concerned about the protection of local bushland, rivers and the visual landscape.

Specific consultation concerns included construction and operation impacts on students and staff at the Principal of Lawrence Hargrave Special Education School. This includes potential loud and intrusive construction impacts which have the potential to impact school activities. There are existing noise and vibration impacts from freight train operations which interrupt teaching activities and affects student's learning, and there is concern this will increase during operation.

The community also expressed concern regarding the need for reinstatement of trees and foliage along the rail corridor, construction impacts on nearby residents (for example from night works) and noise impacts associated with increased freight volumes.

18.2.3.2 Fairfield LGA

Community cohesion, access and connectivity

Fairfield's communities value cultural diversity and the importance of increasing inclusivity and community cohesion. Consultation with Fairfield City Council confirmed the importance of key local events that celebrate cultural diversity, such as the annual Moon Festival in Cabramatta (held in September/October). In addition, Chinese New Year celebrations are also widely celebrated in the LGA, with key events held in Cabramatta over the New Year weekend.

Communities aspire to have improved access to public transport, decreased traffic congestion and increased access to parking in the Fairfield City area.

Local communities also aspire for increased support for youth and elderly citizens.

Car parking including loss or relocation of parking is a key community concern in the local area. The community raised concerns regarding impacts to the continuity of and access to businesses through impacts to parking and access in the area. Additionally, road closures and the works on Sussex Street Bridge could affect community access to the Cabramatta Rugby League Club.

Local amenity and character

Fairfield's communities aspire to live in an attractive and lively city, with more activities in town centres. Communities also aspire for both the built and natural environment, including public open space, to be inviting, well maintained and well used.

Community wellbeing and safety is a key concern of local communities. They desire a reduction in crime rates and road and traffic accidents, and an increase in perceptions of community safety. Community development was seen as a means to strengthen community participation and connection to improve perceptions of safety and increase activity in public spaces.

The community living along Broomfield Street had input into the design of the existing noise wall art work, which contributed to the community's sense of place.

18.3 Assessment of construction impacts

The main potential for socio-economic impacts during construction would occur as a result of:

- changes to access arrangements and connectivity
- amenity impacts as a result of construction works
- impacts to community infrastructure and facilities
- employment generation and other economic benefits, including increased trade.

A summary of the results of the assessment in relation to these potential impacts is provided below.

18.3.1 Access and connectivity

As described in Chapter 8 (Traffic, transport and access), construction of the project would result in temporary impacts to traffic and access within the study area, and an increase in both heavy and light vehicle movements on the local and regional road network. This would impact existing access for residents, visitors, customers, businesses, and service providers along and around the project site. These impacts would include:

- changes to access for pedestrians and cyclists around the construction work areas
- altered movement patterns and traffic routes in some areas due to road closures and diversions

- changed access or increased travel time to community places and facilities
- loss of some areas of parking during construction due to construction workers or the presence of construction activities
- restricted access to private properties located adjacent to the project site
- potential safety risks associated with haulage routes adjacent to Lawrence Hargrave Special Education School.

Changes to traffic, pedestrian, and cyclist access could result in a temporary increase in the distance travelled, increased travel times, inconvenience and delays for some community members.

These potential impacts would be temporary and would be minimised as far as possible by the implementation of the construction traffic, transport, and access management measures provided in section 8.5. These measures would include the development and implementation of a construction traffic management plan, which would aim to:

- minimise disruption to traffic operation, road users, pedestrians, cyclists and access to adjoining properties (private and public)
- limit access restrictions, and where required, provide alternatives to maintain access for the local community.

Road reconfiguration activities on Broomfield Street would affect local parking capacity, with Technical Report 1 - Traffic, transport and access impact assessment indicating that there would be a loss of up to 66 parking spaces depending on the stage of construction. It is likely that the surrounding road network would absorb the loss of parking spaces, however this may have a temporary impact on businesses who use those spaces for employee, customer or visitor parking, commuters who access Cabramatta Station and residents/property owners along Broomfield Street.

Additionally, the following key festivals occur near the project site and could be impacted due to access restrictions associated with the construction works:

- the Cabramatta Moon Festival which occurs on a Sunday in September or October each year in the Cabramatta CBD and involves a number of road closures in the area. Identified haulage routes do not intersect with any of the roads discussed for road closures during the event
- the Chinese Lunar New Year Festival which occurs over the New Year weekend in January or February each year and is usually held in the Freedom Plaza which is located directly west of Cabramatta Station, to the north west of the project site.

Communication with potentially affected users and information provision would assist in reducing uncertainty and the impacts of changes to access and movement patterns. A comprehensive community and stakeholder awareness program would be implemented during construction (as described in Chapter 4 (Consultation)), which would assist in managing these impacts and communicating changes to relevant stakeholders.

18.3.2 Amenity

'Amenity' refers to the pleasant or normally satisfactory aspects of a location which contribute to its overall character and the enjoyment of residents or visitors. Construction of the project may result in the following amenity impacts being experienced by members of the community surrounding the project site:

- increase in noise levels as a result of construction plant and equipment
- increase in traffic movements and congestion (and associated road traffic noise), around the project site and construction haulage routes
- increase in dust generated during construction

- changes in the visual outlook in the vicinity of compounds and construction work areas – particularly potential impacts on existing character and ultimately the overall user experience (particularly for Jacquie Osmond Reserve and Warwick Farm Recreation Reserve), introduction of additional visual clutter (particularly with the removal of the existing noise wall), and interruption of existing sight lines.

These potential impacts and relevant mitigation measures are considered in Chapter 8 (Traffic, transport and access), Chapter 9 (Noise and vibration), Chapter 10 (Air quality) and Chapter 17 (Landscape and visual amenity). Amenity impacts would be temporary, and managed by the mitigation measures outlined in these chapters.

18.3.3 Community infrastructure and facilities

Construction has the potential to affect community infrastructure and facilities located near the project site, as a result of changes in amenity, local access, or requirements for acquisition or temporary use. Key impacts are summarised in Table 18.2.

The amenity impacts noted above may affect the enjoyment of community facilities located close to the project site, particularly outdoor areas.

In addition to the impacts noted in Table 18.2, changes to traffic and transport conditions in the vicinity of the project site could also affect the time and route taken to travel to community facilities. Further information on potential social impacts as a result of access changes is provided above (under access and connectivity). These potential impacts would be temporary, and would be minimised as far as possible by the implementation of the construction traffic, transport, and access management measures provided in section 8.5.

Impacts to specific community facilities in or adjacent to the project site are summarised in Table 18.2.

Table 18.2 Community facilities potentially affected by the project

Community facility	Impact overview
Kampuchea Krom Cultural Centre of NSW	The Kampuchea Krom Cultural Centre of NSW is a registered charity that provides services for the Khmer Community, especially with Buddhist ceremonies. It is located on Broomfield Street directly adjacent (east) of the project site, so would likely be impacted by amenity impacts and impacts to access particularly while utility works are being undertaken. Amenity impacts are not expected to restrict the use or function of the centre. However, implementation of the noise mitigation measures provided in section 9.6 will help mitigate impacts associated with noise on this receiver.
Thien Phuoc Buddhist Association Inc	The Thien Phuoc Buddhist Association Inc. is a registered charity and Buddhist Temple that collects money for poor Vietnamese. It is located on Broomfield Street directly adjacent (east) of the project site, so would likely be impacted by amenity impacts and impacts to access particularly while utility works are being undertaken. Amenity impacts are not expected to restrict the use or function of the temple. However, implementation of the noise mitigation measures provided in section 9.6 will help mitigate impacts associated with noise on this receiver.
Cabramatta Rugby League Club	The Cabramatta Rugby League Club is located about 220 metres west of the project site. The construction of Sussex Street bridge could impact access to the club as Sussex Street is a key access point for community members to walk/cycle/drive to the club. As described in the traffic, transport and access assessment (Technical Report 1- Traffic, transport and access impact assessment) Sussex Street will be closed for some of the bridge construction works due to the movements and placement of cranes. Full closure of the street would be limited to either a possession weekend (two days) or mid-week nights (Sunday to Thursday). Fairfield City Council have noted that many people visit the club during the World Cup event which occurs annually in January, and the rugby league season which occurs from March to October, with large crowds expected for semi-finals and finals games. If inadequately managed, bridge construction activities have the potential to affect community access to the club. This may affect the club itself, as well as disrupt community connections to these sports events. However, implementation of the traffic mitigation measures provided in section 8.5 will help mitigate access impacts, which would only be temporary.

Community facility	Impact overview
Jacquie Osmond Reserve	Jacquie Osmond Reserve and the Jacquie Osmond Softball Centre (located within the reserve) would be directly impacted during construction due to the presence of construction compound C3. Due to construction there would be reduced access to three of the softball diamonds located closest to the compound during construction. This has the potential to affect softball training and competition and cause community concern for way of life and wellbeing. The softball fields are used by the Southern Districts Softball Association as well as a number of secondary schools located near the project site. Parking within the reserve (which is accessed via the access road on the western side of the corridor) would also be restricted due to the presence of the compound, with park users having to park near Warwick Farm Hometown shopping centre and access the park through the southern entry. There is also potential for amenity impacts (mainly noise and visual) to be experienced by users of the park. ARTC would work closely with Liverpool City Council and users of the park to manage how it would be used during construction.
Warwick Farm Recreation Reserve	Warwick Farm Recreation Reserve would be directly impacted due to the presence of work site W1 and construction compound C2. During construction access for pedestrians and cyclists using the shared path from Broomfield Street (via Cabramatta Creek) would be temporarily restricted due to construction vehicles entering W1 and compound C3 in Jacquie Osmond Reserve. Traffic control measures would be implemented to mitigate this impact (refer to section 8.5). Additionally there is a potential for amenity impacts (noise and visual) to users of the reserve due to activities being undertaking within the construction compound and work site. ARTC would work closely with Liverpool City Council and users of the park to manage how it would be used during construction.
Lawrence Hargrave Special Education School	Lawrence Hargrave Special Education School is located adjacent to one of the identified haulage routes (refer to Technical Report 1 – Traffic, transport and access impact assessment), therefore there is the potential for road safety impacts to students, teachers and parents associated with the school, particularly given the vulnerable nature of the students. While there may be the potential for amenity impacts (particularly noise and air), the noise and vibration assessment did not identify the school as a highly affected receiver during construction works. ARTC would consult with the school to understand potential impacts due to construction.

18.3.4 Employment and other economic benefits

Construction of the project would generate employment. It is estimated that the peak workforce required would range from 80 to 220.

This could benefit the local community, as the workforce is likely to include local workers. These jobs are only limited to the workforce that would be directly employed to construct the project, and do not include additional jobs or increased demand stimulated by the project to downstream providers of goods and services. Industries that support construction of the project would also experience economic benefits.

New employment opportunities would also provide the opportunity for training and the development of new skills, which has the potential to benefit the local area and region.

Construction activities also have the potential to result in increased trade for local businesses, particularly those located to the north of the project site near Cabramatta Station.

As existing passenger and freight operations will continue to operate throughout the construction period (other than during programmed rail possession period), minimal impact is expected on rail-reliant industries.

18.3.5 Cumulative impacts

Other projects that have the potential to occur at the same time as the project are described in Appendix E. Of these the following two projects are located within 500 metres of the project site and have the potential to occur at the same time as the project:

- a multistorey residential centre at the corner of Broomfield Street and Cabramatta Road adjacent to Cabramatta Station which would be developed by Moon Investments. The site is zoned B4 Mixed Use and consists of 22 privately owned lots and a section of public laneway owned by Fairfield City Council and has a total area of approximately 12,487 square metres. The site is currently being rezoned to mixed use high density for up to 600 residential/commercial units.
- a new car park is proposed in the Cabramatta town centre by Fairfield City Council, on the corner of Hughes Street and Dutton Lane. Work on the new car park is expected to start in mid-2019 and take around nine months to complete. The 220 space car park connects to the existing multi-deck car park with access to a new lift and pedestrian connection to the existing Dutton Plaza lifts.

Potential cumulative social impacts during construction could include safety risks as a result of increased traffic, and increased amenity impacts as a result of noise, visual change, and dust emissions.

Cumulative traffic and access impacts leading to delays in travel time or difficulties accessing public transport during construction could also lead to indirect social impacts such anxiousness and concern during the construction period. Additionally, as the project will be located next to the SSFL alignment, which was completed in December 2012, there may be a perception of 'construction fatigue' in the local community. Although this occurred more than seven years prior to the construction of the project, with a relatively high proportion of residents living in the area for more than five years (Cabramatta-Lansvale 57 per cent, Warwick Farm 37 per cent), there is potential for these residents to be frustrated with the construction of the project. Genuine consultation with the affected communities and provision of adequate, advance information in different languages, will be critical to maintain trust.

18.4 Assessment of operation impacts

The main potential for socio-economic impacts and benefits during operation would occur as a result of:

- changes to access arrangements, specifically loss of parking
- community amenity impacts
- impacts to community infrastructure and facilities
- economic impacts and benefits.

A summary of the results of the assessment in relation to these potential impacts is provided below.

18.4.1 Access and connectivity

As Broomfield Street and the shared path would be restored to their existing functionality following construction there would be no impacts on local community access during operation.

The reconfiguration of Broomfield Street would result in a permanent loss of up to 11 parking spaces along Broomfield Street. As described in Technical Report 1 - Traffic, transport and impact access assessment this loss is not considered significant as Broomfield Street has the capacity to absorb the potential loss. However, local community members who currently use these parking spaces may perceive the changes in Broomfield Street as a negative impact on their lifestyles, particularly given parking is an existing community concern. This impact is only likely to be temporary as the community adapts to the change.

18.4.2 Amenity

There is the potential for operational noise impacts at selected locations adjacent to the rail corridor. The Technical Report 2 - Noise and vibration assessment identified only one location along Broomfield Street where noise levels were predicted to exceed relevant noise criteria. However, consultation with Lawrence Hargrave Special Education School has indicated that the students are currently impacted by noise from trains, therefore this has the potential to be exacerbated due to the increase in freight train volumes. Where necessary, reasonable and feasible mitigation measures would be incorporated into the final design and project delivery. Further information is

provided in Chapter 9 (Noise and vibration). Additionally ARTC would consult directly with the school to understand the impacts further and

The project would also result in the need to remove trees along Broomfield Street and in Jacquie Osmond Reserve, to facilitate construction works and construction of the retaining wall, embankment and noise wall. The loss of trees in Jacquie Osmond Reserve may affect use of the reserve due to loss of shade provided by the mature trees, which may contribute to the comfort of softball participants and spectators during training and competitions. Potential impacts due to loss of trees and vegetation would be minimised as far as possible by the implementation of the landscape and visual management measures provided in section 17.6.

18.4.3 Community infrastructure and facilities

Apart from the potential amenity impacts, described above there would be no permanent impact on the majority of community infrastructure and facilities located near the project site as a result of operation of the project. The acquisition of land for the passing loop and embankment in Jacquie Osmond Reserve would mean that potentially three of the existing 12 softball diamonds may need to be moved to the east, which could impact on the use of the softball fields. The need to move the softball diamonds, including the associated impacts, would be determined during detailed design in consultation with Liverpool City Council and the Southern Districts Softball Association.

18.4.4 Economic benefits

The main objective of the project is to increase capacity of the freight rail line to meet forecast demand, by increasing efficiency, flexibility and reliability. This has the potential to contribute to long-term economic benefits and both direct and indirect positive impacts on the livelihood of those employed directly by the rail and freight industries and those supplying and supporting those industries.

Increased freight rail efficiency and functionality, and a greater capacity for freight to be transported using rail, would assist in increasing the modal share of freight rail. This could contribute to less congestion on Sydney's roads, with particular relevance to the main roads currently supporting the transportation of freight through the area.

18.4.5 Cumulative impacts

The cumulative benefit of the project with other projects currently occurring in Sydney, such as the Botany Rail duplication project (discussed in Appendix E), during operation is expected result in a net benefit for the community. Considered together with these other projects, the project would:

- increase the capacity of the freight network to support the predicted growth of freight to Port Botany and from the Moorebank Intermodal Terminal
- minimise the reliance on road and other infrastructure to transport freight, resulting in an improvement to local amenity
- help support economic growth and productivity for the Greater Sydney Region
- encourage a shift in freight transport from road to rail, and support a reduced rate of growth in truck movements and associated traffic congestion around Sydney.

18.5 Management of impacts

18.5.1 Approach

18.5.1.1 Approach to mitigation and management

Implementation of a comprehensive approach to consultation, communication, and environmental management during construction would assist in minimising the potential for socio-economic impacts.

Environmental management during construction would be guided by the approach described in Chapter 22 (Approach to environmental management). This would involve preparation of a construction traffic management plan and noise and vibration management plan, to minimise amenity impacts and disruption to the community, and

manage access arrangement during construction. It would also involve preparation of a community and stakeholder engagement plan developed in consultation Fairfield City Council and Liverpool City Council that would aim to detail the approach to communication between ARTC and its Construction Contractor(s), and the community and government authorities.

18.5.1.2 Expected effectiveness

ARTC have experience in managing potential impacts on local communities and businesses as a result of rail developments of a similar scale and scope to this project. Many of the mitigation measures outlined involve effective and ongoing communications with the community and affected land owners.

Community and stakeholder involvement has been and would continue to be tailored to each phase of the project enabling appropriate consideration and balancing of community and stakeholder's social, economic, environment and functional issues to achieve best for project outcomes. A key approach to consultation would be to provide two-way communication channels enabling timely intervention aimed at resolving issues raised by the community and stakeholders.

The CEMP prepared prior to construction would also address the requirements of the project approvals, the environmental management measures outlined in the EIS and all applicable legislation. With regard to socio-economic aspects, mitigation measures are expected to minimise and manage impacts on community life throughout the construction phase. The local and broader community would be notified in advance of construction activities, temporary arrangements, traffic management arrangements and any special construction activities of short duration. As such, impacts to the community are expected to be relatively minor and temporary.

Audits and reporting on the effectiveness of environmental management measures is generally carried out to show compliance with management plans and other relevant approvals and would be outlined in detail in the CEMP prepared for the project. As such, the management of socio-economic impacts throughout the project through implementing the measures outlined in Table 18.3 are considered to be effective.

18.5.2 List of mitigation measures

The mitigation measures that would be implemented to address potential socio-economic impacts are listed in Table 18.3.

Table 18.3 Mitigation measures

Stage	Impact	Measure
Design	Socio-economic impacts	ARTC will continue to work with stakeholders and the community to ensure they are informed about the project and have opportunities to provide feedback to the project team. The existing community contact and information tools will remain in place throughout the duration of the project. Consultation prior to and during construction will involve the use of appropriate tools, including, but not limited to, tools such as community information sessions, briefings, and displays; distribution of project materials in a variety of languages; door knocks; and site signage.
	Community facilities	Prior to construction, consultation will be undertaken with community facilities and event organisers (Cabramatta Moon Festival and Chinese New Year's) with the potential to be impacted by the project, including the cultural centres along Broomfield Street, Fairfield City Council, Liverpool City Council, the SDSA and Lawrence Hargrave Special Education School. Consultation will aim to identify and develop measures to manage the specific construction impacts for individual community facilities and events. These measures would be incorporated into the relevant management plans.

Stage	Impact	Measure
	Community facilities	During design development consultation will be undertaken with Liverpool City Council and the SDSA to minimise impacts on use of the softball fields due to the presence of the embankment and passing loop.
	Community facilities	During design development consultation will be undertaken with Lawrence Hargrave Special Education School regarding existing and future construction noise impacts to identify appropriate mitigation measures.
	Amenity impacts	The community will be given the opportunity through implementation of the existing Stakeholder Engagement Strategy (refer Chapter 4 (Consultation) to provide comment on design and project features which provide local community benefits.
Construction	Economic benefits	Local suppliers will be identified and approached for procurement of goods and services where practicable.
	Community facilities	Access to community facilities and infrastructure will be maintained during construction. Where alternative access arrangements need to be made, these would be developed in consultation with relevant service providers, and communicated to users.

18.5.3 Consideration of the interaction between measures

Mitigation measures in other chapters that are relevant to the management of potential social and economic impacts include:

- Chapter 4 (Consultation) with respect to ongoing consultation during the EIS process, construction and operation phases
- Chapter 8 (Traffic, transport and access), particularly with respect to the management of traffic, public transport arrangements, and access during construction
- Chapter 9 (Noise and vibration) with respect to management of potential noise impacts during construction, to minimise amenity impacts
- Chapter 10 (Air quality) with respect to management of potential air quality impacts during construction
- Chapter 17 (Landscape and visual amenity) with respect to management of potential visual amenity impacts during construction and operation
- Chapter 20 (Health, safety and hazards) with respect to managing potential risks to the community during construction and operation.

Together, all these measures would minimise the potential socio-economic impacts of the project.

18.5.4 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 summarised below.

Residual impacts and benefits following implementation of the mitigation measures described in section 18.5.2, and those provided in other chapters, are predicted to include:

- visual and character changes on along Broomfield Street and at Jacquie Osmond Reserve, which may be considered to be either detrimental or beneficial by different members of the community
- broader economic benefits.

19 Waste

This chapter assesses the predicted waste generation and resource use during construction and operation, and provides a description of how waste and resources will be managed. This chapter was written to address the relevant SEARs which are outlined in Appendix A.

19.1 Assessment approach

A summary of the approach to the assessment is provided in this section, including the legislation, guidelines and/or policies driving the approach and the methodology used to undertake the assessment.

A desktop assessment was carried out to consider potential waste streams likely to be generated as part of the construction and operational stages of the project. Indicative quantities and types of waste have been estimated through a review indicated scale and extent of the project as outlined in the Project Description chapter, the construction methodology and a review of waste quantities for similar projects. Management and mitigation measures were then developed with respect to the relevant legislation and guideline as outlined below.

Further details outlining the methodology are provided in section 19.1.1.

Consideration was given to the *NSW Waste Avoidance and Resource Recovery Strategy 2014-21* (EPA, 2014b). The primary goal of this strategy is to enable NSW to improve environment and community well-being by reducing the environmental impact of waste and using resources more efficiently. This strategy is informed and driven by the waste hierarchy defined in the *Waste Avoidance and Resource Recovery Act 2001* (WARR Act). It is supported by various Acts, regulations and policies including the POEO Act and the Protection of the Environment Operations (Waste) Regulation 2014 (NSW) (POEO Regulation). To support the primary goal of the strategy, the project would be constructed and operated with consideration to the waste hierarchy. Additionally, any waste generated from the project would be disposed of in accordance with regulatory requirements.

19.1.1 Methodology

The assessment involved:

- reviewing key strategic planning policies and documents for waste management relevant to the study area
- identifying potential resource requirements
- identifying potential waste generating activities
- identifying the likely classification of waste generated by the project in accordance with relevant legislation and guidelines
- estimating quantities of waste, where feasible
- identifying available waste management options
- developing a conceptual waste management plan for construction and operation
- identifying lawful disposal or recycling locations.

19.1.2 Risks identified

The preliminary environmental risk assessment undertaken for the project included potential risks associated with waste management. 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 potential risks to waste management during construction and operation was low to medium. The potential risks identified included:

- inappropriate management of waste generated during construction resulting in excessive waste being directed to landfill
- impacts associated with poor waste management during maintenance works.

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).

19.1.3 How potential impacts have been avoided/minimised

As described in Chapter 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 air quality impacts have been avoided/minimised where possible by:

- minimising the project footprint
- reusing existing structures such as the existing noise wall.

19.2 Assessment of construction impacts

19.2.1 Resource requirements

The materials and estimated quantities required for the project are outlined in Table 19.1. The project would require about 8,500 cubic metres of fill for the purpose of embankment widening and fill behind retaining walls. There is the potential for materials, including excavated spoil, to be reused within the project site where practicable to construct the rail formation. The approach to managing excess spoil and other construction wastes is considered in section 19.2.2.

Table 19.1 Resource material requirements and quantities

Activity	Material	Estimated quantity (tonnes unless indicated)
New track/track realignment	Electrical conduit	TBC
	Wiring	6000
	Pre-cast pits	50
	Signal Posts	300
	Aluminium case cabinet	4
	General fill	1,800 m^3
	Concrete, general fill material	4,200 m^3
	Fine crushed rock (engineers material)	1,330 m^3
	Ballast	11,000
	Rail	1388 TM
	Sleepers	2135 no.
	Steel handrail/walkway	TBC

Activity	Material	Estimated quantity (tonnes unless indicated)
Road works	Asphalt	2248
	Concrete (footpath)	372 m^3
	Sand	TBC
	Concrete (Kerbs, Dish Drain, Driveway, Pram Ramp)	486 m^3
	Services pipes	TBC
	Electrical wiring/telegraph poles	TBC
	Imported Select Fill	2954
	Imported Sub-base	2182
	Road base (fine crushed rock)	
	Binding layer	186 m^3
	Pre-cast concrete	76 m^3
	Grates	30
	Line making	2250 m
	Traffic barricades	TBC
Drainage	1200dia RCP installation	575 m
	750dia RCP installation	300 m
	350dia RCP installation	65 m
	Concrete In-Situ Pits	10 no.
	Precast Pits/Headwalls	17 no (pits), 2 no. (headwalls)
Retaining walls	RW01	172 m
	RW02	552 m
	RW03	30 m
New bridges	Pre-cast girders	36 no. (Sussex), 42 no. (Cabramatta)
	Pre-cast Super T Girders	3 no. (Cabramatta)
	Concrete reinforcement	TBC
	Piles	28 no. (Sussex), 36 no. (Cabramatta)
	Lighting	TBC
	Fencing	312 m
	Engineers fill	TBC
	Steel handrail/walkway	175 m

Activity	Material	Estimated quantity (tonnes unless indicated)
	Concrete (Piles)	314 m^3 (assumed 10 m depth)
	Concrete (Headstock & Abutment)	364 m^3
Noise and retaining walls	Hebel panels	697 m^2
	Structural steel	TBC
	Piling casing	TBC
Embankment along Jacquie Osmond Reserve	General fill	2,500 m^3
Other	Landscaping (plants and associated materials)	TBC
	Paint	TBC

The volumes provided in Table 19.1 are estimates only and based on potential maximum volumes that may be required. The actual volumes would be confirmed during detailed design and provided in the CEMP.

19.2.2 Waste generation and management

19.2.2.1 Waste generation

All waste generated during the construction of the project would be managed using the waste hierarchy approach of avoidance and re-use before consideration is given to disposal. All wastes generated would be managed in accordance with the waste provisions contained within the POEO Act.

Soil, sand, ballast, rock or aggregate excavated from within the rail corridor can be reused in accordance with the *Australian Rail Track Corporation excavated material order 2019* which allows for the re-use of ARTC excavated material under Part 9, Clause 93 of the POEO Regulation.

Should waste be found to be unsuitable for reuse or recycling, disposal methods used be selected based on the classification of the waste material in accordance with the *Waste Classification Guidelines: Part 1 Classifying Waste* (NSW EPA 2014). The Waste Classification Guidelines provide direction on the classification of waste, specifying requitements for management, transportation and disposal of each waste category.

Recourse recovery will be applied to the management of generated constructed waste and will include:

- recovery of resources for reuse-reusable, materials generated by the project will be selected for reuse on site, or off site where possible, including the reuse of the major waste streams (general solid waste as per the Preliminary Waste Classification in Chapter 12 (Soils and contamination))
- recovery of resources for recycling-recyclable resources (such as metals, plastics and other recyclable materials) generated during construction will be segregated for recycling and sent to an appropriate recycling facility for processing.

The preliminary waste classification undertaken as part of the limited contamination assessment (Chapter 12 (Soils and contamination)) indicated that soils within the project site would likely meet the classification of General Solid Waste, in accordance with the *NSW EPA Waste Classification Guidelines Part 1: Classifying Waste* (EPA, 2014).

The limited contamination assessment confirmed that the soils are considered suitable to remain within the project site for the uses proposed during operation (rail corridor and road corridor). Based on the findings of the contamination assessment, the project site does not contain gross contamination and does not meet the criteria requiring it to be notified to the EPA under section 60 of the CLM Act.

19.2.2.2 Classification of waste to be generated

The main construction activities anticipated to generate waste are listed in Table 19.2 together with the materials that may be produced, and likely waste classifications where this material cannot be reused or recycled.

Table 19.2 Waste estimates and classification – construction

Activity	Waste	Potential classification	Estimated quantity (tonnes unless indicated)
Clearing and grubbing	Green waste from the removal of trees, shrubs and ground cover that are unable to be mulched and reused within the project	General solid waste (non-putrescible)	TBC
	Rubbish and debris	General solid waste (non-putrescible)	20 tonnes
Topsoil stripping	Topsoil	General solid waste (non-putrescible) or virgin excavated natural material	Included in cut and fill below
Operation of construction machinery	Waste from vehicle/ plant equipment maintenance	General solid waste (non-putrescible) - drained oil filters (mechanically crushed), rags and oily rags only if they contain non-volatile petroleum hydrocarbons and no free liquids. Hazardous waste - containers holding oil, grease and lubricants if residues have not been removed by washing (see Appendix 2 of the *Waste Classification Guidelines Part 1: Classifying Waste* (EPA, 2014)).	Less than one tonne
Rail formation	Sleepers rail	General solid waste (non-putrescible)	In cut and fill
Fencing (temporary and permanent)	Waste metal/timber posts	General solid waste (non-putrescible)	TBC
Utility relocation works	Waste muds	Liquid waste	1200 cubes from potholing
Earthworks (new track/alignment, embankment along Jacquie Osmond Reserve)	Spoil	General solid waste (non-putrescible) as per the preliminary waste classification (refer to Chapter 12 (Soils and contamination))	8,100 metres cubed
	Contaminated spoil (if encountered)	Special waste	TBC
Drainage structures/stormwater	Waste wood and concrete	General solid waste (non-putrescible)	TBC

Activity	Waste	Potential classification	Estimated quantity (tonnes unless indicated)
structures and bridge construction			
	Waste metal	General solid waste (non-putrescible)	1600 tonnes
Installing new kerbs and gutters	Waste concrete (from existing kerbs)	General solid waste (non-putrescible)	440 tonnes
	Waste plastic	General solid waste (non-putrescible)	NA
Diversion of pedestrian pathway	Waste concrete (from existing pathway)	General solid waste (non-putrescible)	TBC
Demolition and replacement of existing noise walls and retaining walls	Waste concrete (panels not reused)	General solid waste (non-putrescible)	1300 tonnes
	Concrete waste (sandstone look blocks)	General solid waste (non-putrescible)	TBC
Welding	Waste metal	General solid waste (non-putrescible)	TBC
Ballasting and tamping	Waste ballast	General solid waste (non-putrescible)	300 tonnes
Site compound operation	Food waste	General solid waste (putrescible)	400 tonnes
	Wastewater	Liquid waste	380 litres
	Waste paper and cardboard	General solid waste (non-putrescible)	2 tonnes
	Waste plastic and glass	General solid waste (non-putrescible)	Less than one tonne

The capping, structural, general fill and ballast quantities in Table 19.2 were taken from three dimensional models prepared as part of the reference design and have been used to calculate the number of truck movements to and from the project site. The volumes provided in Table 19.2 are estimates only and based on potential maximum volumes that may be generated. Approximate waste volumes and the potential classification would be estimated and/or confirmed following finalisation of the detailed design and incorporated into the CEMP prepared for the project.

19.2.2.3 Spoil generation and management

Spoil is soil, rock or dirt excavated and removed from its original location. It is estimated that a total of 4,000 cubic metres of spoil would be generated during construction. The majority of spoil is expected to be reused for either track formation or construction (as described in Chapter 7 (Construction)).

The majority of spoil would be generated during excavation required for the new passing loop, retaining walls and bridges at Cabramatta Creek and Sussex Street. Relatively smaller quantities would be generated during site preparation activities, and from other earthworks such as for the formation treatment. At this stage it is estimated that minor quantities of contaminated spoil may be generated that could not be reused on site. This material would require off-site disposal at an appropriately licenced facility. The amount of spoil to be reused would continue to be refined during detailed design.

Consistent with the waste minimisation hierarchy, the approach to spoil management would follow the hierarchy of options listed in Table 19.3.

Table 19.3 Spoil management hierarchy for the project

Priority	Re-use options	Approach
1	Avoid	Detailed design would include measures to minimise spoil generation.
2	Re-use for construction of the project	There would be a focus on the reuse of material, and optimisation of the design to minimise spoil volumes. Spoil generated during construction would be re-used for the project, including: • re-use spoil for fill, embankment along Jacquie Osmond Reserve and mounds within a short haulage distance of the source • re-use spoil to restore any pre-existing contaminated sites within the project site.
3	Re-use on other projects	Re-use spoil for fill, embankments and mounds on other projects within a financially feasible transport distance of the project site.
4	Disposal	Excess spoil would be disposed of in accordance with the waste management procedure prepared as part of the CEMP.

19.2.2.4 Waste handling and management

Approach to waste minimisation and reuse

Waste management measures have been developed for the identified types of waste in accordance with the waste management hierarchy (refer to Table 19.3). Although the waste management hierarchy has been considered for each waste type, not all waste management options are applicable to a given waste type. For example, some types of waste are non-recyclable. As such, only the applicable waste management options are applied.

Recycling and disposal

The majority of the waste transfer stations are operated by local councils for use by residents. However, the larger landfills and transfer stations are able to accept commercial waste. Arrangements would be made with landfill operators prior to the delivery of waste and recycling to any rural facility to ensure that the waste types and quantities could be accepted.

The approach to waste management during construction is described in section 19.4. The waste management measures proposed to align with the waste management hierarchy are listed in Table 19.5. This table also outlines

the contingency measures (disposal) for wastes that cannot be avoided, reused, recycled or treated. Measures to facilitate segregation and prevent cross contamination are also provided.

19.2.3 Cumulative impacts

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

There is the potential for cumulative impacts associated with demand on resources, including workers, however given the size of this project and other projects occurring in the vicinity of the project site and the type of resources required, the cumulative impacts due to resource demand are considered minimal.

Potential cumulative impacts regarding waste would be avoided in the first instance through development of a waste management procedure and engagement with waste management facilities to ensure that sufficient capacity is available to manage the received waste.

Given the range of waste management facilities identified in the area, and the relatively conventional nature of the waste predicted to be generated by the project, it is expected that appropriate waste management facilities with sufficient capacity will be identified and utilised. No significant cumulative impacts as a result of waste generation are anticipated.

19.3 Assessment of operation impacts

19.3.1 Waste generation and management

The main waste generating activity during operation would relate to track maintenance. Small quantities of green waste may be generated during maintenance activities as a result of vegetation control, herbicide use, and maintenance of the entire rail corridor. Other general debris and litter are also expected to be collected during maintenance. These activities already occur under existing operational conditions.

Maintenance of plant and vehicles would be undertaken at ARTC's existing provisioning centres and not within the project site. Therefore waste from maintenance of plant and vehicles during operation has not been considered further.

The anticipated waste types and likely classifications during operation are listed in Table 19.4.

Table 19.4 Waste estimates and classification – operation

Activity	Waste	Classification
Track maintenance	Green waste	General solid waste (non-putrescible)
	Rubbish and debris	General solid waste (non-putrescible)
	Materials	Suitable rail offcuts or scrap metal (including metal bands from packaging of materials for maintenance and hot waste from welding)

Approach to waste minimisation and reuse

The approach to waste management during operation is described in section 19.4.1. The waste management measures proposed to align with the waste management hierarchy are listed in Table 19.6. This table also outlines the contingency measures (disposal) for wastes that cannot be avoided, reused, recycled or treated. Measures to facilitate segregation and prevent cross contamination are also provided.

Standard ARTC maintenance activities would be undertaken during operations. Typically, these activities include minor maintenance works, such as bridge and culvert inspections, rail grinding and track tamping, through to major maintenance, such as replacement and repair of existing bridge components, culvert repairs and cleaning, reconditioning of track and topping up of ballast as required.

Maintenance activities would continue to be undertaken in accordance with ARTC's Environmental Management System and ARTC's existing EPL (# 3142).

19.3.2 Cumulative impacts

No cumulative impacts would be expected as a result of the operation of the project.

19.4 Management of impacts

19.4.1 Approach

19.4.1.1 Approach to mitigation and management

A construction waste management procedure would be developed for the project as part of the CEMP. Operational procedures would continue to consider waste management in accordance with regulatory requirements. Waste management during construction and/or operation would also be undertaken in accordance with ARTC's existing procedures and EPL. Implementation of these measures would help ensure that waste from the project is managed in an environmentally sound manner, and in accordance with any legislated requirements for waste disposal and waste tracking.

19.4.1.2 Expected effectiveness

ARTC have experience managing potential impacts associated with waste generation as a result of rail developments of similar scale to the project.

All mitigation measures would be consolidated and described in the environmental management plans for construction and operation. The plans would identify measures that are common between waste types and or impact categories. ARTC would engage waste contractors to manage the collection, recycling and disposal of waste that cannot be reused onsite. Waste contractors would also be required to provide evidence of the works compliance with legislation requirements, conditions of approval and standards and guidelines.

In addition, waste auditing and monitoring would be undertaken to ensure that the waste management procedure for construction is scaled with actual waste volumes. As such, the management of waste throughout the project through implementing the measures outlined in Table 19.5, Table 19.6 and Table 19.7 are considered to be effective.

Table 19.5 Approach to waste management – construction

Waste	Hierarchy	Management
Green waste	Avoid	Clearing would be minimised by placing temporary infrastructure in areas that have been previously cleared, degraded or have naturally lower above ground biomass.
	Reduce	Areas to be cleared would be marked to reduce incidental clearing.
	Reuse	As far as practicable, cleared material would be chipped, mulched and stockpiled for reuse during finishing works. Materials with special habitat value, such as hollow bearing logs or trees, would be selectively removed for reuse, or placed in nearby bushland.
	Dispose	Noxious weeds would be disposed of in accordance with relevant guidelines/requirements.
Rubbish and debris	Reuse	Domestic waste to be minimised where possible and other options investigated to promote reuse such as a water filling station instead of disposable water bottles.
	Recycle	Where recycling is considered feasible, rubbish and debris would be stored for collection by an authorised contractor for offsite recycling.
	Dispose	Where rubbish and debris is not recyclable, the waste would be removed to a storage location for collection by an authorised contractor for offsite disposal.
Food waste	Disposal	Putrescible waste would be stored at allocated bins at each site compound, for collection by an authorised contractor, and disposed of offsite.
Wastewater	Dispose	Wastewater/sewage from site compound amenities/ablutions would be removed by an authorised contractor for disposal in accordance with regulatory requirements.
Spoil	Reduce	The project is designed to adhere to the natural ground profile, where practicable, in order to reduce earthworks.
	Reuse	As much spoil as possible will be reused either for track formation/construction or used to create the embankment at Jacquie Osmond Reserve.
	Recycle	Options to recycle spoil would be investigated where practicable and would include consideration of the *Australian Rail Track Corporation excavated material order 2019.*
	Dispose	Only minor quantities of contaminated spoil will require offsite disposal at an appropriately licenced facility.
Topsoil	Reuse	Topsoil would be stockpiled for reuse during rehabilitation. Stockpiles would be managed to maintain soil structure and fertility.
	Treat	Low quality topsoil would be treated with ameliorants to improve structure and fertility.
	Dispose	Surplus or unusable topsoil would be disposed at locations within the rail corridor.
Waste concrete	Avoid	Procurement of surplus concrete powder would be avoided by adhering to the *Sustainable Procurement Guide* (Australian Government, 2013) and the *NSW Government Resource Efficiency Policy* (OEH, 2014).
	Reuse	Sleepers would be reused where appropriate.
	Recycle	Waste concrete would be crushed and recycled where practicable.

Waste	Hierarchy	Management
	Dispose	Waste concrete that cannot be recycled would be collected and stored in designated storage areas for offsite disposal by an authorised contractor.
Waste ballast	Avoid	Procurement of surplus ballast would be avoided by adhering to the *Sustainable Procurement Guide* (Australian Government, 2013) and the *NSW Government Resource Efficiency Policy* (OEH, 2014).
	Recycle	Options to recycle ballast would be investigated where practicable and would include consideration of the *Australian Rail Track Corporation excavated material order 2019.*
	Disposal	All unusable ballast would be placed into spoil mounds.
Waste metal	Avoid	Procurement of surplus metal, including rail, would be avoided by adhering to the *Sustainable Procurement Guide* (Australian Government, 2013) and the *NSW Government Resource Efficiency Policy* (OEH, 2014).
	Reduce	Waste metal would be reduce by limiting offcuts.
	Recycle	Suitable rail offcuts or scrap metal (including metal bands from packaging of construction materials and hot waste from welding) would be stored for collection by an authorised contractor and recycled offsite. Market demand for this recyclable waste would also be considered.
Waste plastic	Avoid	Procurement of surplus plastic would be avoided by adhering to the *Sustainable Procurement Guide* (Australian Government, 2013) and the *NSW Government Resource Efficiency Policy* (OEH, 2014).
	Recycle	Waste plastic would be stored at recycling bins at each site compound, for collection by an authorised contractor and recycled offsite.
	Dispose	Where recycling is not considered feasible, the waste would be collected and stored in designated waste storage areas for collection by an authorised contractor for offsite disposal.
Waste paper	Avoid	Procurement of surplus paper would be avoided by adhering to the *Sustainable Procurement Guide* (Australian Government, 2013) and the *NSW Government Resource Efficiency Policy* (OEH, 2014).
	Reduce	Waste paper from office/administration facilities would be minimised by enabling 'secure print' feature on all printers and by encouraging double-sided printing.
	Recycle	Waste paper would be stored at recycling bins at each site compound, for collection by an authorised contractor, and recycled offsite, where feasible.
	Dispose	Where recycling is not considered feasible, the waste would be collected and stored in designated waste storage areas for collection by an authorised contractor for offsite disposal.
Waste cardboard	Avoid	Procurement of surplus cardboard would be avoided by adhering to the *Sustainable Procurement Guide* (Australian Government, 2013) and the *NSW Government Resource Efficiency Policy* (OEH, 2014).
	Recycle	Waste cardboard would be stored at recycling bins at each site compound, for collection by an authorised contractor, and recycled offsite, where feasible.
	Dispose	Where recycling is not considered feasible, the waste would be collected and stored in designated waste storage areas for collection by an authorised contractor for offsite disposal.
Waste aluminium cans	Recycle	Waste aluminium would be stored at recycling bins at each site compound, for collection by an authorised contractor, clubs or charities, and recycled offsite.

Waste	Hierarchy	Management
Electrical waste	Avoid	Procurement of surplus appliances and cabling would be avoided by adhering to the *Sustainable Procurement Guide* (Australian Government, 2013) and the *NSW Government Resource Efficiency Policy* (OEH, 2014).
	Reuse	Product stewardship arrangements would be sought, with a view to some electrical appliances being reused under return to supplier arrangements.
	Recycle	Electrical waste would be stored at recycling bins at each site compound, for collection by an authorised contractor, and recycled offsite, where feasible. Market demand for this recyclable waste would also be considered.
	Dispose	Where recycling is not considered feasible, the waste would be collected and stored in designated waste storage areas for collection by an authorised contractor for offsite disposal.
Waste oil, grease, lubricants, oily rags and filters	Avoid	Procurement of surplus appliances and cabling would be avoided by adhering to the *Sustainable Procurement Guide* (Australian Government, 2013) and the *NSW Government Resource Efficiency Policy* (OEH, 2014).
	Recycle	Only waste oil and oil filters to be recycled through storage in recycling bins at each site compound, collection by an authorised contractor, and recycling offsite, where feasible.
	Dispose	The waste would be collected and stored in designated waste storage areas for collection by an authorised contractor for offsite disposal. Where feasible, containers holding oil, grease and lubricants would be washed prior to disposal or stored separately for disposal as hazardous waste.
Waste pallets	Avoid	Procurement of surplus pallets would be avoided by adhering to the *Sustainable Procurement Guide* (Australian Government, 2013) and the *NSW Government Resource Efficiency Policy* (OEH, 2014).
	Reduce	Delivery of material on pallets would be limited wherever possible. If materials have to be delivered to site on pallets, ensure that pallets are returned to the supplier at time of delivery, where practicable.
	Reuse	Product stewardship arrangements would be sought, with a view to pallets being reused under the stewardship of the supplier.
	Recover	Options to recover wood from pallets by chipping, for reuse as mulch, would be pursued where practicable.

Table 19.6 Waste management measures – operation

Waste	Hierarchy	Management
Green waste	Reuse	As far as practicable, green waste generated from maintenance activities would be chipped, mulched and reused for vegetation management or collected by an authorised contractor and recycled offsite.
	Dispose	Noxious weeds would be disposed of in accordance with relevant guidelines/requirements.
Rubbish and debris	Recycle	Rubbish and debris includes any unexpected waste encountered during general track and corridor maintenance, and may include scrap metal, plastic, wood and other litter. Such wastes would be would be collected by an authorised contractor and recycled offsite, where recycling is considered feasible.

Waste	Hierarchy	Management
	Dispose	Where rubbish, debris and litter is not recyclable, the waste would be collected by an authorised contractor and disposed offsite at a suitably licenced facility.
Waste metal	Avoid	Procurement of surplus metal, including rail, would be avoided by adhering to the *Sustainable Procurement Guide* (Australian Government, 2013) and the *NSW Government Resource Efficiency Policy* (OEH, 2014).
	Reduce	Waste metal would be reduced by limiting offcuts.
	Recycle	Suitable rail offcuts or scrap metal (including metal bands from packaging of materials for maintenance and hot waste from welding) would be collected by an authorised contractor and recycled offsite. Market demand for this recyclable waste would also be considered.

19.4.2 List of mitigation measures

The mitigation measures that would be implemented to manage waste are listed in Table 19.7.

Table 19.7 Mitigation measures

Stage	Impact	Measure
Detailed design	Excess waste generation	Detailed design will include measures to minimise excess spoil generation during construction of the project. This will include a focus on optimising the design to minimise spoil volumes, and the reuse of material on-site.
Construction	Waste generation and recycling	A recycling target of at least 90 per cent will be adopted for the project. Where possible and fit for purpose; materials will be reused within the project before off-site reuse or disposal options are pursued
	Waste management	A waste management procedure will be prepared and implemented as part of the CEMP. It will include measures to minimise the potential for impacts on the local community and environment, including those listed in Table 19.5.
	Waste segregation	A waste segregation bin scheme will be included in the CEMP and will include locations of segregated bins within compounds, to facilitate segregation and prevent cross contamination.
	Materials	Material quantities will be recorded to monitor usage during each stage of construction.
	Waste and spoil management	Spoil will be managed in accordance with the spoil management hierarchy provided in Table 19.3.
	Waste and spoil management	A reusable spoil target of 90 percent will be adopted for the project. Where possible and fit for purpose, spoil will be beneficially reused within the project before off-site reuse or disposal options are pursued.
	Waste and spoil management	Construction waste will be minimised by accurately calculating materials brought to the site and limiting materials packaging.
	Waste and spoil management	All waste will be assessed, classified, managed and disposed of in accordance with the Waste Classification Guidelines (EPA, 2014a) and waste would be managed in accordance with *The Australian Rail Track Corporation excavated material order 2019*.

Stage	Impact	Measure
	Waste and spoil management	Waste segregation bins will be located at various locations within the project area, if space permits, to facilitate segregation and prevent cross contamination.
Operation	Waste management	Waste management measures will be implemented in accordance ARTC's standard environmental management measures included within its Environmental Management System and the mitigation measures listed in Table 19.6.

19.4.3 Consideration of the interaction between measures

There are interactions between the mitigation measures for waste management and soils and contamination (provided in Chapter 12), and health safety and hazards (provided in Chapter 20). Together, all these measures would ensure appropriate handling of waste materials to minimise the potential for impacts to the community and environment.

19.4.4 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 summarised below.

Construction waste quantities, including estimated spoil generation, spoil reuse, and spoil surplus, would be confirmed during detailed design. Classifications and reuse/recycling/disposal locations would also be confirmed at this stage. However, it is recognised that there is potential for unexpected volumes of potentially contaminated spoil to be generated. Any spoil classified as contaminated in accordance with Waste Classification Guidelines would be directed to a waste management facility that is lawfully permitted to accept that type of contaminated waste. There are a number of solid waste landfills in Sydney that are licensed to accept contaminated soils. Based on the results of the limited contamination assessment (refer Chapter 12 (Soils and contamination)) it is anticipated that the volumes of contaminated spoil generated by the project, if any, would be minor and could be readily accommodated at these facilities.

THIS PAGE HAS BEEN LEFT INTENTIONALLY BLANK

20 Health, safety and hazards

This chapter considers potential hazard, risk, and safety impacts associated with the project, and how these would be mitigated and managed during construction and operation. This chapter was written to address the relevant SEARs which are outlined in Appendix A.

20.1 Assessment approach

20.1.1 Methodology

20.1.1.1 Study area

The study area varies for each health and safety related issue being considered and aligns with studies that support this assessment. For example the study area for the air quality impact assessment (Technical Report 3) is around a 1.5 kilometre concentric circle study area from the project and the noise and vibration impact assessment (Technical Report 2) is around a 1 kilometre study area from the project site. The area considered for public safety is in the immediate vicinity of the project where the public may come into contact with construction sites and road works.

20.1.1.2 Scope of assessment

The assessment focuses on those construction and operational activities with the potential to result in the following:

- potential health impacts, arising from changes such as the loss of public space, changes in air quality or noise impacts
- the likely risks of the project to public safety, such as risks to pedestrian safety from construction works and the handling and use of dangerous goods impacting the community.

A desktop level assessment was undertaken to identify potential impacts from the construction and operation of the project to the health and safety of the surrounding community and environment. The assessment involved:

- reviewing the relevant regulatory framework and applicable guidelines
- identifying sensitive receivers and community infrastructure within the existing environment
- identifying construction and operational activities with the potential to cause health and safety impacts to off-site receivers
- considering the potential impacts associated with hazardous materials, as defined by the guidelines to *State Environmental Planning Policy No 33 – Hazardous and Offensive Development* (SEPP 33)
- qualitatively assessing potential impacts to public health and safety
- consideration of the recommended mitigation measures identified in the EIS technical studies and where necessary, additional mitigation measures that may need to be considered to address community health and safety impacts.

The assessment does not take into account potential health and safety risks to on-site workers associated with normal construction operations, as these are regulated by workplace health and safety legislation (including the *Work Health and Safety Act 2011*), and are not relevant to approval of the project under Division 5.2 of the EP&A Act. Site management would be the responsibility of the construction contractor, who would be required (under the *Work Health and Safety Act 2011*) to manage the site in accordance with relevant regulatory requirements.

20.1.1.3 Health and safety

This health impact assessment draws together and assesses impacts from changes in air quality, noise, public safety and a range of community/social aspects, as these relate to and may impact on the health of the community. As a result, the health impact assessment draws directly on a wide range of other Technical Reports,

to evaluate how the impacts identified in these studies may then either benefit or impact on the health of the community. This study has considered the findings of the following Technical Reports:

- Technical Report 1 – Traffic, transport and access impact assessment
- Technical Report 2 – Noise and vibration impact assessment
- Technical Report 3 – Air quality impact assessment
- Technical Report 6 – Soils and contamination impact assessment
- Technical Report 11 – Social impact assessment

The health impact assessment considered the following guidance:

- *Environmental health risk assessment, guidelines for assessing human health risks from environmental hazards* (Enhealth 2012)
- *Methodology for Valuing the Health Impacts of Changes in Particle Emissions* (EPA, 2013)
- *Health Impact assessment guidelines 2017* (Enhealth, 2017)
- *Health impact assessment: A practical guide* (NSW Health, 2007).

This assessment has reviewed key aspects of the project that may affect the health of the local community. The assessment includes both qualitative and quantitative assessment methods. The approach adopted in for this assessment is as follows:

- an assessment of potential impacts on health associated with project related changes in noise. This is a qualitative assessment of construction and operational noise impacts for the community based on the quantitative findings of Technical Report 2 - Noise and vibration impact assessment.
- an assessment of potential impacts on health associated with project include changes in air quality and noise. This involves a qualitative assessment of construction and operational impacts on community health based on the quantitative findings of Technical Report 3 – Air quality impact assessment.
- an assessment of potential impacts of the project on public safety. This is a qualitative review of impacts that have the potential to impact on public safety during construction and operation.
- an assessment of potential impacts of a range of other project related impacts on community health. This is a qualitative assessment of project related impacts related to traffic, contamination of land and water, changes in green space and access to recreational facilities, public transport, active transport and acquisitions as outlined in the various relevant technical studies.

Dangerous goods and hazardous materials

Hazardous materials are classified based on their health effects, while dangerous goods are classified according to their physical or chemical effects, such as fire, explosion, corrosion and poisoning, which may impact property, the environment or people.

As the project is State significant infrastructure, *Hazardous and Offensive Development Application Guidelines: Applying SEPP 33* (Department of Planning, 2011*)* (Applying SEPP 33) does not apply to the project (refer to section 3.2). However, consideration of SEPP 33 provides a process for identifying a potentially hazardous development by identifying storage and transport screening thresholds. The thresholds in Applying SEPP 33 represent the maximum quantities of hazardous materials that can be stored or transported without the potential for causing a significant off-site risk.

Hazardous materials are defined by Applying SEPP 33 as substances falling within the classification of the Australian Code for the Transport of Dangerous Goods by Road & Rail (National Transport Commission, 2017) ('the Dangerous Goods Code'). Dangerous goods are substances that, because of their physical, chemical (physico-chemical) or acute toxicity properties, present a risk to people, property or the environment. Types of

substances classified as dangerous goods include explosives, flammable liquids and gases, corrosives, chemically reactive or acutely (highly) toxic substances.

20.1.2 Risks identified

The preliminary environmental risk assessment undertaken for the project included potential risks associated with health, safety and hazards. 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 health and safety risks ranged from low to high. Risks with an assessed level of medium or above included:

- impacts from transport, storage and use of hazardous substances and dangerous goods
- adverse health from noise and air pollution during construction
- reduced safety for road users and pedestrians during construction particularly in the vicinity of houses, businesses, and areas of public recreation
- safety impacts due to the presence of construction activities (moving vehicles etc) particularly within recreational areas and near Lawrence Hargrave Special Education School
- impact from spill or accident during the transport, storage and use of hazardous substances and dangerous goods
- increased safety risks due to changes to infrastructure (eg additional length of shared path under bridge) adverse health from noise during operation.

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).

20.1.3 How potential impacts have been avoided/minimised

As described in Chapter 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 noise wall would 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.
- Closure of active transport routes has been minimised by providing a temporary path between Sussex Street and Cabramatta Creek around the proposed worksites to maintain access to public recreation and through traffic for the majority of the construction period.

Potential air quality and contamination impacts have been minimised by minimising the project footprint.

20.2 Existing environment

The existing environment with regards to traffic and access, noise, air quality, contamination and social impacts is described in chapters 8, 9, 10, 12 and 18 respectively.

Other aspects relevant to the consideration of health and safety impacts are discussed below.

20.2.1 Sensitive receivers

The urban setting of the project means that there is the potential for the community to be impacted. The mitigation measures provide in section 20.5.2 will be implemented to manage any construction and operational impacts. A description of existing land use patterns and sensitive receivers surrounding the project area is provided in Chapter 16 (Land use and property).

Sensitive receivers include members of the community travelling through the study area or are situated in close proximity to the project site and operational rail corridor and residents living near the project site.

The study area for the assessment covers two statistical areas (level 2 areas) within the Fairfield and Liverpool LGAs. The two areas of relevance to this assessment are:

- Cabramatta-Lansvale – which encompasses the suburb of Cabramatta in which the project site is located.
- Warwick Farm – which encompasses the suburb of Warwick Farm in which the project site is located.

A detailed profile of the local communities is provided in section 18.2.

20.2.2 Community infrastructure

The suburbs of Cabramatta and Warwick Farm both contain a large range of community facilities and services including:

- residential homes and gardens with the closest receivers residing on Broomfield Street and Sussex Street
- community facilities eg including the Lawrence Hargrave Special Education School (refer to section 18.2.2 for a complete list of community facilities)
- footpaths and shared paths including the Cycleway
- roads including local roads such as Broomfield Street, Sussex Street, Station Street and Railway Parade and arterial roads such as Hume Highway
- Jacquie Osmond Reserve including the sports facilities predominantly used for softball
- Warwick Farm Recreation Reserve
- Hometown Warwick Farm retail area, Peter Warren Automotive and other local businesses.

The project site and surrounding area contains the usual overhead and underground utilities common to a suburban area. This includes:

- stormwater drainage pipes on the eastern and western sides of Broomfield Street
- sewer rising main and gravity main located parallel to the rail corridor in Jacquie Osmond Reserve and Peter Warren Automotive
- power poles and power lines on the eastern side of Broomfield Street

No known high pressure dangerous goods pipelines are located within or adjacent to the project site.

20.2.3 Existing health of the population

There are a large number of factors to consider in relation to the existing health of a local community. The health of the community is influenced by a combination of interacting factors including age, socio-economic status, social networks, behaviours, beliefs and lifestyle, life experiences, country of origin, genetic predisposition and access to health and social care. While it is possible to review existing health statistics for the local health district surrounding the project and compare them to the Greater Sydney area and NSW, it is not possible to identify a causal source or specifics of the project site and surrounding communities.

There are higher levels of disadvantage in Cabramatta-Lansvale and Warwick Farm compared to the LGAs which they are within and the Greater Sydney (ABS, 2016). These measures include lower income, educational attainment, English language skills, unemployment, dwellings without motor vehicles, and higher need for assistance with self-care, communication or mobility services, due to illness, age or disability. Health related behaviours that are linked to poorer health status and chronic disease, including cardiovascular and respiratory diseases (such as asthma), cancer, and other conditions, that account for much of the burden of morbidity and mortality in later life.

20.3 Assessment of construction impacts

20.3.1 Public safety

20.3.1.1 Safety for road user, pedestrians and cyclists

Construction of the project would require the temporary closure and diversion of pedestrians and cyclists and road and traffic lane closures (refer to section 7.6.5). This is likely to include the following changes:

- partial road closures would be required on Broomfield Street and Sussex Street to allow for road reconfiguration and rail bridge construction
- potential full road closures on Broomfield Street and Sussex Street for short periods at night with appropriate diversions in place to ensure minimal disruption to transport networks
- temporary diversion of a section of the Cycleway would be required. A temporary shared path would be provided between Sussex Street and Cabramatta Creek during construction of the new bridges
- the temporary shared path over Cabramatta Creek would be closed when the crane is being operated for the construction of Cabramatta Creek bridge (up to two weeks).

These changes can result in the following impacts and risks:

- confusion about available routes and access, resulting in traffic collisions between road users and pedestrians and cyclists crossing at unsafe locations
- injury to sensitive receivers passing construction areas adjacent to roads and active transport routes from falling objects, collapse of structures such as walls or materials being dropped during loading/unloading
- injury to sensitive receivers or property damage from collision with construction vehicles.

A construction traffic management plan would be prepared prior to the commencement of works as part of the CEMP. The aim of the CEMP would be to ensure appropriate practices are adopted to maintain the safety of road users within and near to the site. This would include providing safe movement of traffic for both the general public and construction workers through defined routes, diversions, signage, safe crossing points for pedestrians and cyclist and where needed traffic management staff. Deliveries and loading/unloading activities would be restricted to areas specified within the construction traffic management plan and separated from the general public and transport routes.

Standard mitigation measures such as appropriate layout of compounds sites, construction methodology and hoardings would be detailed in the CEMP. Construction methodologies would include avoiding lifting of equipment above pedestrian routes and appropriate hoarding to contain construction activities within the project site.

The potential for the above activities to cause safety impacts is considered to be low, based on works being undertaken in accordance with NSW workplace safety laws. These laws require construction sites to have adequate site security, which includes appropriate fencing and hoarding to separate construction activities from the community.

20.3.1.2 Safety for public recreation users and neighbouring residential areas

Compound sites are proposed within Jacquie Osmond Reserve and Warwick Farm Recreation Reserve and access to the project site would be required through both these reserves and would use the unnamed track on the eastern side of the rail corridor.

This would result in the movement of construction vehicles near the point where shared path users cross underneath the rail corridor between Jacquie Osmond Reserve and Warwick Farm Recreation Reserve.

Construction work relating to vegetation clearance, replacing the noise wall, Sussex Street bridge and associated changes to the road corridor will take place in close proximity to residences on Broomfield Street, Sussex Street and streets intersecting with these. This would mean that residents and vehicles will be accessing properties in proximity to the use of construction vehicles and equipment.

Where impacts are not mitigated through the use of hoarding (separating the person from the risk) active traffic management would be used to minimise the potential for impacts as construction vehicles and equipment access the project site.

20.3.2 Underground and aboveground utilities

As described in Chapter 7 (Construction) a number of utilities are present in the project site and would need to be adjusted, relocated and/or protected to enable construction. In addition, there is the potential for unidentified underground utilities to be present within the project site. The potential rupture of underground utilities during excavation or collision of plant and equipment with aboveground services could pose risks to public safety. Rupture or contact with services during works could also result in releases and/or short-term outages, as could the relocation of utilities and services.

The potential for rupture or contact with services during construction activities would be minimised by undertaking utilities investigations, to confirm the location of utilities prior to intrusive or relocation works, and consulting with service providers as part of the detailed design phase. Mitigation measures would be employed during construction works in accordance with relevant service provider requirements. This could include use of tiger tails or a spotter when operating machinery within proximity to overhead power lines. Potential contamination

Previous assessment undertaken for the design and construction of the SSFL (Parson Brinkerhoff (2006)) identified a number of contaminants of potential concern based on current and former land uses within the project site. These include heavy metals, hydrocarbons (TRH/BTEX/PAHs), pesticides/herbicides, arsenic and asbestos.

Exposure to these contaminants could result in health and safety impacts to the community and environment through.

- direct contact or incidental ingestion of contaminants
- inhalation of volatile compounds or dust
- vertical and horizontal migration of contaminants from the shallow soil into the underlying groundwater. subsequent migration could then occur into the wider groundwater aquifer
- surface water runoff and migration into surface water.

Analytical results from a limited contamination assessment undertaken in the project site to inform this EIS (refer to Technical Report 6- Soils and contamination impact assessment) were below the nominated health investigation criteria at all sample locations and asbestos was not encountered during the investigation or in analysed soil samples. This indicates a low health risk from existing contaminants, noting that there is potential for unexpected finds to be identified during construction works.

Health and safety impacts associated with potential exposure to contaminated and hazardous materials would be minimised through implementation of an unexpected finds protocol and standard management measures within the CEMP.

Additional contamination could be created during the construction stage due to spills and leaks from construction vehicles, equipment or from materials stored in the site compound area. This is discussed further in section 20.3.5.

20.3.3 Emergency vehicle movements

As described in section 7.6.5, construction of the project would result in temporary impacts to traffic and access within and around the project site. The construction of the Sussex Street bridge would require the full closure of this street for a short period during night works to minimise disruption to the road network. This could cause delays and/or potential access restrictions to some emergency vehicle movement in the area. Emergency vehicles would be provided with priority access. This could include traffic management stopping other traffic or works temporarily stopping to allow emergency vehicles to pass.

The traffic impact assessment concluded that the road network performance would not decline as a result of construction and alternate routes would be established during full street closures. Sussex Street bridge has an existing low clearance level of two metres, which limits its current use for some emergence vehicles. Therefore, any delays from vehicles using an alternate route to Sussex Street would likely be minor.

Impacts from delays and potential access restrictions would be managed through the implementation of a traffic management plan and appropriate traffic controls, which would consider emergency vehicle access, the required width of roads and movements. Ongoing liaison with local councils, Roads and Maritime Services, and emergency services organisations would be undertaken as part of the detailed design phase to confirm any additional measures to mitigate potential impacts to emergency vehicle movements. Consultation would continue through construction to ensure emergency access protocols are managed effectively as the traffic management and location of construction works change.

20.3.4 Storage, handling, and transport of dangerous goods and hazardous materials

Dangerous goods that may be used during construction are listed in Table 20.1 The storage and handling of these dangerous goods and hazardous materials during the construction work has the potential to impact the surrounding community and environment if leaks and spills occur or if excessive amounts of dangerous goods are stored or transported exacerbating the potential for fire, explosion or inhalation impacts.

These potential dangerous goods and hazardous materials have been compared to the storage and transport thresholds in the guidance document Applying SEPP 33 (refer to Table 20.1). These thresholds represent the maximum amounts of dangerous goods that can be stored or transported to and from the project site without causing a significant risk to the community or environment.

Table 20.1 Dangerous goods volumes and thresholds

Material	Dangerous Good Code Class	Storage method	SEPP 33 thresholds		
			Storage volume	Minimum storage distance from sensitive receivers	Transport
Diesel	C11; 3 PG III2	20 litre drums/ carry cans	Greater than 5 tonnes, if stored with other Class 3 flammable liquids	5 metres	Not applicable if not transported with Class 3 dangerous goods
Petrol	C11; 3 PG III2	20 litre drums	Greater than 5 tonnes, if stored with other Class 3 flammable liquids	5 metres	Not applicable if not transported with Class 3 dangerous goods
Lubricating and hydraulic oils and greases	C2	20 litre drums	n/a	n/a	Not applicable, if not transported with Class 3 dangerous goods
Acetylene	2.1	Cylinders (up to 55 kg) in rack	Greater than 0.1 tonnes (100 kg)	15 metres	2 tonnes; 30 times per week
Cement	n/a	Bags/pallets (in container)	n/a	n/a	Not subject to Applying SEPP 33 transport thresholds
Premix concrete	n/a	Bags/pallets (in container)	n/a	n/a	Not subject to Applying SEPP 33 transport thresholds
Concrete curing compounds	n/a	20 litre drums	n/a	n/a	Not subject to Applying SEPP 33 transport thresholds
Concrete retardant	3 PG III	205 litre drums	Greater than 5 tonnes	5 metres	10 tonnes; 60 times per week
Epoxy glue	3 PG III	Small containers	Greater than 5 tonnes	5 metres	10 tonnes; 60 times per week
Coagulants	n/a	1,000 litre intermediate bulk containers	n/a	n/a	Not subject to Applying SEPP 33 transport thresholds
Acids	8 PG II	1,000 litre intermediate bulk containers	Greater than 25 tonnes	n/a	2 tonnes; 30 times per week
Bases	8 PG II	1,000 litre intermediate bulk containers	Greater than 25 tonnes	n/a	2 tonnes; 30 times per week

Material	Dangerous Good Code Class	Storage method	SEPP 33 thresholds		
			Storage volume	Minimum storage distance from sensitive receivers	Transport
Disinfectant	8 PG III	500 litre intermediate bulk containers	Greater than 50 tonnes	n/a	2 tonnes; 30 times per week
Anti-scalent	n/a	100 litre drums	n/a	n/a	Not subject to Applying SEPP 33 transport thresholds
Membrane preservative	8 PG III	10 litre drums	Greater than 50 tonnes	n/a	2 tonnes; 30 times per week
De-bonding agents	n/a	Drums/ containers	n/a	n/a	Not applicable
Contaminated waste	Dependent on nature of material	Bunded areas or removed directly from site	Dependent on nature of material	Dependent on nature of material	Dependent on nature of material
Paint	n/a	20 litre drums	n/a	n/a	Not subject to Applying SEPP 33 transport thresholds

In general, low volumes of dangerous goods would be stored in construction compounds adjacent to the rail corridor. The quantity of goods stored would be commensurate with the demand for those goods so that excess goods are not sitting idle.

The incorrect storage or mishandling of these goods and chemicals could also result in the potential contamination of air, soils, surface water and/or groundwater. This could result in health and safety impacts to the community through inhalation and/or direct contact, fires and explosions or impacts to the environment due to the contamination of land and water.

Health and safety impacts associated with potential exposure to dangerous goods and hazardous materials would be minimised through implementation of standard management measures within the CEMP relating to storage requirements and handling protocols. This would accord with ARTC's risk management framework, environmental management system and safety management system (refer to section 20.5.1). In addition, the storage, handling and transport of dangerous goods would be undertaken in accordance with the Dangerous Goods (Road and Rail Transport) Regulation 2009 and the Code of practice for the storage and handling of dangerous goods (WorkCover NSW, 2005)

Storage of dangerous goods and hazardous materials would be avoided where possible in the proposed Warwick Farm Recreation Reserve compound site (C2) due to its location near Lawrence Hargrave Special Education School.

20.3.5 Health impacts

20.3.5.1 Access

Construction of the project would require the temporary diversion of pedestrians and cyclists around the construction site, a short-term closure of the shared path and occasional road and traffic lane closures (refer to section 7.6.5).

A portion of the local population walk to work (Cabramatta-Lansvale 5 per cent, Warwick Farm 10.8 per cent), and catch a train to work (Cabramatta-Lansvale 18.5 per cent, Warwick Farm 22.8 per cent) (ABS, 2018). This impact may affect local residents that use the Parramatta to Liverpool Rail Trail Cycleway and the shared path over Cabramatta Creek to access their place of employment, train stations or public facilities. This may change people's daily commute routes and times, or how they access facilities.

Compound sites are proposed within Jacquie Osmond Reserve and Warwick Farm Recreation Reserve and access to the project site would be required through both these reserves. This would result in minor temporary changes to reserve access points (for approximately two weeks when components of the Cabramatta Creek bridge are being constructed), cordoning off some areas within the reserves and the reduced amenity of neighbouring areas from noise, as discussed in section 20.3.1. Three of the 12 softball diamonds would be unavailable during construction.

These activities could result in the following impacts:

- confusion and increased anxiety for pedestrians, cyclist and road users relating to access arrangement to regular transport routes and recreational facilities
- pedestrians and cyclists choosing a less active method of transport to avoid areas of construction resulting in a loss of the health benefit of active transport
- confusion and increased anxiety for sensitive receivers wanting to use public areas, relating to access arrangement and if the sites are open and available for use
- temporary loss of informal recreational areas and soft ball diamonds and reduced amenity of remaining facilities, reducing community use and related health benefits derived from an active lifestyle.

A construction traffic management plan would be prepared prior to the commencement of works as part of the CEMP. The aim of the CEMP is to maintain the safety of road users within and near to the site. This would include

providing safe movement of traffic for both the general public and construction workers through defined routes, diversions, signage, safe crossing points for pedestrians and cyclist and where needed traffic management staff.

Public consultation prior construction and the use of appropriate notifications and signage during construction would inform the public about the routes to access and the availability of areas of recreation. Consultation with key stakeholders such as Southern Districts Softball Association would be carried out to ensure the active lifestyle of members could be maintained at this location.

20.3.5.2 Air quality impacts

Construction activities are associated mainly with vehicle movements, groundworks, vegetation removal and concrete sawing, may cause emissions of dust to be dispersed into the atmosphere. The air quality impact assessment (refer to Technical Report 3) has predicted that air quality criteria are met within 30 metres from the boundary of the project site. . There are a number of residents, businesses and public facilities such as active transport routes and public reserves within 30 metres including residents along Broomfield Street and Sussex Street.

Changes to air quality have the potential to disturb and cause irritation to some residents and workers of local businesses when spending time outdoors. Users of sport and recreation facilities within 30 metres of the works (Jacquie Osmond Reserve, Warwick Farm Recreation Reserve, Lawrence Hargrave School playground) may also be exposed to dust, which has the potential to affect sports training and competition participants, and informal users of the facilities. People who may be more sensitive to dust impacts from the project include students of Lawrence Hargrave School, infants, the elderly and people with asthma.

The aim would be to prevent significant impacts on receptors through the use of effective mitigation. Standard mitigation relating to dust reduction measures and diesel emissions from plant and equipment would be included in the CEMP to minimise potential impacts. However, even with a rigorous management measures in place, it is not possible to guarantee that the dust mitigation measures would be effective all the time. As the project is linear and works would be staged, impacts would be temporary and localised according to where the construction activity work is occurring. Where appropriate mitigation measures are implemented, the potential for health impacts to occur as a result of dust generated or emissions from vehicles during construction is considered to be low.

Exposure to additional dust can be reduced at residential and business properties, and indoor community facilities, by partially or fully closing windows and spending time indoors when construction is occurring nearby. Spending less time outdoors may impact some resident's active lifestyles and the health benefits resulting from this. However, this is expected to be temporary and localised according to where the construction activity work is taking place.

20.3.5.3 Noise and vibration

Construction activities and associated vehicle movements and deliveries result in increases in noise and vibration, with the potential to affect surrounding sensitive receivers.

According to the noise and vibration impact assessment (refer to Technical Report 2), construction of the project would result in a temporary increase in noise levels for sensitive receivers within 150 metres of the project site, with some specific localised construction activities causing 'highly intrusive' noise impacts on receivers close to the project site. Residents and businesses within a 600 metres radius of construction works also have the potential to experience noise impacts during night time construction activities.

Sensitive receivers within 140 metres of the construction works have the potential to experience impacts on human comfort during construction. These impacts would be occasional and not continuous throughout the construction period.

Noise and vibration impacts may affect the amenity of nearby residential properties, businesses and community facilities. This could reduce the use of outdoor areas, and the associated health benefits from an active lifestyle.

Noise impacts can also cause sleep disturbance for residents located close to construction works during the night time, and for shift-workers during the daytime. The study area may include vulnerable communities who may be more sensitive to noise and vibration impacts, such as people with a higher need for assistance with self-care, communication or mobility services, due to illness, age or disability. However, as a linear project worst case noise

and vibration impacts would be temporary and localised according to where the construction activity work is occurring.

Users of surrounding social infrastructure who may be more sensitive to noise and vibration impacts include students of Lawrence Hargrave Special Education School (within 100 metres). It is likely students who attend the school may be more vulnerable to noise and vibration impacts. This may result in diminished comfort, concentration, daily routine and overall wellbeing of the students. Consultation with the school will be carried out prior to works commencing.

Noise impacts to a hospital could result in levels of anxiety, sleep deprivation or annoyance to patients or interfere with ability of staff to carry out their work. Liverpool Hospital is located around 600 metres from the closest part of the project site. This is at the very edge of the potential impact area for noise. However, it is located further from the more significant construction impacts (ie areas where piling for bridges or demolition of the noise wall are located) and therefore impacts are not predicted. Standard mitigation measures proposed to minimise impacts to receivers closer to the project would also benefit and minimise impacts to Liverpool Hospital.

Given that the project's main site compound is located within part of Jacquie Osmond Reserve, users of the playing fields would have the potential to experience noise and vibration impacts. This may affect participants during training sessions, weekend competitions and tournaments, causing changes to the way in which participants make use of the facility. Three softball diamonds would be affected Impacts are expected to be low with the exception of tournaments which would result in a larger number of players and greater use of facilities at one time. Public consultation would be undertaken to inform detailed construction planning and signage would establish as necessary to inform the public about access and the availability of areas of recreation. Consultation with key stakeholders such as Southern Districts Softball Association would be carried out to ensure the active lifestyle of members could be maintained at this location as much as possible.

20.3.6 Other health and safety risks

A number of other construction activities could result in impacts to the safety the local community if improperly managed. These include:

- items falling off vehicles during the transportation of equipment, excavated spoil and material to and from site
- transportation of hazardous goods to and from the project site
- potential for risks to pedestrian/public safety resulting from unauthorised access to construction work areas.

Safety risks during construction and transportation of materials by road or rail would be managed by the implementation of standard workplace health and safety requirements including the requirements of the Dangerous Goods Code' and ARTC's risk management framework (refer to section 20.5.1).

The potential for unauthorised access to result in safety risks is considered to be low, based on NSW workplace safety laws. This requires construction sites to have adequate site security, which includes appropriate fencing and access restrictions. The construction contractor would need to ensure that construction sites are secure at all times, construction plant and equipment could not be activated by unauthorised persons and take all possible actions to prevent entry by unauthorised persons.

20.3.7 Cumulative impacts

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

There are no other known construction projects proposed in the immediate vicinity of the project site, and therefore no cumulative impacts relating to safety issues with other projects are predicted.

Cumulative impacts relating to transportation of hazardous goods and related safety risks during construction are predicted to be low and would managed by the implementation of standard workplace health and safety requirements including the requirements of the Dangerous Goods Code and ARTC's risk management framework.

As the air quality impacts from the construction of the project are predicted to be transitory and criteria are met within 30 metres from the boundary of the project site, the cumulative impacts would be minimal unless an additional source of dust (to this project) was generated close to receptors. There are no other known construction projects proposed for the area.

As the noise impacts from the construction of the project are predicted to be transitory and confined to an area near the boundary of the project, the cumulative impacts would be minimal unless additional sources (to this project) of noise 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 low due to the separation distances between the construction areas for the project and other proposals. Therefore no significant 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.

20.4 Assessment of operation impacts

20.4.1 Public safety

20.4.1.1 Safety for road user, pedestrians and cyclists

Following completion of the project, road, pedestrian and cycle facilities would be re-instated in a similar or same location, as described in section 6.2.4. Therefore, there would be no additional impacts to the safety of road users, pedestrians and cyclists from operation of the project.

The new rail bridge over Sussex Street would extend the existing road, cycle and pedestrian routes which go under the rail bridges. The landscape and visual impact assessment for the project (refer to Technical Report 10) outlines the use of Crime Prevention Through Environmental Design principles, to be included in the proposed lighting design for the connections under the bridge to achieve adequate illumination during the night time.

The repositioned retaining wall and noise wall on Broomfield Street would be designed with appropriate tolerances to wind shear and potential collapse and would meet appropriate standards. Therefore any safety issues related to collapse of structures is considered low.

20.4.1.2 Safety for public recreation users and neighbouring residential areas

Following completion of the project Warwick Farm Recreation Reserve would be returned to its pre-construction condition and public access routes to these areas. Therefore, there would be no additional impacts to public health and safety from the operation of the project.

Jacquie Osmond Reserve and its access points would be returned to its pre-construction condition. It would however, be slightly smaller by a few metres, due to the expanded rail corridor. It would also have a new retaining wall between the public area and the rail corridor for part of the length of the reserve. The structural analysis and design of the wall would meet the appropriate standards. Therefore any safety issues related to the retaining wall are considered low.

On completion of the project, the road corridor along Broomfield Street and Sussex Street would be re-instated in a similar location, as described in section 6.2.4. The rail corridor would be a few metres closer to these residents. There would be no additional impacts to the safety of residents living on these streets and any rail incidents would be managed according to ARTC existing risk management framework outlined in section 20.5.1.

20.4.2 Underground and aboveground utilities

Some utilities would be relocated during construction. No further changes to utilities are expected during operation of the project and therefore no impacts to sensitive receivers are anticipated.

20.4.3 Storage, handling and transport of dangerous goods and hazardous materials

There are no areas within the operational site that would be used for the permanent storage of chemicals.

The amount of hazardous materials and dangerous goods that would be used during maintenance activities would be much smaller than the volumes required during construction. Hazardous materials and dangerous goods required during maintenance would be similar to those listed in Table 20.1. These would be managed within the ARTC's existing risk management framework outlined in section 20.5.1 and standard operating procedures established for the existing SSFL. Any potential risks of leaks or emissions are considered to be low. Health and safety impacts to the community from exposure to these contaminants through inhalation and/or direct contact, is considered to be low.

Transport of hazardous materials and dangerous goods via rail during freight operations has the potential to cause impacts to the surrounding community and the environment through leaks and spills. The transport of hazardous materials and dangerous goods would be the responsibility of the freight operator/s and would be undertaken in accordance with relevant standards and regulatory requirements including the Dangerous Goods Code, ARTC's existing EPL (EPL #3142) and ARTC's standard operating procedures.

20.4.4 Emergency vehicle movements

Operation of the project would not change existing vehicle access arrangements, increase flooding of roads or lower the existing height restrictions under bridges. Therefore, there would be no additional impacts to emergency vehicle movements as a result of the project. However, flooding would occur at the same public road locations as it is currently occurring.

20.4.5 Health impacts

20.4.5.1 Changes to access

Following completion of the project, Warwick Farm Recreation Reserve and Jacquie Osmond Reserve would be returned to its pre-construction condition with the same public access routes to these areas. The existing 12 softball diamonds within Jacquie Osmond Reserve would returned to pre-construction condition. Health benefits associated with the full use of public areas for sport and informal recreation would be returned to the local community.

As described in Technical Report 10 - Landscape and visual impact assessment, the urban design of the project would include considering improving pedestrian and cyclist safety. Clear sightlines would be provided following the clearance of existing vegetation between Sussex Street and the pedestrian bridge over Cabramatta Creek. This would improve visibility of pedestrians and cyclists to passing vehicles and improve the ability of active transport users to see the road clearly before crossing Sussex Street. Clear sightlines would also be provided through strategies such as reduction of unnecessary clutter on paths (such as bollards and light poles) and adequate lighting especially in relation to the addition of bridge structures and new signage.

Signage and lighting would also be installed where the shared path diverts from Cabramatta Creek under the bridge at Jacquie Osmond reserve. This will improve connectivity and safety in this location.

20.4.5.2 Air quality impacts during operation

Some community members may be sensitive to dust and emissions from operational trains. Sensitive receivers would include people with asthma, elderly, infants, and students at Lawrence Hargrave School.

According to the air quality impact assessment (Technical Report 3), an increase in average annual levels of contributing pollutants (such as dust and emissions) from operation of the project are predicted to be negligible. Dust and emissions would continue to be managed in accordance with ARTC's standard operating procedures and ARTC's existing EPL. Operational impacts resulting in additional impacts to health are therefore considered to be negligible.

20.4.5.3 Noise and vibration impacts during operation

The noise and vibration impact assessment (Technical Report 2) indicates that overall operational noise and vibration impacts will be negligible; however, surrounding community members may perceive the additional noise

from trains to be a nuisance. One residential property may be impacted by the project during operation and as a result further reasonable and feasible mitigation will be explored to mitigate this impact.

There is also potential for students of Lawrence Hargrave Special Education School to be more vulnerable to the increased train noise; however, the school is already directly next to the rail corridor and the proposed operational alignment will be on the opposite side of the existing corridor to the location of the school. As such it is expected that there wouldn't be a noticeable difference to students as a result of this project.

20.4.6 Other safety issues and hazards

Potential impacts to the safety of the local community during operation include:

- security risks from unauthorised access or vandalism.
- security of the rail corridor would be undertaken in accordance with ARTC's standard operating procedures and risk management framework which would include continued maintenance of security features such as fencing.

20.4.7 Cumulative impacts

Potential health and safety impacts during operation of the project associated with other approved and proposed projects are not anticipated to increase the risks to public safety or health when combined with the operational project.

20.5 Management of impacts

20.5.1 Approach

20.5.1.1 Approach to mitigation and management

In general, potential health and safety impacts would be avoided by:

- managing construction and operation in accordance with relevant legislative policy requirements and ARTC's existing risk management framework (discussed further below)
- designing, constructing, and operating the project to minimise risks to health and safety
- implementing the management and mitigation measures provided in Table 20.2.

During construction a CEMP would be prepared minimise the risks to community safety which would include:

- actions to avoid impacts, such as compound and worksite layouts, appropriate hoarding, security features and storage requirements for hazardous and dangerous goods
- actions to minimise impacts, such as dust and noise management, appropriate management of contaminated spoil, incident management and spill response procedures.

Response to emergencies during operation would be undertaken in accordance with ARTC's existing Safety Management System and associated procedures (refer to section 20.5.1). Maintenance activities would be managed through ARTC's existing maintenance procedures.

20.5.1.2 ARTC's risk management framework

As part of ARTC's operational systems and procedures, ARTC has an existing management framework for managing risks and minimising impacts associated with operating its infrastructure. This includes avoiding, minimising and managing risks related to public safety and incident management. The project would be managed through the existing ARTC operational systems and procedures.

The existing framework includes, but is not limited to:

- ARTC Environmental Management System and its associated procedures, work instructions and tools
- ARTC's existing Safety Management System

- ARTC Strategic Risk Management Protocols RM-01
- ARTC Incident Management Procedure SP-03-08
- ARTC Incident Management Manual TA44
- ARTC Rail Safety Risk Management Procedure SP-03-00
- General Instructions, Train Marshalling, Rail Infrastructure Corporation version 4.0 (2004)
- General Instructions, Loading Restrictions, Rail Infrastructure Corporation version 3.3 (2004)
- ARTC Train Operating Conditions (TOC) Manual – Division Pages (Version 13, TS TOC.2: 2018 issue 2)
- ARTC Monitoring and Responding to Extreme Weather Events Procedure (OPE-PR-014)
- ARTC Train Operating on Catastrophic Fire Days Work Instruction (OPE-WI-009).

20.5.1.3 Expected effectiveness

ARTC and its contractors have experience managing potential air quality, noise and health and safety impacts associated with the construction and operational phases of rail development projects. Compliance with ARTC's risk management framework, Safety Management System and implementing of the mitigation measures outlined in Table 20.2 through the CEMP are expected to be effective in managing the potential risks to health and safety.

Monitoring of safety measures would occur daily as part of routine site management procedures, for movement of hazardous goods, safe workplace practices, and regular testing and monitoring of any fire and life safety systems. Audits and reporting on the effectiveness of environmental management measures is generally carried out to demonstrate compliance with management plans and other relevant approvals and would be outlined in detail in the CEMP prepared for the project.

Regular monitoring and inspections would be undertaken during construction to confirm the effectiveness of mitigation measures. Monitoring and inspections would include, but not be limited to Project Contractor's supervisory inspections on a daily basis, environmental representative weekly inspections and any monitoring relating to management of noise and air quality emissions.

20.5.2 List of mitigation measures

The mitigation measures that would be implemented to address potential risk, health and safety impacts are listed in Table 20.2. These measures would be in addition to the mitigation measures outlined to manage the following:

- impacts to traffic and transport, refer to section 8.5
- noise and vibration impacts, refer to section 9.6
- air quality impacts, refer to section 10.5
- impacts from contamination, refer to section 12.5
- social impacts, refer to section 18.5.

Table 20.2 Mitigation measures

Stage	Impact	Measure
Design	Public health and safety	A hazard analysis will be undertaken during the detailed design stage to identify further risks to public safety from the project, and how these will be mitigated through safety in design and construction methodology.
	Public safety from collapse of structures, embankments or walls	All structures such as the retaining wall in Jacquie Osmond Reserve and the noise wall on Broomfield Street will be designed to meet appropriate standards, with sufficient tolerances to loads and wind gusts to prevent collapse.

Stage	Impact	Measure
	Safety of road, pedestrian and cycle connections under the widened Sussex Street bridge	Lighting design under the Sussex Street bridge will consider the Crime Prevention Through Environmental Design principles.
Construction	Public safety from, fires, explosions, flooding and inundation	The CEMP will include emergency response procedures in consultation with relevant stakeholders. It would include measures to minimise the potential for health and safety impacts on the local community and environment such as fire management procedures.
	Public safety from collapse of structures, embankments or walls	Construction methodology will be selected to ensure collapse of partially built structures so not occur during construction. The CEMP will include emergency response procedures in consultation with relevant stakeholders. It would include measures to minimise the potential for health and safety impacts on the local community and environment should an incident occur.
	Rupture or damage to services and utilities	The location of utilities, services, and other infrastructure will be identified prior to construction to determine requirements for access to, diversion, protection and/or support. This will include as required, undertaking utilities investigations, including intrusive investigations, and consultation with service providers.
	Anxiety, confusion and safety concerns from changes to roads, footpaths and cycle routes	A construction traffic management plan will be prepared as part of the CEMP as per mitigation measure C1.1. This will detail the actions and infrastructure needed to ensure a continuous, safe and efficient movement of traffic for both the general public and construction workers. This will include defined routes, diversions, signage, safe crossing points for pedestrians and cyclists and where needed, traffic management staff.
	Public health and safety from falling items contact with construction sites.	An appropriate layout of compounds sites, construction methodology and hoardings to will be established to prevent any construction items exiting the site in an uncontrolled manner. This will meet all relevant requirements of NSW workplace safety laws.
	Reduced health benefits from changes to areas of public recreation and active transport routes	Public consultation will be carried out prior and during construction to inform the public about the routes to access and the availability of public reserves and softball area. Signage will be provided to identify access points to reach areas of public recreation and active transport routes. Consultation with key stakeholders such as Southern Districts Softball Association will be carried out to ensure the active lifestyle of members could be maintained at this location.
	Unauthorised access to the project site resulting in injury or fatalities	NSW workplace safety laws which require construction sites to have adequate site security, such as appropriate fencing will be followed. Appropriate actions or security devices will be used to prevent construction plant and equipment being activated by unauthorised people.
	Reduced public use of Jacquie Osmond Reserve and Warwick Farm Recreation Reserve	All public areas will be returned to their pre-construction condition and the same public access routes to these areas. The existing 12 softball diamonds within Jacquie Osmond Reserve will be reinstated to pre-construction condition in consultation with the Southern Districts Softball Association.

Stage	Impact	Measure
Operation	Unauthorised access to the rail corridor	Security of the rail corridor will be undertaken in accordance with ARTC's standard operating procedures and risk management framework which will include continued maintenance of security features such as fencing.
	Public health and safety from emissions/leaks of dangerous goods and hazardous materials	Operation of the project will be undertaken in accordance with ARTC's standard operating procedures and EPL 3142.

20.5.3 Consideration of the interaction between measures

Mitigation measures to control impacts to health and safety of the community may replicate mitigation measures proposed for the control of impacts associated with noise, air quality, water quality, contamination, traffic and access, social impacts and waste management.

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 ease of implementation.

20.5.4 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 summarised below.

The mitigation and management measures outlined in section 20.5.2 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. An unplanned incident could still occur without prior notice which can degrade safety, result in emissions, or harm to the environment. There is the possibility that unplanned incidents can result in severe injury and/or death and may require the partial or full closure of the affected roadway, rail corridor or public reserve for an extended period. This risk is inherent with the operation of a complex infrastructure construction project.

With the implementation of design features and the safeguards identified in this chapter, the residual impact associated with hazards and risks associated with the project are considered low.

21 Climate change and greenhouse gases

This chapter provides the climate change risk assessment for the project and considers the projects contribution to greenhouse gas emissions. It predicts the volume of greenhouse gases emissions, the potential risks that climate change could have on the project, and provides recommended adaptation controls and mitigation measures. It has been informed by the climate change assessment undertaken by GHD. A full copy of the climate change assessment report is provided as Technical Report 12 – Climate change risk assessment. The report was written to address the relevant SEARs which are outlined in Appendix A.

21.1 Assessment approach

21.1.1 Methodology

21.1.1.1 About climate change

Climate change has the potential to alter the frequency, intensity and distribution of extreme weather related natural hazards, including more intense and frequent heat waves, droughts, floods and storm surges. The risk of climate change impacts on rail infrastructure need to be considered as part of the design process, as structures need to be designed to last for many years, and therefore need to be resilient to climate change.

Climate change adaptation planning and risk management is an evolving field. Responses to reduce the risks of climate change broadly fall into two categories: mitigation and adaptation. Using the definitions of IPCC (2007), mitigation aims to reduce human effects on the climate system by strategies to reduce greenhouse gas sources and emissions, and to enhance greenhouse gas sinks. Adaptation refers to adjustments in response to actual or anticipated climate changes or their effects, to moderate harm or to exploit beneficial opportunities. Infrastructure design and planning needs to incorporate adaptation measures, based on the assessed risk of climate change to a proposal.

Although climate projections represent the presently accepted forefront of climate change science, there is still a high level of uncertainty that exists regarding the climate changes that may actually eventuate. The inevitability of uncertainty is stated within Australian Standard 5334:2013 Climate change adaptation for settlements and infrastructure – a risk based approach, and it is recognised that decisions and adaptation planning processes should be flexible enough to cope with potential knowledge gaps.

21.1.1.2 Climate change risk assessment

The purpose of the climate change risk assessment for the project is to:

- identify the potential climatic events and hazards that could impact the project, based on its scale, location, structural components and design life
- assess climate change risk under two timeframes and emission scenarios to provide an indication of potential risks
- link infrastructure vulnerability associated with climate change to the design of the project, and potential adaptation options to improve structure resilience.

The overall approach to the assessment involved modelling two potential climate change scenarios for the study area using the Commonwealth Scientific and Industrial Research Organisation's (CSIRO) 'Australian Climate Futures' climate change modelling tool, and assessing the potential risks for the project based on these scenarios.

The assessment involved:

- reviewing climate data
- developing projections of the future climate in the study area and as per AS 5334, determining the climate projection scenarios for the assessment and the Representative Concentration Pathway (RCP)

- near term, moderate scenario using 2030 and RCP 4.5
- long term, extreme scenario using 2090 and RCP 8.5

- undertaking a detailed climate change risk assessment and determining risk ratings
- identifying potential adaptation measures and/or design strategies based on the identified risks and potential impacts.

A detailed description of the assessment methodology is provided in Chapter 3 of Technical Report 12. A summary of the results is provided in the following sections.

21.1.1.3 About greenhouse gases

A greenhouse gas is a gas that absorbs and emits radiant energy which then warms the atmosphere. A greenhouse gas assessment quantifies the total greenhouse gases produced directly and indirectly from an activity. The purpose of this assessment is to assess the volume and potential impact of emissions on the environment from the construction and operation of the project.

Global Warming Potential is a metric used to quantify and communicate the relative contributions of different gases to climate change over a given period of time. Global Warming Potential accounts for the radiative efficiencies of various gases and their lifetimes in the atmosphere, allowing for the impacts of individual gases on global climate change to be compared relative to those for the reference gas carbon dioxide.

This assessment used the Global Warming Potential levels provided Department of the Environment and Energy (2018) National Greenhouse Accounts. The greenhouse gases considered in this assessment and the corresponding Global Warming Potential for each gas are listed in Table 21.1. These are reflective of radiative forcing over a 100 year time horizon.

Table 21.1 Greenhouse gases and 100 year global warming potentials

Greenhouse gas	Global Warming potential	Discussion
Carbon dioxide (CO_2)	1	NA
Methane (CH_4)	25	Methane has 25 times more warming potential than CO_2
Nitrous oxide (N_2O)	298	Nitrous oxide has 298 times more warming potential than CO_2

Source: Department of the Environment and Energy (2018) National Greenhouse Accounts (Appendix 1).

21.1.1.4 Greenhouse gas emissions methodology

The greenhouse gas assessment involved:

- identifying relevant aspects of energy use and emissions from construction and operation and considered possible emissions sources of greenhouse gases, including (CO_2), nitrous oxide (N_2O), and methane (CH_4.
- determining the tonnes of carbon dioxide equivalent emissions (t CO_2-e) for each activity and the total greenhouse gas emissions attributable to the project
- providing a qualitative assessment of the impacts of greenhouse gas emissions, including reduction of greenhouse gas from diversion of road freight to rail
- recommending greenhouse gas mitigation and reduction opportunities.

This assessment considered only greenhouse gas emissions sources within the boundary of the project, and excludes upstream and downstream emissions. The following emission sources were considered in the assessment scope:

- fuel and electricity consumption during construction activities
- fuel used in the delivery of materials, plant and equipment
- construction personnel commuting
- fuel and electricity consumption during operations.

This assessment has not included emissions likely to be negligible such as small quantities of chemicals, hydrocarbon leaks or vegetation clearance. It also does not include Scope 3 emissions (ie embodied energy of construction materials, management of waste materials), or diesel consumption by freight trains and associated GHG emissions which are the responsibility of the freight company.

Activity data used for the GHG assessment was provided by ARTC or estimated by GHD. All Emission Factors used were as per the NGER (Measurement) Determination. The assessment was based on emission factors available at the time of the assessment and future changes in emission factors were not considered.

21.1.2 Risks identified

The preliminary environmental risk assessment undertaken for the project included potential risks associated with Aboriginal heritage. 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 climate change and greenhouse gas risks was medium. Risks with an assessed level of medium or above include:

- increased electricity and fuel use during construction
- increased demand on local and regional resources during construction
- greenhouse gas emissions from combustion of fuels during plant/vehicle operation
- increased energy consumption associated with the use of site compounds.

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).

21.1.3 How potential impacts have been avoided/minimised

As described in Chapter 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 climate change and greenhouse gas impacts have been avoided/minimised where possible by the following:

- climate change risks identified were integrated and validated into the overarching Safety in Design hazard log
- wind loading, drainage and other weather phenomenon has been considered in the reference design
- drainage has been considered at reference design to minimise impacts to flood risk.
- the immunity of the rail line to flood risk has been built into the design and is greater than a 1 in 200 year event

- design life of the varying infrastructure components has been considered at reference design. The rail bridge structure and retaining wall structure are anticipated to have a 100 year design life. The road and noise wall design is anticipated to have a 25 years design life.

21.2 Existing environment

21.2.1 Climate baseline relating to the project site

A review of existing climate data and past extremes has identified the following features of the project site and surrounding area:

- the project site has been known to flood, in particular the Cycleway and Broomfield Street, both as a result of limited stormwater drainage causing over land flows and from Cabramatta Creek flooding
- some vegetation along Cabramatta Creek has been mapped in a number of vegetation classes on the bushfire prone land map
- the project site is impacted by extreme heat events. Fairfield City Council and Liverpool City Council are both part of the Western Sydney Regional Organisation of Councils (WSROC) which identifies urban heat as a major concern for western Sydney.

21.2.2 Climate projections

The key messages relating to the location of the project site as presented on CSIRO's Climate Change in Australia projection summary tool (CSIRO and BOM, 2015) are as follows:

- average temperatures will continue to increase in all seasons with very high confidence
- more hot days and warm spells are projected with very high confidence. Fewer frosts are projected with high confidence
- decreases in winter rainfall are projected with medium confidence. Other changes are possible but unclear
- increased intensity of extreme rainfall events is projected, with high confidence
- mean sea level will continue to rise and height of extreme sea-level events will also increase with very high confidence
- a harsher fire-weather climate in the future with high confidence
- on annual and decadal basis, natural variability in the climate system can act to either mask or enhance any long-term human induced trend, particularly in the next 20 years and for rainfall.

Detailed trends of climate data are provided in section 4.3 of Technical Report 12.

21.2.3 Greenhouse gases

Australia's national greenhouse gas emissions, by sector, for the year to December 2017 are presented in Table 21.2. Total annual emissions are 533.7 Mt CO_2-e.

The most recently published state-based emissions inventory is for 2016. NSW greenhouse gas emissions, by sector, for the 2016 year are also presented in Table 21.2. Total annual emissions are 131.6 Mt CO_2-e.

Table 21.2 Australian and NSW greenhouse gas emissions

Emissions Source	2017 Australian Emissions (Mt CO_2-e) [1]	2016 NSW Emissions (Mt CO_2-e) [2]
Energy – Electricity	184.5	51.8
Energy – Stationary Energy excluding electricity	96.9	15.3
Energy – Transport	100.0	27.4
Energy – Fugitive Emissions	55.4	15.6
Industrial processes and product use	35.8	13.2
Agriculture	71.2	17.5
Waste	12.6	3.2
Land Use, Land Use Change and Forestry	-22.7	-12.5
Overall Total	533.7	131.6

Source:

Department of the Environment and Energy (2018) *Quarterly Update of Australia's National Greenhouse Gas Inventory: December 2017*

Department of the Environment and Energy (2018) *State and Territory Greenhouse Gas Inventories: 2016*

21.3 Assessment of construction impacts

21.3.1 Greenhouse gases

Assumptions used in estimating greenhouse gas emissions for the construction and operation of the project are listed in Table 21.3.

Activity data used for the greenhouse gas emissions assessment was provided by ARTC or estimated by GHD. All Emission Factors used were as per the Commonwealth Department of Environment and Energy National Greenhouse and Energy Reporting (NGER) (Measurement) Determination 2008 (1 July 2018 version). The assessment was based on emission factors available at the time of the assessment and future changes in emission factors were not considered.

Table 21.3 Greenhouse gas assessment assumptions by source – construction

Parameter	Assumption
Diesel combustion – stationary energy purposes	Diesel use has been estimated by ARTC at 6,500 L/week for the duration of the construction period for mobile and stationary plant and equipment. This equates to 676 kL over the 2 year construction period. This covers construction of the new rail track, track realignment, bridge works, road works and ancillary infrastructure.
Diesel combustion – transport purposes	Diesel use for employee commuting was estimated at 197 kL over the construction period, based on maximum number of employees during possession and non-possession periods. Diesel use for transporting plant and equipment to site was estimated as 273 kL over the construction period, based on average heavy truck movements.
Electricity use	Electricity used at the three site compounds (site offices, meal rooms, first aid rooms, toilet/showers) has been estimated at 334 MWh, based on typical loads for demountable buildings.

Construction emissions are estimated in Table 21.4 as approximately 3,400 tCO_2-e.

Table 21.4 Construction emissions

Activity	Emissions (t CO2-e)
Diesel combustion – transport purposes	1,281
Diesel combustion – stationary energy purposes	1,832
Electricity use	274
Total	3,386

The quantity of emissions estimated to occur during construction are estimated at approximately 3,400 tCO_2-e during the entire construction period. Construction emissions would be of limited duration over two years. Australia's national greenhouse gas emissions, are presented in Table 21.3 above.

Estimated emissions savings from shifting freight transport from road to rail is estimated at approximately 9,900 tCO_2-e/annum for the SSFL. Any emissions from construction of the project are more than offset by the potential savings in emissions from shifting some freight transportation from road to rail.

21.3.2 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 relating to emissions are predicted to be transitory and confined to an area 30 metres from the boundary of the project, the cumulative impacts would be minimal unless an additional source of diesel emission emissions and electricity use (to this project) was generated. There are no other known construction projects proposed in the immediate vicinity of the project.

21.4 Assessment of operational impacts

21.4.1 Climate change

This initial climate change risk assessment identified eleven climate hazards and associated risks which are applicable to the project. Current control measures were identified which describe the controls and adaptation measures incorporated within the scope of reference design, which addresses the requirement of the SEARs to incorporate climate change risk mitigation in design. Additionally, potential controls were identified which represent adaptation actions which could be implemented at detailed design, or operation, assisting in minimising residual impact.

No high or very high risks were identified, in part reflecting the effective adaptation measures already identified and implemented as part of reference design. A summary of the low and medium climate change risks identified, including the existing controls and initial assessment of consequence and likelihood, is provided in Table 21.5. Principle risks identified related to flooding and storms. These risks are discussed further below.

21.4.1.1 Flooding

Flood risk to the project could arise from flooding of Cabramatta Creek or inundation from runoff from surrounding streets if storm drainage reaches capacity. Climate change flood risks have been assessed in Technical Report 5 – Hydrology and flooding impact assessment, by increasing the modelled runoff from rainfall in the 100 year event by 10 per cent to account for increased rainfall expected in the future. This is greater than the four per cent increase to the 1 in 20 year rainfall event which is projected for 2030.

The immunity of the rail line has been built into the design and is greater than a 1 in 200 year event. Modelling of the 1 in 500 year event indicates the potential for overtopping of the rail track further south of the rail bridge around Jacquie Osmond Reserve and just north of the car yard.

The flood modelling determined that in existing circumstances there is significant flooding for Broomfield Street for the 1 in 100 year flood event with 10 per cent addition for climate change (Technical Report 5 – Hydrology and flooding impact assessment). This includes inundation to houses and unsafe velocity flows on some parts of the street. Due to existing stormwater capacity constraints the immunity for Broomfield Street is less than the 10 per cent AEP (more frequent than 1 in 10 years), and the flood immunity for the cycleway is assessed as the same (in light of the detailed modelling not covering events more frequent than this). These are indirect risks to ARTC which will not be the asset owner or operator of Broomfield Street or the Cycleway at the end of the project. The risk already exists and is experienced in the area due to the level of the asset in the landscape and the capacity of existing infrastructure. The project does not alter the risk – ARTC proposes to match the existing infrastructure capacity and not worsen the existing situation, noting that engineering controls to reduce the risk of significant flooding of Broomfield Street and the cycleway are not reasonably feasible.

21.4.1.2 Storms

Extreme wind and storms were rated as medium risks due to the safety consequences of these events. For example the risk of noise wall collapse would be rare, but walls have been known to fall and cause a fatality in exceptional circumstances. Generally, appropriate maintenance regimes would mitigate storm activity more broadly, ensuring that the potential for debris and blocked drains is kept to a minimum. ARTC currently has a policy Monitoring and Responding to Extreme Weather Events, which provides direction around inspection frequencies for various extreme weather alerts including wind and rainfall events. Adoption of this policy in the management of the project would provide mitigation to storm event impacts in line with ARTC current practices.

The most difficult climate change risks to anticipate and manage occur where multiple events coincide. For example, although flooding has been shown to be a low risk for the project, if maintenance schedules allow debris to block drainage systems then the controls cannot be relied upon, and the risk of flooding would become heightened. This has been reflected in the storm risk identified in Table 21.5, where debris and high intensity rainfall are likely to coincide.

Table 21.5 Climate risk assessment summary

Hazards	Risk	Existing control measures	ARTC initial risk rating			Potential control measures including existing ARTC operational procedures	ARTC residual risk rating			Comments
			Consequence	Likelihood	Risk rating		Consequence	Likelihood	Risk rating	
Extreme wind	Noise wall collapse due to extreme wind event causing fatality, environmental damage or cost	1. Noise wall designed to Australian wind code AS1170.2 resulting in design wind gust velocity of 143 km/h (greater than maximum projected wind gust of 137.4 km/h	Extreme	Rare	MED	None identified	Extreme	Rare	MED	Applicable to 2030 scenario
4% increase to 1 in 20 year rainfall	Cabramatta Creek floods rail track causing operational delay	1. Ballasted track provides drainage for rainfall 2. Detailed modelling shows immunity to more than 1 in 200 year event	Minor	Rare	LOW	None identified	Minor	Rare	LOW	Applicable to 2030 scenario
4% increase to 1 in 20 year rainfall	Rail track floods due to poor drainage causing operational delay	1. Ballasted track provides drainage for rainfall 2. Current stormwater flows to be matched (at a minimum)	Minor	Unlikely	LOW	None identified	Minor	Unlikely	LOW	Applicable to 2030 scenario
4% increase in 1 in 20 year rainfall	Broomfield Street becomes flooded due to poor drainage causing reputational damage, damage to houses, road closure or serious injury (indirect risk to ARTC)	1. Design will match current stormwater flow rates 2. Flood modelling has been performed to assess flood risk for a range of scenarios including climate change	Major	Unlikely	MED	1. ARTC to consult with asset owner, Fairfield City Council, regarding the drainage design	Major	Unlikely	MED	Applicable to 2030 scenario

Hazards	Risk	Existing control measures	ARTC initial risk rating			Potential control measures including existing ARTC operational procedures	ARTC residual risk rating			Comments
			Consequence	Likelihood	Risk rating		Consequence	Likelihood	Risk rating	
4% increase in 1 in 20 year rainfall	Cabramatta Creek floods cycleway causing serious injury to cyclists (indirect risk to ARTC)	No project controls at this stage.	Moderate	Possible	MED	1. ARTC to consult with asset owner, Fairfield City Council, regarding the drainage design	Moderate	Possible	MED	Applicable to 2030 scenario
Higher extreme heat and solar radiation	Rail track buckling causing delays and increased management effort and cost	1. Concrete sleepers in design to reduce movement 2. Creep heat monitoring is standard rail design practice	Minor	Unlikely	LOW	1. Heat affects are currently managed via an operational procedure, the Area Stability Maintenance Plan, guided by ANG-210 – this includes a measure that speed restrictions are put in place in extreme heat based upon the neutral temperature of the rail.	Minor	Unlikely	LOW	Applicable to 2030 scenario
Higher extreme heat and solar radiation	Signalling equipment loses efficiency causing increased energy consumption, reduced design life and cost of replacement	1. Critical signalling equipment (Point machines and interlocking) rated to operate up to 70°C	Not significant	Unlikely	LOW	1. Re-specification of equipment at end of design life to account for climate change	Not significant	Unlikely	LOW	Applicable to 2030 scenario

Hazards	Risk	Existing control measures	ARTC initial risk rating			Potential control measures including existing ARTC operational procedures	ARTC residual risk rating			Comments
			Consequence	Likelihood	Risk rating		Consequence	Likelihood	Risk rating	
Intense storms	More intense storms disrupt operations of paths, rail track or road from fallen debris blocking access or drainage	1. Flooding analysis has been performed to consider the flood profile of the project and the surrounding environment. 2. Noise wall provides some protection to track infrastructure	Minor	Likely	MED	1. Implementation of an appropriate maintenance regime to limit blocked drainage in line with ARTC's existing Major Periodic Maintenance regime	Minor	Possible	LOW	Applicable to 2030 and 2090 scenarios
Lightning strikes	Lightning strike causes damage to electrical and signalling assets, causing operational delay and cost	1. Bonding of equipment to rails and cross-bonding of all current and proposed tracks reduces effects of lightning strikes	Minor	Unlikely	LOW	None identified	Minor	Unlikely	LOW	Applicable to 2030 and 2090 scenarios
Increased bushfire weather	More frequent bushfires impact operations of SSFL	1. Additional loop provided by project allows adaptive SSFL management	Minor	Possible	LOW	1. Implementation of an appropriate bushfire management plan in line with ARTC's current policies	Minor	Possible	LOW	Applicable to 2030 and 2090 scenarios

21.4.2 Greenhouse gases

Assumptions used in estimating greenhouse gas emissions for the operation of the project are listed Table 21.6.

Activity data used for the greenhouse gas emissions assessment was provided by ARTC or estimated by GHD. All emission factors used were as per the National Greenhouse and Energy Reporting (Measurement) Determination 2008, which was made under subsection 10(3) of the *National Greenhouse and Energy Reporting Act 2007*.

The assessment was based on emission factors available at the time of the assessment and future changes in emission factors were not considered.

Table 21.6 Greenhouse gas assessment assumptions by source – operation

Parameter	Assumption
Electricity use	Signalling controls use a small quantity of electricity during operations, estimated at approximately 14 kVA. This is equivalent to 110 MWh per annum. Operations of the SSFL are controlled from ARTC's Network Control Centre South in Junee. There is no additional electricity use at this control centre from the project.
Freight shift	The expected additional diversion of freight from road to rail due to the project would result in fuel savings. A conservative emission factor for road freight of 59 gCO_2-e/tonne.km was used, compared with 30 gCO_2-e/tonne.km for rail freight. The estimated additional freight transported due to the project was estimated as 340,589,000 tonne.km per annum (36 wagons per train, 75 tonne capacity, 50% loading, 36 km (SSFL distance from Macarthur to Sefton) and increase in freight from 24 to 36 trains/day each way, at 80% capacity on average). It was assumed that 100% of this additional freight would have otherwise been transported by road over the same distance. This was calculated for the whole of the SSFL as this project removes the bottleneck from the SSFL.

The only emissions from the project during operations are from minor electricity use in signalling operations. These emissions are estimated at 100 tCO_2-e per annum.

Australia's national greenhouse gas emissions, are presented in Table 21.3. Total annual emissions are 533.7 Mt CO_2-e. Total annual NSW emissions are 131.6 Mt CO_2-e. Annual emissions from the project during operations would account for approximately 0.00002 per cent of Australia's annual emissions and 0.0001 per cent of NSW's annual emissions, which is insignificant. Emissions during operation are negligible and therefore no mitigation measures are recommended.

Estimated emissions savings from shifting freight transport from road to rail is estimated at approximately 9,900 tCO_2-e/annum for the SSFL. Any emissions from operation of the project are more than offset by the potential savings in emissions from shifting some freight transportation from road to rail.

21.4.3 Cumulative impacts

Greenhouse gas emissions during operation of the project are predicted to be insignificant and are more than offset by the potential savings in emissions from shifting some freight transportation from road to rail. Therefore no cumulative impacts with other project is predicted.

The climate change predictions are based on projection data. This already includes global climate projections that relate to how the world may respond to the challenge of a changing climate, the need to continue to produce and use energy and resources, and the global greenhouse gas emissions that may occur. This has therefore, already accounted for cumulative impacts.

21.5 Recommended mitigation measures

21.5.1 Approach

21.5.1.1 Approach to mitigation and management

Climate change itself as a risk source is not under the control of the project. Nevertheless, controls or adaptations may be implemented to reduce the likelihood or the consequences of extreme climate events which may transpire as a result of climate change.

Potential adaptation measures have been identified in Table 21.5 to mitigate the risk identified. Typically there is a lag between climate change science and incorporation of the newly observed climate data into Australian Standards, therefore designing to standards cannot be wholly relied upon to ensure climate change risk is mitigated, without further consideration. Therefore ARTC will review the climate change risks identified in this assessment in the event of design changes during detailed design and improvements in adaptation knowledge.

21.5.1.2 Expected effectiveness

Some adaptations would need to be implemented during design, while others such as management protocols would ideally be implemented by the time the project is operational. The additional adaptation mitigation measures would ensure the risks are manageable within the project design and through the ARTC operational management system.

21.5.2 List of mitigation measures

The mitigation measures that would be implemented to address potential climate change impacts are listed in Table 21.7.

Table 21.7 Mitigation measures

Stage	Impact	Measure
Design	Design development changing climate change risk	ARTC will: • apply the climate change risk assessment and its existing control measures as incorporated into the reference design, in implementing the project, or • in the event of design changes, during detailed design, review the climate change risks identified in this assessment in order to amend existing control measures or identify additional control measures to reduce the climate change related risks to the project with no 'very high' or 'high' residual climate related risks remaining.
	Risks from climate change	ARTC will implement all potential adaptation measures identified in Table 21.5 so far as is reasonably practicable to reduce climate change risk.
	Improvements in climate change projections	In the event of significant new scientific climate change projections becoming available during detailed design, ARTC will review the relevant climate change risks and control measures identified in this assessment in order to confirm that there are no 'very high' or 'high' residual climate related risks remaining.
	Reduction in greenhouse emissions	Opportunities to reduce greenhouse gas emissions will be investigated during detailed design. This will include: • opportunities for low emission construction materials • locally sourced materials to reduce travel related emissions • use of recycled material options (eg Asphalt).

Stage	Impact	Measure
Construction	Emission of greenhouse gases	The CEMP will include the following requirements: • all plant and equipment used during the construction works will be regularly maintained to ensure fuel efficiency • sustainable procurement practices will be adopted where feasible • plant and equipment will be switched off when not in constant use and not left idling • air conditioning and lights in site compound buildings will be turned off when not in use • energy efficient vehicles or equipment will be selected where available.

21.5.3 Consideration of the interaction between measures

Mitigation measures to reduce climate change risk and greenhouse gas emissions may replicate mitigation measures proposed for the control of impacts associated with air quality, flooding and drainage.

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.

21.5.4 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 summarised below.

The mitigation and management measures outlined in section 21.5 have been designed to minimise greenhouse gas emissions and minimise climate change risks. The project will however result in some greenhouse gas emissions which will contribute to climate change.

Infrastructure is designed to function and perform within the environment that it exists, and to respond to the variable weather conditions for which it has been designed. State, national and international design standards and codes of practice exist to provide the parameters necessary to ensure the desired reliability and level of resilience of various infrastructure components to extreme conditions.

The project is however subject to climate change uncertainty, from the risks posed to a physical infrastructure by climate hazards under the influence of climate change. For any infrastructure to be resilient to the impacts of climate change, consideration must be made to the climate hazards which are applicable to the infrastructure type and broader context, including periodic review to incorporate the latest climate science. The results of a climate change risk assessment at any stage of a design promotes resilience and consideration of adaptation, either through designed adaptations or in allowance for future adaptive capacity. However, the inherent uncertainty of climate change predictions means residual impacts could be realised in either the short term or decades from today. These risks would be managed through implementation of appropriate maintenance regimes and continued management protocols to protect climate change risks.

THIS PAGE HAS BEEN LEFT INTENTIONALLY BLANK