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M4-M5 Link

Environmental Impact Statement

August 2017

Main Volume Chapters 16 to 30

Volume 1C

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16 Contamination

This chapter assesses the potential contamination impacts associated with the M4-M5 Link project (the project). This chapter has been informed by **Appendix R** (Technical working paper: Contamination).

The Secretary of the NSW Department of Planning and Environment (DP&E) has issued environmental assessment requirements for the project. These are referred to as Secretary's Environmental Assessment Requirements (SEARs). **Table 16-1** sets outs these requirements and the associated desired performance outcomes that relate to contamination of soils, and identifies where they have been addressed in this environmental impact statement (EIS).

Table 16-1 SEARs – contamination

Desired performance outcome	SEARs	Where addressed in the EIS
13. Soils The environmental values of land, including soils, subsoils and landforms, are protected. Risks arising from the disturbance and excavation of land and disposal of soil are minimised, including disturbance to acid sulfate soils and site contamination.	1. The Proponent must verify the risk of acid sulfate soils (Class 1, 2, 3 or 4 on the Acid Sulfate Soil Risk Map) within the area likely to be impacted by, the project.	The potential for acid sulfate soils to occur within the project footprint is addressed in **section 16.3.1**. Further discussion is also provided in **Chapter 15** (Soil and water quality).
	2. The Proponent must assess the impact of the project on acid sulfate soils (including impacts of acidic runoff offsite) in accordance with the current guidelines and detail the mitigation measures proposed to minimise potential impacts.	Potential impacts of acid sulfate soils is provided in **section 16.3.1**. Mitigation for acid sulfate soils is provided in **section 16.5**. Further discussion is also provided in **Chapter 15** (Soil and water quality).

Desired performance outcome	SEARs	Where addressed in the EIS
	3. The Proponent must assess whether the land is likely to be contaminated and identify if remediation of the land is required, having regard to the ecological and human health risks posed by the contamination in the context of past, existing and likely (or potential) future land uses. Where assessment and/or remediation is required, the Proponent must document how the assessment and/or remediation would be undertaken in accordance with current guidelines.	Qualitative assessment of the potential contamination risks is addressed in **section 16.3** and **section 16.4**. Specific remediation actions for construction ancillary facilities are provided in **Appendix R** (Technical working paper: Contamination). Commitment to undertaking and implementing a Remediation Action Plan is provided in **section 16.5**. Human health risks are discussed in **Appendix K** (Technical working paper: Human health risk assessment).
	4. The Proponent must assess whether salinity is likely to be an issue and if so, determine the presence, extent and severity of soil salinity within the project area.	Soil salinity is discussed in **Chapter 15** (Soil and water quality).
	5. The Proponent must assess the impacts of the project on soil salinity and how it may affect groundwater resources and hydrology.	Soil salinity is discussed in **Chapter 15** (Soil and water quality). Potential impacts on groundwater are discussed in **Chapter 19** (Groundwater).
	6. The Proponent must assess the impacts on soil and land resources (including erosion risk or hazard). Particular attention must be given to soil erosion and sediment transport consistent with the practices and principles in the current guidelines.	Impacts on soil and land resources (including erosion risk or hazard) are addressed in **Chapter 15** (Soil and water quality).
	7. The Proponent must assess the impact of any disturbance of contaminated groundwater and the tunnels should be carefully designed so as to not exacerbate mobilisation of contaminated groundwater and/or prevent contaminated groundwater flow.	Disturbance of contaminated groundwater is summarised in **section 16.3** and **section 16.4**. Potential impacts on groundwater are addressed in **Chapter 19** (Groundwater).

16.1 Assessment methodology

16.1.1 Relevant legislation and policies

The requirement to undertake an assessment of potential contamination impacts as a result of the project is underpinned by relevant NSW legislation. **Appendix R** (Technical working paper: Contamination) provides a preliminary assessment of contamination risks associated with the surface disturbance areas of the project in accordance with the following legal instruments.

Contaminated Land Management Act 1997 (NSW)

The *Contaminated Land Management Act 1997* (NSW) (CLM Act) promotes the better management of contaminated land by establishing a process for investigating and (where appropriate) remediating land that the NSW Environment Protection Authority (NSW EPA) considers to be contaminated significantly enough to require regulation under Division 2 of Part 3 of the Act.

Particular objects of the CLM Act are to:

- Set out accountabilities for managing contamination if the NSW EPA considers the contamination is significant enough to require regulation under Division 2 of Part 3 of the CLM Act
- Set out the role of the NSW EPA in the assessment of contamination and the supervision of the investigation and management of contaminated sites
- Provide for the accreditation of site auditors of contaminated land to ensure appropriate standards of auditing in the management of contaminated land
- Ensure that contaminated land is managed with regard to the principles of ecologically sustainable development.

The assessment of contaminated land and the subsequent requirement for mitigation and/or management measures for the project will be guided by the objects of the CLM Act.

Protection of the Environment Operations Act 1997 (NSW)

The *Protection of the Environment Operations Act 1997* (NSW) (POEO Act) is the key piece of environment protection legislation administered by the NSW EPA. The POEO Act enables the government to set out explicit protection of the environment policies (PEPs) and adopt more innovative approaches to reducing pollution. This chapter considers the requirements of the POEO Act in the formulation of mitigation measures to avoid or reduce potential impacts as a result of the project.

Environmentally Hazardous Chemicals Act 1985 (NSW)

The *Environmentally Hazardous Chemicals Act 1985* (NSW) (EHC Act) provides a mechanism for regulating chemicals of environmental concern throughout their entire life cycle. These requirements are set out in chemical control orders and may require a licence or prohibit certain activities. The activities may include storing, transporting or treating chemicals and/or their wastes.

The EHC Act would be relevant for activities undertaken during construction and operation of the project. The Act ensures that particular chemicals and/or chemical wastes generated as a result of the project that have a significant potential or actual impact on the environment, are adequately controlled.

State Environmental Planning Policy No. 55 – Remediation of Land

The purpose of the State Environmental Planning Policy No. 55 – Remediation of Land (SEPP 55) is to establish ‘best practice’ for managing land contamination through the planning and development control process. The assessment uses SEPP 55 to promote the remediation of contaminated land for the purpose of reducing the risk of harm to human health or any other aspect of the environment.

16.1.2 Relevant guidelines

The assessment for the project also considers the following key guidelines applicable to contamination identification, assessment and management:

- *Guidelines on the Duty to Report Contamination under the Contaminated Land Management Act 1997* (NSW EPA 2015)
- *Guidelines for the Site Auditor Scheme* (Second Edition) (NSW Department of Environment and Conservation (DEC) 2006)
- *Guidelines for the Assessment and Management of Groundwater Contamination* (DEC 2007)
- National Environment Protection (Assessment of Site Contamination) Measure (ASC NEPM) 2013 (National Environment Protection Council (NEPC) 1999)

- *Environmental Guidelines: Solid Waste Landfills* Second Edition (NSW EPA 2016)
- *Guidelines for Consultants Reporting on Contaminated Sites* (NSW Office of Environment and Heritage (OEH) 2011)
- *Guidelines for the Assessment and Management of Sites Impacted by Hazardous Ground Gases* (NSW EPA 2012)
- *National Water Quality Management Strategy, Paper No. 4, Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Volume 1, The Guidelines* (Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) 2000)
- *Acid Sulfate Soils Assessment Guidelines,* Acid Sulfate Soils Management Advisory Committee ((ASSMAC) 1998).

16.1.3 Study area

The study area for the contamination assessment is the same as the project footprint, which comprises the location of all operational infrastructure and areas where construction activities would occur. Particular emphasis has been given to those areas where historical land use activities have impacted soil, sediment and groundwater and which would require remediation and/or management during the construction and operation of the project.

The study area for the contamination assessment has been assessed in two parts:

- An assessment of the surface components of the project (construction and operational activities)
- An assessment of the project tunnel alignment to identify potential sources of groundwater contamination.

For further information on the construction and operational components of the project, refer to **Chapter 6** (Construction work) and **Chapter 5** (Project description) respectively.

The twelve construction ancillary facilities and surrounding areas assessed for contamination are listed below. To assist in informing the development of a construction methodology that would manage constructability constraints and the need for construction to occur in a safe and efficient manner, while minimising impacts on local communities, the environment, and users of the surrounding road and other transport networks, two possible combinations of construction ancillary facilities at Haberfield and Ashfield have been assessed in this EIS. The construction ancillary facilities that comprise these options have been grouped together in this EIS and are denoted by the suffix a (for Option A) or b (for Option B).

- Construction ancillary facilities at Haberfield (Option A), comprising:
  - Wattle Street civil and tunnel site (C1a)
  - Haberfield civil and tunnel site (C2a)
  - Northcote Street civil site (C3a)
- Construction ancillary facilities at Ashfield and Haberfield (Option B), comprising:
  - Parramatta Road West civil and tunnel site (C1b)
  - Haberfield civil site (C2b)
  - Parramatta Road East civil site (C3b)
- Darley Road civil and tunnel site (C4)
- Rozelle civil and tunnel site (C5)
- The Crescent civil site (C6)
- Victoria Road civil site (C7)
- Iron Cove Link civil site (C8)
- Pyrmont Bridge Road tunnel site (C9)

- Campbell Road civil and tunnel site (C10).

The project tunnel alignment was assessed in order to identify potential sources of groundwater contamination. The tunnel alignment was split into the following sections for ease of interpretation:

- Haberfield to Annandale and Rozelle: Parramatta Road at Haberfield to Whites Creek at Annandale
- Rozelle to Iron Cove and Balmain: City West Link at Annandale to Wellington Street and Theodore Street at Balmain
- Annandale to Camperdown: Whites Creek at Annandale to Bishopgate Lane at Camperdown
- Camperdown to Newtown: Bishopgate Lane at Camperdown to Lord Street at Newtown
- Newtown to St Peters: Lord Street at Newtown to Mary Street at St Peters.

16.1.4 Methodology

The method adopted for the contamination assessment consisted of:

- A review of relevant data and background information including, but not limited to, previous contamination assessments, land titles, council records, NSW EPA records and Universal Business Directories Pty Ltd (UBD) business directories historical records to evaluate whether historical land uses were likely to have caused contamination of soil and groundwater
- A preliminary assessment of the nature and location of infrastructure, hazardous materials and other features located within the study area, both current and historical
- A review of available published geological and hydrogeological information for the construction ancillary facilities and study area
- A search of the NSW Government’s groundwater bore database for groundwater bores within a one kilometre radius of the study area and review of available groundwater monitoring results for the project
- A search of the NSW EPA list of contaminated sites within 500 metres of the study area
- A review of selected historical images (including aerial photographs) and survey maps for the study area, which may provide an indication of historically contaminating land uses
- Completion of site inspections to assist with the identification of potential on and off-site sources of contamination and to understand the general condition of the construction ancillary facilities and construction sites and surrounding area
- Assessment of intrusive investigations completed within the project footprint and previous reports prepared to identify the areas and contaminants of concern
- An assessment of potential construction and operational impacts that may result from contaminated land or water (including a preliminary qualitative risk assessment (see below))
- Identification of mitigation measures to reduce or minimise the effects of potential impacts.

To assess the potential construction and operational impacts for the project, a preliminary qualitative risk assessment was undertaken based on the review of information.

The risk assessment follows the standard source, receptor, pathway methodology, where potential receptors have been defined as:

- Project construction workers and visitors
- Surrounding land users such as the general public and nearby residents and commercial workers
- Receiving water bodies
- Intrusive maintenance workers
- Future site users of final land use such as commercial, open space or residential
- Ecological receptors.

To identify the risk rating, a preliminary qualitative contamination risk assessment matrix in **Table 16-2** was used.

Table 16-2 Preliminary qualitative risk assessment matrix

Consequence	Likelihood of soil or groundwater contamination to be present				
	Very unlikely to be present and limited in extent	Potentially present and limited in extent	Potentially present and widespread	Most likely present and widespread	Known to be present and widespread
No or unlikely exposure pathway*	Low	Low	Low	Medium	Medium
Exposure pathway likely to be present*	Low	Medium	Medium	High	High
Exposure pathway present*	Medium	Medium	High	High	High

Note:

* Without implementation of appropriate controls or remediation as recommended in **section 16.5.**

A full explanation of the risk assessment methodology is detailed in **Appendix R** (Technical working paper: Contamination).

16.2 Existing environment

The following section identifies the site history, land use and any previous investigations carried out in the study area. For further information on soils and geology, including identifying the risk of acid sulfate soils across the site, refer to **Chapter 15** (Soil and water quality). For further information on hydrogeology, refer to **Chapter 19** (Groundwater). Contaminants of potential concern for each area is summarised in **section 16.2.14**.

16.2.1 Wattle Street civil and tunnel site (C1a)

Site description and surrounding land use

The Wattle Street civil and tunnel site at Haberfield is within the project footprint of the Wattle Street (City West Link) interchange construction zone for the M4 East project. The site would be located in an area comprising former residential properties, demolished as part of the M4 East project. The site is currently being used as a construction ancillary facility for the M4 East project.

The site slopes to the northeast and southwest and is surrounded by the land uses described in **Table 16-3**.

Table 16-3 Surrounding land use – Wattle Street civil and tunnel site (C1a) at Haberfield

Direction	Description of surrounding land use and proximity to the site
North	• Wattle Street, low density residential properties • Reg Coady Reserve (120 metres topographically down-gradient) (northeast) • Dobroyd Canal (Iron Cove Creek) (250 metres down-gradient)
South	• Low density residential properties
East	• Ramsay Street followed by low density residential properties (down-gradient)
West	• M4 East construction ancillary facilities and commercial/industrial properties along Parramatta Road

Site history

Key findings relevant to the Wattle Street civil and tunnel site (prior to the construction of the M4 East project) include:

- Historical aerial photographs from between 1930 and 2014 showed that low density residential properties were located within and surrounding the site
- A car sales yard was located 130 metres topographically down-gradient and southwest of the site (225-227 Parramatta Road), which was a former laundry/dry cleaner from 1919 to 1982
- A car service centre was located 125 metres topographically down-gradient and southwest of the site (235-237 Parramatta Road)
- A search of the NSW EPA records of notices and list of NSW contaminated sites identified no sites within 500 metres of the project.

Limited investigations were undertaken to inform the M4 East EIS (GHD 2015). Subsequent to M4 East project approval, soil and groundwater investigations were undertaken at the site (Ramboll Environ 2016a) to inform contamination management measures. Asbestos was the primary contaminant of concern identified.

Further detail on the site history and previous investigations for the Wattle Street civil and tunnel site is provided in **Appendix R** (Technical working paper: Contamination).

16.2.2 Haberfield civil and tunnel site (C2a)

Site description and surrounding land use

The Haberfield civil and tunnel site would be located in an area comprising former residential and commercial properties, demolished as part of the M4 East project. The site is currently being utilised as a construction ancillary facility for the M4 East project.

The Haberfield civil and tunnel site slopes to the southwest and is surrounded by the land uses described in **Table 16-4**.

Table 16-4 Surrounding land use – Haberfield civil and tunnel site (C2a) at Haberfield

Direction	Description of surrounding land use and proximity to the site
North	• Construction ancillary facilities used by the M4 East project and residential properties • Dobroyd Canal (Iron Cove Creek) 400 metres to the north
South	• Walker Avenue, a gym and mixed residential and commercial land use
East	• Residential properties (adjacent and up-gradient)
West	• Parramatta Road, Bunnings Warehouse, The Infants Home preschool and Long day care centre

Site history

Key findings relevant to the Haberfield civil and tunnel site (prior to the construction of the M4 East project) include:

- Historical aerial photographs from between 1930 and 2015 showed that low density residential properties were located within and surrounding the site
- From 1968, a number of car dealerships were located in the area along with a laundry proprietor and dry cleaners.

With the exception of limited investigations undertaken to inform the M4 East EIS (GHD 2015), no soil or groundwater investigations are known to have been completed within the Haberfield civil and tunnel site.

Further detail on the site history for the Haberfield civil and tunnel site is provided in **Appendix R** (Technical working paper: Contamination).

16.2.3 Northcote Street civil site (C3a)

Site description and surrounding land use

The Northcote Street civil site at Haberfield would be located in an area comprising former residential and commercial properties, demolished as part of the M4 East project. The site is currently being utilised as a construction ancillary facility for the M4 East project.

The site slopes to the west is surrounded by the land uses described in **Table 16-5**.

Table 16-5 Surrounding land use – Northcote Street civil site (C3a) at Haberfield

Direction	Description of surrounding land use and proximity to the site
North	• Wolseley Street • Muirs Prestige Smash Repairs (20 metres north and across gradient) • Speedway Service Station (35 metres north and across gradient) • Automotive Hospital (80 metres north and across gradient) • Platinum Car Wash Café (former petrol station) (100 metres north and across gradient) • Little VIPs Childcare Centre (100 metres north and across gradient) • Dobroyd Canal (Iron Cove Creek) (195 metres north)
South	• Wattle Street • Haberfield civil and tunnel site (C2a) • Residential properties (45 metres across gradient) • Bunnings warehouse (45 metres down-gradient)
East	• Residential properties (adjacent and up-gradient)
West	• Parramatta Road • Various retail shops and fast food restaurants (20 metres down-gradient) • Residential properties (70 metres down-gradient)

Site history

Key findings relevant to the Northcote Street civil site include (prior to the construction of the M4 East project):

- Historical aerial photographs from between 1930 and 2016 showed that low density residential properties were located within and surrounding the site
- Industrial activities included the presence of a service station that was subsequently used as a garden shop from 1980 until 2016. Truck and car dealerships were also prominent along with associated workshops.

With the exception of limited investigations undertaken to inform the M4 East EIS (GHD 2015), no soil or groundwater investigations are known to have been completed within the Northcote Street civil site.

Further detail on the site history for the Northcote Street civil site is provided in **Appendix R** (Technical working paper: Contamination).

16.2.4 Parramatta Road West civil and tunnel site (C1b)

Site description and surrounding land use

The Parramatta Road West civil and tunnel site would be located on land currently utilised for commercial purposes (including a car dealership and associated maintenance facilities). The Parramatta Road West civil and tunnel site drains north towards Dobroyd Canal (Iron Cove Creek) and is surrounded by land uses listed in **Table 16-6**.

Table 16-6 Surrounding land use – Parramatta Road West civil and tunnel site (C1b) at Ashfield

Direction	Description of surrounding land use and proximity to the site
North	• Great Western Highway/Parramatta Road • Alt Street • Northern portion of the C3b site (currently Muirs Kia Sales) 201–203 Parramatta Road, Ashfield • Further north is residential and commercial/industrial land use and Walker Avenue
South	• Bland Street • Vacant sites (202-204 and 220 Parramatta Road, Ashfield) formerly Brescia Furniture Showroom (destroyed by fire) and 192 Parramatta Road Ashfield formerly car sales yard (Sydney GPS Motors) currently occupied by the M4 East for construction purposes (M4 East Parramatta Road civil site C10) • Low to medium density residential along Bland Street and Chandos Street
East	• Parramatta Road East civil site (C3b) – currently Muirs Holden and Muirs Kia Sales • Low density residential housing on Bland and Alt Streets
West	• Low to high density residential housing on Bland Street and Alt Street • Chaya's Family Day Care on Alt Street (about 50 metres west of the site)

Site history

Key findings relevant to the Parramatta Road West civil and tunnel site include:

- Aerial photographs showed that the site and surrounds comprised of predominantly residential land use throughout the 1930s to 1960s. From the 1970s, commercial development increased along Parramatta Road
- The site appears to have been used as a car sales yard since the 1970's and owned by various commercial/industrial businesses from the 1930s to 1960s
- A former mechanical workshop has been identified around 20 metres north of the site.

Previous soil and groundwater sampling works have been carried out (GHD 2015) which indicated some exceedances of contaminant concentrations above the ASC NEPM health investigation levels and groundwater investigation levels.

Further detail on the site history and previous sampling results for the Parramatta Road West civil and tunnel site is provided in **Appendix R** (Technical working paper: Contamination).

16.2.5 Haberfield civil site (C2b)

The Haberfield civil site is an alternative design to the Haberfield civil and tunnel site (C2a). This civil site (C2b) would not be used to support tunnelling. The location of the Haberfield civil site (C2b) would be the same as the Haberfield civil and tunnel site (C2a), however it would require less land at the surface. Therefore, information relevant to the site description and site history remain the same as those discussed in **section 16.2.2**.

16.2.6 Parramatta Road East civil site (C3b)

Site description and surrounding area

The Parramatta Road East civil site would be located within an area currently comprising commercial properties, including a car dealership and associated maintenance facilities. The Parramatta Road East civil site drains north towards Dobroyd Canal (Iron Cove Creek) and is surrounded by land listed in **Table 16-7**.

Table 16-7 Surrounding land use – Parramatta Road East civil site (C3b) at Haberfield

Direction	Description of surrounding land use and proximity to the site
North	• Alt Street and Walker Avenue • Former laundry/dry cleaner on corner of Walker Avenue and Parramatta Road • Further north is residential and commercial/industrial land use (including car sales yard and Wattle Street
South	• Great Western Highway/Parramatta Road • Bland Street • Juvenile Justice – Yasmar training facility located between Bland Street and Chandos Street on Parramatta Road • Vacant sites (202–204 and 220 Parramatta Road Ashfield formerly Brescia Furniture Showroom (destroyed by fire) and 192 Parramatta Road Ashfield formerly car sales yard (Sydney GPS Motors) currently occupied by the M4 East for construction purposes (M4 East Parramatta Road civil site C10) and low to medium density residential Low to medium density residential along Bland and Chandos Streets
East	• Low density residential housing on Bland and Alt Streets • Haberfield Public school on the corner of Bland Street and Denman Avenue
West	• Great Western Highway/Parramatta Road • Parramatta Road West civil and tunnel site (C1b) currently Muirs Holden Automotive servicing and sales and NSW Roads and Maritime Services (Roads and Maritime) land various commercial leases on corner of Bland Street and Parramatta Road • Low to high density residential housing on Bland and Alt Streets • Chaya's Family Day Care on Alt Street (about 50 metres west of the C1b site)

Site history

Key findings relevant to the Parramatta Road East civil site include:

- Previous use of the site includes a newsagency, television repairs and sales business, and ownership by Rennon Motors Pty Ltd
- As part of the previous investigations for the M4 East project in 2014, two of the boreholes that were drilled are on the boundary of the site.

Previous soil and groundwater sampling works have been carried out (GHD 2015) which indicated some exceedances of contaminant concentrations above groundwater investigation levels.

Further detail on the site history and previous sampling results for the Parramatta Road East civil and tunnel site is provided in **Appendix R** (Technical working paper: Contamination).

16.2.7 Darley Road civil and tunnel site (C4)

Site description and surrounding land use

The Darley Road civil and tunnel site would be located on land owned by RailCorp – Transport for NSW. This land comprises a two storey vacant brick building with a fibre cement roof which has been renovated and now used as a commercial retail outlet. The western portion of the land is paved with bitumen and is used as a carpark servicing the retail outlet. The eastern portion of the site consists of a paved and landscaped area.

The land is bound to the north by the Leichhardt North light rail stop and line, to the south by Darley Road and Canal Road to the west.

The Darley Road civil and tunnel site slopes to the west and is surrounded by the land uses listed in **Table 16-8**.

Table 16-8 Surrounding land use – Darley Road civil and tunnel site (C4) at Leichhardt

Direction	Description of surrounding land use and proximity to the site
North	• Sydney Light Rail line and Leichhardt North light rail stop • City West Link followed by low to medium density residential properties
South	• Darley Road followed by low to medium density residential properties • An industrial building which operates as an antiques business fronting Darley Road • Monzo petrol station 100 metres southeast along Norton Street
East	• Norton Street followed by low to medium density residential properties and some commercial/industrial properties along Norton Street
West	• Charles Street and light rail corridor followed by Blackmore Park • Hawthorne Canal 300 metres west of C4 adjacent to Blackmore Park and Canal Road

Site history

Key findings relevant to the Darley Road civil and tunnel site include:

- Based on historical aerial photographs, the land was mostly cleared and vacant with one small building near the centre-north part of the land prior to 1950
- Industrial activities included a concrete facility and steel guttering production as well as additional light industry uses, including a bakery and vehicle storage
- Underground storage tanks (USTs) were also present, but understood to have been decommissioned.

Previous site investigations have been carried out (Environmental Investigation Services 2002 and HLA-Envirosciences Pty Ltd 2007) and results were all lower than the current ASC NEPM health investigation levels and health screening levels for commercial/industrial land use.

Further detail on the site history and previous sampling results for the Darley Road civil and tunnel site is provided in **Appendix R** (Technical working paper: Contamination).

16.2.8 Rozelle civil and tunnel site (C5)

Site description and surrounding area

The Rozelle civil and tunnel site would be located within the Rozelle Rail Yards at Lilyfield and Rozelle and encompasses an area of about 13.5 hectares.

Existing railway tracks, rail related infrastructure, buildings, surface wastes/stockpiles and noxious weeds are being removed from part of the Rozelle Rail Yards site at Rozelle as part of site management works, which were assessed separately in the Rozelle Rail Yards site management works review of environmental factors (REF) (Roads and Maritime 2016). The site management works will be completed prior to construction of the project commencing.

The Rozelle civil and tunnel site drains to Rozelle Bay and is surrounded by land uses as detailed in **Table 16-9**.

Table 16-9 Surrounding land use – Rozelle civil and tunnel site (C5) at Rozelle

Direction	Description of surrounding land use and proximity to the site
North	• Low to medium density residential properties • Lilyfield Road • Easton Park
South	• City West Link • Whites Creek followed by Brenan Street and then low to medium density residential properties • James Craig Road, commercial and industrial wharves, Maritime NSW, and Australian Superyacht Services Sydney • Rozelle Bay
East	• Victoria Road bridge followed by the former White Bay Power Station
West	• Construction site for the CBD and South East Light Rail Rozelle maintenance depot • Low to high density residential properties (topographically up-gradient to the southwest and northwest)

Site history

Key findings relevant to the Rozelle civil and tunnel site include:

- Prior to 1900 the eastern third of the site was part of Rozelle Bay, which was reclaimed to build the Rozelle Rail Yards. From 1914 to 1930s the land was acquired by The Commissioner for Railways, which became the Public Transport Commission of New South Wales (1970s) and then State Rail Authority of New South Wales (1980s). The railyards were transferred to Sydney Harbour Foreshore Authority in 2000 (which was absorbed into Government Property NSW in 2015)
- Various industries operated in the Rozelle Rail Yards including panel beaters, petroleum companies, logistics, boat and seafood businesses
- Historical aerial photographs showed City West Link was formerly part of the Rozelle Rail Yards until between 1982 and 1991.

Several previous investigations have been carried out at the site, including fill, natural soil and groundwater samples collected as part of a site investigation undertaken by AECOM in 2016. Results include some ASC NEPM health investigation levels and ecological investigation levels being exceeded for some contaminants. Additional contamination investigations were carried out to inform management measures for the Rozelle Rail Yards site management works REF.

Further detail on the site history and sampling results for the Rozelle civil and tunnel site is provided in **Appendix R** (Technical working paper: Contamination).

16.2.9 The Crescent civil site (C6)

Site description and surrounding area

The Crescent civil site at Annandale is currently vacant. The site was previously used for boat, plant and machinery storage and maintenance. The site is currently owned by Roads and Maritime and encompasses an area of around 6,620 square metres. The site is used to access commercially leased jetties. Rozelle Bay is a tidal harbour embayment located immediately adjacent. Rozelle Bay has been substantially modified by land reclamation activities and receives urban runoff from the suburbs of Rozelle, Lilyfield, Annandale and Forest Lodge.

The Crescent civil site at Annandale is anticipated to drain in an easterly direction towards Rozelle Bay, which is located immediately adjacent to and east of the site and is surrounded by land uses detailed in **Table 16-10**.

Table 16-10 Surrounding land use – The Crescent civil site (C6) at Annandale

Direction	Description of surrounding land use and proximity to the site
North	• Parkland, pedestrian and cyclist corridors which collectively form part of road verge above Whites Creek and Easton Park drainage into Rozelle Bay immediately east of the intersection of The Crescent and City West Link • Rozelle Rail Yards
South	• The Crescent and intersection with Johnston Street and Petersham TAFE College Annandale Campus. Above the intersection of these roadways is the Inner West Light Rail line • Federal Park adjacent to Rozelle Bay • Medium and low density residential properties
East	• Rozelle Bay, jetties, pontoons and marina
West	• The Crescent, residential land use further west, Buruwan Park adjacent to Whites Creek running west to east parallel to City West Link • Above Buruwan Park the Rozelle Bay light rail stop, tracks and associated infrastructure

Site history

It is understood that the site has been previously used for marine storage and maintenance purposes. The site history prior to that is unknown, however there is potential that the area has been filled and was previously part of Rozelle Bay. The Rozelle Rail Yards Site Management Works REF (Roads and Maritime 2016) noted that historic reports indicate Rozelle Bay is one of the most heavily polluted areas of Sydney Harbour.

Previous samples at the site (Jacobs (2015b)) have been undertaken and indicate that soil and groundwater is likely to be contaminated.

AECOM carried out soil and sediment investigation at the site in 2017 with some samples exceeding the human health United States Environmental Protection Agency residential regional screening levels and ASC NEPM ecological screening levels. Further detail on site history and sampling results at The Crescent civil site at Annandale is provided at **Appendix R** (Technical working paper: Contamination).

16.2.10 Victoria Road civil site (C7)

Site description and surrounding area

The Victoria Road civil site would be located in an area currently comprising residential and commercial properties at Rozelle. The site slopes to the east and southeast and is surrounded by the land uses listed in **Table 16-11**.

Table 16-11 Surrounding land use – Victoria Road civil site (C7) at Rozelle

Direction	Description of surrounding land use and proximity to the site
North	• Quirk Street and Victoria Road, with medium density residential properties to the northwest and commercial retail outlets about 100 metres to the north • Rosebud Cottage Child Care Centre about 75 metres topographically up-gradient
South	• Lilyfield Road followed by medium density residential properties and then the Rozelle Rail Yards, City West Link and then Rozelle Bay wharves • Rozelle Bay about 300 metres to the south
East	• Victoria Road, White Bay Power Station, Glebe Container Terminal and White Bay
West	• Medium and low density residential properties

Site history

Previous industrial uses included a service station and non-descript commercial buildings. No soil or groundwater investigations are known to have been completed within the Victoria Road civil site.

Further detail on the site history for the Victoria Road civil site is provided in **Appendix R** (Technical working paper: Contamination).

16.2.11 Iron Cove Link civil site (C8)

Site description and surrounding area

The Iron Cove civil site would be located along the southern side of Victoria Road at Rozelle, in an area currently comprising residential, commercial and industrial properties, road corridor and open space. The surrounding land use is summarised in **Table 16-12**.

Table 16-12 Surrounding land use – Iron Cove Link civil site (C8) at Rozelle

Direction	Description of surrounding land use and proximity to the site
North	• Bridgewater Park and residential apartments located directly to the north down-gradient • United 24 Service Station, Andrew Lyall Car Dealership and Caltex Service Station, VRS prestige (mechanics) and a substation are located directly adjacent up-gradient of the site • Iron Cove Bridge located immediately north down-gradient of the site
South	• 7 Eleven Service Station is located adjacent up-gradient • Low density residential properties are located adjacent up-gradient
East	• Rozelle Primary School is located about 200 metres topographically up-gradient • Further east are Rozelle shops and low to medium density residential
West	• King George Park is adjacent and topographically down-gradient

Direction	Description of surrounding land use and proximity to the site
	• Iron Cove (Parramatta River) located 50 metres and topographically down-gradient

Site history

Key findings relevant to the Iron Cove civil site include:

- The former Balmain Power Station was located directly north and adjacent to the site and was previously regulated by the NSW EPA due to the presence of a range of contaminants including PCBs and asbestos. The NSW EPA notices were revoked in August 1997 following remediation of the site
- Previous industrial uses included timber merchants, carpenters, motor garages, petrol stations, metal founders, laundries and copper and vat maker businesses
- Residential properties have also been in the area since at least 1930.

No contamination investigations are known to have been completed within the Iron Cove civil and construction site.

Further detail on the site history for the Iron Cove civil site is provided in **Appendix R** (Technical working paper: Contamination).

16.2.12 Pyrmont Bridge Road tunnel site (C9)

Site description and surrounding area

The Pyrmont Bridge Road tunnel site is located at Annandale in an area currently comprising various commercial properties. The site slopes to the northwest and is surrounded by the land uses listed in **Table 16-13**.

Table 16-13 Surrounding land use – Pyrmont Bridge Road tunnel site (C9) at Annandale

Direction	Description of surrounding land use and proximity to the site
North	• Pyrmont Bridge Road, followed by commercial/industrial and residential properties (topographically down-gradient) and then Johnstons Creek 150 metres northwest and about 280 metres north
South	• Parramatta Road followed by the Bridge Road School and commercial and medium to high density residential properties • Alfred’s Dry Cleaning located about 315 metres topographically up-gradient • Johnstons Creek is also located about 150 metres northwest up-gradient
East	• Booth Street followed by commercial and medium to high density residential properties • Grace Dry Cleaning and Laundry located about 95 metres topographically up-gradient • BP Connect Camperdown service station located about 270 metres topographically up-gradient
West	• Camperdown Service Centre located about 50 metres topographically down-gradient • James Squires Brewery located adjacent and topographically down-gradient • 7 Eleven service station located about 65 metres topographically down-gradient

Site history

Key findings relevant to the Pyrmont Bridge Road tunnel site include:

- A number of industrial and commercial business have been present at the site since around 1948
- Previous industrial uses included earth moving equipment manufacturers, motor car/truck dealers and storage facilities, electrical suppliers, blacksmiths and welders, spring manufacturers, textile manufacturers, annunciators and electroplaters.

No soil or groundwater investigations are known to have been completed within the Pyrmont Bridge Road tunnel site. Further detail on the site history for the Pyrmont Bridge Road tunnel site is provided in **Appendix R** (Technical working paper: Contamination).

16.2.13 Campbell Road civil and tunnel site (C10)

Site description and surrounding area

The Campbell Road civil and tunnel site is located at St Peters, on land currently being used as a construction site for the New M5 project. This land would be handed over to the project when it is no longer needed for New M5 construction. The site slopes to the southeast and is surrounded by the land uses listed in **Table 16-14**.

Table 16-14 Surrounding land use – Campbell Road civil and tunnel site (C10) at St Peters

Direction	Description of surrounding land use and proximity to the site
North	• Medium to high density residential properties • Commercial properties including Barbara's Prestige Smash Repairs and Australian Refined Alloys • Campbell Road • Sydney Park
South	• Former Alexandria Landfill/St Peters interchange construction site (part of the New M5 project)
East	• Commercial/industrial properties including Real Foods, former smash repairs and taxi base, and former Sims Metal Management scrap metal depot
West	• Former Alexandria Landfill/St Peters interchange construction site (part of the New M5 project) • Retail and warehouse commercial businesses • Princes Highway • Medium to high density residential properties

Site history

Key findings relevant to the Campbell Road civil and tunnel site include:

- The site was a mixture of unknown commercial/industrial land use and agricultural land use prior to 1908. From 1908 to 1962, there was the Ralford pit quarry and brick works
- The City of Sydney Council operated a solid waste 'inert/non-putrescible' landfill (Alexandria Landfill) within the former quarry from 1988 until 2002 when the landfill was purchased and operated by Dial-A-Dump Industries in 2015
- At the St Peters interchange construction site, the property was occupied by market gardens prior to 1923. After 1923 the brick works infrastructure (buildings, furnaces and chimneys) was constructed on the site. The brick works was demolished in 1970 and then the property was used

for storing crushed sandstone. The crushed sandstone stockpile (known as Bradshaw Mountain) was unused and became vegetated after 2004

- At the Holland Street lot, the property was previously occupied by a fishing line manufacture from 1926 to 1947, laminated timber veneer manufacturers until 1970, a storage company until 1995, Brambles Australia Ltd until 1999 and then Glenridge Holdings
- Other uses at the site include a bakery, workshops, warehouses and various commercial businesses.

Previous investigations for the New M5 project encompass the Campbell Road civil and tunnel site, which indicated some contaminant concentrations exceeded the ASC NEPM health investigation levels and ecological investigation levels.

Further detail on the site history and previous sampling results for the Campbell Road civil and tunnel site is provided in **Appendix R** (Technical working paper: Contamination).

16.2.14 Contaminants of potential concern

The contaminants of potential concern for each area are summarised in **Table 16-15**. Further detail is provided at **Appendix R** (Technical working paper: Contamination).

Table 16-15 Contaminants of potential concern

Area	Description	Contaminants of potential concern
Wattle Street civil and tunnel site (C1a)	• Demolition of former buildings (potentially containing asbestos or lead paint) • Use of the site as a construction ancillary facility for the M4 East project and associated potential for leaks and spills • Use of plant and machinery and excavation activities. However, the site would be returned generally to pre-construction condition before being handed over to M4-M5 Link construction contractor	• Lead • Asbestos • Metals • Polycyclic aromatic hydrocarbons (PAHs) • Hydrocarbons
Haberfield civil and tunnel site (C2a) and Haberfield civil site (C2b)	• Demolition of former buildings (potentially containing asbestos or lead paint) • Small scale mechanical workshops and laundry may have been operational within the property, which may have historically stored and handled oils, fuels and solvents	• Total recoverable hydrocarbons (TRH) • Benzene, toluene, ethylbenzene, xylenes and naphthalene (BTEXN) • PAHs • Volatile organic compounds (VOCs) • Lead • Asbestos • Metals

Area	Description	Contaminants of potential concern
Northcote Street civil site (C3a)	• Use of the site as a construction ancillary facility as part of the M4 East project. Demolition activities, tunnelling and use of plant and machinery and excavation activities. However, the site would be returned generally to pre-construction condition before being handed over to M4-M5 Link construction contractor • Previous mechanical workshops and petrol station on the site may have stored and handled oils, fuels and solvents and the former underground petroleum storage system including USTs and pipelines may still be in situ, which has a risk of historical leaks	• TRH • BTEX • PAHs • VOCs • Lead • Asbestos
Parramatta Road West civil and tunnel site (C1b) and Parramatta Road East civil site (C3b)	• Demolition of former buildings (potentially containing asbestos or lead paint) • Surrounding areas may have been filled using potentially contaminated sources • Previous mechanical workshops and petrol station on the site may have stored and handled oils, fuels and solvents and the former underground petroleum storage system including USTs and pipelines may still be in situ, which has a risk of historical leaks	• Metals • TRH • BTEX • PAHs • VOCs • Lead • Asbestos • Polychlorinated biphenyls (PCBs) • Organochlorine Pesticides (OCPs) • Organophosphate Pesticides (OPPs)
Darley Road civil and tunnel site (C4)	• A decommissioned UST is to the west of the site, which may have localised petroleum contamination • Fill from unknown sources is present on the site, which may contain potentially contaminated sources • The Sydney Buses Leichhardt Depot and manufacturing sites are located up-gradient	• Metals • PAHs • TRH • Asbestos • Semi Volatile Organic Hydrocarbons (SVOCs)
Rozelle civil and tunnel site (C5)	• Fill on site contains elevated concentrations of contaminants above applicable human health and ecological criteria. Asbestos was also identified in fill in several locations • Previous uses as timber yard, rail yard and manufacturing • Acid sulfate soil risk identified • The Crescent civil site (C6)	• Metals • TRH • PAH • Asbestos • Acid sulfate soils • OCPs

Area	Description	Contaminants of potential concern
The Crescent civil site (C6)	• Imported fill of unknown origin • Elevated concentrations of contaminants above ecological criteria • Acid sulfate soil risk identified • Potential for up-gradient contaminants to be mobilised via sediment and stormwater following into Whites Creek and Easton Park drain into Rozelle Bay • Previous uses of the Rozelle civil and tunnel site (C5) nearby • Boat maintenance activities within Rozelle Bay	• Asbestos • PFAS – PFOS and PFHxS • Metals • PAHs • Phathalates • Acid sulfate soils • Tributyltin • SVOCs • VOCs • TRH • BTEXN
Victoria Road civil site (C7)	• Previous underground petroleum storage system located on site, which has a risk of historical leaks • Demolition of former buildings (potentially containing asbestos or lead paint)	• TRH • BTEXN • PAHs • Lead • Asbestos
Iron Cove Link civil site (C8)	• Demolition of former buildings (potentially containing asbestos or lead paint) • Imported fill from an unknown origin • Previous mechanical workshops and petrol station on the site may have stored and handled oils, fuels and solvents and the former underground petroleum storage system including has a risk of historical leaks • Acid sulfate soil risk identified	• Metals • TRH • BTEX • PAHs • OCPs • PCBs • Asbestos • VOCs • SVOCs
Pyrmont Bridge Road tunnel site (C9)	• Previous mechanical workshops on the site may have stored and handled oils, fuels and solvents	• Metals • TRH • BTEXN • PAHs • VOCs • Asbestos • PCBs
Campbell Road civil and tunnel site (C10)	• Former solid waste landfill and recycling facility • Imported fill from an unknown origin • Unknown former commercial/industrial purposes	• Landfill gases (from adjacent landfill) • Metals

Area	Description	Contaminants of potential concern
	• Demolition of former buildings (potentially containing asbestos or lead paint)	• PAHs • Asbestos • Metals • TRH • SVOCs • VOCs • BTEXN

16.2.15 Tunnel alignment – Haberfield to Annandale and Rozelle

Current and former potentially contaminating land uses

Current and former potentially contaminating land uses identified within 300 metres of the tunnel alignment include petroleum storage and workshops, former 5th Ordnance Leichhardt Depot, former public works depot, former petrol station, former steel manufacturers, boiler makers, plastic manufactures, former metal engineering, electroplating, non-metal founding, timber supplies and panel beaters and the former Cumberland brick pit filled.

Notified and regulated sites

Sites notified to the NSW EPA under section 60 of the CLM Act or formerly regulated by the NSW EPA under the CLM Act and within 300 metres of the tunnel alignment are listed in **Table 16-6**.

Table 16-16 Contaminated sites notified to or regulated by the NSW EPA – Haberfield to Annandale and Rozelle

Property	Status	Proximity to alignment
Bus Depot (Area E) Corner of Balmain Road and City West Link, Leichhardt	Reported to the NSW EPA under section 60 of the CLM Act. Currently under assessment by the NSW EPA.	300 metres north of the alignment
RailCorp Leichhardt 7 Darley Road, Leichhardt	Reported to the NSW EPA under section 60 of the CLM Act. NSW EPA assessed the site as not requiring regulation under the CLM Act.	150 metres north of the alignment

Licensed sites

Sites licensed under the POEO Act and within 300 metres of the tunnel alignment are listed in **Table 16-17**.

Table 16-17 POEO Register – Haberfield to Annandale and Rozelle

Property	Licence number	Proximity to alignment
M4 East Homebush Bay Drive to Parramatta Road, Burwood	Environment Protection Licence (EPL) 20734	Adjacent
Sydney Trains (Railcorp) Network, Railway	EPL 12208	Above alignment

Groundwater quality

Groundwater monitoring was undertaken as part of the combined geotechnical and contamination investigations for the M4-M5 Link project. Samples were collected and analysed for metals (arsenic, cadmium, chromium, copper, nickel, lead, mercury and zinc), TRH, VOCs and SVOCs. Exceedances of two analytes (zinc and nickel) were discovered in two of the boreholes. The results are summarised in **Appendix R** (Technical working paper: Contamination) and **Appendix T** (Technical working paper: Groundwater).

16.2.16 Tunnel alignment - Rozelle to Iron Cove and Balmain

Current and former potentially contaminating land uses

Current and former potentially contaminating land uses identified within 300 metres of the tunnel alignment include petroleum storage, dry cleaners, and various manufacturing and metal foundries.

Notified and regulated sites

Sites notified to the NSW EPA under section 60 of the CLM Act or formerly regulated by the NSW EPA under the CLM Act and within 300 metres of the tunnel alignment are listed in **Table 16-18**.

Table 16-18 Contaminated sites notified to or regulated by the NSW EPA – Rozelle to Iron Cove and Balmain

Property	Status	Proximity to alignment
White Bay Power Station Rozelle	Reported to the NSW EPA under section 60 of the CLM Act. NSW EPA assessed the site as not requiring regulation under the CLM Act.	70 metres north and topographically down-gradient of the alignment
Balmain Power Station Terry Street, Rozelle	Formerly regulated by the NSW EPA due to a range of contaminants including PCBs and asbestos. The NSW EPA notices were revoked in August 1997 following remediation of the site.	80 metres north and topographically down-gradient of the alignment
Former Chemplex Factory 35 Terry Street, Rozelle	Formerly regulated by the NSW EPA due to metals and organic compounds. The notices were revoked in 1997.	300 metres north and topographically down-gradient of the alignment
Caltex service station 121 Victoria Road, Rozelle	Currently under assessment by the NSW EPA after being notified under section 60 of the CLM Act.	Immediately adjacent to the alignment
7 Eleven service station, 178–180 Victoria Road, Rozelle	Currently under assessment by the NSW EPA after being notified under section 60 of the CLM Act.	Immediately adjacent to the alignment

Licensed sites

There were no sites licensed under the POEO Act within 300 metres of the tunnel alignment. Licenses in the broader area include boat construction and maintenance activities around Rozelle Bay and White Bay, and construction activities associated with the CBD and South East Light Rail project to the west of the Rozelle Rail Yards.

Groundwater quality

Groundwater monitoring was undertaken as part of the combined geotechnical and contamination investigations for the M4-M5 Link project. Samples were collected and analysed for metals (arsenic, cadmium, chromium, copper, nickel, lead, mercury and zinc), TRH, VOCs and SVOCs. Only one borehole recorded an exceedance relating to arsenic. The results are summarised in **Appendix R** (Technical working paper: Contamination).

16.2.17 Tunnel alignment - Annandale to Camperdown

Current and former potentially contaminating land uses

Current and former potentially contaminating land uses identified within 300 metres of the tunnel alignment include petroleum storage, uncontrolled filling in a former clay pit, dry cleaning and various historical manufacturing sites.

Notified and regulated sites

Sites notified to the NSW EPA under section 60 of the CLM Act or formerly regulated by the NSW EPA under the CLM Act and within 300 metres of the tunnel alignment are listed in **Table 16-19**.

Table 16-19 Contaminated sites notified to or regulated by the NSW EPA – Annandale to Camperdown

Property	Status	Proximity to alignment
O'Dea Reserve Salisbury Lane, Camperdown	Formerly regulated under the CLM Act due to PAHs, lead and TPH from uncontrolled backfilling of a former clay-pit with a range of materials.	Directly above the alignment
Mobil service station 198 Parramatta Road, Annandale	Reported to the NSW EPA under section 60 of the CLM Act. Currently under assessment by the NSW EPA.	220 metres east and up topographic gradient of the alignment

Licensed sites

No sites licensed under the POEO Act were within 300 metres of the tunnel alignment.

Groundwater quality

Although deep groundwater monitoring wells have been installed within the vicinity of the Camperdown to Annandale section of the tunnel alignment, they are understood to have been screened between 40 and 50 metres below ground level and are not considered likely to detect any shallow groundwater contamination.

16.2.18 Tunnel alignment – Camperdown to Newtown

Current and former potentially contaminating land uses

Current and former potentially contaminating land uses identified within 300 metres of the tunnel alignment include dry cleaning, petroleum storage, workshops and manufacturing. Further detail on the current potentially contaminating land uses is provided in **Appendix R** (Technical working paper: Contamination).

Notified and regulated sites

Sites notified to the NSW EPA under section 60 of the CLM Act or formerly regulated by the NSW EPA under the CLM Act and within 300 metres of the tunnel alignment are listed in **Table 16-20**.

Table 16-20 Contaminated sites notified or regulated by the NSW EPA – Camperdown to Newtown

Property	Status	Proximity to alignment
Caltex service station 26 Enmore Road, Newtown	Reported to the NSW EPA under section 60 of the CLM Act. Currently under assessment by the NSW EPA.	Directly adjacent (west side) and above the alignment

Licensed sites

No sites licensed under the POEO Act are within 300 metres of the tunnel alignment.

Groundwater quality

Although deep groundwater monitoring wells have been installed within the vicinity of the Camperdown to Newtown section of the tunnel alignment, they are understood to have been screened between 40 and 50 metres below ground level and are not considered likely to detect any shallow groundwater contamination.

16.2.19 Tunnel alignment – Newtown to St Peters

Current potentially contaminating land uses

Current and former potentially contaminating land uses identified within 300 metres of the tunnel alignment between Newtown and St Peters include petroleum storage, dry cleaning (now closed), potentially workshops and manufacturing, a former landfill, paint manufacturing and uncontrolled filling.

Further detail on the current potentially contaminating land uses is provided in **Appendix R** (Technical working paper: Contamination).

Notified and regulated sites

Sites notified to the NSW EPA under section 60 of the CLM Act or formerly regulated by the NSW EPA under the CLM Act and within 300 metres of the tunnel alignment are listed in **Table 16-21**.

Table 16-21 Contaminated sites notified to or regulated by the NSW EPA – Newtown to St Peters

Property	Status	Proximity to alignment
BP Express service station 2 Princes Highway, St Peters	Reported to the NSW EPA under section 60 of the CLM Act. Currently under assessment by the NSW EPA.	80 metres east and across topographic gradient of the alignment
Former Tidyburn Facility 53 Barwon Park Road, St Peters	Formerly regulated under the CLM Act. Concentrations of naphthalene were present in groundwater on the site at concentrations above the relevant trigger values for the protection of aquatic ecosystems. TPHs were also present in groundwater at elevated concentrations. A Site Audit Statement (SAS) and Site Audit Report (SAR) were prepared certifying that the site was suitable for residential land use with minimal opportunity for soil access, including units. The site has been redeveloped into a high density residential apartment building with basement car park.	Immediately east and across topographic gradient of the alignment
Camdenville Park May Street, St Peters	Reported to the NSW EPA under section 60 of the CLM Act. NSW EPA assessed the site as not requiring regulation under the CLM Act.	25 metres west and up topographic gradient of the alignment

Licensed sites

Sites licensed under the POEO Act and within 300 metres of the tunnel alignment are listed in **Table 16-22**.

Table 16-22 POEO Register – St Peters to Newtown

Property	Licence number	Proximity to alignment
Metropolitan Demolitions And Recycling 396 Princes Highway, St Peters	EPL 11483	300 metres south and down topographic gradient of the alignment
CPB Contractors Pty Ltd New M5 St Peters interchange (former Alexandria Landfill)	EPL 4627	Above and adjacent to alignment

Groundwater quality

Groundwater monitoring was undertaken for the New M5 project around the St Peters interchange and additional monitoring wells were monitored as part of the combined geotechnical and contamination investigations for the M4-M5 Link project. The results are summarised in **Appendix R** (Technical working paper: Contamination) and show that the relevant trigger levels were exceeded across the majority of contaminants tested.

16.3 Assessment of potential construction impacts

The project has the potential to generate contamination during construction and operation, including the potential to disturb existing contaminated lands at surface works locations.

16.3.1 Construction ancillary facilities

The assessment of impacts for surface works during construction is presented in **Table 16-23**. Site layouts showing construction work areas are shown in **Chapter 6** (Construction work).

Table 16-23 Risk assessment for potential construction impacts

Area	Construction works	Potential contamination impacts	Likelihood of contamination	Consequence	Risk[1]
Wattle Street civil and tunnel site (C1a) at Haberfield	• Stockpiling within cut-and-cover structure • Excavations and tunnelling for ramps using roadheaders • Minor civil and finishing (pavement and line-marking) works	The demolition of former buildings and use of lead paint which may have resulted in localised areas of asbestos containing material (ACM) and lead paint flakes in soil. If present and not appropriately controlled, there is potential for: • Inhalation and/or ingestion risk to site workers of hazardous building materials via dust • Cross contamination associated with the incorrect handling or disposal of spoil/unexpected finds • Accidental leaks and spills from the use of the site as a construction ancillary site. The site would be demobilised and earthworks carried out by the M4 East contractor to provide finished levels that are consistent with the original ground surface before being handed over to the M4-M5 Link contractor.	Very unlikely and limited in extent	Exposure pathway likely to be present	Low
Haberfield civil and tunnel site (C2a) at Haberfield	• Minor civil construction and shallow excavation associated with the substation • Demolition activities and use of plant and machinery • Use of existing M4 East facilities (currently under construction)	Historical land uses of former dry cleaners, workshops associated with former car dealerships and mechanics may have caused soil and groundwater contamination at the western end of the site. Isolated soil contamination may be present from demolition or construction of former buildings and use of lead paint which may have resulted in localised areas of ACM and lead paint flakes in surface soil. If present and not appropriately controlled, there is potential for: • Accidental leaks and spills from the use of the site as a construction ancillary site • Demolition activities to mobilise contaminants. The site would be demobilised and earthworks	Very unlikely and limited in extent	Exposure pathway likely to be present	Low

Area	Construction works	Potential contamination impacts	Likelihood of contamination	Consequence	Risk[1]
		carried out by the M4 East contractor to provide finished levels that are consistent with the original ground surface before being handed over to the M4-M5 Link contractor.			
Northcote Street civil site (C3a) at Haberfield	• Use of existing M4 East facilities (currently under construction) • Demolition activities and use of plant and machinery	Historical land uses within the site may have caused soil and potentially groundwater contamination (potential former petrol station and workshops). If present and not appropriately controlled, there is potential for: • Accidental leaks and spills from the use of the site as a construction ancillary site • Demolition activities to mobilise contaminants. The site would be demobilised and earthworks carried out by the M4 East contractor to provide finished levels that are consistent with the original ground surface before being handed over to the M4-M5 Link contractor.	Very unlikely and limited in extent	Exposure pathway likely to be present	Low
Parramatta Road West civil and tunnel site (C1b) at Ashfield	• Demolition of existing buildings and structures • Utility works • Establishment of site offices, amenities and temporary infrastructure • Laydown and storage of materials • Delivery of materials, plant and equipment • Construction of an acoustic shed • Construction of a temporary	Historical and current land uses including car servicing, potential USTs, former dry cleaner, workshops associated with former car dealerships and mechanics may have resulted in soil and groundwater contamination. Soil contaminations (PAHs) have also been previously identified to the east of the site (GHD 2015). If present and not appropriately controlled, there is potential for: • Demolition activities to mobilise contaminants (ACM and lead paint) • Inhalation and/or ingestion risk to site workers from hazardous building materials and PAHs in excavated soil via dust • Cross contamination associated with the incorrect handling or disposal of	Potentially present and widespread	Exposure pathway likely to be present	Medium

Area	Construction works	Potential contamination impacts	Likelihood of contamination	Consequence	Risk[1]
	access tunnel • Tunnel excavation, stockpiling of excavated material and spoil haulage • Mechanical installation and fitout of the tunnels • Finishing works • Demobilisation	spoil/unexpected finds • Accidental leaks and spills from the use of the site as a construction ancillary site.			
Haberfield civil site (C2b) at Haberfield	• Establishment of site offices, amenities and temporary infrastructure • Delivery, laydown and storage of materials • Civil works • Landscaping • Demobilisation	Historical land uses of potential former dry cleaners and workshops associated with former car dealerships and mechanics at the western end of the site may have caused soil and groundwater contamination. The remainder of the site was historically residential therefore no other outstanding areas of concern were identified. Isolated soil contamination may be present from demolition or construction of former buildings and use of lead paint which may have resulted in localised areas of ACM and lead paint flakes in surface soil. Demolition activities, use of plant and machinery and excavation activities are proposed which could result in: • Inhalation and/or ingestion risk to site workers from hazardous building materials (if present) and PAHs in surface soil via dust • Accidental leaks and spills from the use of the site as a construction ancillary site. The site would be demobilised and earthworks carried out to provide finished levels that are consistent with the original ground surface before	Very unlikely and limited in extent	Exposure pathway likely to be present	Low

Area	Construction works	Potential contamination impacts	Likelihood of contamination	Consequence	Risk[1]
		being handed over to the M4-M5 Link contractor.			
Parramatta Road East civil site (C3b) at Haberfield	• Demolition of existing structures • Establishment of site offices, amenities and temporary infrastructure including temporary noise barriers • Utility works • Establishment of site offices and workforce amenities • Civil works • Landscaping • Demobilisation	Historical and current land uses for car servicing, USTs, former dry cleaner, workshops associated with former car dealerships and mechanics may have caused soil and groundwater contamination. Isolated soil contamination may be present from demolition or construction of former buildings and use of lead paint which may have resulted in localised areas of ACM and lead paint flakes in surface soil. Soil contaminations (PAHs) have also been previously identified to the east of the site (GHD 2015). Demolition activities, use of plant and machinery and excavation activities are proposed which could result in: If present and not appropriately controlled, there is potential for: • Inhalation and/or ingestion risk to site workers from hazardous building materials (if present) and PAHs in surface soil via dust • Cross contamination associated with the incorrect handling or disposal of spoil/unexpected finds • Accidental leaks and spills from the use of the site as a construction ancillary site.	Known to be present	Exposure pathway potentially present	Medium
Darley Road civil and tunnel site (C4) at Leichhardt	• Demolition and UST decommissioning • Excavation for the temporary access tunnel • Stockpiling	Previous soil investigations identified fill material with slightly elevated metals and PAHs, although the site is still suitable for ongoing commercial/industrial land use. A UST has also been decommissioned. If present and not appropriately controlled, there is potential for: • Direct contact, inhalation and ingestion risk to	Known to be present and widespread	Exposure pathway potentially present	Medium

Area	Construction works	Potential contamination impacts	Likelihood of contamination	Consequence	Risk[1]
	• Road works • Construction of permanent operational infrastructure	site workers from contaminated soil or hazardous building materials via dust • Discharge of contaminated surface water to the stormwater system and ultimately Hawthorne Canal and Iron Cove • Incorrect handling or disposal of spoil • Disturbance of actual or potential acid sulfate soils at the western end of the site which could impact local soil and water quality.			
Rozelle civil and tunnel site (C5) at Rozelle	• Demolition of structures, including buildings • Excavations for tunnel portals and cut and cover tunnels • Road construction • Stockpiling in acoustic sheds • Construction of temporary and permanent infrastructure • Tunnelling (for ventilation/road construction) • Utility works • Drainage infrastructure including upgraded culvert to Rozelle Bay	Previous soil investigations identified metals (lead, arsenic, cadmium and zinc), asbestos, petroleum sourced Light Non-Aqueous Phase Liquid (LNAPL) and PAHs exceeding the land use criteria for open space and commercial/industrial. Potential construction impacts include: • Impacts on site workers and the local community through contact with contaminants and asbestos released during demolition and ground disturbance works • Exposure of underlying ground surface following removal of vegetation, ballast stockpile and excavated spoil resulting in the potential mobilisation of contamination that may be present within the site • Impacts as a result of sediment basins interacting with groundwater on the site resulting in dewatering and potential contamination of groundwater • Contamination resulting from potential leaks and spills from equipment and plant • Erosion and off-site transport of sediment and	Known to be and widespread	Exposure pathway likely to be present	High

Area	Construction works	Potential contamination impacts	Likelihood of contamination	Consequence	Risk[1]
		contamination via overland flow and stormwater runoff, affecting the water quality of Easton Park drain, Whites Creek and Rozelle Bay • Direct contact, inhalation and ingestion risk to site workers from contaminated soil or hazardous building materials via dust • Discharge of contaminated surface water and extracted groundwater to the stormwater system and ultimately Rozelle Bay • Disturbance of actual or potential acid sulfate soils at the western end of the site which could impact local soil and water quality.			
The Crescent civil site (C6) at Annandale	• Site establishment • Utility works • Temporary stockpiling • Road works, including construction of a new road bridge over Whites Creek • Widening and improvement works along Whites Creek • Construction of the culvert below City West Link (Easton Park drain) • Construction and dewatering of coffer dam(s) in Rozelle Bay • Finishing works • Excavating, filling and grading	Previous investigations have indicated soil, sediment and groundwater contamination associated with historical filling and more recent industrial/commercial maritime operation. There is an existing management plan to manage identified contamination on part of the site. Potential construction impacts include: • Impacts on site workers and the local community through contact with contaminants and asbestos released during demolition and ground disturbance works • Exposure of underlying ground surface during excavation resulting in the potential mobilisation of contamination • Contamination resulting from potential leaks and spills from equipment and plant • Erosion and off-site transport of sediment and contamination via overland flow and stormwater runoff, affecting the water quality of	Known to be present and widespread	Exposure pathway likely to be present	High

Area	Construction works	Potential contamination impacts	Likelihood of contamination	Consequence	Risk[1]
	of disturbed areas • Landscaping and construction of pedestrian and cyclist paths and bridges.	Whites Creek and Rozelle Bay • Adverse impacts on the environment as a result of the inappropriate management of waste generated by construction activities • Direct contact, inhalation and ingestion risk to site workers from contaminated soil or hazardous building materials via dust • Adverse impacts on ecological receptors from the discharge of contaminated surface water and sediment to Rozelle Bay • Adverse impacts on ecological receptors from the mobilisation of disturbed contaminated sediment within Rozelle Bay • Cross contamination from the incorrect handling of contaminated soil, fill, sediment, groundwater and surface water • Accidental spills and leaks from equipment and plant used during construction • Disturbance of actual or potential acid sulfate soils at the western end of the site which could impact local soil and water quality.			
Victoria Road civil site (C7) at Rozelle	• Demolition of existing buildings • Establishment of site sheds, laydown areas and/or site offices.	There are historical land uses within and surrounding the site which may have caused soil and potentially groundwater contamination. Further intrusive investigations would be required to assess the risk posed during construction. There is potential for inhalation and ingestion risk to site workers from contaminated soil or hazardous building materials via dust, and the potential for leaks or spills from equipment and plant used during construction.	Very unlikely and limited in extent	Exposure pathway likely to be present	Low

Area	Construction works	Potential contamination impacts	Likelihood of contamination	Consequence	Risk[1]
Iron Cove Link civil site (C8) at Rozelle	• Demolition • Bulk excavations for tunnel portals and cut-and-cover tunnels • Soft ground tunnelling • Road construction works • Construction of permanent operational infrastructure • Construction works for the bioretention facility and formalised car park at Manning Street • Utility works • Landscaping	There are historical land uses within and surrounding the site which may have caused soil and potentially groundwater contamination. Further intrusive investigations would be required to assess the risk posed during construction of areas of potential concern. Potential construction impacts include: • Direct contact, inhalation and ingestion risk to site workers from contaminated soil or hazardous building materials via dust • Discharge of contaminated surface water to the stormwater system and ultimately Iron Cove • Disturbance of actual or potential acid sulfate soils at the northeast corner of the site and within the area of the proposed bioretention facility located within King George Park, adjacent to Manning Street at Rozelle • Potential for leaks or spills from equipment and plant used during construction.	Potentially present and widespread	Exposure pathway likely to be present	Medium
Pyrmont Bridge Road tunnel site (C9) at Annandale	• Demolition • Excavation for the temporary access tunnel • Minor road works	There are historical land uses within and surrounding the site which may have caused soil and potentially groundwater contamination. Further intrusive investigations would be required to assess the risk posed during construction. Potential construction impacts include: • Direct contact, inhalation and ingestion risk to site workers from contaminated soil or hazardous building materials via dust • Discharge of contaminated surface water to the stormwater system and ultimately Johnstons Creek, which discharges to Rozelle Bay.	Potentially present and widespread	Exposure likely to be present	Medium

Area	Construction works	Potential contamination impacts	Likelihood of contamination	Consequence	Risk[1]
Campbell Road civil and tunnel site (C10) at St Peters	• Road works • Tunnelling and associated excavation and stockpiling • Excavation for temporary access tunnel to provide construction access to mainline • Construction of cut and cover structures • Construction of permanent operational infrastructure	There are known soil and groundwater contamination and landfill gas and leachate at the site. The remediation and management of the site is being undertaken as part of the construction of the St Peters interchange for the New M5 project. During excavation activities, there is potential for the following impacts: • Inhalation and/or exposure risk from landfill gases for site workers and surrounding land users • Direct contact, inhalation and ingestion risk to site workers or surrounding human receptors from leachate, landfill refuse and contaminated soil by dust • Discharge of contaminated surface water and groundwater/leachate to Alexandria Canal • Disturbance of actual or potential acid sulfate soils which could impact local soil and water quality • Potential for leaks or spills from equipment and plant used during construction.	Known to be present and widespread	Exposure pathway likely to be present	High

Note:

1

Table 16-2 outlines the preliminary qualitative contamination risk assessment matrix that the risk level is based on.

16.3.2 Tunnelling

A review of potential contamination sources along the tunnel alignment identified the presence of potential, current and former contamination sources. These are summarised in **Appendix R** (Technical working paper: Contamination).

During tunnel construction, groundwater would be extracted from the tunnelling process, which would subsequently require disposal. The extracted water would be either:

- Treated onsite and then discharged to stormwater under an EPL or to sewer under a trade waste agreement
- Transported to a liquid waste facility.

Potential impacts on receiving water bodies associated with the construction of new drainage outlets and drainage infrastructure adjustments and upgrades could occur at the following locations:

- Rozelle Bay
- Iron Cove
- Whites Creek
- Easton Park drain
- Receiving waters of Sydney Harbour.

Potential pre-mitigation impacts on workers could include exposure to extracted contaminated groundwater from either direct contact or inhalation of vapours, or vapours encountered during tunnelling.

There is potential for shallow tunnelling, such as near portals, temporary access tunnels or cut-and-cover tunnels, to encounter groundwater that is impacted from contamination from sources such as petrol stations with dissolved and undissolved petroleum hydrocarbon plumes or other industrial sources. The identified highest risk locations are considered to be:

- Parramatta Road, Annandale: The temporary access tunnel connecting the mainline tunnel to the Pyrmont Bridge Road tunnel site (C9) passes directly south of the 7 Eleven service station that is presently under assessment by the NSW EPA under section 60 of the CLM Act. The temporary access tunnel may be relatively shallow as it passes the service station and could potentially intercept a dissolved or undissolved (ie LNAPL) petroleum plume
- Wattle Street, Haberfield: The Wattle Street entry and exit ramps are located in an area historically occupied for residential land use in the suburb of Haberfield. There is potential for ACM and lead paint to be present in surface soils
- Darley Road, Leichhardt: The temporary access tunnel to the Darley Road civil and tunnel site (C4) passes between former manufacturing businesses and former steel manufacturers and boiler makers. There is potential for metals, PAHs, TPH, asbestos, VOCs, SVOCs to be present in shallow surface soils and/or groundwater
- Parramatta Road west, Ashfield: The temporary access tunnel to the Parramatta Road West civil and tunnel site (C1b) is generally located within the northern portion of the site and traverses north along Parramatta Road. There is potential for ACM (from demolition and redevelopment works along Parramatta Road and associated filling) and PAHs to be present in shallow surface soils and/or groundwater
- Rozelle Rail Yards, Rozelle: previously identified LNAPL within the Rozelle civil and tunnel site (C5) could be impacted by dewatering for tunnelling around the Rozelle interchange and is likely to be encountered during future tunnelling/portal construction, if not remediated prior
- Victoria Road, Rozelle: The Iron Cove Link tunnel between Darling Street and Terry Street passes beneath or directly adjacent to several service stations, some of which are presently under assessment by the NSW EPA under section 60 of the CLM Act, as well as several former dry cleaners

- Campbell Road, St Peters: The tunnel portal area and temporary access tunnel within the former Alexandria Landfill at the New M5 St Peters interchange due to leachate and landfill gases. The tunnel at this section is shallow and would be exposed to landfill leachate if appropriate mitigation measures are not implemented.

With the exception of the former Alexandria Landfill (assessed as part of the New M5 project), other sections of the tunnel are at depths greater than 30 metres and therefore the likelihood of encountering plumes with high concentrations of contaminants is low given that deep contamination (greater than 30 metres below ground level) has generally not been identified along the proposed M4-M5 Link tunnel alignment. However, the extracted groundwater is likely to contain concentrations of metals and nutrients above background concentrations and low concentrations of chemical and petroleum hydrocarbon contaminants from the types of sources listed in the previous table. Notwithstanding, tunnels would be drained to construction water treatment facilities prior to discharge to receiving surface water bodies.

Dewatering during construction works may cause changes in the migration of plumes of contaminated groundwater by changing groundwater gradients and drawing the contamination towards the tunnel. This is most likely in areas where the tunnels are shallow and approaching the surface such as the temporary access tunnel at Parramatta Road, Annandale, and the Iron Cove section near and beneath Victoria Road at Rozelle. This is discussed further in **Appendix T** (Technical working paper: Groundwater).

Temporary construction water treatment plants would be located at each construction ancillary facility where tunnelling would occur, and would be designed to treat construction water and groundwater inflows encountered during construction. The level of treatment would consider the characteristics of the water requiring treatment, operational constraints or practicalities, and associated environmental impacts. The treatment would be developed in accordance with ANZECC (2000) and with consideration to the relevant NSW Water Quality Objectives as discussed in **Appendix Q** (Technical working paper: Surface water and flooding).

16.4 Assessment of potential operational impacts

16.4.1 Permanent operational facilities

Potential contamination impacts associated with the presence of roads and permanent operational infrastructure is presented in **Table 16-24**. Leachate within the former Alexandria Landfill would be treated by the existing water treatment plant constructed for the New M5 project and discharged to sewer under the existing trade waste agreement with Sydney Water. Therefore, leachate within the former Alexandria Landfill does not form part of this assessment.

The Parramatta Road ventilation facility located adjacent to Parramatta Road between Wattle Street and Walker Avenue has been assessed as part of the M4 East project. The M4-M5 Link project includes the internal fit out of this structure.

The construction ancillary facilities that are not anticipated to be used for permanent operational infrastructure would be rehabilitated at the end of construction. Construction facilities that will not include new operational infrastructure are:

- Northcote Street civil site (C3a)
- Parramatta Road West civil and tunnel site (C1b)
- Parramatta Road East civil site (C3b)
- Pyrmont Bridge Road tunnel site (C9).

At the completion of M4-M5 Link construction the landscaping (where applicable) and residual land obligations as detailed in the M4 East and New M5 conditions of approval would be carried out by these respective projects. As such there are no anticipated operational impacts of these construction ancillary facilities during operation and these are not discussed further in this section.

Table 16-24 Risk assessment for potential operational impacts

Operational area	Permanent infrastructure	Potential operational impacts	Likelihood of contamination	Consequence (without implementation of appropriate controls)	Risk
Wattle Street at Haberfield	• Roadway	Accidental leaks and spills on constructed roadways from vehicles and vehicle accidents.	Very unlikely and limited in extent	Exposure pathway may be present, if leaks and spills occur	Low
Parramatta Road at Haberfield	• Parramatta Road ventilation facility	Minimal soil or groundwater contamination impacts would be expected from the operation of the ventilation facility. Sources of contamination could be from small volumes of oils, fuels, solvents and other chemicals used for operation and maintenance if not stored and handled in accordance with regulations.	Very unlikely and limited in extent	Exposure pathway may be present	Low
Darley Road at Leichhardt	• Motorway operation complex (MOC1) including a permanent water treatment facility and substation on western portion of the site	Accidental leaks and spills of water treatment chemicals from the operation of the permanent water treatment facility and discharge of inadequately treatment wastewater.	Very unlikely limited in extent	Exposure pathway may be present	Low
Rozelle Rail Yards at Rozelle	• Roads, entry and exit ramps and tunnel portals • Motorway operation complexes (MOC2 and MOC3) including: – Rozelle ventilation facility – Water treatment plant – Constructed wetland – Substations – Workshop facilities/bulky equipment store	• Accidental spills of water treatment chemicals or discharge of inadequately treatment wastewater • Minimal soil or groundwater contamination impacts from the operation of the ventilation facility, substation, workshop, water treatment facility, fire pump room and water tanks. Sources of contamination could be from small volumes of oils, fuels, solvents and other chemicals used for operation and maintenance if not stored and handled in accordance with regulations. The end land use for a large portion of the site	Potentially present and widespread, if leaks and spills occur	Exposure pathway may be present	Medium

Operational area	Permanent infrastructure	Potential operational impacts	Likelihood of contamination	Consequence (without implementation of appropriate controls)	Risk
	– Fire pump room and water tanks	would be open space. Due to the presence of existing soil and groundwater contamination from historical activities, the area would require further investigation post construction to assess operational land use suitability for recreational open space.			
The Crescent at Annandale	• Road infrastructure • Pedestrian and cyclist paths	Accidental leaks and spills on constructed roadways from vehicles and vehicle accidents.	Very unlikely and limited in extent	Exposure pathway may be present, in the event of leaks and spills	Low
Victoria Road at Rozelle	• Road infrastructure • Pedestrian and cyclist paths	Accidental leaks and spills on constructed roadways from vehicles and vehicle accidents.	Very unlikely and limited in extent	Exposure pathway may be present, in the event of leaks and spills	Low
Iron Cove Link at Rozelle	• Roads, entry and exit ramps and tunnel portals • Motorway operation complex (MOC4) including Iron Cove Link ventilation facility • Substation (land subject to landscaping)	• Accidental leaks and spills on constructed roadways from vehicles and vehicle accidents • Minimal soil or groundwater contamination from the operation of the substation and ventilation facility.	Potentially present	Exposure pathway may be present	Medium

Operational area	**Permanent infrastructure**	**Potential operational impacts**	**Likelihood of contamination**	**Consequence** (without implementation of appropriate controls)	**Risk**
Campbell Road at St Peters	• Roads, including dive structures, tunnel portals and entry and exit ramps • Motorway operation complex (MOC5) including Campbell Road ventilation facility • Substation • Workshop facilities/bulky equipment store	• Minimal soil or groundwater contamination from the operation of the ventilation facility, substation and workshop • Accidental leaks and spills on constructed roadways from vehicles and vehicle accidents.	Potentially present and widespread	Exposure pathway unlikely to present	Medium

16.4.2 Tunnels

During operation, groundwater seepage would need to be extracted from the tunnels, treated and discharged to receiving water bodies. As part of the tunnel design, some sections would be lined to reduce the ingress of groundwater into the tunnels.

Groundwater quality may be impacted along parts of the tunnel alignment due to overlying contamination sources impacting groundwater. An assessment of the expected groundwater seepage rates and groundwater drawdown which may have an effect on existing groundwater contamination plumes is provided in **Chapter 19** (Groundwater).

The extracted groundwater could contain concentrations of metals and nutrients above background concentrations and low concentrations of chemical and petroleum hydrocarbon contaminants. Water collected from within the tunnels would be treated to an appropriate standard to prevent environmental harm prior to discharge (refer to **Chapter 15** (Soil and water quality)). If not treated adequately, the discharge of the groundwater to receiving water bodies could contribute to poor water quality. However, the potential for this to occur is considered to be extremely low.

Tunnel drainage infrastructure would be designed to accommodate a combination of contaminated water ingress events including groundwater ingress, stormwater ingress at portals, tunnel wash-down water, fire suppressant deluge or fire main rupture and spillage of flammable and other hazardous materials. Separate sumps would be provided at tunnel sags, one to collect groundwater ingress and one to collect the other potential water sources. The two tunnel drainage streams from the mainline works would be pumped to a water treatment facility at Darley Road, Leichhardt. Potential discharge and disposal options for treated flows from the facility are discussed in **Chapter 15** (Soil and water quality).

Tunnel drainage for Rozelle would be pumped to a water treatment facility and constructed wetland at the Rozelle Rail Yards, with treated flows ultimately discharged to Rozelle Bay. Tunnel drainage from around one kilometre of the northbound and 600 metres of the southbound tunnel would be captured by the New M5 drainage system and conveyed to the New M5 operational water treatment plant at Arncliffe, which ultimately drains to the Cooks River.

An assessment of the potential impacts on the receiving bodies is provided in **Chapter 15** (Soil and water quality).

16.5 Management of impacts

The mitigation and management measures provided in **Table 16-25** would be implemented during construction and operation of the project to reduce or minimise the potential impacts created by contamination risks. These measures are expected to make the land to be used as part of the project suitable for the proposed end use. Potentially contaminated sites identified in **section 16.2.14** would be subject to further investigation, remediation and/or management. Further details on the environmental management measures are provided in **Appendix R** (Technical working paper: Contamination).

An UDLP would be prepared for the project. Areas of land not required for the construction or operation of the project but that have been identified as being subject to the UDLP would be rehabilitated and landscaped to be consistent with the UDLP. Remaining project land would be rehabilitated and returned to finished levels generally consistent with the original ground surface. The future use of remaining project land would be outlined in the Residual Land Management Plan to be prepared for the project.

Wattle Street civil and tunnel site (C1a), Haberfield civil and tunnel site (C2a) and Northcote Street civil site (C3a) would be developed in accordance with the conditions of approval for the M4 East project. The Campbell Road civil and tunnel site (C10) would be developed consistent with the conditions of approval for the New M5 project.

Table 16-25 Environmental management measures – contamination

Impact	No.	Environmental management measure	Timing
Construction			
Impacts on site workers and/or local community through disturbance and mobilisation of contaminated material	CM01	Potentially contaminated areas directly affected by the project will be investigated and managed in accordance with the requirements of guidance endorsed under section 105 of the CLM Act. This includes further investigations in areas of potential contamination identified in the project footprint. If contamination posing a risk to human or ecological receptors is identified, a Remediation Action Plan will be prepared.	Construction
	CM02	Asbestos handling and management will be undertaken in accordance with an Asbestos Management Plan (as part of the Work Health and Safety Plan) as described in **Chapter 23** (Resource use and waste minimisation).	Construction
	CM03	A hazardous materials assessment will be carried out prior to and during the demolition of buildings. Demolition works will be undertaken in accordance with the relevant Australian Standards and relevant NSW WorkCover Codes of Practice, including the Work Health and Safety Regulation 2011 (NSW).	Construction
	CM04	The Construction Waste Management Plan for the project, prepared as described in **Chapter 23** (Resource use and waste minimisation), will include procedures for handling and storing potentially contaminated substances.	Construction
	CM05	Stockpile management procedures will be implemented to control dust, odour and cross contamination.	Construction
	CM06	The discovery of previously unidentified contaminated material will be managed in accordance with an unexpected contaminated lands discovery procedure, as outlined in the *Guideline for the Management of Contamination* (Roads and Maritime 2013) and detailed in the CEMP. The procedure will include: • Cease work in the vicinity • Initial assessment by an appropriately qualified environmental consultant • Further assessment and management of contamination, if confirmed, in accordance with section 105 of the CLM Act.	Construction
Impacts on soil and water quality through incorrect handling of contaminated material	CM07	A Construction Soil and Water Management Plan will be prepared for the project including procedures to manage potentially contaminated stormwater runoff and acid sulfate soils, as described in **Chapter 15** (Soil and water quality).	Construction
	CM08	Measures identified in **Chapter 25** (Hazard and risk) will be implemented to appropriately store dangerous goods and reduce the potential for environmental contamination due to spills and leaks.	Construction

Impact	No.	Environmental management measure	Timing
Operation			
Accidental spills during operation	OCM09	Procedures to address spills, leaks and tunnel washing will be developed as part of an Operational Environmental Management Plan (OEMP) and implemented during operation of the project.	Operation

17 Flooding and drainage

This chapter describes the potential flooding and drainage impacts associated with the project. The chapter has been informed by flooding and drainage assessments provided in **Appendix Q** (Technical working paper: Surface water and flooding).

The Secretary of the NSW Department of Planning and Environment (DP&E) has issued environmental assessment requirements for the project; these are referred to as Secretary's Environmental Assessment Requirements (SEARs). **Table 17-1** sets out these requirements and the associated desired performance outcomes that relate to flooding and water (hydrology), and identifies where they have been addressed in this environmental impact statement (EIS).

Table 17-1 SEARs – flooding and water (hydrology)

Desired performance outcome	SEARs	Where addressed in the EIS
12. Flooding The project minimises adverse impacts on existing flooding characteristics. Construction and operation of the project avoids or minimises the risk of, and adverse impacts from, infrastructure flooding, flooding hazards, or dam failure.	1. The Proponent must assess and (model where required) the impacts on flood behaviour during construction and operation for a full range of flood events up to the probable maximum flood (taking into account sea level rise and storm intensity due to climate change) including: (a) how the tunnel entries and cut-and-cover sections of the tunnels would be protected from flooding during construction works;	An assessment of flood behaviour during construction and operation is provided in **section 17.3** and **section 17.4** respectively. A description of how tunnel entries and cut-and-cover sections of the tunnels would be protected from flooding during construction is provided in **section 17.3** and **section 17.5**. As assessment of the potential impacts of future climate change on flood behaviour is provided in **section 17.4.3**.
	(b) any detrimental increases in the potential flood affectation of the project infrastructure and other properties, assets and infrastructure;	Consideration of potential flood affectation is provided in **section 17.3.1**, **section 17.3.2** and **section 17.4**.
	(c) consistency (or inconsistency) with applicable Council floodplain risk management plans;	Consistency with applicable floodplain risk management plans is provided in **section 17.3** and **17.4**.
	(d) compatibility with the flood hazard of the land;	Compatibility with the flood hazards is discussed in **section 17.3.1** and **section 17.4.1**.
	(e) compatibility with the hydraulic functions of flow conveyance in flood ways and storage areas of the land;	Compatibility with flood ways and storage areas is discussed in **section 17.3.1**.

Desired performance outcome	SEARs	Where addressed in the EIS
	(f) whether there will be adverse effect to beneficial inundation of the floodplain environment, on, or adjacent to or downstream of the site;	Beneficial inundation is discussed in **section 17.1.3**. The potential for adverse effects during construction and operation are provided in **section 17.3** and **section 17.4** respectively.
	(g) downstream velocity and scour potential;	Downstream velocities and scour potential are considered in **section 17.3.2** and **section 17.4.5**. Also refer to Chapter 15 (Soil and water quality).
	(h) impacts the development may have upon existing community emergency management arrangements for flooding. These matters must be discussed with the State Emergency Services and Council;	Emergency management arrangements for flooding are considered in **section 17.4.2**, including a commitment to discuss with the State Emergency Services and Council during the detailed design stage.
	(i) any impacts the development may have on the social and economic costs to the community as consequence of flooding;	Likelihood of social and economic impacts is provided in **section 17.4.4**.
	(j) whether there will be direct or indirect increase in erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses;	Refer to Chapter 15 (Soil and water quality) and Chapter 18 (Biodiversity).
	(k) any mitigation measures required to offset potential flood risks attributable to the project;	Mitigation and management measures are provided in **section 17.5**.
	2. The assessment should take into consideration any flood studies undertaken by local government councils, as available.	Relevant flood studies used are provided in **section 17.1.1** and **section 17.1.3** and Appendix Q (Technical working paper: Surface water and flooding).

Desired performance outcome	SEARs	Where addressed in the EIS
10. Water - Hydrology Long term impacts on surface water and groundwater hydrology (including drawdown, flow rates and volumes) are minimised. The environmental values of nearby, connected and affected water sources, groundwater and dependent ecological systems including estuarine and marine water (if applicable) are maintained (where values are achieved) or improved and maintained (where values are not achieved). Sustainable use of water resources.	1. The Proponent must describe (and map) the existing hydrological regime for any surface and groundwater resource (including reliance by users and for ecological purposes) likely to be impacted by the project, including stream orders, as per the FBA.	Refer to **section 17.2.3** for the existing hydrological regime for surface water resource. Refer to **Chapter 15** (Soil and water quality) for information on the hydrological regime. Refer to **Chapter 19** (Groundwater) for groundwater resource. Refer to **Chapter 18** (Biodiversity) for further consideration of the Framework for Biodiversity Assessment (FBA).
	2. The Proponent must prepare a detailed water balance for ground and surface water including the proposed intake and discharge locations, volume, frequency and duration for both the construction and operational phases of the project.	A water balance for surface water for construction and operation is summarised in **section 17.3** and **section 17.4** respectively and in detail in **Appendix Q** (Technical working paper: Surface water and flooding). Refer to **Chapter 19** (Groundwater) and **Appendix T** (Technical working paper: Groundwater) for groundwater inflow predictions.
	3. The Proponent must assess (and model if appropriate) the impact of the construction and operation of the project and any ancillary facilities (both built elements and discharges) on surface and groundwater hydrology in accordance with the current guidelines, including:	An assessment of potential surface hydrological impacts during construction and operation is provided in **section 17.3** and **section 17.4** respectively. Groundwater hydrology is assessed in **Chapter 19** (Groundwater).

Desired performance outcome	SEARs	Where addressed in the EIS
	(a) natural processes within rivers, wetlands, estuaries, marine waters and floodplains that affect the health of the fluvial, riparian, estuarine or marine system and landscape health (such as modified discharge volumes, durations and velocities), aquatic connectivity and access to habitat for spawning and refuge;	Refer to **section 17.3** and **section 17.4** for discharge impacts on hydrology and natural processes. Refer to **Chapter 15** (Soil and water quality) for geomorphological and scour impacts. Refer to **Chapter 18** (Biodiversity) for potential impacts on aquatic connectivity and access to habitat.
	(b) impacts from any permanent and temporary interruption of groundwater flow, including the extent of drawdown, barriers to flows, implications for groundwater dependent surface flows, ecosystems and species, groundwater users and the potential for settlement;	Refer to **Chapter 19** (Groundwater) for impacts on groundwater and **Chapter 18** (Biodiversity) for impacts on groundwater dependant ecosystems and species.
	(c) changes to environmental water availability and flows, both regulated/licensed and unregulated/rules-based sources;	Changes to environmental water availability and flows are discussed in **section 17.3.1**, **section 17.3.2** and **section 17.4.5** and in **Appendix Q** (Technical working paper: Surface water and flooding).
	(d) direct or indirect increases in erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses;	Refer to **Chapter 15** (Soil and water quality) and **Chapter 18** (Biodiversity).
	(e) minimising the effects of proposed stormwater and wastewater management during construction and operation on natural hydrological attributes (such as volumes, flow rates, management methods and re-use options) and on the conveyance capacity of existing stormwater systems where discharges are proposed through such systems; and	Proposed management measures are provided in **section 17.5**. Discussion on conveyance capacity is provided in **section 17.3** and **section 17.4**.

Desired performance outcome	SEARs	Where addressed in the EIS
	(f) water take (direct or passive) from all surface and groundwater sources with estimates of annual volumes during construction and operation.	Water balance and discharge volumes for surface water are provided in **section 17.4.5** and in detail in **Appendix Q** (Technical working paper: Surface water and flooding). Refer to **Chapter 19** (Groundwater) and **Appendix T** (Technical working paper: Groundwater) for groundwater balance and volumes.
	4. The Proponent must identify any requirements for baseline monitoring of hydrological attributes.	No monitoring of hydrological attributes in surface water bodies was considered to be required for the project given that no surface water extraction from urban waterways would be undertaken and considering the nature of the receiving waterways. Refer to **Chapter 19** (Groundwater) for groundwater attributes.
	5. The assessment must include details of proposed surface and groundwater monitoring.	For proposed surface water monitoring refer to **Chapter 15** (Soil and water quality). For proposed groundwater monitoring refer to **Chapter 19** (Groundwater).
	6. The proposed tunnels should be designed to prevent drainage of alluvium in the palaeochannels.	Refer to **Chapter 19** (Groundwater).

17.1 Assessment methodology

17.1.1 Relevant legislation, policies and guidelines

Relevant legislation

The *Water Act 1912* (NSW) and the *Water Management Act 2000* (NSW) (WM Act) are the two key pieces of legislation for the management of water in NSW and contain provisions for the licensing of water access and use. The *Water Act 1912* (NSW) is being progressively phased out and replaced by the WM Act, but its provisions remain in force in respect of areas of NSW where water sharing plans under the WM Act have not yet been made.

The objects of the WM Act are to provide for the sustainable and integrated management of the state's water sources for the benefit of both present and future generations. The WM Act implicitly recognises the need to allocate and provide water for the environmental health of our rivers and groundwater systems, while also providing licence holders with more secure access to water and greater opportunities to trade water through the separation of water licences from land. The WM Act manages the state's water resources through water sharing plans. The water sharing plans are used to set out the rules for the sharing of water in a particular water source between water users and the environment and rules for the trading of water in a particular water source.

The project is located within an area covered by the *Water Sharing Plan for the Greater Metropolitan Region Unregulated River Water Sources* (DPI-Water 2011). This Plan includes rules for protecting the environment, water extraction, managing licence holders' water accounts, and water trading within the plan area.

The Sydney Regional Environmental Plan (Sydney Harbour Catchment) 2005 is also relevant to this flooding and drainage assessment. Waterway zones have been specifically tailored to suit the differing environmental characteristics and land uses of the harbour. This has resulted in a stronger zoning system that provides greater clarity and certainty for applicants and consent authorities in development considerations and applications. Definitions of the different zones are provided in the Sydney Regional Environmental Plan (Sydney Harbour Catchment) 2005.

Relevant policy and guidelines

The assessment of potential flooding impacts of the project on existing flood regimes has been conducted in accordance with the requirements of the *Floodplain Development Manual* (NSW Department of Infrastructure, Planning and Natural Resources, now the NSW Office of Environment and Heritage (OEH) 2005), which incorporates the NSW Government’s Flood Prone Land Policy. The key objectives of this policy are to identify potential hazards and risks, reduce the impact of flooding and flood liability on owners and occupiers of flood prone property, and to reduce public and private losses resulting from floods. This policy also recognises the benefits of the use, occupation and development of flood prone land.

Other relevant government policies and guidelines were also considered as part of the assessment of the project’s potential flooding and drainage impacts. These are outlined in **Appendix Q** (Technical working paper: Surface water and flooding) and in **Chapter 15** (Soil and water quality).

The floodplain planning provisions of the local environmental plans and development control plans applicable to the Inner West (formerly Ashfield, Leichhardt and Marrickville) and the City of Sydney local government areas (LGAs) were considered as part of this assessment. The assessment undertaken in **Appendix Q** (Technical working paper: Surface water and flooding) is generally consistent with the various flood studies undertaken by the Inner West and City of Sydney LGAs.

17.1.2 Study area

The study area for the flooding and drainage assessment includes the project’s surface construction and operational footprints, as well as areas where potential surface water and flooding impacts could occur as a result of the construction or operation of the project. **Figure 17-1** shows the study area for the flooding and drainage assessment.

Twelve construction ancillary facilities are described and assessed in this EIS. To assist in informing the development of a construction methodology that would manage constructability constraints and the need for construction to occur in a safe and efficient manner, while minimising impacts on local communities, the environment, and users of the surrounding road and other transport networks, two possible combinations of construction ancillary facilities at Haberfield and Ashfield have been assessed in this EIS. The construction ancillary facilities that comprise these options have been grouped together in this EIS and are denoted by the suffix a (for Option A) or b (for Option B).

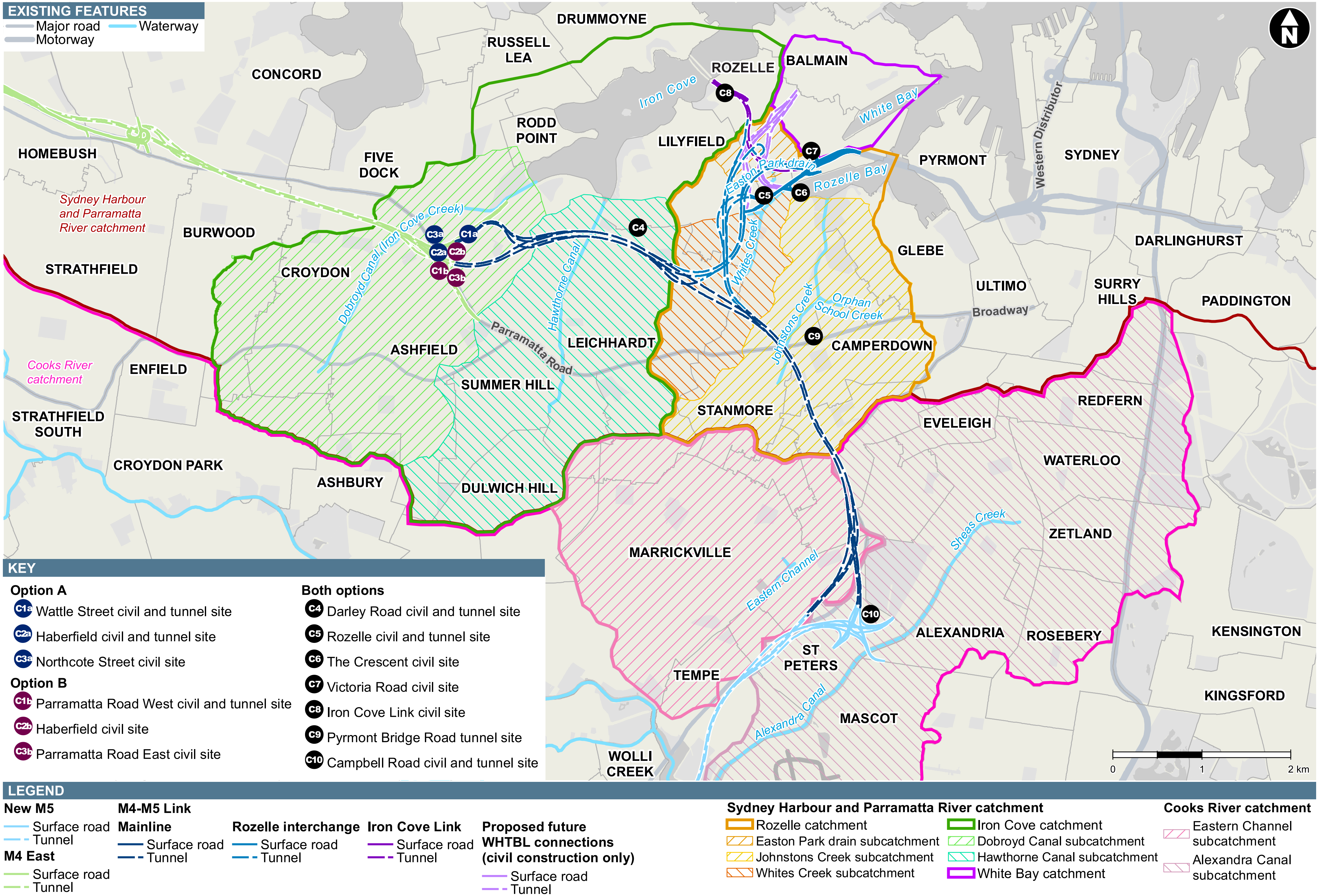


Figure 17-1 Flooding and drainage assessment study area

17.1.3 Method of assessment

The approach taken to assessing the potential flooding and drainage impacts associated with the project included:

- A desktop review and analysis of existing information to characterise the existing environment, identify surface water receptors, existing flood behaviours and drainage infrastructure, and identify potential issues
- A field assessment to confirm and supplement the findings of the desktop analysis and refine understanding of potential issues
- Assessment of potential construction and operational impacts (including cumulative impacts) related to flooding, drainage, and surface water, including hydrologic and hydraulic flood modelling where required
- Identification of appropriate measures to mitigate potential impacts.

Desktop analysis

A desktop analysis was carried out to determine the existing surface water environment within the study area and qualitatively assess potential impacts. The desktop analysis included consideration of:

- Readily available data and information from previous studies on surface water within the study area. This included previous flooding and surface water studies that have been used to inform the M4 East EIS and New M5 EIS
- Other technical working papers included in this EIS, including those relating to groundwater, contamination and biodiversity.

The studies and models that were reviewed as part of this assessment are listed in **Appendix Q** (Technical working paper: Surface water and flooding). The key studies included:

- Whites Creek Catchment Management Study (Sydney Water 1990)
- Johnstons Creek SWC55 Capacity Assessment (Sydney Water 1995)
- Hawthorne Canal Flood Study, Final Draft (Ashfield and Marrickville Councils 2013a, WMAwater)
- Dobroyd Canal Flood Study, Final Draft (Ashfield and Burwood Councils 2013b, WMAwater)
- Johnstons Creek Catchment Flood Study (City of Sydney Council 2015, WMAwater)
- Leichhardt Flood Study (Leichhardt Council 2014a, Cardno)
- Alexandra Canal Catchment Flood Study (City of Sydney Council 2014b, Cardno).

Information on the existing environmental conditions within the study area was collected from the following sources:

- The Inner West Council and the City of Sydney Council
- NSW Government agencies: NSW Roads and Maritime Services (Roads and Maritime), Sydney Motorway Corporation (SMC), UrbanGrowth NSW, Sydney Water and Transport for NSW.

Field assessment

Field assessments were undertaken to visually assess the locations of the proposed surface elements and understand the potential flood risk associated with the project. Field assessments were conducted over three separate occasions in 2016.

Impact assessment

The assessment of surface water quality impacts during project construction and operation is provided in **Chapter 15** (Soil and water quality). A staged approach was undertaken to determine the level of assessment required for flooding. This enabled the assessments to be tailored to individual sites and targeted towards the locations considered to be at greatest risk of flooding.

The level of assessment required was determined by considering:

- Existing flood risk information
- Flood risk to the project, including tunnel portals and construction ancillary facilities
- Potential flooding impacts on surrounding areas as a result of the project, including other properties, assets and infrastructure.

Adopting this approach enabled consideration of areas that could potentially be subject to a high flood risk during the design of the interchanges and construction sites. This included identifying opportunities to:

- Provide easements from areas identified at risk of flooding to maintain existing flow paths, where feasible
- Locate land uses across the site based on vulnerability to flooding. For example, locating car parks in areas of a site considered at high risk of flooding and placing tunnel ramps away from areas of flooding.

The process for establishing flood risk and the level of assessment required is provided in **Figure 17-2**. Surface features within the study area associated with the project (interchanges and construction sites) were assessed through this process. On this basis, it was identified that quantitative assessments would be required for the Rozelle interchange, Iron Cove Link and Darley Road sites.

The SEARs for the project refer to 'adverse effect on beneficial inundation'. Beneficial inundation is considered to be more applicable to natural wetland habitats or a rural agricultural environment. Therefore, in the context of this EIS and considering that the project is located in a highly urbanised environment, the flood assessment has considered adverse effects on general flooding behaviour on, or adjacent to, the site.

Quantitative assessment

For locations where a quantitative assessment was required, the following approach was undertaken:

- Development of new hydrologic and hydraulic flood models
- Running of the flood models to identify flood behaviour under present day (pre-project) conditions for the 10 year, 100 year average recurrence interval (ARI) events, as well as the probable maximum flood (PMF)
- Assessment of the potential impact the project would have on flooding characteristics during and post-construction
- Assessment of the impact a partial blockage of major hydraulic structures would have on flood behaviour under post-construction conditions
- Assessment of the impact that future climate change would have on flood behaviour under post-construction conditions.

The 10 year ARI, 100 year ARI and PMF design events were chosen for the quantitative assessment as they represent a range of different flood events from more frequent (ie 10 year ARI) to extreme event (ie PMF). The flood behaviour across the three events was found to be very similar. Therefore, the assessment of other design events is likely to result in similar outcomes. Further detail on the methodology adopted for locations that required a quantitative assessment is provided in Annexure C of **Appendix Q** (Technical working paper: Surface water and flooding). The potential impacts on the project from flooding caused by climate change are addressed in **Chapter 24** (Climate change risk and adaptation).

Process for establishing flood risk and the level of assessment required

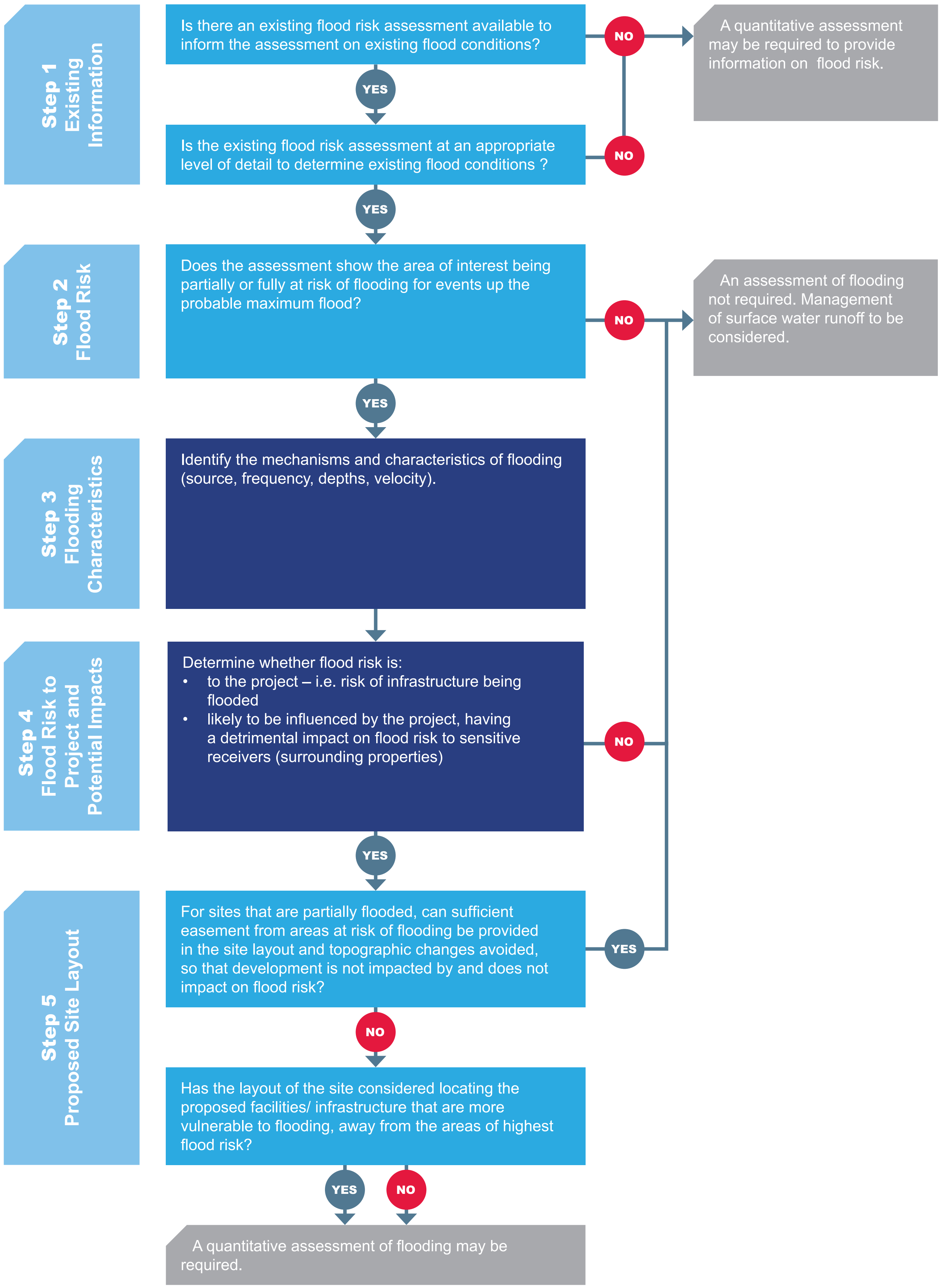


Figure 17-2 Process for establishing flood risk

Hydrologic standards

The standards adopted in the assessment of transverse drainage and flood mitigation measures were established in accordance with the *Floodplain Development Manual* (OEH 2005) and current Roads and Maritime standards. The hydrologic standards adopted are based on matching the level of protection to the risk and consequence of flooding. The standards adopted for the project infrastructure and the impacts on existing developments are summarised in **Table 17-2**.

Table 17-2 Hydrologic standards

Project infrastructure	Standard
Tunnel portals and ancillary facilities (ventilation facility, water treatment plants, substations)	Located above the PMF level or the 100 year ARI flood level plus 0.5 metres freeboard (whichever is greater).
Emergency response facilities (motorway control centre, fire water tank, pump buildings)	Located above the PMF level or the 100 year ARI flood level plus 0.5 metres freeboard (whichever is greater).
Modifications to existing road network	Modifications to existing roads at their point of connection to the project are to be configured such that the existing level of flood immunity is maintained. Temporary modifications to existing roads during the construction staging would maintain the existing level of flood immunity where feasible, taking the duration of the construction stages into consideration.
Impacts on existing development	**Standard**
Operational	The 100 year ARI flood standard is to be adopted in the assessment of measures required to mitigate any adverse flooding impacts attributable to the project. Changes in flood behaviour under PMF conditions would be assessed to identify impacts on critical infrastructure and significant changes in flood hazard resulting from the project.
Construction	Construction-related flood risks and impacts need to be evaluated in the context of the construction period to set requirements that are commensurate to the period of time that the risk exposure occurs. To this end, the assessment identifies the risks and potential impacts associated with construction activities at the site so that informed decisions can be made on the flood criteria to be set as part of the flood risk management plan for the construction of the project.

17.2 Existing environment

A general description of the geomorphology and water quality of the existing catchment and watercourse environments is provided in **Chapter 15** (Soil and water quality). This section outlines:

- Catchments and watercourses within the study area
- Existing drainage infrastructure and surface water management infrastructure of the study area
- The existing flood behaviour of the study area.

17.2.1 Catchments and watercourses

Descriptions of catchments and key waterways within the Sydney Harbour and Parramatta River catchment that have the potential to be impacted by the project are provided in **Chapter 15** (Soil and water quality). Mapping of the existing hydrological regimes is provided in **Appendix Q** (Technical working paper: Surface water and flooding).

The predominant waterways within the Sydney Harbour and Parramatta River catchment that would be traversed or affected by the project include Dobroyd Canal (Iron Cove Creek), Hawthorne Canal, Whites Creek, Johnstons Creek and Easton Park drain. Dobroyd Canal (Iron Cove Creek) and Hawthorne Canal discharge into Iron Cove, while Whites Creek, Johnstons Creek and Easton Park drain discharge into Rozelle Bay.

Figure 17-1 shows the waterways and associated catchments within the study area that are intersected by or downstream of the project.

Dobroyd Canal (Iron Cove Creek)

Dobroyd Canal, also known as Iron Cove Creek, drains parts of the inner west suburbs of Ashfield, Burwood, Haberfield, Croydon, Drummoyne and Canterbury and discharges into Iron Cove (Cardno Lawson Treloar 2008). The canal is tidal to upstream of Parramatta Road.

The canal, which is owned and managed by Sydney Water for trunk line drainage, is shown in **Figure 17-3** and comprises an open concrete-lined channel between Iron Cove and the intersection of Carshalton and Norton streets with underground branches extending upstream. This waterway runs parallel to the Wattle Street interchange and the tunnel portal of the project. Riparian areas are grassed or planted native and exotic vegetation. Construction ancillary facilities (identified in **Figure 17-1**) that are located within the Dobroyd Canal (Iron Cove Creek) catchment include:

- Wattle Street civil and tunnel site (C1a)
- Haberfield civil and tunnel site (C2a)/Haberfield civil site (C2b)
- Northcote Street civil site (C3a)
- Parramatta Road West civil and tunnel site (C1b) and Parramatta Road East civil site (C3b).

The Wattle Street interchange would drain to Dobroyd Canal (Iron Cove Creek) during operation of the WestConnex program of works.

Figure 17-3 Dobroyd Canal (Iron Cove Creek) at Timbrell Park

Hawthorne Canal

Hawthorne Canal starts in Lewisham and flows into Iron Cove at Dobroyd Point. The channel, which is owned and managed by Sydney Water for trunk line drainage, is shown in **Figure 17-4** and is generally constructed from unreinforced concrete with the base of the channel comprising paved brick for a section upstream of Parramatta Road (Sydney Water 2014).

The main channel is tidal to upstream of Parramatta Road and the channel width varies from about two metres in upper areas to about 22 metres at its confluence with Iron Cove (WMAWater 2013a). The project’s tunnel alignment crosses beneath Hawthorne Canal adjacent to Hawthorne Parade, about 300 metres upstream of Iron Cove. The proposed operational water treatment plant at Darley Road, Leichhardt, would discharge to Hawthorne Canal. The Darley Road civil and tunnel site (C4) is located within the catchment.

Figure 17-4 Hawthorne Canal at Blackmore Park

Whites Creek

Whites Creek is a brick and concrete-lined channel, which is owned and managed by Sydney Water for trunk line drainage that flows through the suburbs of Leichhardt and Marrickville, discharging into Rozelle Bay. The channel is shown in **Figure 17-5** and varies between circular and covered sections in the upper reach, and open channel sections in the lower reach.

The lower reach of Whites Creek is located to the south of the proposed Rozelle interchange and associated road upgrades. Proposed works in this area include the redevelopment of City West Link and The Crescent intersection, and the construction of new culverts into Rozelle Bay. There would also be an upgrade and widening of the existing bridge structure that crosses Whites Creek at The Crescent. The Crescent civil site (C6) is located around the junction of Whites Creek and Rozelle Bay.

Sydney Water is investigating potential opportunities for naturalisation within a section of Whites Creek at Annandale. A concept design has been developed for the Whites Creek naturalisation project, which includes the replacement of deteriorating concrete banks and low flow channel with a combination of rocks, native plants and sandstone blocks or concrete.

The Sydney Water naturalisation works at Whites Creek would be located adjacent to Railway Parade and Hutchinson Lane at Annandale, to the south of the proposed Rozelle interchange. Construction timeframes for these naturalisations works are not currently known. Channel naturalisation works extending from Rozelle Bay to the re-aligned The Crescent would be carried out as part of the project to integrate with Sydney Water's naturalisation works.

Figure 17-5 Whites Creek at Brenan Street

Johnstons Creek

The Johnstons Creek catchment is situated within the suburbs of Glebe, Annandale, Petersham and Newtown, immediately west of the Sydney central business district (CBD). The channel, which is owned and managed by Sydney Water for trunk line drainage, consists of a wide open concrete section at the Rozelle Bay end and brick walls further upstream.

The project's mainline tunnel alignment is proposed to traverse beneath Johnstons Creek adjacent to Bridge Street, Stanmore, south of Parramatta Road. The Pyrmont Bridge Road tunnel site (C9) is located within the Johnstons Creek catchment.

Sydney Water is investigating potential opportunities for naturalising a section of Johnstons Creek at Annandale. The potential works on Johnstons Creek proposed by Sydney Water extend from Rozelle Bay to around 20 metres south of The Crescent. The construction schedule for the works is currently unknown.

Easton Park drain

Easton Park drain conveys runoff from the suburb of Rozelle and runs between Denison Street adjacent to Easton Park and Rozelle Bay. The drain originates from a series of stormwater networks that discharge into a brick-lined, open channel south of Lilyfield Road. The open channel section passing through the industrial area between Lilyfield Road and the Rozelle Rail Yards is about 175 metres long and shown in **Figure 17-6**. The open channel then discharges into a culvert that runs underneath the Rozelle Rail Yards and into Rozelle Bay, to the east of the intersection of City West

Link and The Crescent. Observations of the outfall into Rozelle Bay suggest that discharges from the culvert are influenced by tidal fluctuations in Rozelle Bay.

Easton Park drain passes through the proposed Rozelle interchange, and also the Rozelle civil and tunnel site (C5), from Lilyfield Road in the north to Rozelle Bay in the south. It is proposed to divert Easton Park drain into a new channel to convey flows through Rozelle Rail Yards, with the former Easton Park drain decommissioned. An upsized culvert would be provided to discharge flows into Rozelle Bay.

Figure 17-6 Easton Park drain adjacent to Lilyfield Road

Rozelle Bay

The Rozelle Bay catchment (see **Figure 17-7**) is highly urbanised and comprises an area of about 857 hectares. Rozelle Bay is located between the suburbs of Glebe, Annandale, Lilyfield and flow inputs include Whites Creek, Johnstons Creek and Easton Park drain. The foreshore is actively used for recreational fishing and boating by NSW patrol vessels and maritime industries including the Sydney Heritage Fleet located on the western shore of Rozelle Bay. Rozelle Bay is classified as W1 Maritime Waters under the Sydney Regional Environmental Plan (Sydney Harbour Catchment) 2005*.* The edges of the bay are either fully developed, with some retaining walls and relatively narrow, or mainly grassed riparian areas.

Rozelle Bay would be a receiving waterbody for discharge from the operational water treatment plant at Rozelle and runoff from the proposed Rozelle interchange and associated road upgrades. A new outlet would be constructed within Rozelle Bay to receive the stormwater flows from the Rozelle interchange. The Rozelle civil and tunnel site (C5) and The Crescent civil site (C6) are located within the Rozelle Bay catchment. The Victoria Road civil site (C7) is located on the boundary of Rozelle Bay and White Bay catchments.

Figure 17-7 Rozelle Bay foreshore

White Bay

The White Bay catchment is surrounded by the suburbs of Balmain and Rozelle with White Bay wharf and White Bay Cruise Terminal to the north and Glebe Island to the south. White Bay is classified as W1 Maritime Waters in the Sydney Regional Environmental Plan (Sydney Harbour Catchment) 2005.

The Victoria Road civil site (C7) is located on the boundary of the White Bay and Rozelle Bay catchments. A portion of the proposed Victoria Road upgrade between Hornsby Street and Robert Street would drain to White Bay. Drainage along this section of road would be reinstated as part of the road upgrade with connection to the existing drainage network on Victoria Road. The location and size of the drainage works would be confirmed during detailed design, assessed as necessary and managed in accordance with the measures outlined in **Appendix F** (Utilities Management Strategy).

Iron Cove

Iron Cove is a bay within the Parramatta River estuary. **Figure 17-8** shows an image of Iron Cove immediately downstream of Iron Cove Bridge. Dobroyd Canal (Iron Cove Creek) and Hawthorne Canal both discharge into Iron Cove.

A portion of the proposed road upgrades (ie the widening of a section of Victoria Road) associated with the Iron Cove Link would drain into Iron Cove, using existing outlets or via a new direct drainage outlet should the existing outlets not be suitable. The proposed Iron Cove Link civil site (C8) and bioretention basin and car park improvement works within King George Park, adjacent to Manning Street at Rozelle, would be located within the Iron Cove catchment.

Figure 17-8 Iron Cove immediately downstream of Iron Cove Bridge

Alexandra Canal

The Alexandra Canal catchment (including Sheas Creek) includes the suburbs of Alexandria, Rosebery, Erskineville, Beaconsfield, Zetland, Waterloo, Redfern, Newtown, Eveleigh, Surry Hills and Moore Park. The catchment is heavily altered, predominantly covered by commercial, industrial and residential development, with a small amount of parkland such as Sydney Park and Moore Park (see **Figure 17-9**).

Alexandra Canal flows into the Cooks River near the north-western corner of Sydney Airport. As it was originally built for navigation by boat for transportation purposes, it is much larger than technically required to convey stormwater from the catchment.

The project’s proposed underground connection to the St Peters interchange and ventilation facility, as well as the Campbell Road civil and tunnel site (C10), would be within the Alexandra Canal catchment.

Figure 17-9 Alexandra Canal downstream of Canal Road

Eastern Channel

The mainline tunnel alignment runs through part of the catchment of the Eastern Channel that is located near Murray Street, Marrickville to its confluence with the Cooks River adjacent to Tempe Station. However, no surface works or discharges, surface operational facilities or surface carriageways are proposed within the catchment. As such the project is not expected to impact the channel. No further assessment of the Eastern Channel in relation to flooding and drainage impacts has been undertaken.

17.2.2 Drainage

Due to the extensive urban nature of the study area, there is a dense network of drainage infrastructure conveying stormwater flows for small storm events. These drainage features are illustrated and discussed in detail in **Appendix Q** (Technical working paper: Surface water and flooding).

This network manages stormwater flows predominantly from the roads and impervious areas of the catchments before discharging into the local waterways and canals, including Dobroyd Canal (Iron Cove Creek), Hawthorne Canal, Easton Park drain, Whites Creek, Johnstons Creek and Alexandra Canal. During larger storm events when the capacity of the existing drainage system is exceeded, runoff flows overland to these waterways and canals.

The former Rozelle Rail Yards site is an area that has little known formal drainage other than:

- The Easton Park drain and associated drains in the north of the site
- An open channel running west to east along the base of the rock-wall to the south of Lilyfield Road, between Denison Street and Cecily Street. The channel discharges into a culvert underneath 92–94 Lilyfield Road. It is likely that this drain discharges into the Easton Park drain
- A small number of pits and pipes found throughout the site.

The existing drainage infrastructure on the former Rozelle Rail Yards site is likely to be of relatively poor condition as a consequence of its age and a lack of maintenance since the site ceased to be an active rail facility in the late 1990's. The Easton Park drain is the only known discharge point from the northern section of the site.

From the limited drainage information available for the Rozelle Rail Yards, it is expected that rainfall and runoff from the site would generally drain through a combination of infiltration, evaporation and the local drainage network (condition unknown). Observations made on-site following rainfall, indicate that water pools across the site including at the stormwater pits adjacent to (east of) the existing workshop in the southwest corner.

There are some Sydney Water and Council road drainage assets near the former Rozelle Rail Yards, some of which connect into the Easton Park drain. The catchment to the northwest of the proposed Rozelle interchange is connected to Whites Creek via a brick-arch culvert that passes underneath the CBD and South East Light Rail site and the Inner West Light Rail line. This provides a sub-surface connection between Whites Creek and a catchment north of Lilyfield Road.

At Iron Cove, there is an Inner West Council stormwater drainage system serving the existing road network to the southeast and east of the proposed Iron Cove Link. The drainage network on Victoria Road is reported to generally consist of pipes 300 millimetres to 450 millimetres in diameter.

To the south of the proposed Darley Road tunnel and civil site (C4), an Inner West Council stormwater drainage system serves the road network. The drainage network on Darley Road is reported to consist of pipes 2,400 millimetres in diameter receiving surface water inputs from drainage to the east and to the south.

The age or quality of some of these existing stormwater drainage assets may reflect the age of the buildings and houses in the area. Therefore, some of the assets are potentially nearing, at, or beyond the end of their design life. The stormwater network is owned by Sydney Water and the Local Government authorities (Inner West and City of Sydney councils).

A number of drainage networks would need to be crossed by the proposed road alignment, particularly in areas where the proposed road works are at or near the surface ie the western and southern ends of the project, interchanges, cut-and-cover sections and tunnel portals.

17.2.3 Hydrology and flooding

Flood risk in the study area has increased since the onset of urbanisation, as a consequence of:

- Development occurring prior to the installation of road drainage systems in the 1900s
- Development occurring in overland flow paths or in localised topographic depressions and encroaching into floodplains, which reduces storage capacity
- Culverting and channelisation of watercourses which increases the speed of water travelling through the system
- Increases in impermeable land, resulting in increased runoff during rainfall events.

This means that the watercourse flow rates and water levels respond more quickly to rainfall events, due to reduced storage and infiltration capability within the catchments. Areas affected by flooding (local and regional) are discussed below.

Council flood studies have been prepared for the major catchments that the project would cross. The main one is the Leichhardt Flood Study (Cardno 2014a), undertaken in 2015. The new Inner West Council is currently considering that flood study in their preparation of a Floodplain Risk Management Study and Plan for the new Council. In the absence of a floodplain risk management plan, the assessment of flood behaviour (existing and future) has therefore been based on the Leichhardt Flood Study.

Existing flood behaviour

Wattle Street interchange

The Wattle Street interchange (part of the M4 East project) is in the catchment of Dobroyd Canal (Iron Cove Creek). Due to the interface of this project with the M4 East project and timing for completion of these projects, the ‘existing’ flood conditions at the Wattle Street interchange has been taken to be the post-construction situation for the M4 East project. This is because the flood conditions at this location would change after completion of the M4 East project, and new flood mitigation measures would be in place to protect the M4-M5 Link project upon completion. Cumulative assessment of flood impacts is provided in **Chapter 26** (Cumulative impacts).

The western section of the interchange is not affected by creek flooding, only by localised stormwater runoff. Mitigation measures, such as local piped drainage systems, an on-site detention basin, and an overland flow path would be delivered by the M4 East project to capture local runoff upstream and connect into the new interchange drainage system. Excess flows in events greater than the 100 year ARI up to the PMF would be diverted around the western tunnel portal towards Parramatta Road.

The eastern end of the interchange is affected by flooding from Dobroyd Canal (Iron Cove Creek). The road crest for the eastern tunnel portal has been located above the PMF level to prevent flooding of the tunnel portals. The tunnel ventilation facility at the Wattle Street interchange (Parramatta Road ventilation facility) is also protected from flooding in events up to the PMF.

For the Wattle Street interchange, the mitigation measures provided by the M4 East project mean that the risk of flooding to the M4-M5 Link project at this location from a PMF is considered to be low. As the M4-M5 Link would not change the design surface layout or levels of the interchange, the impact of the project is considered to be negligible and no additional mitigation measures are necessary at this location. Therefore, a quantitative assessment of impacts at this location is not required.

St Peters interchange

The St Peters interchange (delivered as part of the New M5 project) is in the catchment of Alexandra Canal. Because the New M5 would be primarily delivered before the M4-M5 Link project, the 'existing' flood conditions at the St Peters interchange are represented by the post-construction situation for the New M5 project.

The St Peters interchange is generally not affected by flooding from Alexandra Canal and only the area around the intersection of Campbell Road and Burrows Road is flood affected in events up to the 100 year ARI. Critical infrastructure, such as the motorway operations complexes are generally located above the PMF level, including the tunnel ventilation facility at the interchange.

The design of the New M5 project is providing enabling works for the M4-M5 Link project construction site within the St Peters interchange, including provision of flood mitigation measures. As a result, the risk of flooding to the M4-M5 Link project from a PMF is considered to be low and no additional mitigation measures are necessary for the project at this location. A quantitative assessment of impacts at this location is therefore not required.

Rozelle interchange

The Rozelle interchange would be located within and adjacent to the Rozelle Rail Yards in the catchment of Rozelle Bay and Whites Creek. The Rozelle Rail Yards is comprised of reclaimed land located within a disused rail cutting. The site spans a topographic low with levels ranging from about two metres to seven metres Australian Height Datum (AHD). The site is bound by excavated, near-vertical rock walls up to eight metres high along the northern boundary and a fill-embankment in the southwest section adjacent to City West Link.

Two watercourses are located within this section of the study area: Easton Park drain and Whites Creek. The Easton Park drain drains a heavily urbanised catchment of around 55 hectares to the north of the Rozelle Rail Yards and discharges to Rozelle Bay through a combination of stormwater pipes, lined open channel and culverted reaches. Once it has passed under Lilyfield Road the drain is an open concrete lined section for about 170 metres through the Industrial Estate on Lilyfield Road. It then flows into a culvert passing under the Rozelle Rail Yards before discharging to Rozelle Bay just east of the intersection of City West Link and The Crescent. Observations of the outfall suggest that discharges from the culvert are influenced by tidal fluctuations at Rozelle Bay.

Whites Creek is located to the south of both the Rozelle Rail Yards and City West Link. The watercourse drains a dense urban catchment area of around 262 hectares originating about 1.9 kilometres southwest of the Rozelle Rail Yards. The upstream section of the creek is conveyed within a culverted system, owned by Sydney Water, flowing in a north-easterly direction before discharging into an open channel at Annandale. Downstream near the proposed Rozelle interchange, Whites Creek is a brick and concrete lined open channel about nine metres wide. It is spanned by several road and rail crossings near the Rozelle Rail Yards and discharges into Rozelle Bay immediately east of The Crescent and is also tidally influenced.

Although there is no known direct surface water connection between the Rozelle Rail Yards site and Whites Creek, there are potential indirect surface pathways, including:

- The adjacent Inner West Light Rail line passes underneath City West Link and may present a pathway for surface water to exchange between the Rozelle Rail Yards site and a drain that discharges into Whites Creek
- In extreme rainfall events, surface water potentially flowing across City West Link and into the lower reaches of Whites Creek near The Crescent or vice versa.

Rozelle Bay is about 65 metres south of the Rozelle Rail Yards. The Bay is tidal and receives urban runoff from the suburbs of Rozelle, Lilyfield, Annandale, Glebe and Forest Lodge. On average the Bay experiences two tidal cycles a day with a mean high water springs level of 0.69 metres AHD and mean low water spring level of -0.64 metres AHD reported for Port Jackson.

The Leichhardt Flood Study suggests that a significant area of the Rozelle Rail Yards site would be inundated with floodwater in the five year ARI event, with localised depths of over 0.5 metres on Lilyfield Road near Easton Park. A larger area would be inundated during the 100 year ARI event with depths of up to one metre on Lilyfield Road adjacent to Easton Park.

Flooding along Whites Creek is fairly well confined to the main channel, but there are breakout areas mainly along the southeast bank, affecting properties along Railway Parade in particular. Both The Crescent and City West Link have 100 year ARI flood immunity from creek flooding under existing conditions in the vicinity of the study area. Some ponding occurs on these roads due to localised pavement runoff.

The flood extent and depth maps suggest that the Rozelle Rail Yards site acts as a storage area for floodwater. The site of the proposed Rozelle interchange is classed as a flood control lot in the Leichhardt Development Control Plan (Leichhardt Council 2013).

As the site is below the flood planning level and is flood prone land (potentially impacted by the PMF), it is considered to be at high risk of flooding. A quantitative assessment of flood risk was therefore undertaken for the Rozelle interchange.

The results of the flood modelling of existing conditions shows that the Rozelle Rail Yards site is subject to surface water inputs through both piped drainage discharges and overland flow, from a number of external catchments to the north and west. More details on the flood model development are provided in **Appendix Q** (Technical working paper: Surface water and flooding).

As the Rozelle Rail Yards site is within a topographic low, it receives runoff from relatively steep, contributing catchments to the north and west. This, combined with the limited capacity of the local drainage network, means that the site functions as a floodway for overland flow and provides a significant area for floodwater storage. Floodways are areas of the floodplain where a significant discharge of water occurs during floods. They are areas that, even if only partially blocked, would cause a significant redistribution of floodwaters or a significant increase in flood levels.

The main surface outlet from the Rozelle Rail Yards is at a low point on City West Link, where excess floodwater spills over the road and discharges into Rozelle Bay. However, overtopping of City West Link currently occurs in relatively large, infrequent flood events greater than the 100 year ARI.

The existing flood conditions for the 10 and 100 year ARI design events and PMF are shown in **Figure 17-10** to **Figure 17-12**. The figures highlight that the Rozelle Rail Yards site currently provides a large area of surface water storage during these events. During the PMF event, depths across the site reach over 1.5 metres at the low point near the intersection with The Crescent. Areas of higher ground along City West Link at the southern boundary of the site and along Lilyfield Road to the northeast are outside of the PMF flood extent.

Flow velocities across the site during flood events are generally low. For example, in the 100 year ARI event, peak flow velocities are less than 0.5 metres per second across the most of the site, and typically less than 0.2 metres per second. Zones of faster moving floodwaters up to around two metres per second occur in the vicinity of the existing workshop in the southwest corner of the site.

Flood hazards according to the *Floodplain Development Manual* (NSW Government 2005) are shown in **Figure 17-13** for the 100 year ARI. Easton Park drain and Whites Creek, as well as its overbank areas including sections of Railway Parade, are considered high flood hazard zones. This is consistent with the Leichhardt Flood Study. The Rozelle Rail Yards site is generally a low flood hazard area, except for a small area near Victoria Road.

The Rozelle Rail Yards site is generally not subject to flooding from Whites Creek as the Inner West Light Rail line and City West Link provide physical barriers to flow. However, during the PMF, Whites Creek overtops the structure at The Crescent and flows in an easterly direction along City West Link, merging the floodwaters from the Rozelle Rail Yards and Whites Creek.

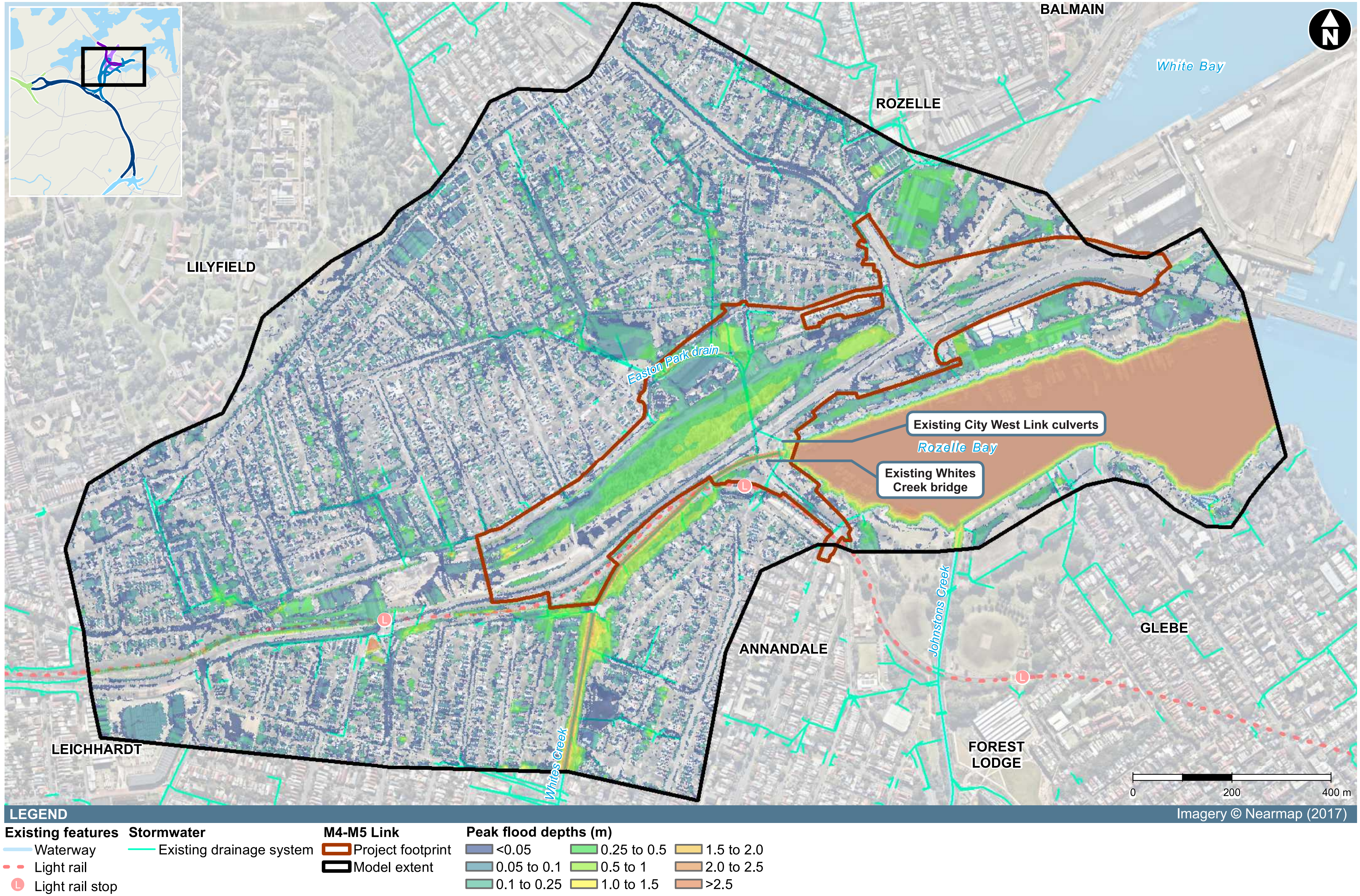


Figure 17-10 Present day flood behaviour – Rozelle interchange - peak flood depths (10 year ARI)

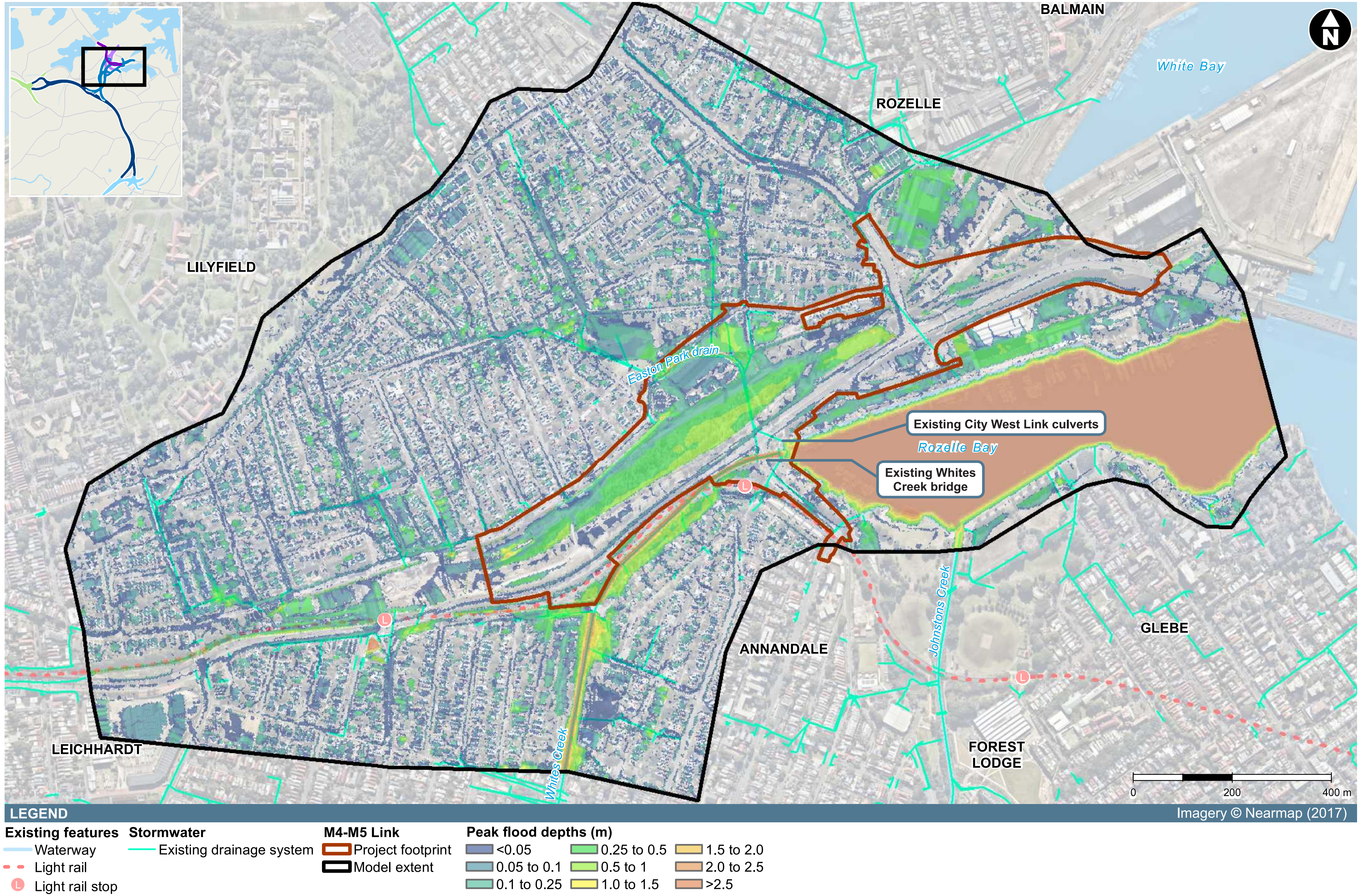


Figure 17-11 Present day flood behaviour – Rozelle interchange - peak flood depths (100 year ARI)

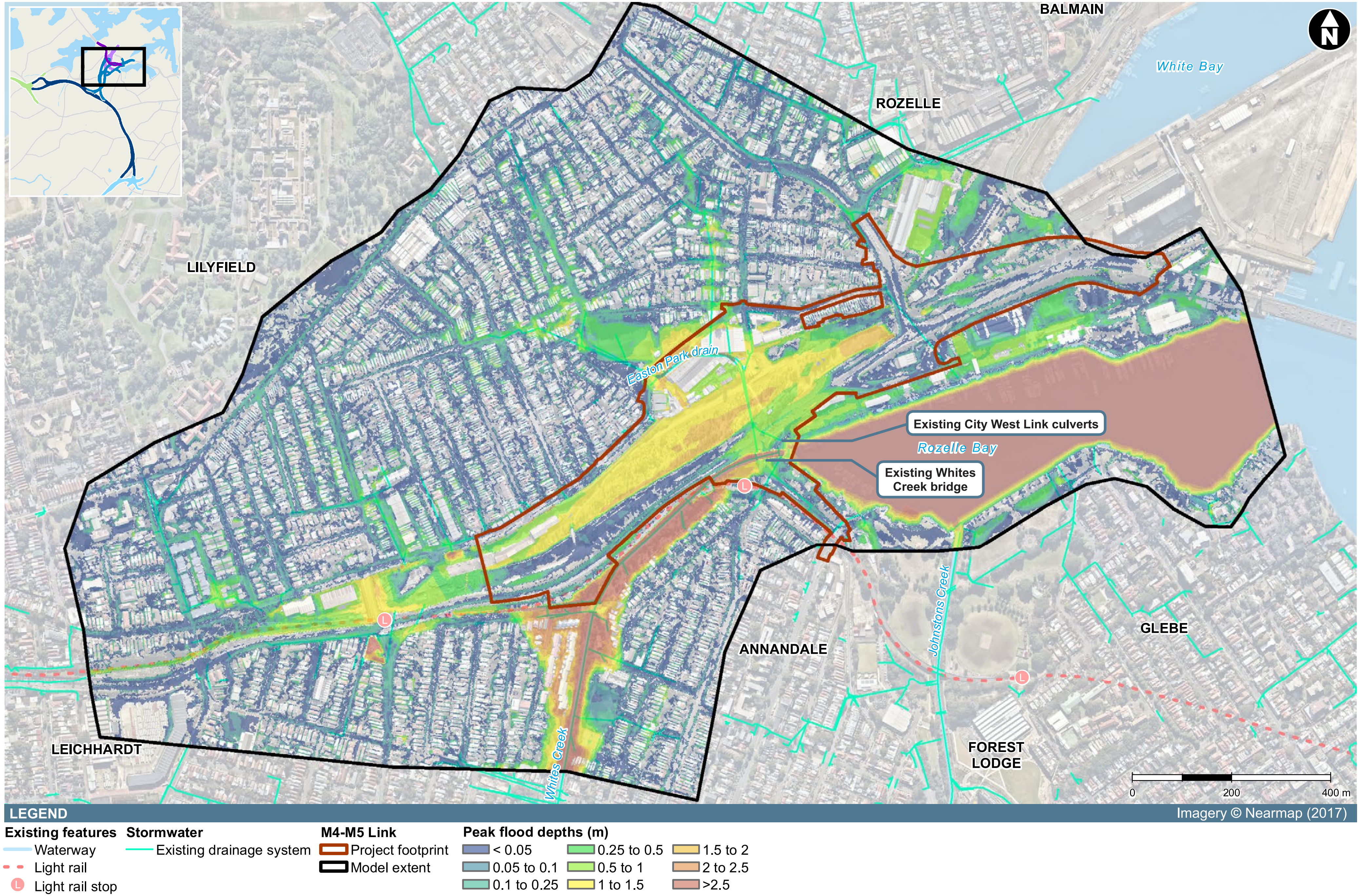


Figure 17-12 Present day flood behaviour – Rozelle interchange - peak flood depths (PMF)

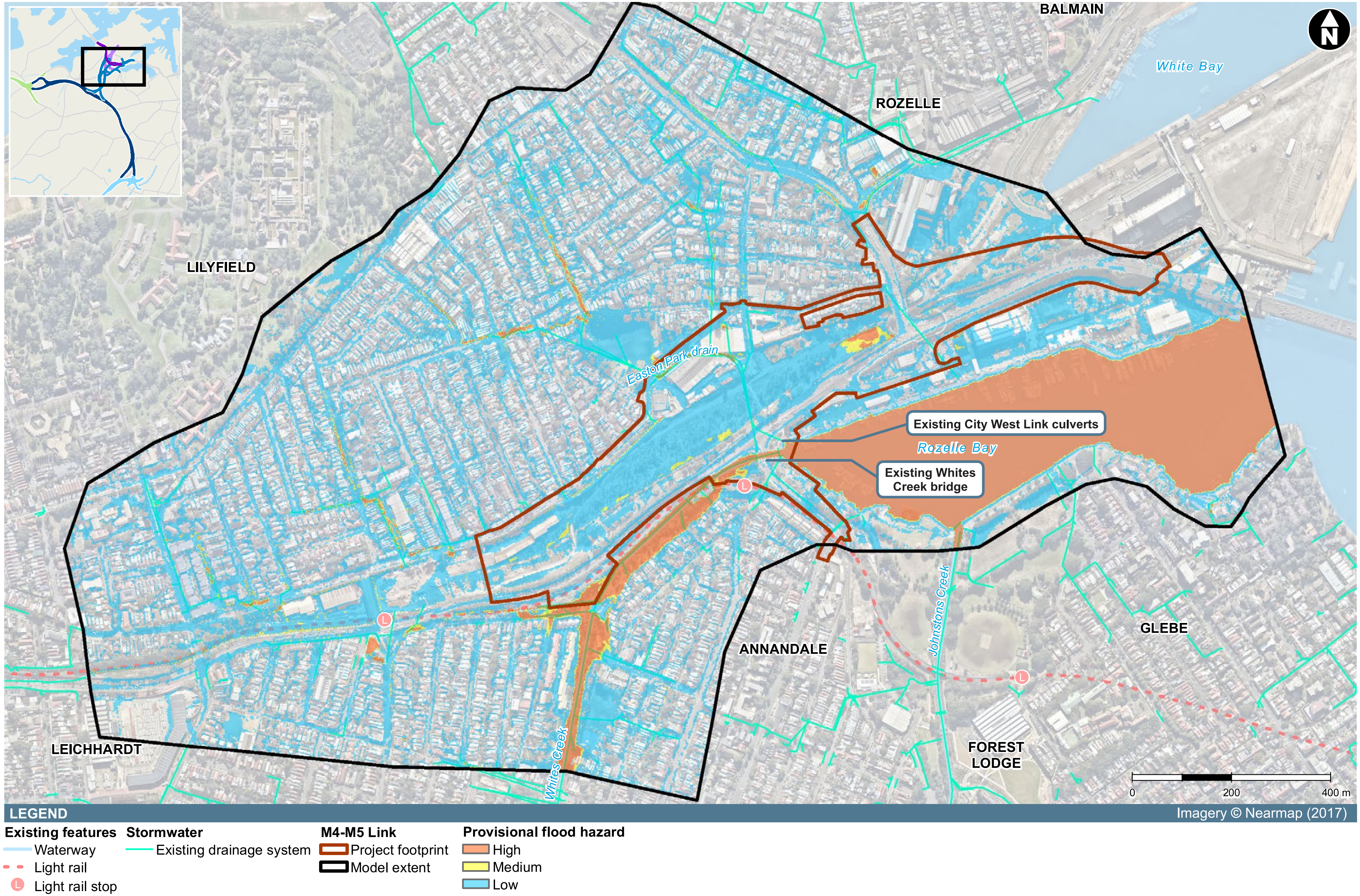


Figure 17-13 Present day flood behaviour – Rozelle interchange - provisional flood hazard (100 year ARI)

Iron Cove Link

The proposed Iron Cove Link would connect to Victoria Road within the Iron Cove catchment. The area slopes from the southeast (about 24 metres AHD) to the northwest (about 16 metres AHD) towards Iron Cove Bridge. The closest waterway in proximity to Iron Cove Link is Iron Cove, located to the northwest of the proposed Rozelle interchange.

The existing flood conditions for the 10 and 100 year ARI design events and PMF are shown in **Figure 17-14** to **Figure 17-16**. Maximum water depths of less than 0.25 metres are found on Victoria Road near the proposed Iron Cove Link, with the deeper water generally found on the northern carriageway. During the PMF event, depths across the site reach 0.3 metres near the intersection with Terry Street.

Flow velocities across the site during flood events reach up to 2.0 and 2.5 metres per second for the 10 year and 100 year ARI events respectively. This is due to the topographic levels along Victoria Road dropping towards Iron Cove Bridge. Flood hazards for the 100 year ARI are shown in **Figure 17-17**.

The hazards associated with main overland flow paths are predominantly medium hazard. However, there are localised areas of high hazard on the northern carriageway of Victoria Road. This is consistent with the Leichhardt Flood Study.

An assessment of flood risk posed to the Iron Cove Link was undertaken by comparing the location of the portals to the PMF flood extents presented in the Leichhardt Flood Study report and model results. This location is subject to runoff generated in the small catchment to the north and east and conveyed along the roads, mainly Victoria Road and Crystal Street. The site is not identified as a flood control lot in the Leichhardt Development Control Plan 2013.

The flood mapping suggests that the Iron Cove Link portals may be at risk of inundation from overland flow paths on Victoria Road during the PMF event. The water flows in a north-westerly direction along Victoria Road towards Iron Cove Bridge. The median traffic barrier along Victoria Road provides an obstruction to overland flows and deflects floodwaters towards Iron Cove Bridge.

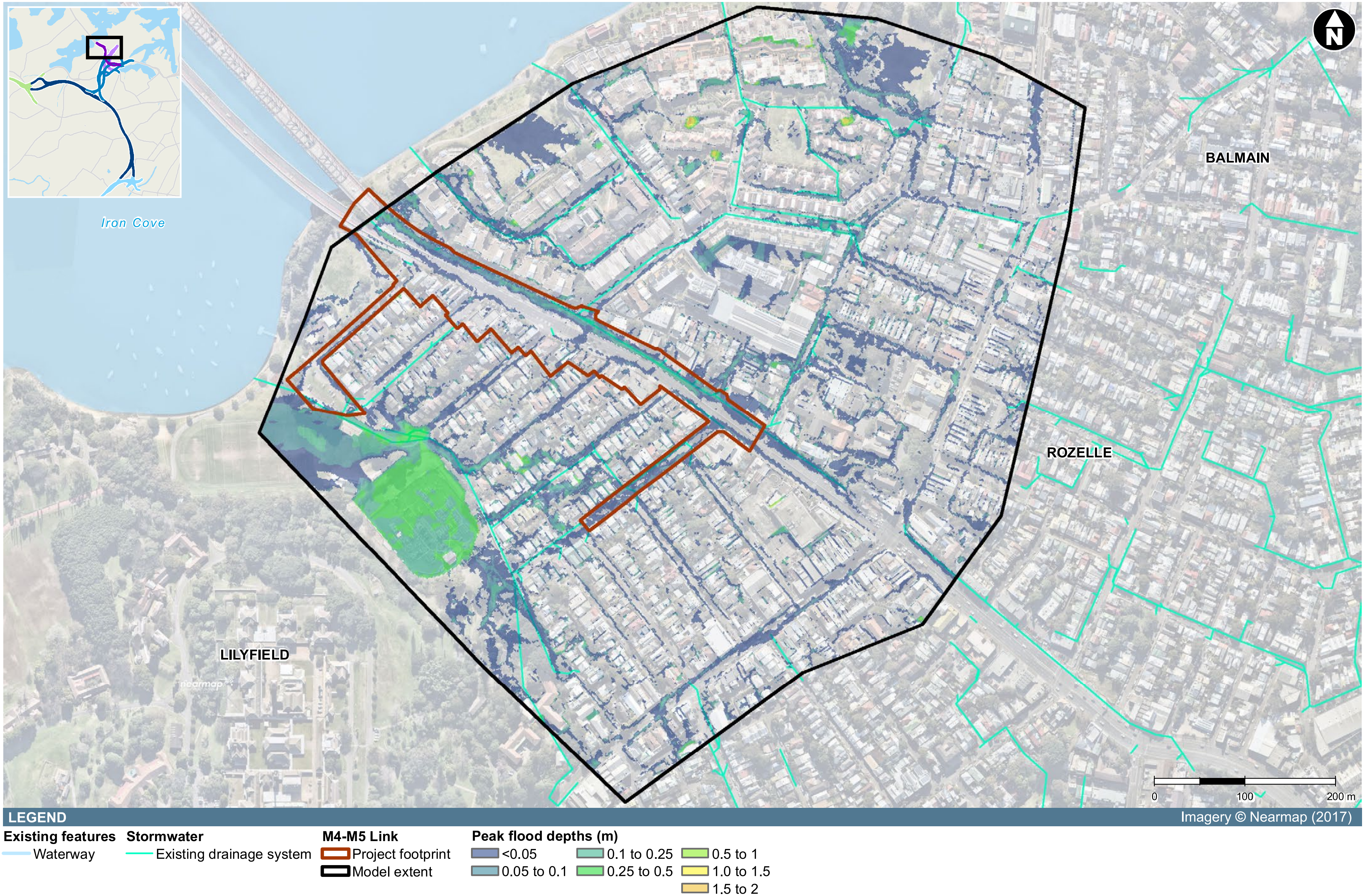
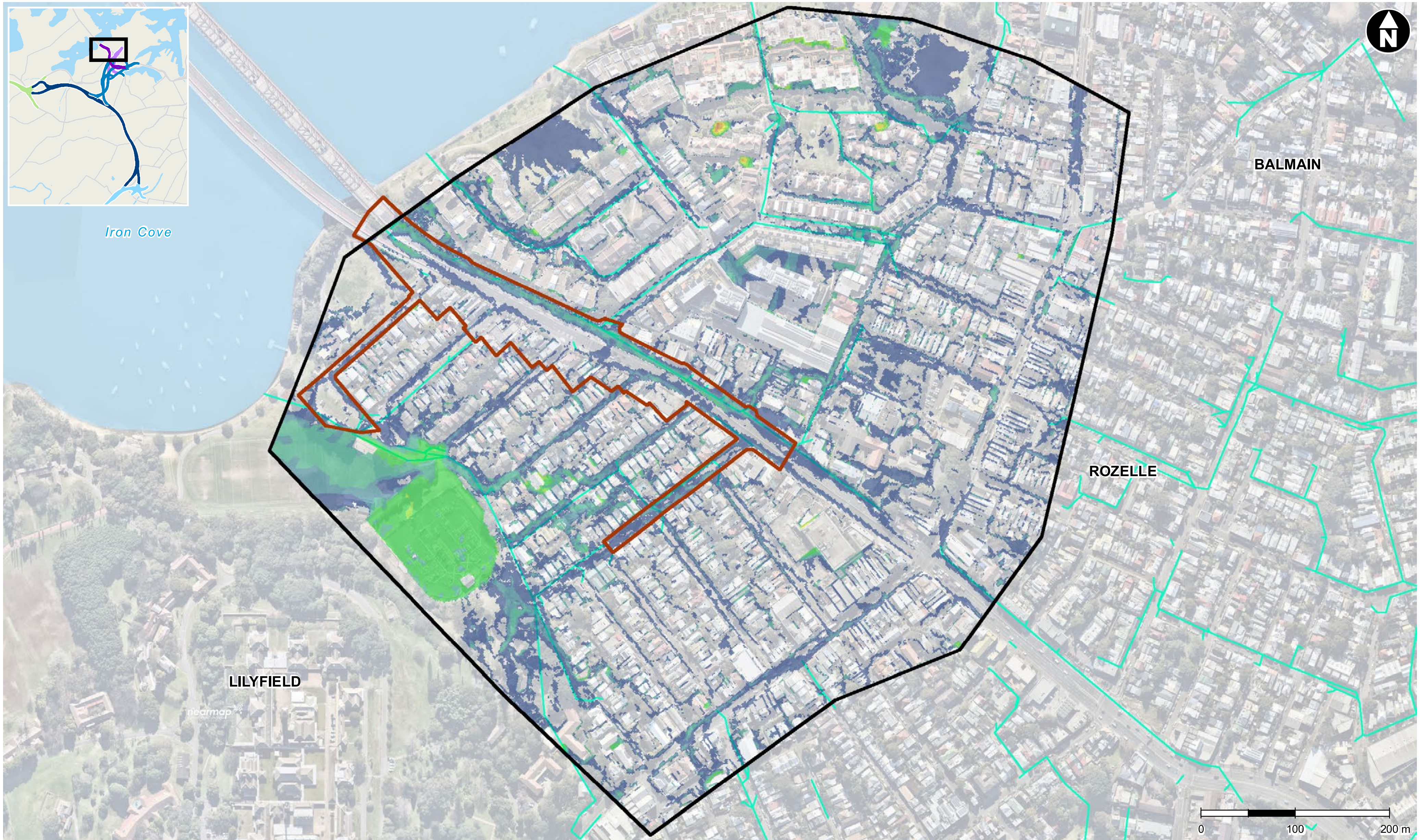


Figure 17-14 Present day flood behaviour – Iron Cove Link - peak flood depths (10 year ARI)



LEGEND

Imagery © Nearmap (2017)

Existing features
- Waterway

Stormwater
- Existing drainage system

M4-M5 Link
- Project footprint
- Model extent

Peak flood depths (m)
- <0.05
- 0.05 to 0.1
- 0.1 to 0.25
- 0.25 to 0.5
- 0.5 to 1
- 1 to 1.5
- 1.5 to 2
- 2.0 to 2.5

Figure 17-15 Present day flood behaviour – Iron Cove Link - peak flood depths (100 year ARI)

LEGEND

Imagery © Nearmap (2017)

Existing features
- Waterway

Stormwater
- Existing drainage system

M4-M5 Link
- Project footprint
- Model extent

Peak flood depths (m)
- <0.05
- 0.05 to 0.1
- 0.1 to 0.25
- 0.25 to 0.5
- 0.5 to 1
- 1 to 1.5
- 1.5 to 2
- 2 to 2.5
- >2.5

Figure 17-16 Present day flood behaviour – Iron Cove Link - peak flood depths (PMF)

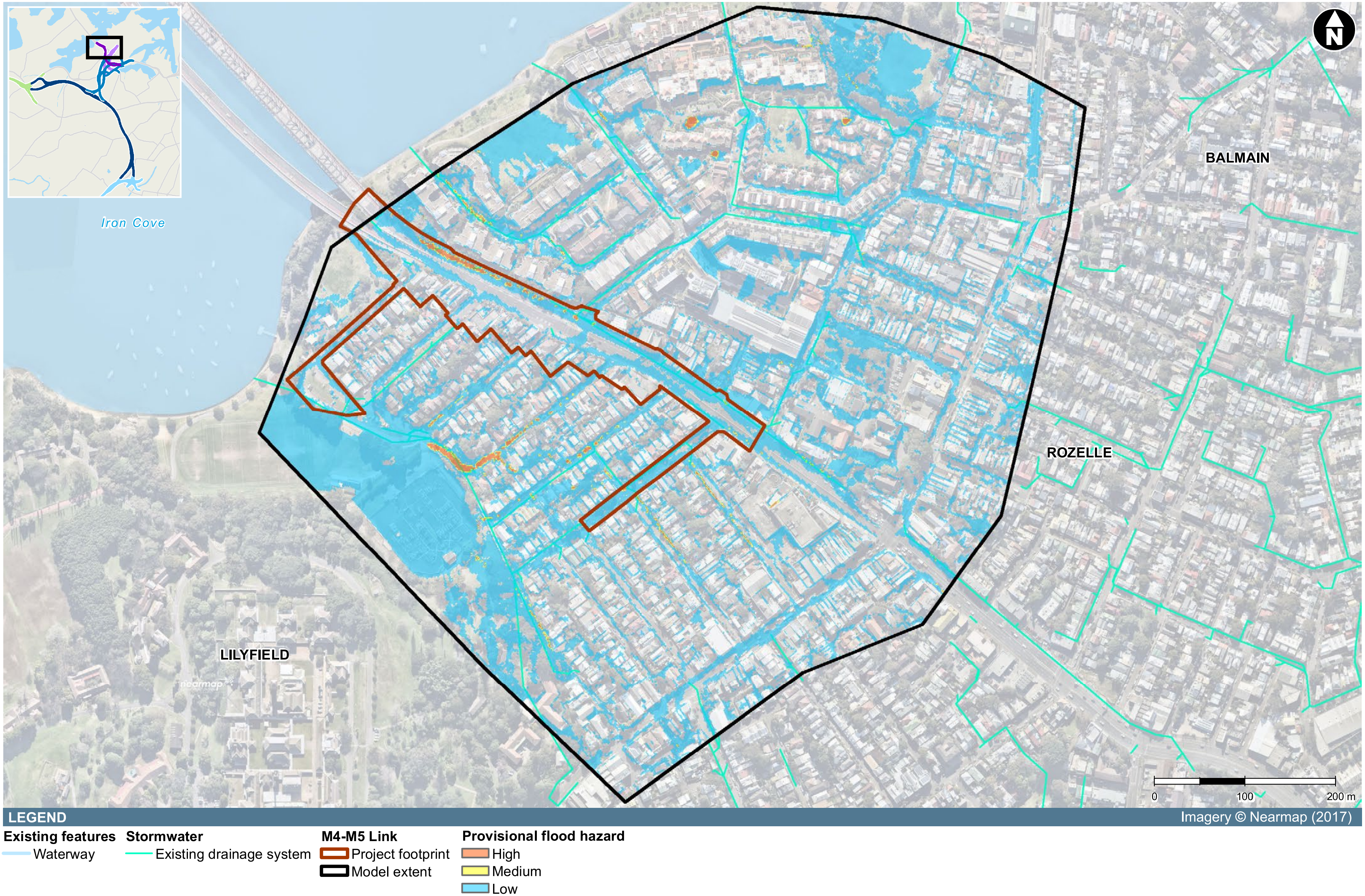


Figure 17-17 Present day flood behaviour – Iron Cove Link - provisional flood hazard (100 year ARI)

Darley Road

The Darley Road civil and tunnel site (C4), where the operational water treatment plant for the project may be located, is situated south of City West Link in the catchment of Hawthorne Canal. The site is situated in an area that has been assessed by two flood studies, the Hawthorne Canal Flood Study (WMAWater 2013a) commissioned by Ashfield and Marrickville Councils, and the Leichhardt Flood Study.

The site slopes east to west with ground levels dropping from about 12 metres AHD to four metres AHD. The eastern side of the Darley Road site sits higher than the Inner West Light Rail line to the north, with levels dropping by about eight metres in its western extent and sitting lower than the rail line.

The Hawthorne Canal Flood Study shows that the Darley Road site is on the fringe of the 100 year ARI flood extent. However, most of the site may be inundated in a PMF, particularly the western half of the site, with depths of up to 0.5 metres within the site and up to one metre around the intersection of Darley Road and Charles Street. The Leichhardt Flood Study identified that part of the Darley Road civil and tunnel site (C4) may be subject to flooding during the PMF to similar depths. The site is identified as a flood control lot in the Leichhardt Development Control Plan 2013.

The site itself has a limited catchment area and the presence of low walls on the eastern side of the site reduces the potential for runoff to enter from higher ground near City West Link, deflecting it onto Darley Road and around to the south of the site.

During the PMF event, the northeast section of the site is subject to flooding as a consequence of water spilling onto the site from the Leichhardt North light rail stop platform area. The western section, which is the lowest part of the site, is inundated by floodwater during the PMF event as a consequence of water spilling from the Inner West Light Rail line, as well as from water that collects at the topographic low point near the junction of Darley Road and Charles Street.

Localised inundation depths of less than 0.2 metres are expected for the 10 year ARI event. Maximum depths on the western section of the site are about 0.8 metres for the PMF event (**Figure 17-18** to **Figure 17-20**).

The velocity of water through the site is generally less than 0.1 metres per second except on the steeper areas where water flows from Darley Road onto the site. Velocities on Darley Road are estimated to be up to 1.5 metres per second along the kerb line. Flood hazards near the site are generally low, but medium to high hazards are estimated along the north-eastern boundary with the Inner West Light Rail line (see **Figure 17-21**).

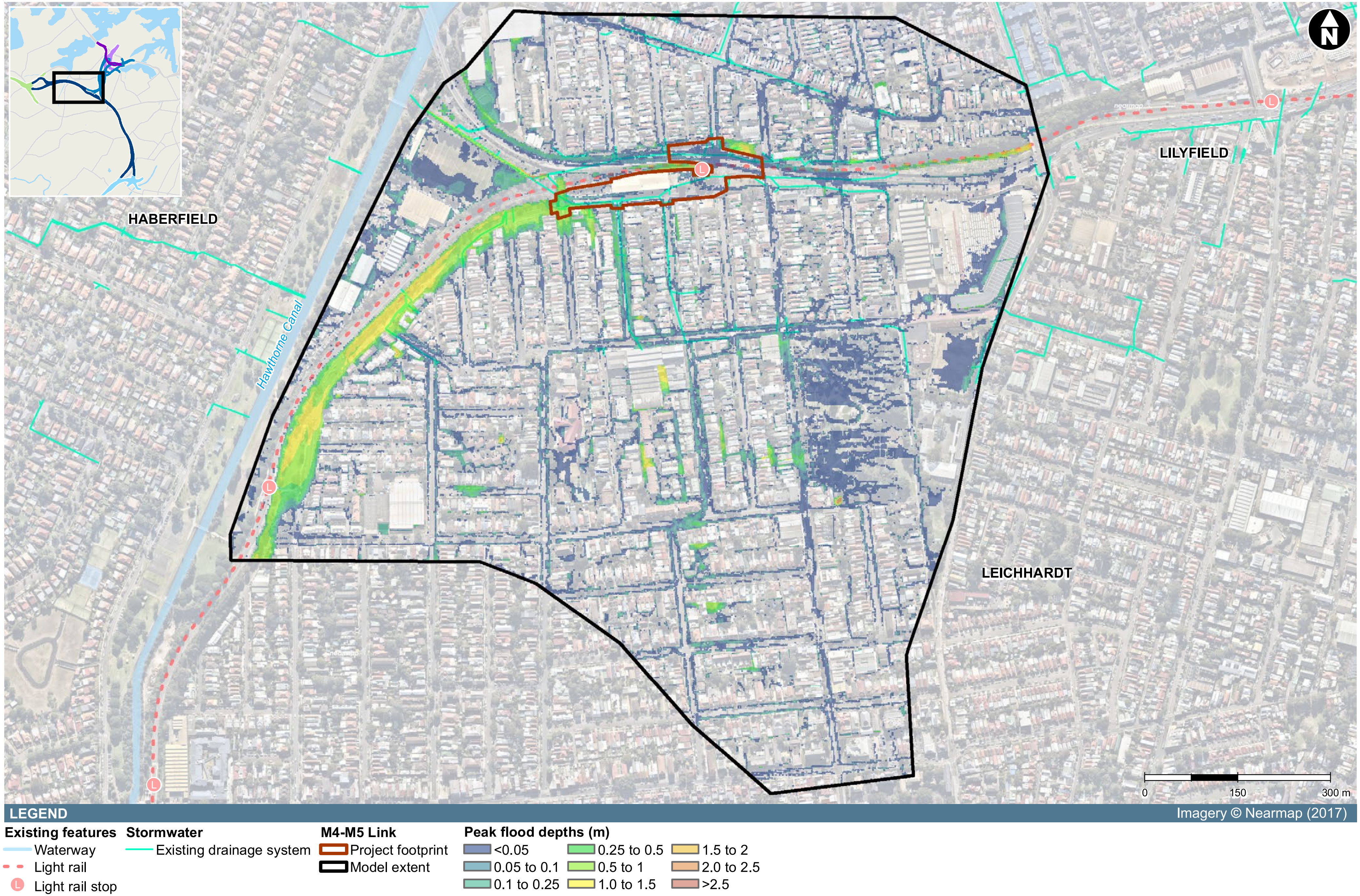


Figure 17-18 Present day flood behaviour – Darley Road - peak flood depths (10 year ARI)

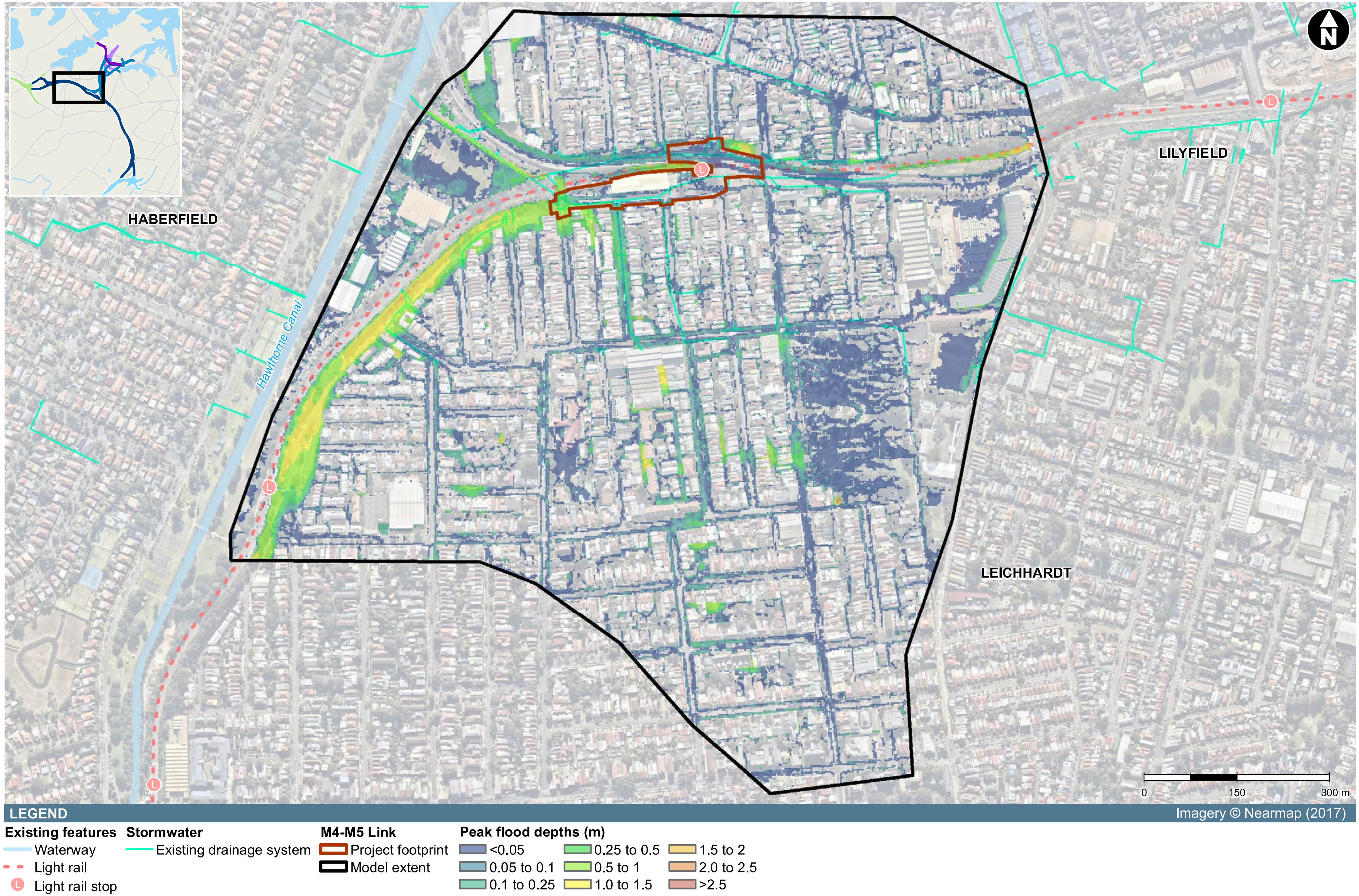


Figure 17-19 Present day flood behaviour – Darley Road - peak flood depths (100 year ARI)

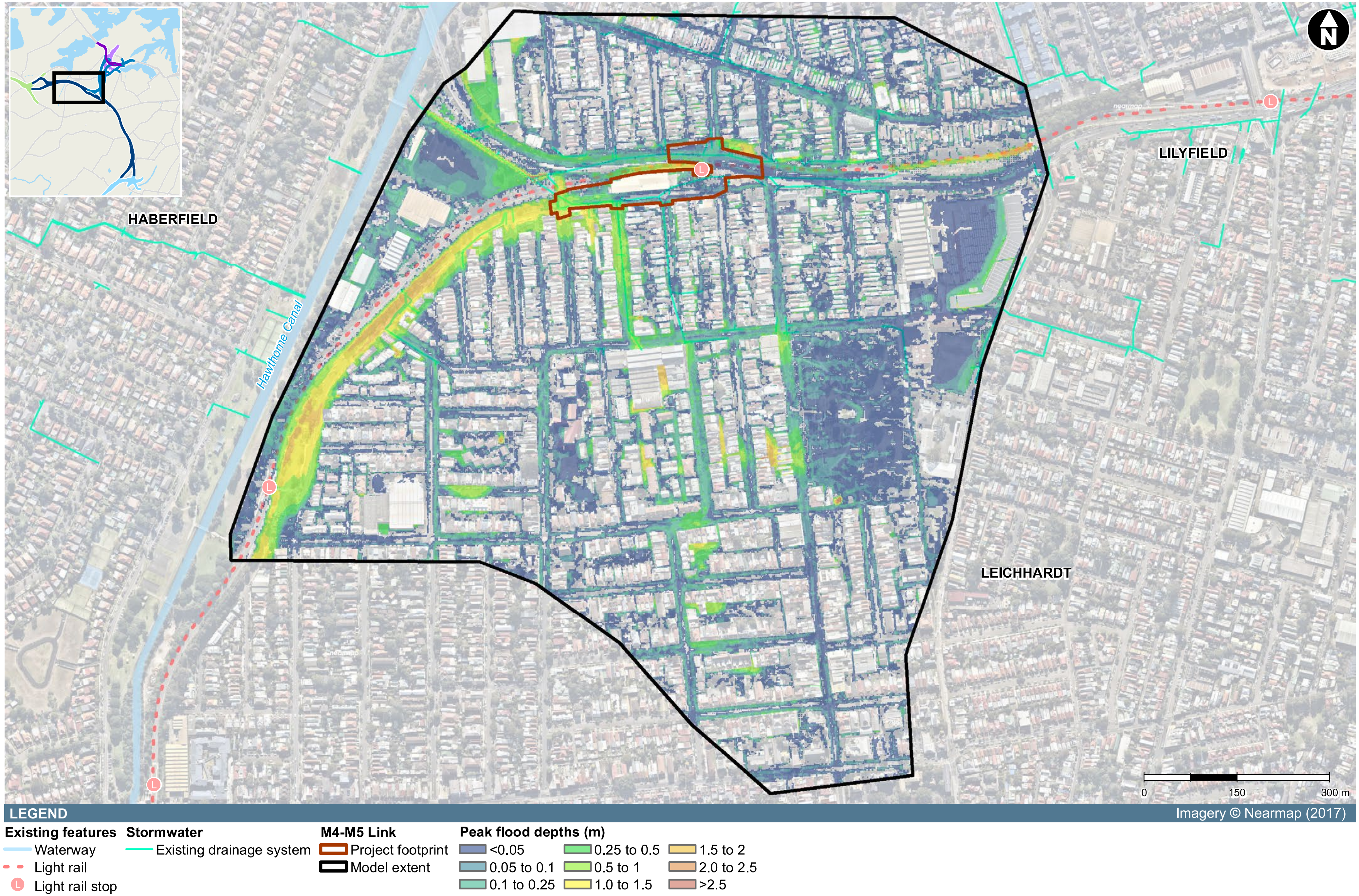


Figure 17-20 Present day flood behaviour – Darley Road - peak flood depths (PMF)

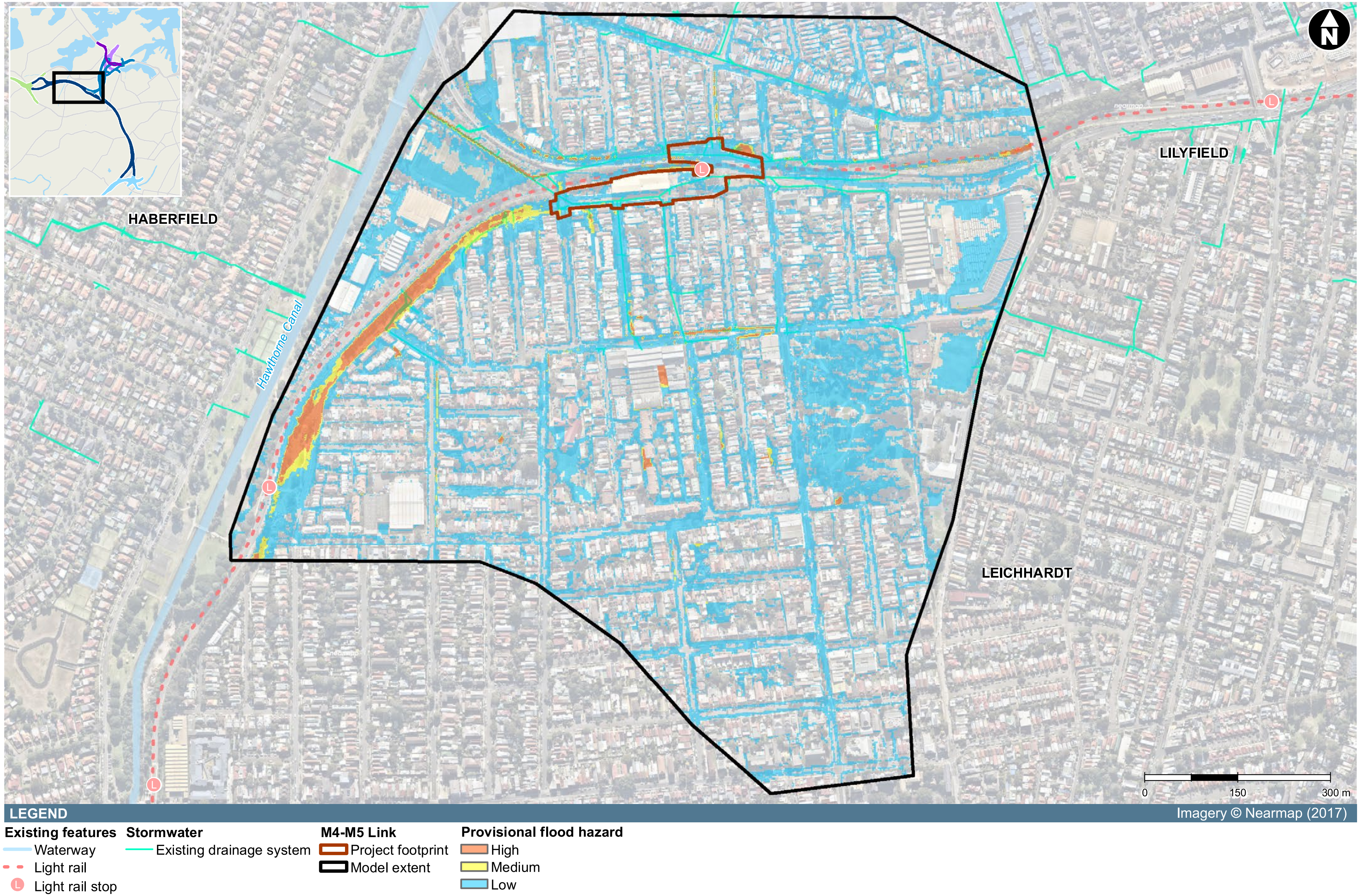


Figure 17-21 Present day flood behaviour – Darley Road - provisional flood hazard (100 year ARI)

Pyrmont Bridge Road

The Pyrmont Bridge Road tunnel site (C9) is located near the top of the Johnstons Creek catchment. There is only a small catchment draining to the site, but the dense existing built environment means that a substantial amount of runoff is channelled along Bignell Lane, with water ponding at the low point along this lane. The local drainage system connects to the road drainage system on Pyrmont Bridge Road before draining towards Johnstons Creek.

The Leichhardt Flood Study identified flood depths generally between 0.1 metres and 0.2 metres along Bignell Lane and up to one metre at the low point towards the western end of Bignell Lane in the 100 year ARI event. Given the small catchment size, the relatively high flood depths are a result of the confined overland flow path.

During construction, the existing buildings on the site are proposed to be demolished and replaced with facilities, which would cover a smaller area. This would allow for less concentrated overland flows paths, greater opportunity for infiltration and would also reduce the potential to displace water and impact surrounding properties. With appropriate site drainage to manage runoff at the Pyrmont Bridge Road tunnel site (C9), the risk of flooding to the site from overland flow is considered to be low. Measures would include a combination of temporary piped drainage, open drains and swales, overland flow paths and sedimentation and erosion control measures.

Existing flood behaviour summary

A summary of the existing flood conditions at the surface features during the operational phase of the project is presented in **Table 17-3**. This is based on a review of existing flood risk assessments and identifies if further quantitative assessment is required to assess flood risk and impacts of the project.

Table 17-3 M4-M5 Link operational surface features and existing flood risk

Project surface feature	Catchment	Existing flood risk assessment	Existing flood risk review	Further assessment required?
Wattle Street interchange	Dobroyd Canal (Iron Cove Creek)	M4 East EIS (Roads and Maritime 2015a); M4 East Final Design (CSJ 2016a, b)	The project portals (tunnel entries) and cut and cover sections of the M4-M5 Link have been constructed as part of the M4 East project. M4 East has designed raised road crests at the entry to the tunnels above the PMF level. The M4 East ventilation facility at Walker Avenue (Parramatta Road ventilation facility) has been designed to be flood protected in design storm events up to the PMF by providing bunds and walls around the site and local drainage systems to direct stormwater runoff away from critical buildings. The project would not change the M4 East design surface layout or levels, therefore it is considered that the: • Risk of flooding to the project tunnel structure in a PMF event is low • The project would not have an impact on flood risk to surrounding properties at this location. Therefore, no further mitigation measures are required beyond those	No

Project surface feature	Catchment	Existing flood risk assessment	Existing flood risk review	Further assessment required?
			provided by the M4 East project.	
Rozelle interchange	Easton Park drain Rozelle Bay, Whites Creek	Leichhardt Flood Study (Cardno 2014a)	The Rozelle Rail Yards site is subject to extensive flooding in the five year ARI event. Limited information is available on flood depths at the Rozelle Rail Yards and the potential risk to the project (inundation of portals). The project has the potential to displace water and impact on flood risk to surrounding properties at this location. A replacement bridge structure is proposed over Whites Creek at The Crescent. Critical project infrastructure such as the Rozelle motorway operations complexes (MOC2 and MOC3) and tunnel ventilation facility are proposed at the Rozelle Rail Yards site.	Yes
Iron Cove Link	Iron Cove	Leichhardt Flood Study (Cardno 2014a)	An overland flow path is present on Victoria Road for the five year ARI event. Floodwater depths of up to 0.3 metres for the PMF. Peak flow velocities between two and three metres per second for PMF. Potential risk to project (inundation of portals and flooding of the Iron Cove Link motorway operations complex (MOC4)). Potential for project to displace water and impact on flood risk to surrounding properties at this location.	Yes
St Peters interchange	Alexandra Canal	M5 EIS (Roads and Maritime 2015b) New M5, Substantial Detailed Design report, Rev D (AJJV 2016a)	The tunnel stubs for the project and St Peters interchange are being constructed as part of the New M5 project. Mitigation measures for the New M5 project include a bund around the perimeter of the interchange and upgrades to the local drainage network around the interchange. The New M5 tunnel ventilation facility (St Peters ventilation facility) has been designed to be above the PMF event. The project portals would be at low risk of flooding as they are protected from the PMF by the measures provided by	No

Project surface feature	Catchment	Existing flood risk assessment	Existing flood risk review	Further assessment required?
			the New M5 project. The tunnel ventilation facility for the M4-M5 Link project would be above the tunnel portal and would therefore also be flood protected up to the PMF event. The project would not change surface levels or layout outside of the perimeter flood bund and therefore would not have a detrimental impact on flood risk to surrounding properties at this location. No further mitigation is required at this location.	
Darley Road	Hawthorne Canal	Hawthorne Canal Flood Study (WMAwater 2013a) Leichhardt Flood Study (Cardno 2014a)	Localised ponded water on the north-eastern side of the site for 20 year ARI event. Flood water depths up to 0.8 metres during the PMF event. Potential risk to project (inundation of portals and Darley Road motorway operations complex (MOC1)). Potential to displace water and impact on flood risk to surrounding properties.	Yes

17.3 Assessment of potential construction impacts

Construction works have the potential to change flood behaviour and impact on the surrounding environment. In addition, flooding has the potential to impact on areas within and near construction sites for the project (ie potential inundation of project sites).

An assessment of the flood risks to the project and the surrounding environment, along with development of appropriate mitigation measures, has been carried out in accordance with the *Floodplain Development Manual* (OEH 2005), the requirements of the previous WestConnex program of works environmental approvals and industry guidelines.

Construction of the project would involve a range of activities at sites of both permanent and temporary occupancy. The construction activities associated with the project that could result in impacts if not mitigated include:

- Enabling and temporary works, including construction power, water supply, ancillary site establishment, demolition works, property adjustments and public transport modifications (if required)
- Construction of the road tunnels, interchanges, intersections and roadside infrastructure
- Haulage of spoil generated during tunnelling and excavation activities
- Fitout of the road tunnels and support infrastructure, including ventilation and emergency response systems
- Construction and fitout of the motorway operations complexes and other ancillary operations buildings
- Realignment, modification or replacement of surface roads, bridges and underpasses

- Implementation of environmental management and pollution control facilities for the project.

An assessment of construction impacts associated with water extraction, flooding and drainage is provided in the following sections.

17.3.1 Flooding and drainage

This section considers flood behaviour resulting in potential detrimental increases in the potential flood affectation of the project infrastructure and other properties, assets and infrastructure. Flooding during construction of the project could potentially impact areas within and near the construction sites. Flood related impacts during construction could include:

- Inundation of excavated tunnels
- Damage to facilities, infrastructure, equipment, stockpiles and downstream sensitive areas caused by inundation from floodwaters
- Increased risk of flooding of adjacent areas due to temporary loss of floodplain storage (due to displacement of water) or impacts on the conveyance of floodwaters.

Tunnel portals would be located at the Wattle Street interchange, the Rozelle interchange, along Victoria Road near the eastern abutment of Iron Cove Bridge (associated with the Iron Cove Link) and at the St Peters interchange. Tunnel portals at the Wattle Street interchange and the St Peters interchange are being built by the M4 East and New M5 projects respectively.

Tunnel portals would be constructed using cut-and-cover techniques (refer to **Chapter 6** (Construction work) for a description of this construction technique). Tunnelling would also occur via temporary access tunnels that would connect the Parramatta Road West civil and tunnel site (C1b), the Darley Road civil and tunnel site (C4), the Pyrmont Bridge Road tunnel site (C9) and the Campbell Road civil and tunnel site (C10) with the mainline tunnels.

Ingress of floodwater into the tunnel shafts or cut and cover excavations during construction would pose a risk to personal safety for those working in the tunnel. Where these facilities occur within the floodplain, such as at Darley Road at Leichhardt and Rozelle, protection measures such as bunding or floodwater barriers would be provided to ensure floodwaters do not enter shafts or portals.

Other flood impacts during construction, such as flooding of site facilities or stockpiles and erosion of cleared areas, are expected to be minor and would be adequately managed through the management and mitigation measures identified in **section 17.5**.

These would include adjusting the construction ancillary facility designs and planning sites to recognise the identified flood conditions and minimise the potential for off-site flood impacts. The indicative layouts of the construction ancillary facilities have been developed to provide setback from high risk flooding areas (ie high flood hazard areas and overland flow paths) to minimise impacts on existing flow paths, where feasible. All formwork, access tracks and other temporary works would be located outside of the existing Whites Creek channel.

While there is the potential for temporary structures (used to support permanent structures, materials, plant, equipment or people) to reduce the available waterway area beneath the replacement bridge, the longer spans of the bridge would be designed to mitigate potential impact on flood behaviour. It is also likely that the replacement bridge would comprise pre-cast members, meaning that the waterway would not be obstructed by any additional temporary structures associated with an alternative cast *in situ* type approach. This approach would also result in a comparatively shorter timeframe for installation of the bridge.

The likelihood of flooding and a summary of the potential impacts of construction sites (as shown in **Figure 17-1**) and associated construction activities on flood risk are provided in **Table 17-4**. These are based on preliminary construction plans and indicative layouts, which would be refined in the future as the detailed design and site construction planning is further developed.

Table 17-4 Construction ancillary facilities and flooding

Construction ancillary facility	Facilities	Existing flood risk (source, mechanisms)	Potential impacts
C1a Wattle Street civil and tunnel site (part of M4 East project footprint)	• Dive structure into the mainline tunnel • Buildings • Parking • Laydown area	• Dobroyd Canal (Iron Cove Creek) catchment • Western side of the site inundated by PMF overland flow path • M4 East project has mitigated flood risk from overland flow, channelling PMF flow towards Parramatta Road junction and away from the dive structure. • M4 East EIS (2015a), M4 East Detailed Design (CSJ 2016a,b)	None anticipated – area flooded in the PMF only used for vehicle access. No topographic changes proposed therefore negligible impacts on flood risk.
C2a Haberfield civil and tunnel site (part of M4 East project footprint)	• Mechanical and electrical fitout of existing M4 East Ventilation facility (Parramatta Road Ventilation facility) • Office, storage and laydown area • Sub-station • Parking • Stockpiling underground	• Dobroyd Canal (Iron Cove Creek) catchment • Outside of PMF flood extent for mainstream flooding and overland flow path • M4 East EIS (2015a), M4 East Detailed Design (CSJ 2016a,b)	None anticipated – area outside of PMF flood extent.
C3a Northcote Street civil site (part of M4 East project footprint)	• Parking • Laydown area	• Dobroyd Canal (Iron Cove Creek) catchment • Outside of PMF flood extent for mainstream flooding and overland flow path • M4 East EIS (2015a), M4 East Detailed Design (CSJ 2016a,b)	None anticipated – area outside of PMF flood extent.
C1b Parramatta Road West civil and tunnel site	• Acoustic shed • Laydown area • Temporary dive structure into the mainline tunnel	• Dobroyd Canal (Iron Cove Creek) catchment • Outside of 100 year ARI flood extent for mainstream flooding • Overland flow paths along Parramatta Road, Bland Street and Alt Street	None anticipated – area just on the fringe of PMF flood extent. No overland flow paths through the site. No topographic changes proposed for Parramatta Road, Bland Street and Alt Street, therefore overland flow paths would be maintained.

Construction ancillary facility	Facilities	Existing flood risk (source, mechanisms)	Potential impacts
C2b Haberfield civil site (part of M4 East project footprint)	• Parking • Office, storage and laydown area • Ventilation facility (Parramatta Road Ventilation facility)	• Dobroyd Canal (Iron Cove Creek) catchment • Outside of PMF flood extent for mainstream flooding and overland flow paths • M4 East EIS (2015a), M4 East Detailed Design (CSJ 2016a,b)	None anticipated – area outside of PMF flood extent.
C3b Parramatta Road East civil site	• Parking	• Dobroyd Canal (Iron Cove Creek) catchment • Outside of PMF flood extent for mainstream flooding	None anticipated – area outside of PMF flood extent.
C4 Darley Road civil and tunnel site	• Temporary access tunnel for construction • Buildings and laydown area • Parking • Acoustic shed and spoil handling area • Temporary sub-station	• Hawthorne Canal catchment • Localised shallow flooding from 10 year ARI and 100 year ARI flow path from light rail line • Majority of the site may be inundated in a PMF with depths up to 0.5m at the western end of the site • Hawthorne Canal Flood Study (WMA Water 2013a), Leichhardt Flood Study (Cardno 2014a), AECOM flood modelling (2016)	Potential displacement of water by bunding of tunnel ramps to prevent floodwater ingress, as well as presence of temporary noise walls, buildings/hoarding, acoustic shed, stockpiles and other structures.
C5 Rozelle civil and tunnel site	• Dive structure into the mainline tunnel • Buildings and laydown area • Parking • Acoustic shed and spoil handling areas • Temporary sedimentation pond and water treatment plant • Ventilation facility • Temporary drainage structures	• Easton Park drain catchment • Mainstream flooding and overland flow paths • Located within 10 year, 100 year ARI and PMF flood extent • AECOM flood modelling (2016)	Potential displacement of water by bunding of ramps to prevent floodwater ingress, as well as presence of temporary noise walls, buildings/hoardings, buildings, stockpiles and other structures.

Construction ancillary facility	Facilities	Existing flood risk (source, mechanisms)	Potential impacts
C6 The Crescent civil site	• Construction of Whites Creek bridge • Widening and improvement works to Whites Creek • Construction of culverts from Rozelle Rail Yards • Buildings and laydown area • Parking	• Whites Creek catchment • On the edge of Rozelle Bay • Located outside 100 year ARI flood extent but within PMF flood extent • AECOM flood modelling (2016)	Potential displacement of water by hoardings, buildings, stockpiles and other structures.
C7 Victoria Road civil site	• Buildings • Parking	• Rozelle Bay catchment • Outside of PMF flood extent • Leichhardt Flood Study (Cardno 2014a)	None anticipated – area outside of PMF flood extent.
C8 Iron Cove Link civil site	• Dive structure into Iron Cove Link tunnel • Buildings • Temporary water treatment plant • Workshop and storage	• Iron Cove catchment • Overland flow paths on Victoria Road for 10 year ARI event • Leichhardt Flood Study (Cardno 2014a), AECOM flood modelling (2016)	Potential displacement of water by bunding of ramps to prevent floodwater ingress, as well as activities to widen the road.
C9 Pyrmont Bridge Road tunnel site	• Temporary access tunnel for construction • Buildings and laydown area • Workshop • Parking • Acoustic shed and spoil handling area • Temporary sub-station	• Johnstons Creek catchment • Overland flow in 10 year ARI event, depths of over 1m limited to Bignell Lane • Johnstons Creek Catchment Flood Study (WMA Water 2015), Leichhardt Flood Study (Cardno 2014a)	Potential displacement of water by bunding of ramps to prevent floodwater ingress, as well as presence of temporary noise walls, buildings/hoardings, acoustic shed, offices and other structures.

Construction ancillary facility	Facilities	Existing flood risk (source, mechanisms)	Potential impacts
C10 Campbell Road civil and tunnel site (part of New M5 project footprint).	• Dive structure into the mainline tunnel • Buildings and laydown area • Parking • Acoustic shed and spoil handling area	• Alexandra Canal • Outside of 20 year ARI and PMF flood extent associated with mainstream flooding • New M5 EIS (2015), AJJV Detailed Design (2016)	The New M5 project is providing the construction site platform within the St Peters interchange, including designing to protect the construction site from flooding. No impacts anticipated on the basis that the New M5 project is assessing impacts and providing mitigation, such as a temporary stormwater drainage strategy to divert flows around and away from stockpile sites and other vulnerable infrastructure.

Localised flooding and drainage

All construction works would have the potential to impact local overland flow paths and existing minor drainage paths. Disruption of existing flow paths, both of constructed drainage systems or those of overland flow paths, could occur as a result of:

- Disruption of existing drainage networks during decommissioning, upgrade or replacement of drainage pits and pipes
- Interruption of overland flow paths by installation of temporary construction ancillary facilities
- Sediment entering drainage assets and causing blockages
- Overloading the capacity of the local drainage system.

These are typical impacts faced on most construction projects and would be addressed by adopting industry standard mitigation measures. Consideration of these impacts would be included during future detailed design and construction planning phases, along with consideration of the typical mitigation measures described in **section 17.5** and **Appendix F** (Utilities Management Strategy). Assessment and mitigation of sedimentation is provided in **Chapter 15** (Soil and water quality).

17.3.2 Hydrological impacts

Water balance

The SEARs make reference to a detailed water balance for ground and surface water. Due to the staging and variable nature of construction activities, presence of a potable water supply and highly disturbed nature of the receiving waterways, the water balance assessment has been limited to estimation of rainwater and groundwater reuse volumes and daily treated wastewater discharge volumes. Volume estimates are provided in **Appendix Q** (Technical working paper: Surface water and flooding). A summary of the findings for water use and water discharges is provided below.

The total volume of water required during construction of the project is estimated to be around 900 megalitres. The use of non-potable water would be preferred over potable water where possible.

Non-potable water demands include:

- Surface activities such as dust suppression, wheel washing and plant washing
- Underground activities such as road header dust suppression, rock bolting and plant washdown.

Stormwater and other non-potable sources such as treated tunnel groundwater and treated 'dirty' construction water would be reused for non-potable water demands during construction. It is not proposed that surface water would be extracted from the local urban waterways.

The extent to which non-potable water sources can be used would be variable and governed by workplace health and safety considerations, economic feasibility, the functional specifications of the design and the availability and quality of non-potable water.

Construction wastewater (including stormwater, groundwater and construction water) would be generated from all temporary construction ancillary facilities with the exception of the Northcote Street civil site (C3a), which would be used for parking and construction support only.

The total volume of wastewater generated during construction would vary according to rainfall, construction activities taking place, the amount of groundwater infiltrating into the tunnel, and the length of the tunnel that has been excavated.

Indicative daily discharge rates, ranging from 10 kilolitres per day at The Crescent civil site (C6) to 2,400 kilolitres per day at Rozelle civil and tunnel site (C5) are provided in **Appendix Q** (Technical working paper: Surface water and flooding). A qualitative assessment of the impacts of the discharges to the receiving waterways and bays is provided in the following section.

Discharges

The discharge of treated construction water would generate a minor increase in the base flow rates of the receiving waterways. Anticipated discharges are likely to be continuous. The locations of discharge points into Dobroyd Canal (Iron Cove Creek), Hawthorne Canal, Easton Park drain and Alexandra Canal, all modified waterways, are within reaches that are tidally influenced. As the flow variability and water level at the discharge locations is dominated by tides, and given the urban setting and artificial nature of the waterways, it is unlikely that discharges during construction would significantly impact on natural processes at these locations. The ultimate discharge point to Johnstons Creek from Pyrmont Bridge Road tunnel site (C9) could potentially be slightly upstream of the tidal limit. Given the artificial nature of the waterway, the indicative additional baseflow is unlikely to impact on any natural processes within the waterway.

Iron Cove and Rozelle Bay would also receive direct discharges from the project. As they are large tidal waterbodies associated with the Parramatta River Estuary and Sydney Harbour, the discharge volumes would not impact on flow variability or water levels within the bay. Given this, and the highly disturbed nature of these receiving waterways, the construction site discharges are not considered to pose an impact on any natural processes within Iron Cove or Rozelle Bay.

Waterway works

It is proposed to divert the Easton Park drain at Rozelle into a new channel to convey flows through the Rozelle Rail Yards. Once these diversions works are complete, the former Easton Park drain would be decommissioned. Given the artificial nature of the waterway, the decommissioning of the existing drain would be unlikely to impact on natural processes.

Works would also be undertaken on Whites Creek as part of the redevelopment of the City West Link and The Crescent intersection and proposed naturalisation of Whites Creek. Given the artificial and tidal nature of the waterway, whilst water levels are likely to be controlled locally to facilitate the construction works (for example, using a coffer dam); this is unlikely to impact on any natural processes within the waterway. Potential water quality impacts are assessed in **Chapter 15** (Soil and water quality).

17.4 Assessment of potential operational impacts

This section describes the flooding and drainage impacts associated with the project during operation and includes:

- Operational flood risks at locations where the potential flooding impacts required that a quantitative assessment of flood risk be undertaken (see **section 17.2.3**)
- Consideration of emergency management and response procedures
- Potential impacts of future climate change on the operation of the project
- Impacts on existing drainage infrastructure
- Hydrological impacts including stormwater runoff and discharge into waterways.

17.4.1 Operational flood risks

The Rozelle interchange, Iron Cove Link and Darley Road motorway operations complex (MOC1) would be partially located within the PMF flood extent, which has the potential to impact on the interchange and tunnel portals. The design of the interchange would prevent flooding of the portals for events up to the PMF or the 100 year ARI event plus 0.5 metres freeboard (whichever is greater). Freeboard is a safety factor for greater protection against different types of flooding and is typically expressed in metres above a flood level for flood protective or control works. Therefore, mitigation measures are required to prevent any floodwater ingress during these events.

Preventing floodwater ingress has the potential to displace floodwaters where the interchange blocks existing flow paths, or reduces available floodplain storage. This may result in potential impacts on surrounding properties. This is particularly the case at Rozelle Rail Yards, as this area functions as a floodway and provides a significant amount of storage of floodwater in larger events such as the 100 year ARI and PMF.

Rozelle interchange

Due to the high risk of flooding at the Rozelle interchange, the proposed layout and design has been influenced by flood risk and drainage considerations. An assessment of potential flood impacts at the proposed Rozelle interchange was undertaken. This included modelling the installation of bunds/walls set at or above the greater of the PMF flood level or 100 year ARI plus 0.5 metres around the perimeter of the portals/ramps associated with the interchange (refer to **Chapter 5** (Project description) for portal descriptions), to prevent floodwater ingress into the tunnel.

At the Rozelle interchange tunnel portals, the PMF flood levels are generally greater than the 100 year ARI plus 0.5 metre levels. The preliminary results for the 100 year ARI event indicated that there would be a re-distribution of flows due to the proposed changes to existing overland flow paths.

Around the Easton Park drain (north of the Rozelle interchange) and along Whites Creek, the installation of more efficient drainage channels as part of the project (refer to **Chapter 5** (Project description)) would reduce flood levels. In the remainder of the Rozelle Rail Yards site, the proposed new buildings and other infrastructure would be raised above ground for flood protection, meaning flood levels would generally be higher than existing.

The proposed tunnel ventilation facilities, substation and water treatment plant would be located adjacent to the new western and northern channels and would need to be set above PMF flood level or 100 year ARI plus 0.5 metres (whichever is greater). Raising surface levels along City West Link to prevent floodwater ingress into the Rozelle interchange was shown to influence overland flows spilling from Whites Creek (upstream and around The Crescent) during the PMF. The model indicated that raising of surface levels and obstructing the overland flow path could lead to a potential increase in flood levels of up to 0.5 metres upstream of The Crescent in the 100 year ARI event. This would have the potential to impact surrounding properties.

To retain the existing function of the site as a flood storage area, minimise impacts in the 100 year ARI event (as per the design standards listed in **Table 17-2**) and mitigate the potential increase in flood risk for surrounding properties, the design now includes:

- Large transverse conveyance systems for the existing Easton Park drain and the catchment to the west, passing through the interchange under City West Link and discharging into Rozelle Bay
- An increase to the waterway area for the Whites Creek bridge structure under The Crescent.

The conveyance system modelled for Easton Park drain and the western catchment includes a ‘low-flow’ channel to carry flows of around a two year ARI event, with a defined landscaped overland flow path sized to convey larger flows up to the 100 year ARI. PMF flows would then spread across the adjacent open space areas. The western channel would cross under the proposed New M5 tunnel connection to City West Link ramps and Western Harbour Tunnel ramps (within the Rozelle Rail Yards site) before combining with the northern channel to then pass under City West Link and discharge into Rozelle Bay. The channels would range in width from about two metres to six metres and the overbank flow path from about nine metres to 18 metres through the Rozelle interchange. The large open channels and allowance for floodwaters to spread out onto adjacent areas compensates for the loss of informal flood storage that the Rozelle Rail Yards provide under existing conditions.

The flood modelling suggests that this approach, combined with improved local road drainage along Lilyfield Road to convey runoff to the Easton Park drain, is likely to reduce potential impacts to an acceptable level ie no adverse flood impacts on adjoining properties for the 100 year ARI event. This conforms to the standards provided in **Table 17-2**. Peak flood depths for the 10 year and 100 year ARI event and PMF under proposed design conditions are shown in **Figure 17-22** to **Figure 17-24**.

To minimise flood impacts, the proposed interchange limits the raising of road crest levels for City West Link and The Crescent to generally within 0.3 metres of existing levels. Flood modelling has indicated that this would maintain the flood immunity of City West Link, but would still allow floodwaters to overtop the road in extreme events, such as the PMF.

Adverse flood level impacts on the north of City West Link are generally contained within the project boundary in events up to the 100 year ARI. Where flood impacts extend outside the project boundary, the increases in flood levels are minor and localised which means there is unlikely to be any impact on surrounding properties. In the PMF, potential flood level impacts of up to 0.04 metres are estimated to the east of Victoria Road, outside of the site. The design of the Rozelle interchange infrastructure would take into account increases in flood levels within the site.

To the south of City West Link, along Whites Creek, no adverse flood impacts are modelled in events up to the 100 year ARI (see **Figure 17-25**). The Crescent would be realigned west of its current alignment, roughly following the light rail corridor before crossing over Whites Creek. The new bridge has been designed to provide 100 year ARI flood immunity.

The skewed angle of The Crescent when realigned, and additional lanes, would result in a wider bridge structure than presently existing. To achieve increased hydraulic conveyance and compensate for the wider bridge, the length of the new bridge would be increased to two 16 metre spans. The topography of the land between the new bridge and Rozelle Bay (immediately south of Whites Creek on the right overbank) would be re-profiled to provide a landscaped overland flow path. When the capacity of the Whites Creek channel is exceeded, floodwater would spill over the southern bank, pass underneath The Crescent and discharge into Rozelle Bay. Bridge piers are proposed to be located along the overland flow path and not within the main channel to minimise flood impacts.

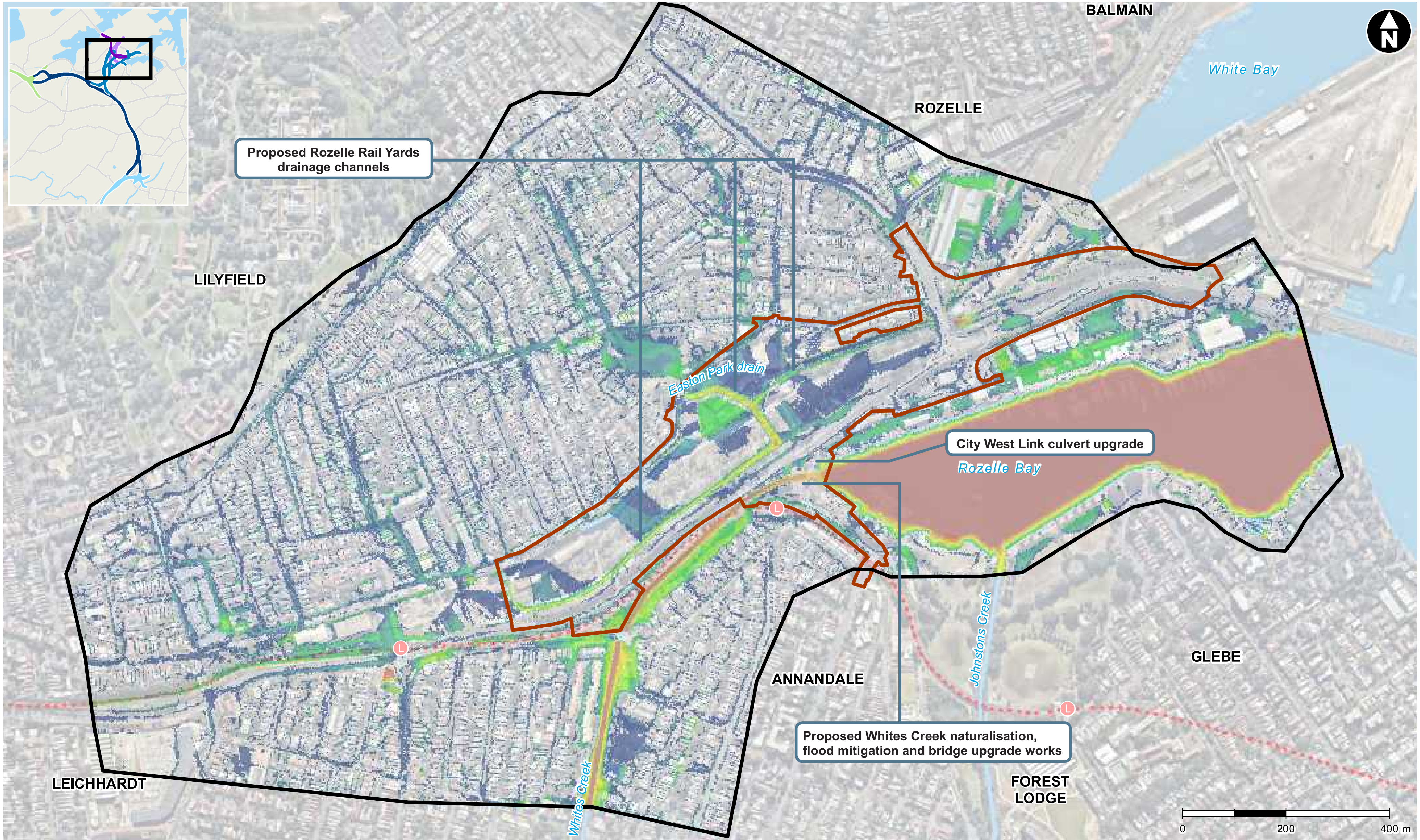
In the PMF, flood impacts of up to 0.4 metres are estimated along Whites Creek (see **Figure 17-26**). This is due to the larger footprint of the proposed road embankments and wider bridge structure (compared to existing). Further widening of the Whites Creek channel is constrained by the existing light rail embankment and raising the road levels on City West Link would potentially raise flood levels, so neither of these are feasible options.

These changes in flood behaviour under PMF conditions would be investigated further during detailed design to identify potential impacts on critical infrastructure and significant changes in flood hazard as a result of the project.

Peak flow velocities outside Whites Creek and the new drainage channels would generally remain below 0.5 metres per second in the 100 year ARI, which is similar to existing conditions. At the new bridge over Whites Creek at The Crescent, peak flow velocities entering Rozelle Bay are likely to increase due to the increased conveyance capacity of the new structure. Velocities for the new overland flow path under the bridge would be up to two metres per second. It is expected that peak flow velocities entering Rozelle Bay from the Rozelle Rail Yards would generally be less than two metres per second. Appropriate scour protection of the new overland flow path and stabilisation of all the outlets to Rozelle Bay would be installed. This would be undertaken to prevent scour of potentially contaminated sediments in Rozelle Bay.

Peak flow velocities in the new drainage channels through the Rozelle Rail Yards would generally be less than 1.5 metres per second. The flood hazard for the land near the interchange would not change substantially from existing conditions. The new drainage channels through the former Rozelle Rail Yards would be high hazard areas (as defined in the Floodplain Development Manual (NSW Government 2005)) as they are formal conveyance systems, like the Easton Park drain and Whites Creek. The overland flow paths through the Rozelle Rail Yards would have a low flood hazard, which is consistent with flood hazards in recreational areas that are flood prone in the vicinity, such as Easton Park to the north.

The proposed drainage channels and new waterway structures would maintain the flood immunity of City West Link and The Crescent by providing 100 year ARI flood immunity around the interchange. Flood conditions along City West Link would be improved in events greater than the 100 year ARI and up to the PMF. Flood depths under existing conditions at the low point on City West Link to the north of the intersection with The Crescent are up to one metre in the PMF. Under proposed conditions these could be significantly reduced to around 0.5 metres. The flood modelling undertaken suggests that the mitigation measures would minimise impacts on surrounding properties for the 100 year ARI event and therefore satisfy the required design standards. Refinements to the flood model would be required to inform the detailed design of the proposed interchange.



LEGEND

Imagery © Nearmap (2017)

Existing features
- Waterway
- Light rail
- Light rail stop

M4-M5 Link
- Project footprint
- Model extent

Peak flood depths (m)
- <0.05
- 0.05 to 0.1
- 0.1 to 0.25
- 0.25 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 2.5
- >2.5

Figure 17-22 Proposed design conditions flood behaviour – Rozelle interchange - peak flood depths (10 year ARI)

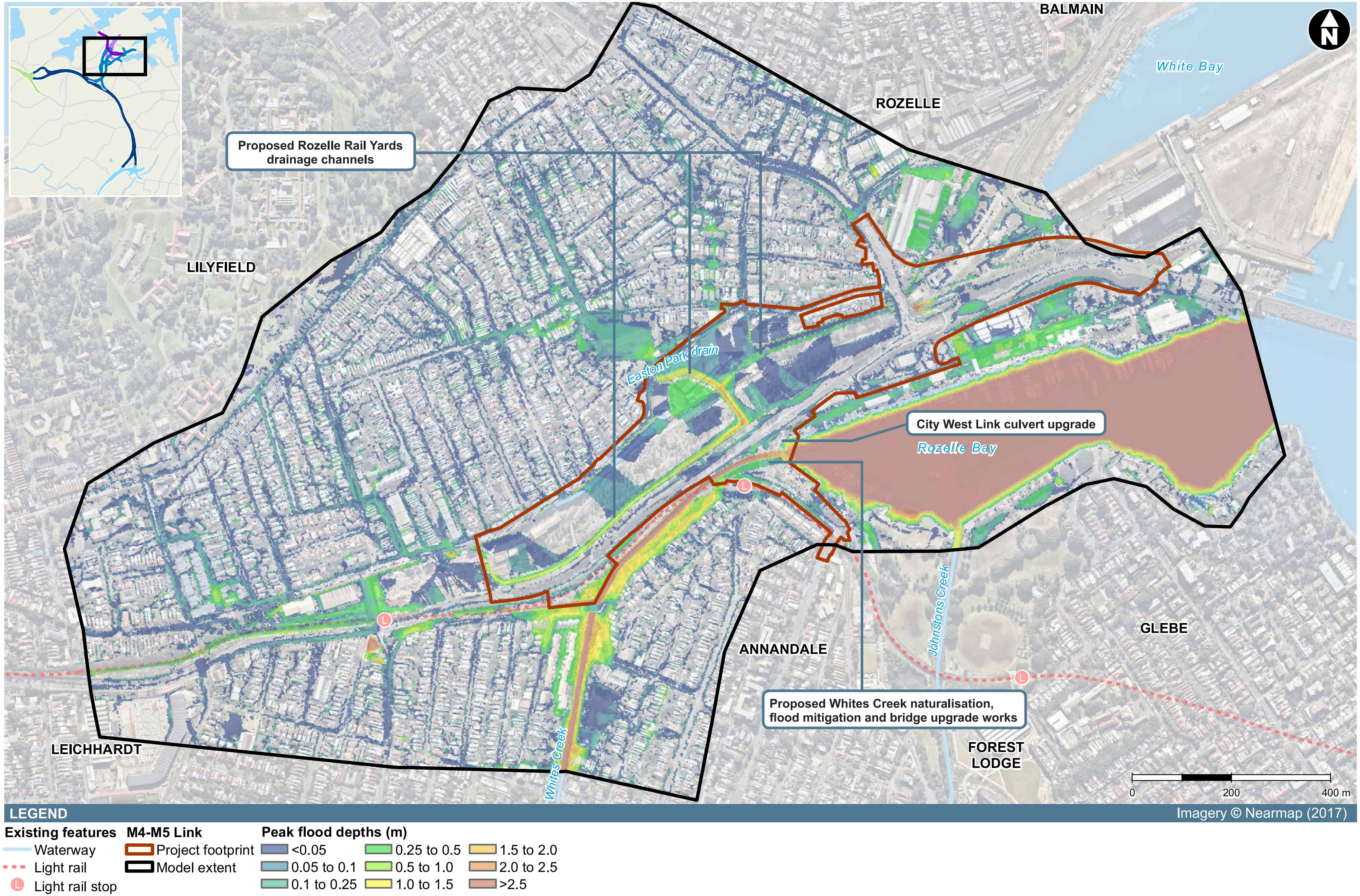


Figure 17-23 Proposed design conditions flood behaviour – Rozelle interchange - peak flood depths (100 year ARI)

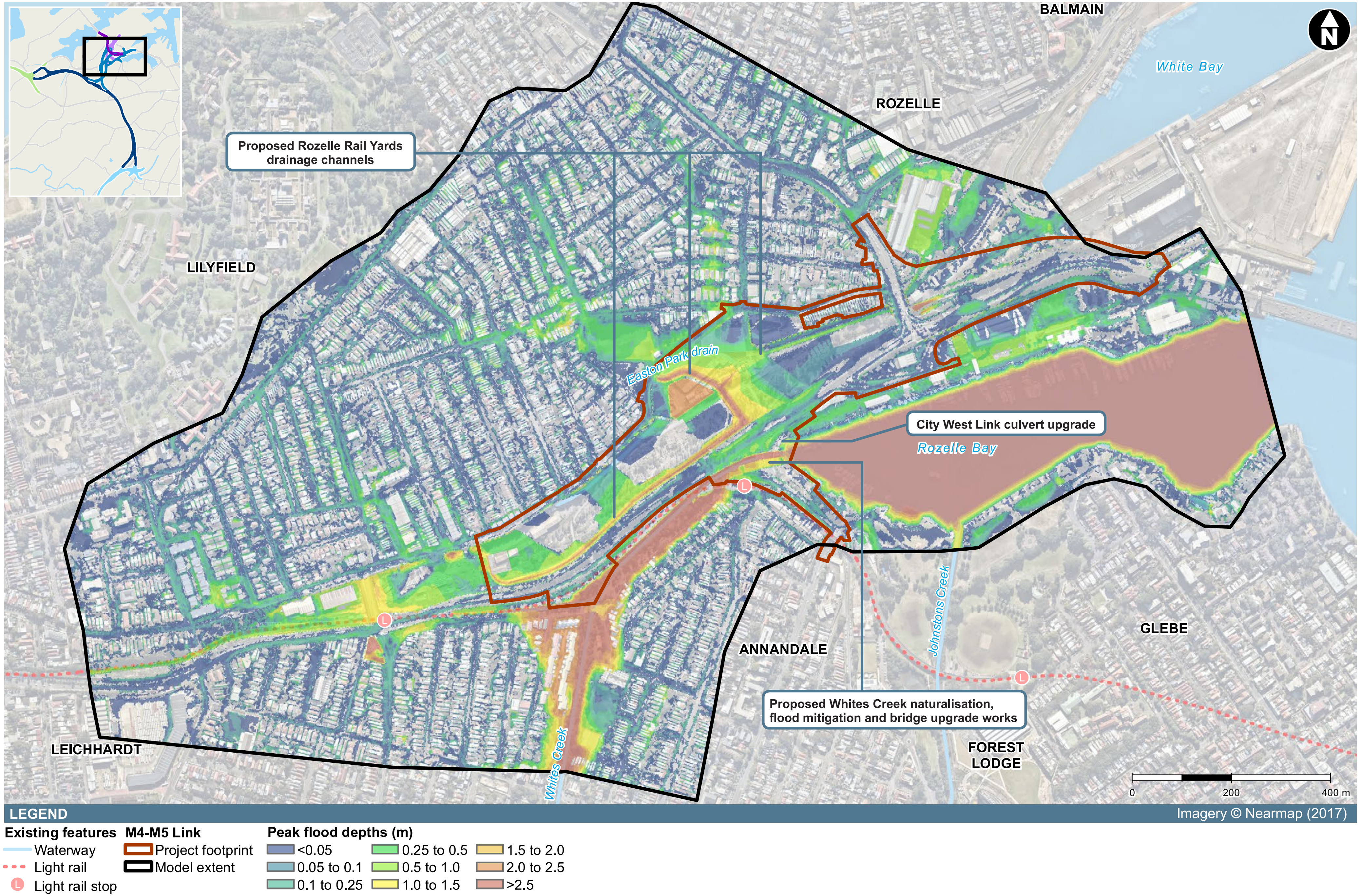


Figure 17-24 Proposed design conditions flood behaviour – Rozelle interchange - peak flood depths (PMF)

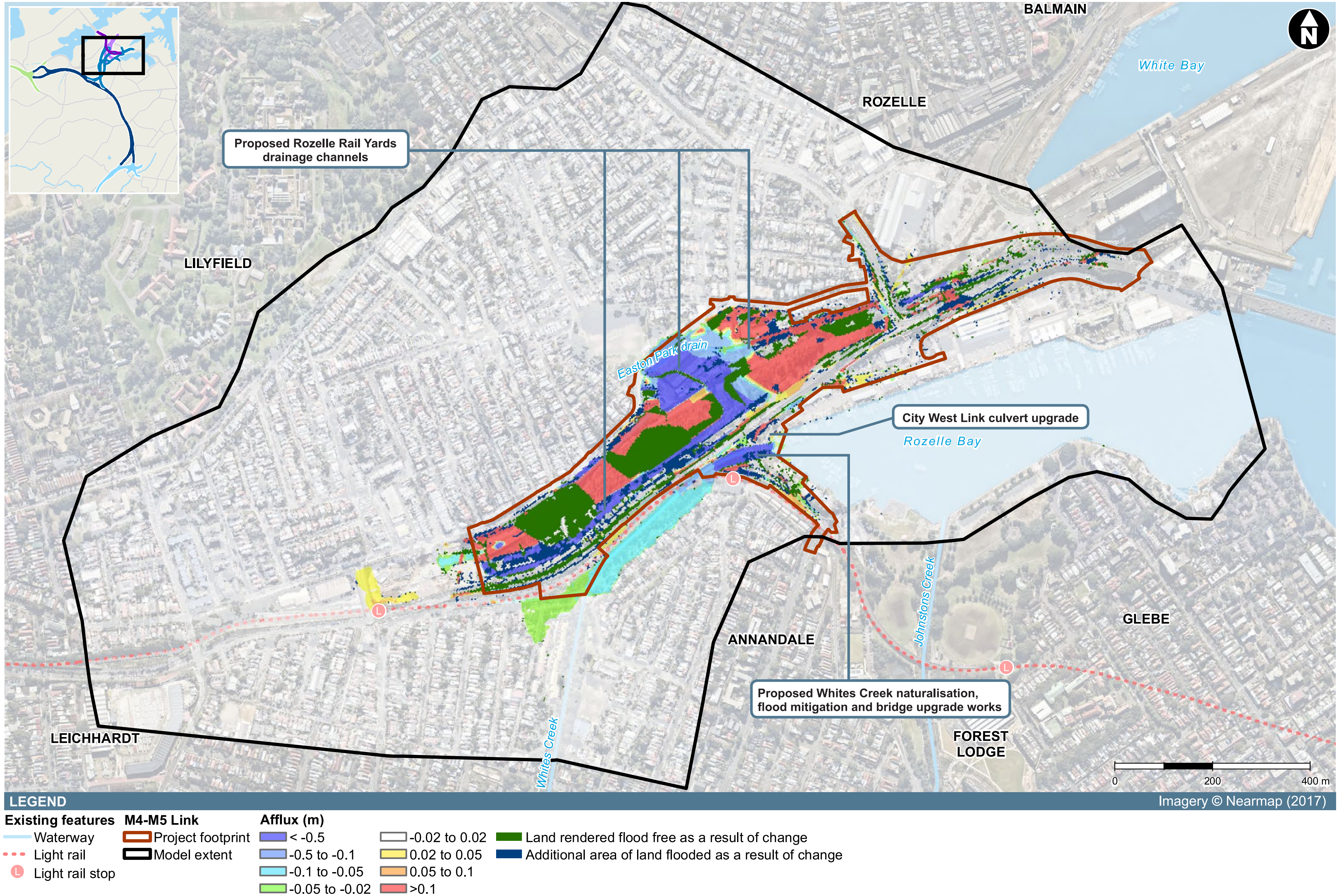


Figure 17-25 Proposed design conditions flood behaviour – Rozelle interchange - relative flood impact (100 year ARI)

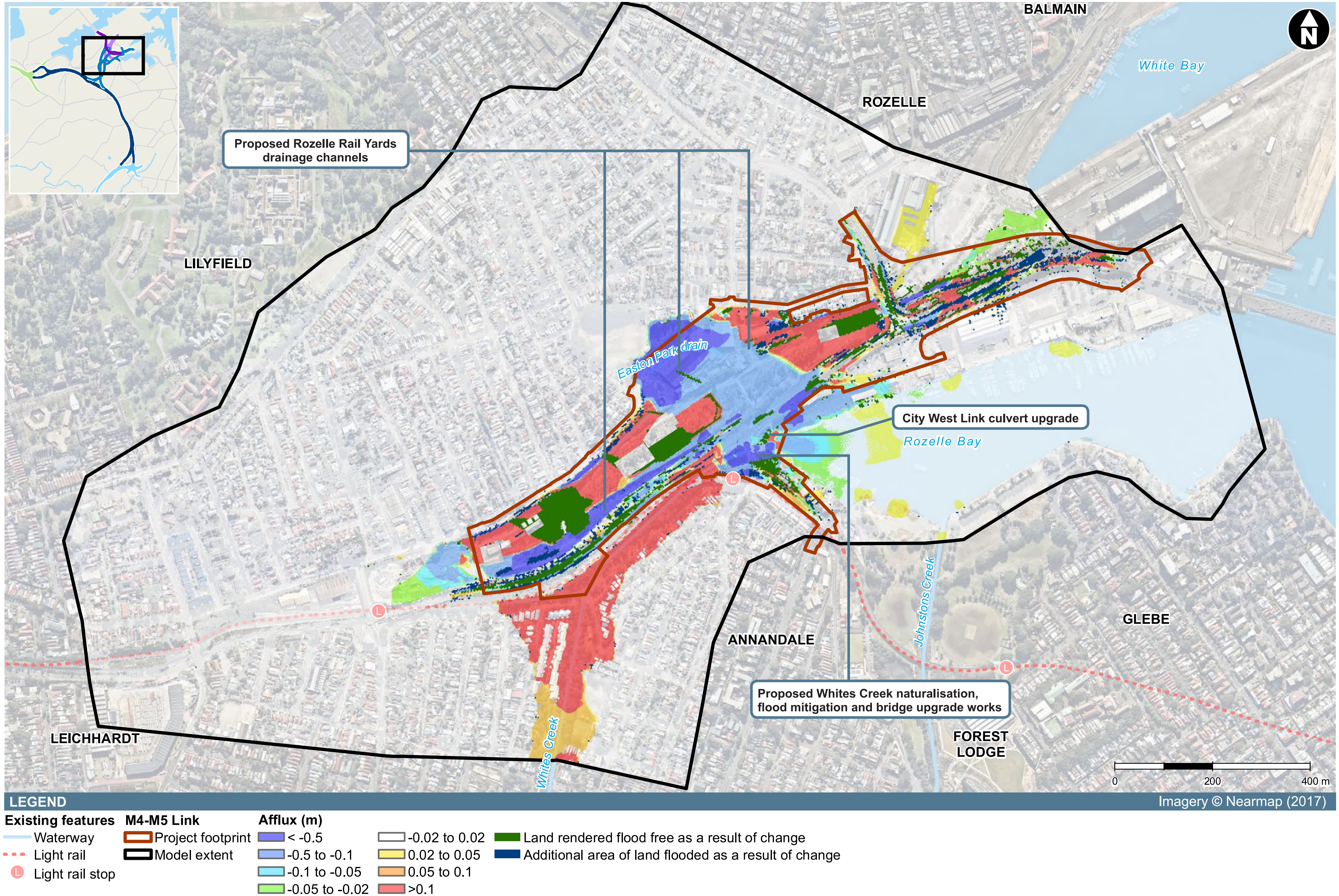


Figure 17-26 Proposed design conditions flood behaviour – Rozelle interchange - relative flood impact (PMF)

Iron Cove Link

Peak flood depths for the 10 year ARI event, 100 year ARI event and PMF under proposed design conditions are shown in **Figure 17-27** to **Figure 17-29**.

Within the Iron Cove Link, floodwater on the southern (westbound) carriageway heading towards Iron Cove Bridge reaches depths of between 0.5 metres and 0.8 metres in the 10 year ARI and PMF, respectively. This is associated with a topographic depression in the proposed road levels at this location.

Increases in flood levels are predominantly limited to within the Iron Cove Link and Victoria Road for the 100 year ARI and PMF event. The catchment at Iron Cove generally drains from the northeast towards the Iron Cove Link. Changes in road levels along the main alignment, particularly at the intersections with existing local roads could lead to localised flood impacts along the northern (eastbound) carriageway. These impacts would be managed through limiting the raising of road levels and upgrading the road drainage system to manage changed overland flow paths. The road levels and drainage system would be confirmed during detailed design, assessed as necessary and managed in accordance with the measures outlined in **Appendix F** (Technical working paper: Utilities Management Strategy).

There is also a risk of flood impacts on adjoining properties at the edge of Iron Cove east of the alignment (see **Figure 17-30** and **Figure 17-31**). Between Terry Street and Iron Cove Bridge, the portals would reduce the number of surface traffic lanes on Victoria Road from four lanes to three lanes. As the road acts as a major overland flow path, the reduced road width would also mean a reduced flow path width and more concentrated flows. This could be managed through upgrading the road drainage network to compensate for the reduced overland flow path width.

To minimise the residual risk of flooding of the road and the portals, the design of the road drainage system around the tunnel portals would be designed to manage surface runoff in this area, particularly for the southern tunnel due to the topographic low at this location.

The drainage network under Victoria Road would be upgraded to collect local surface water runoff draining to the portals up-gradient of Crystal Street and at Terry Street. The water would then be diverted into a new drainage network and discharged into Iron Cove. Barriers or flood bunds would be set at or above the PMF flood level (or 100 year ARI plus 0.5 metres, whichever is the greater) to provide protection to the exposed sections of the portal from runoff from the adjacent roads.

To minimise the potential impact on surrounding properties, the road would be graded and kerb lines used to keep runoff away from the portals, and within the road reserve; to a discharge point into Iron Cove (exact location to be determined during detailed design). Where possible, the road runoff would be directed to the proposed new bioretention facility within King George Park, adjacent to Manning Street at Rozelle, prior to discharge to Iron Cove.

Infrastructure such as the Iron Cove Link motorway operations complex (MOC4) and substation are proposed to be located at the southern end of the interchange. This infrastructure would be protected from local stormwater runoff flooding the site through the provision of bunds or raising floor levels to the PMF or 100 year ARI plus 0.5 metres (whichever is greater). At the Iron Cove interchange the 100 year ARI level plus 0.5 metres is usually greater than the PMF level.

Peak flow velocities within the Iron Cove Link area are predicted to be up to 2.2 metres per second in the 100 year ARI, which is similar to existing conditions. The flood hazard for the land near Iron Cove Link does not change substantially from existing conditions.

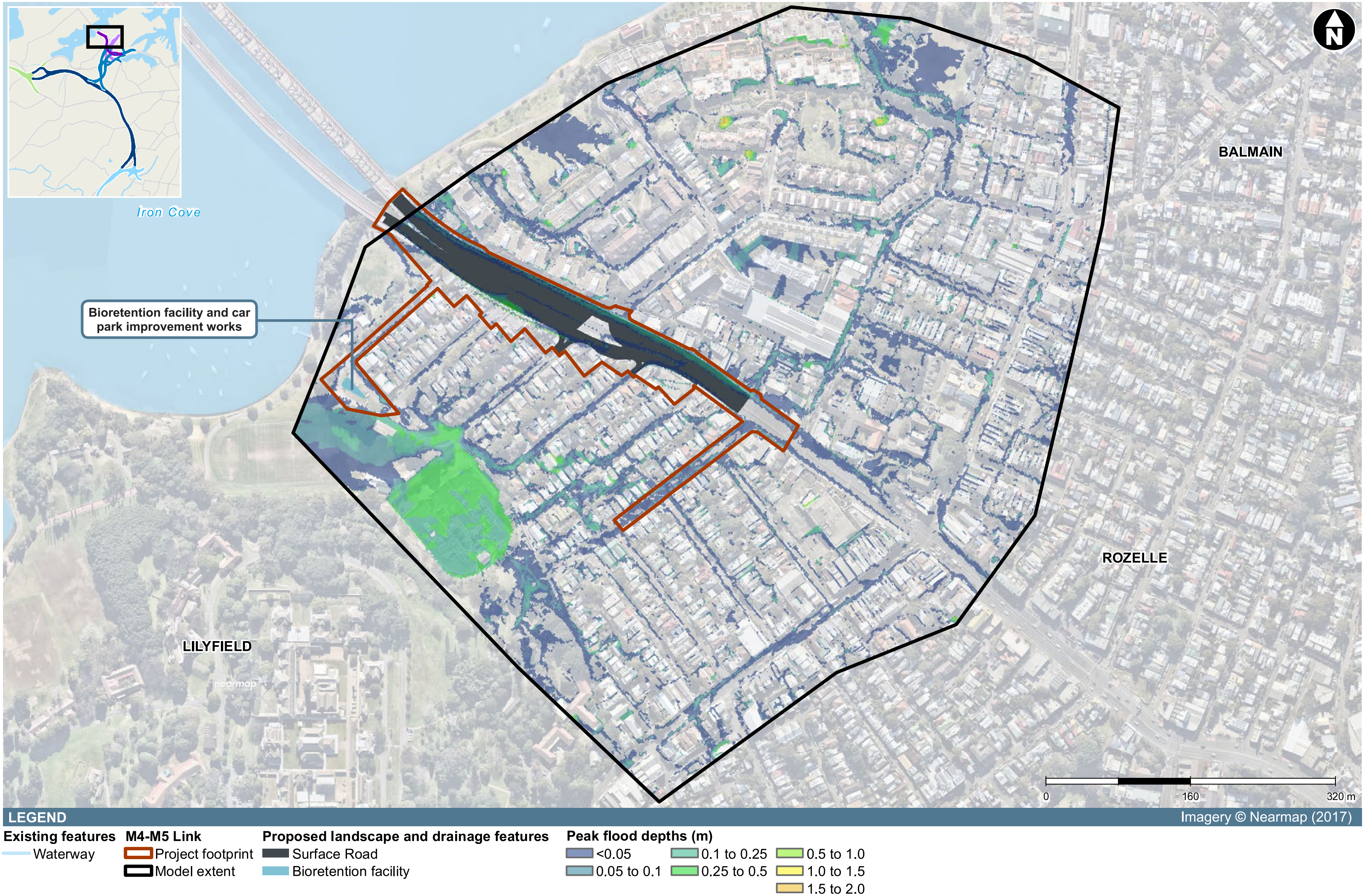


Figure 17-27 Proposed design conditions flood behaviour – Iron Cove Link - peak flood depths (10 year ARI)

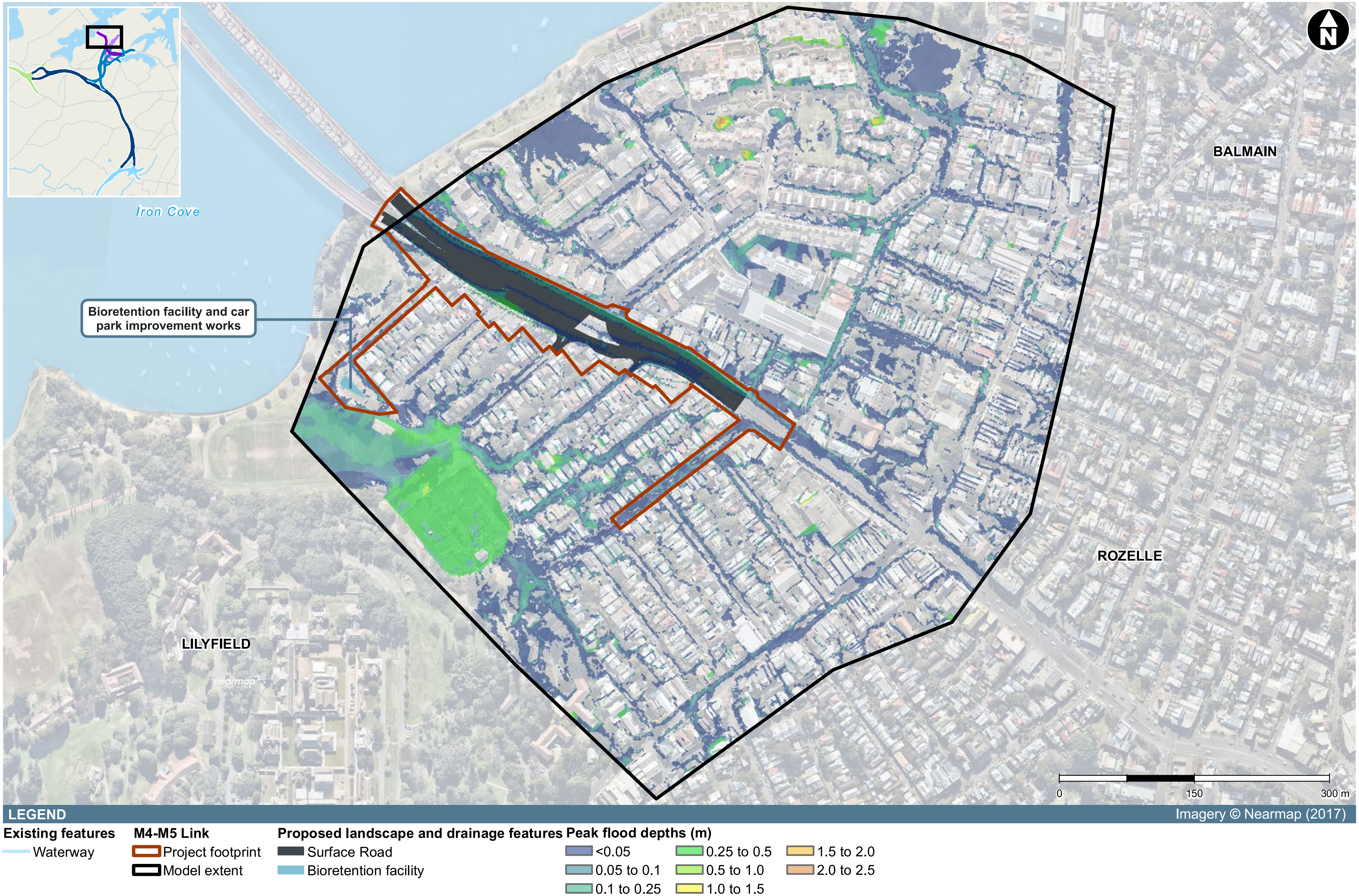


Figure 17-28 Proposed design conditions flood behaviour – Iron Cove Link - peak flood depths (100 year ARI)

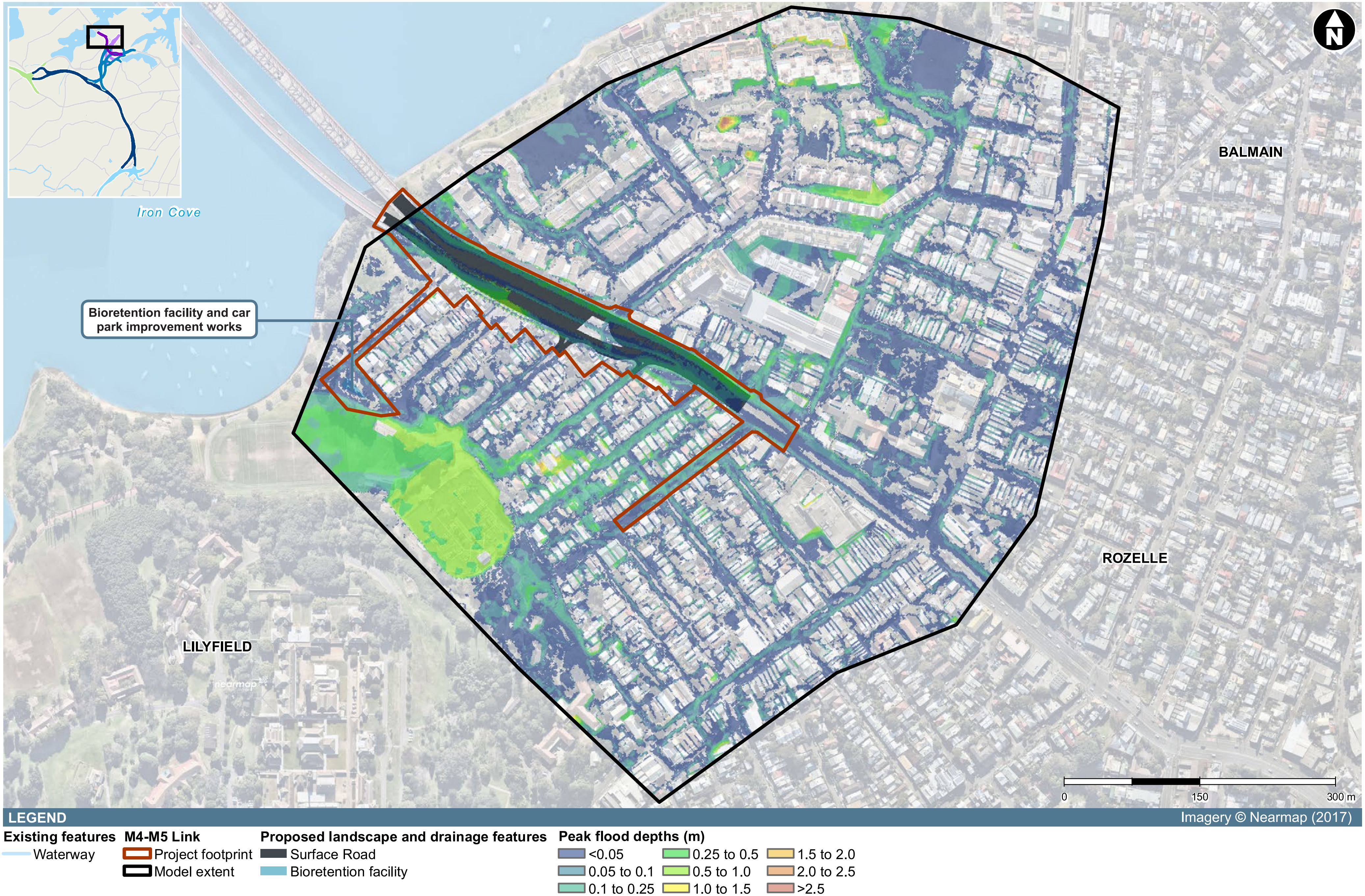


Figure 17-29 Proposed design conditions flood behaviour – Iron Cove Link - peak flood depths (PMF)

LEGEND

Imagery © Nearmap (2017)

Existing features
- Waterway

M4-M5 Link
- Project footprint
- Model extent

Proposed landscape and drainage features
- Surface Road
- Bioretention facility

Afflux (m)
- < -0.5
- -0.5 to -0.1
- -0.1 to -0.05
- -0.05 to -0.02
- -0.02 to 0.02
- 0.02 to 0.05
- 0.05 to 0.1
- >0.1
- Land rendered flood free as a result of change
- Additional area of land flooded as a result of change

Figure 17-30 Proposed design conditions flood behaviour – Iron Cove Link - relative flood impact (100 year ARI)

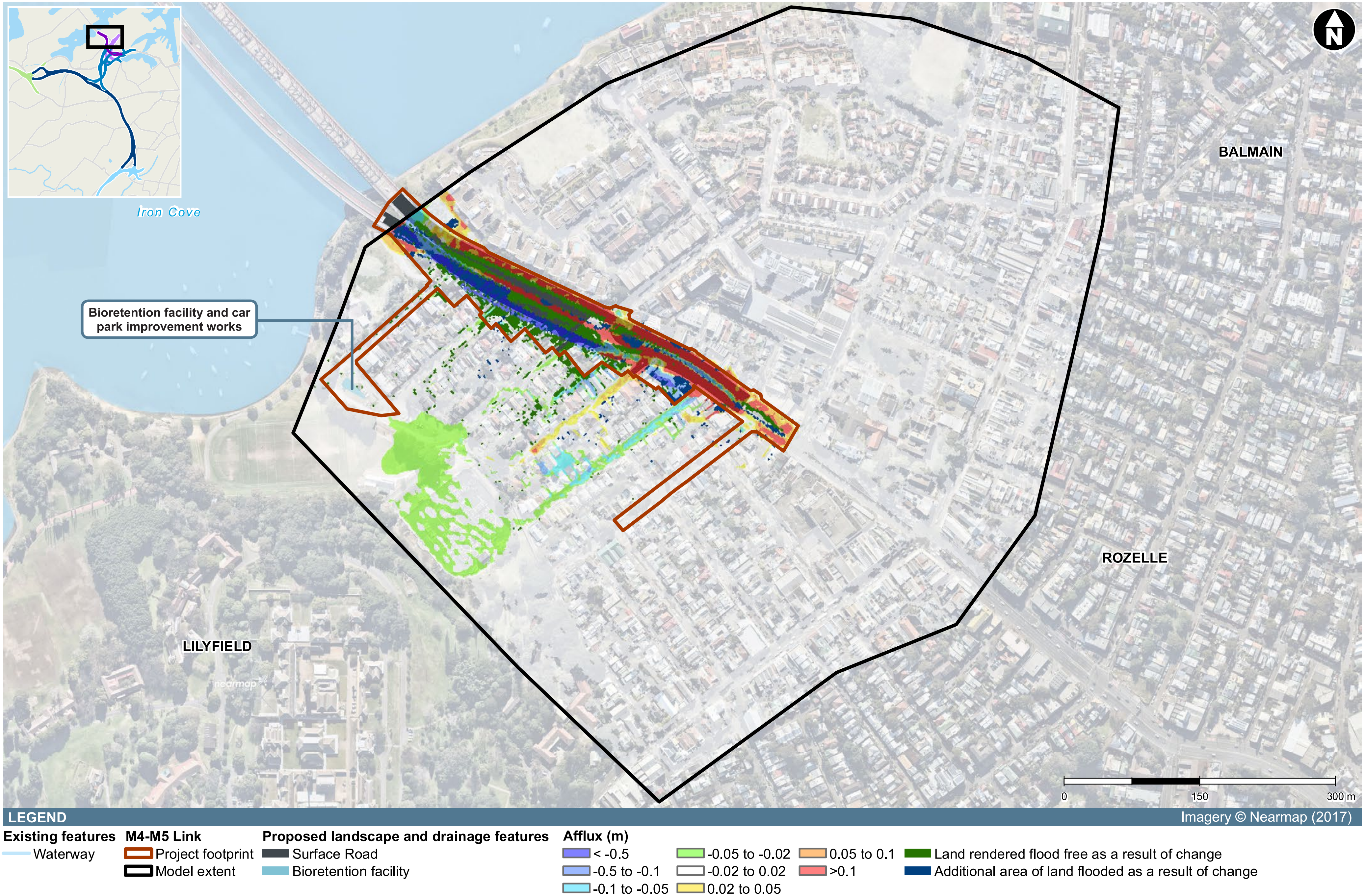


Figure 17-31 Proposed design conditions flood behaviour – Iron Cove Link - relative flood impact (PMF)

Darley Road

The proposed Darley Road operational facilities would include an operational water treatment plant for tunnel drainage and a substation.

An assessment of potential flood impacts at the Darley Road site for events up to the PMF event was undertaken by assuming bunds/walls around most of the site in order to prevent floodwater ingress to the water treatment plant and substation.

Flood protection for vulnerable infrastructure, such as the Darley Road motorway operations complex (MOC1) need to be set at PMF flood level or 100 year ARI plus 0.5 metres, whichever is the greater. At the Darley Road site, there are locations where the 100 year ARI level plus 0.5 metres is greater than the PMF level. Peak flood depths for the 10 year ARI event, 100 year ARI event and PMF under proposed design conditions are shown in **Figure 17-32** to **Figure 17-34**.

It was found the water exclusion strategy for the vulnerable infrastructure on the site (water treatment plant and substation) would lead to localised increases in flood levels on Darley Road and the Inner West Light Rail line (see **Figure 17-35** and **Figure 17-36**). Surrounding properties would not be adversely impacted in the events up to the 100 year ARI. In the PMF, minor flood impacts of up to 0.3 metres are estimated to the west of the site along Darley Road and Charles Street. Impacts on the Inner West Light Rail line would need to be managed in consultation with Transport for NSW by either providing a managed flow path through the site, while still protecting vulnerable infrastructure, and/or by providing additional piped drainage systems. This strategy would be further developed during detailed design when site layouts are finalised.

Peak flow velocities along Darley Road would be similar to existing conditions at 1.5 metres per second. Provisional flood hazards would also be similar to existing conditions.

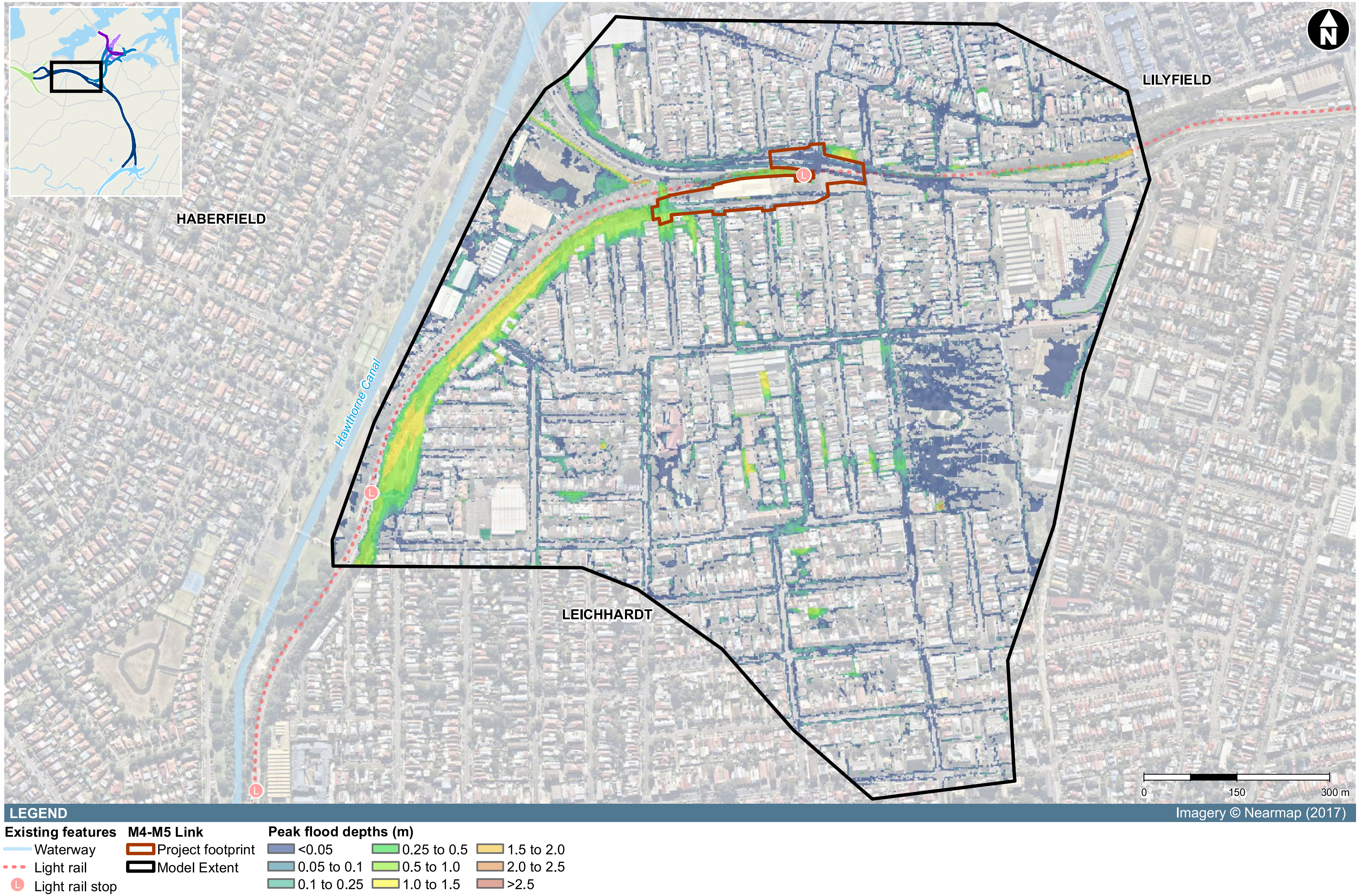


Figure 17-32 Proposed design conditions flood behaviour – Darley Road - peak flood depths (10 year ARI)

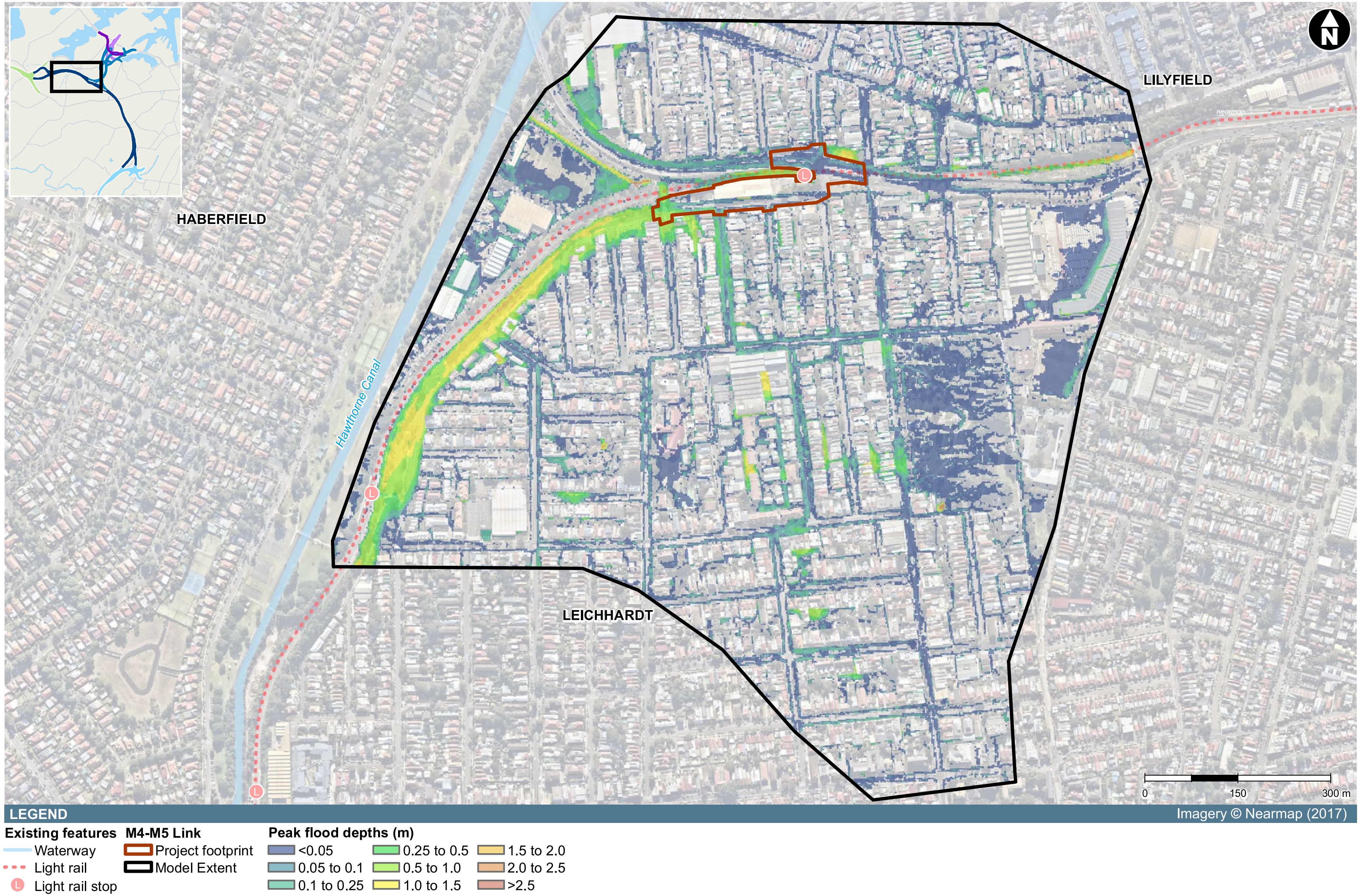


Figure 17-33 Proposed design conditions flood behaviour – Darley Road - peak flood depths (100 year ARI)

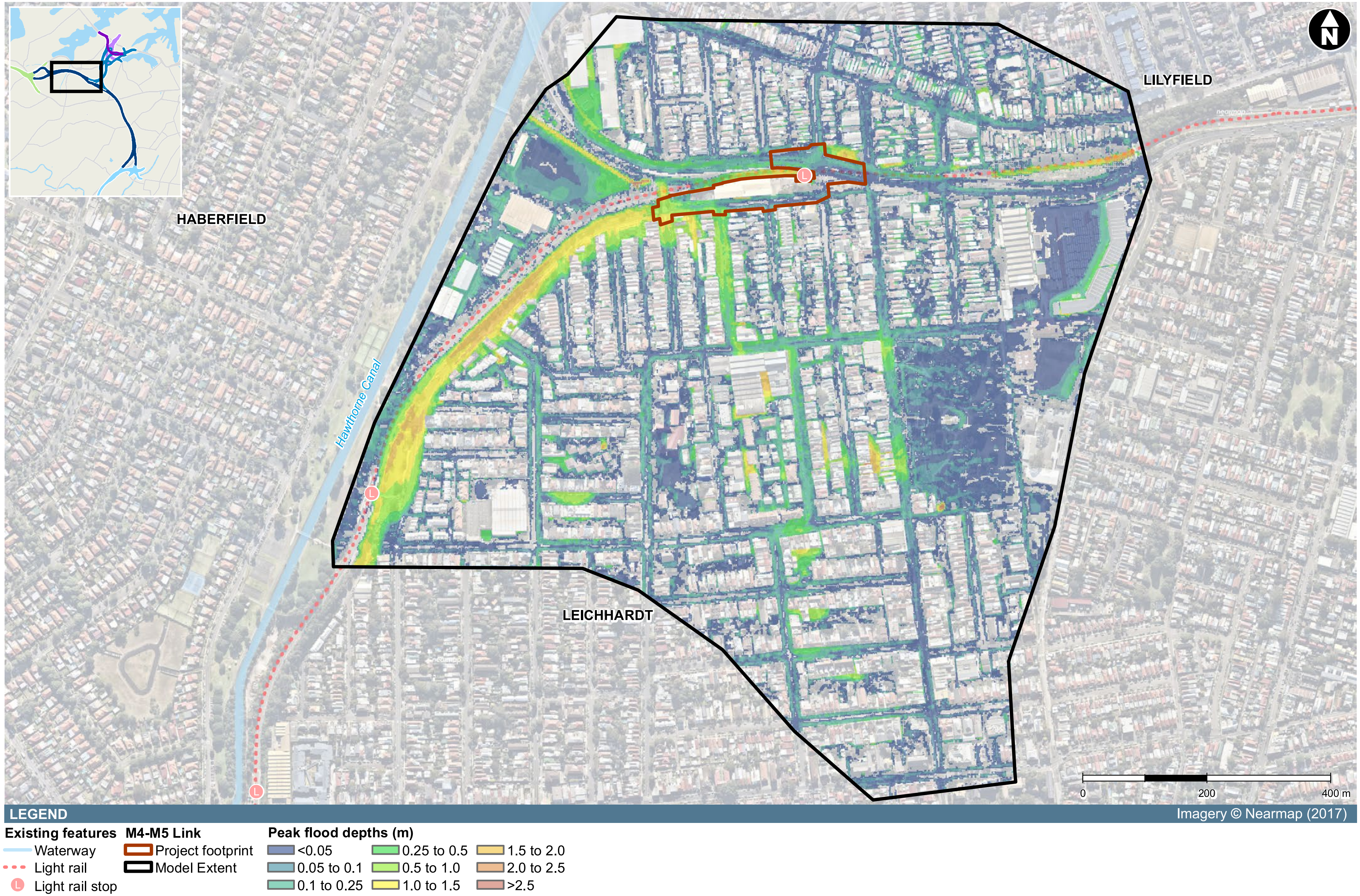
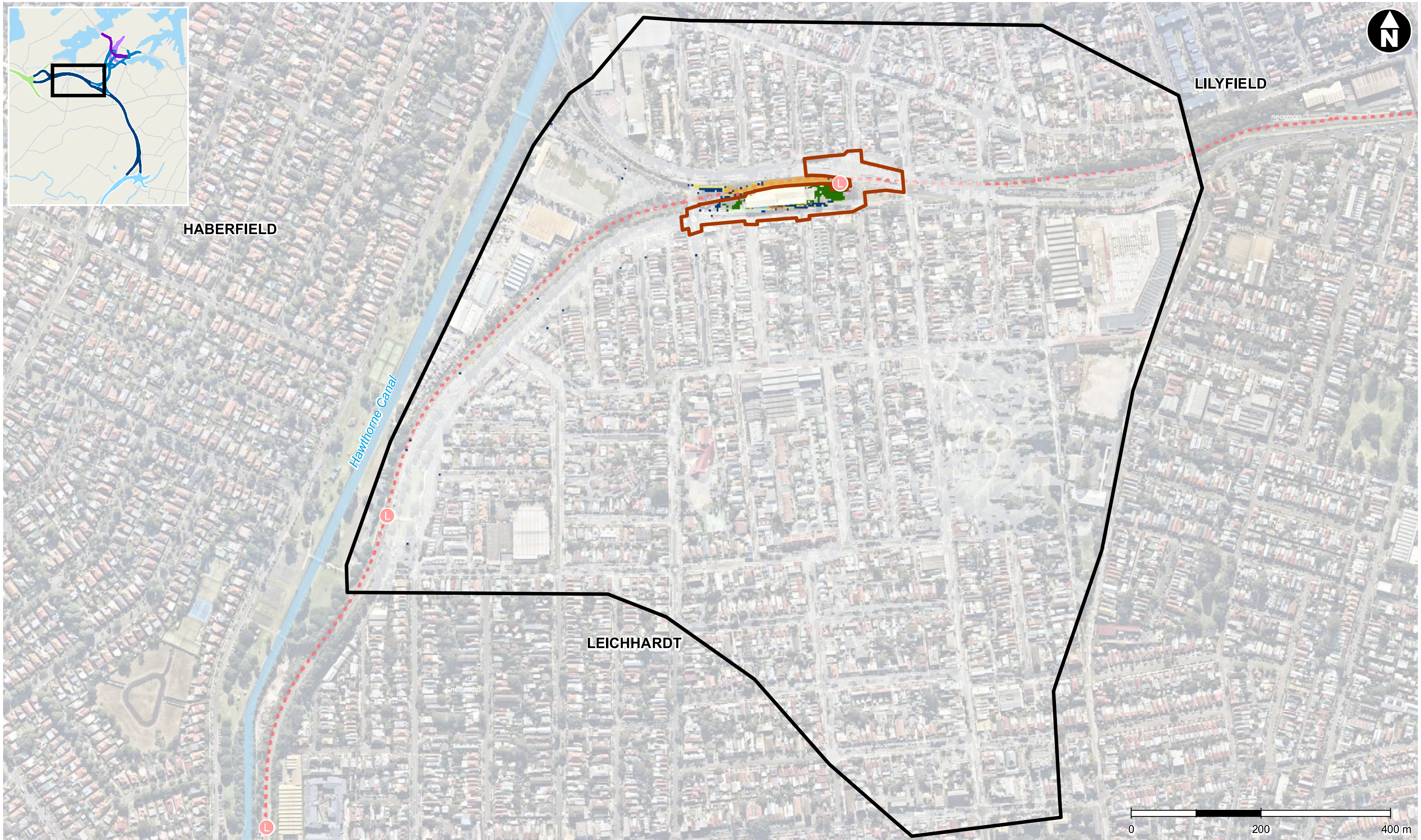


Figure 17-34 Proposed design conditions flood behaviour – Darley Road - peak flood depths (PMF)



LEGEND

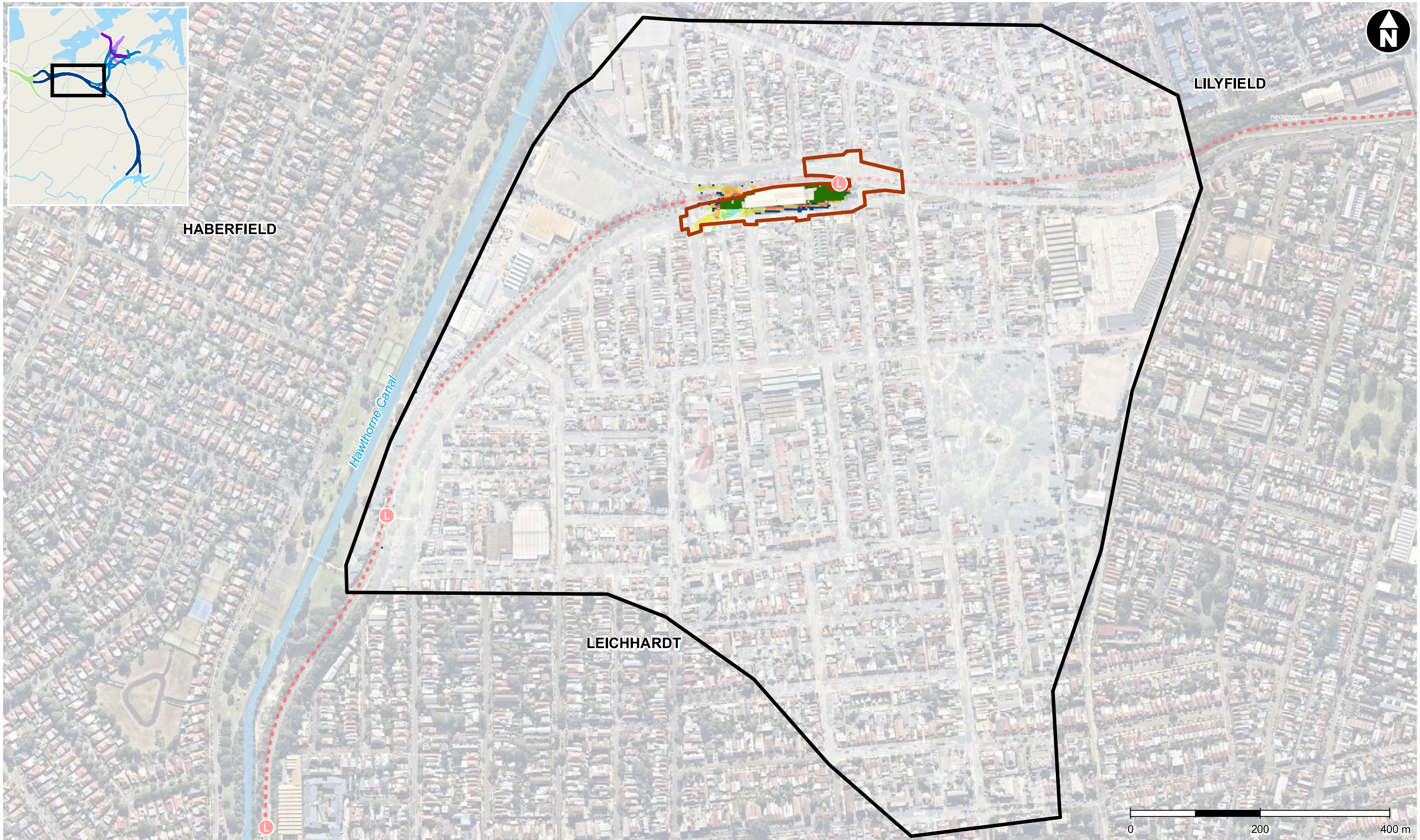
Imagery © Nearmap (2017)

Existing features
- Waterway
- Light rail
- Light rail stop

M4-M5 Link
- Project footprint
- Model Extent

Afflux (m)
- -0.5 to -0.1
- -0.1 to -0.05
- -0.05 to -0.02
- -0.02 to 0.02
- 0.02 to 0.05
- 0.05 to 0.1
- >0.1
- Land rendered flood free as a result of change
- Additional area of land flooded as a result of change

Figure 17-35 Proposed design conditions flood behaviour – Darley Road - relative flood impact (100 year ARI)



LEGEND

Existing features
- Waterway
- Light rail
- Light rail stop

M4-M5 Link
- Project footprint
- Model Extent

Afflux (m)
- -0.5 to -0.1
- -0.1 to -0.05
- -0.05 to -0.02
- -0.02 to 0.02
- 0.02 to 0.05
- 0.05 to 0.1
- >0.1
- Land rendered flood free as a result of change
- Additional area of land flooded as a result of change

Figure 17-36 Proposed design conditions flood behaviour – Darley Road - relative flood impact (PMF)

17.4.2 Emergency management and response procedures

Council emergency management and response procedures relating to flooding have not been assessed in detail as they are still under development as part of the Inner West Council's Floodplain Risk Management Study and Plan. The Inner West Council is working toward formation of a Floodplain Risk Management Committee. Consideration would be given to council emergency and response procedures during detailed design, dependent on the timing for finalisation of these by the relevant council.

There are no local State Emergency Services (SES) flood plans for the area. The NSW State Flood Plan, which is a sub plan of the State Emergency Management Plan, has been reviewed as part of this assessment. The design has taken into consideration the general recommendations set out in the NSW State Flood Plan with regards to managing flooding. The flood assessment has been undertaken in accordance with the *Floodplain Development Manual* (NSW Government 2005) and has sought to minimise adverse flood impacts. During the detailed design stage, relevant flooding information would be provided to council and SES to assist in informing the Floodplain Risk Management process.

17.4.3 Potential impacts of future climate change

Future climate change could lead to sea level rise and a potential increase in rainfall intensity and frequency. This could affect flood behaviour over the life of the project. As a result, an assessment of the potential impact of climate change on flood behaviour near the project has been undertaken. For further detail on the potential impacts of future climate change refer to **Appendix Q** (Technical working paper: Surface water and flooding) and **Chapter 24** (Climate change and risk adaption).

Wattle Street and St Peters interchanges

For the Wattle Street and St Peters interchanges, potential impacts of future climate change have already been considered in the design of the M4 East and New M5 projects. Climate change impact assessments are described in the design documentation for those projects. Therefore, no additional climate change assessments are required for these areas.

Rozelle interchange

The Rozelle interchange is close to Rozelle Bay and both sea level rise and potential increases in rainfall intensity could exacerbate flooding near the interchange.

Based on the guidelines set out in The *Floodplain Risk Management Guideline – Practical Consideration of Climate Change* (DECC 2007), a number of different scenarios were adopted in the assessment of the potential climate change impacts at the Rozelle interchange over the design life of the project. These scenarios are summarised in **Appendix Q** (Technical working paper: Surface water and flooding) and were based on a combination of:

- 200 year and 500 year ARI rainfall intensities, assumed to represent 10 per cent or 30 per cent increase in 2016 (present day) rainfall intensities, respectively
- A rise in sea level by 0.4 metres or 0.9 metres.

The flood model developed for the flood assessment around the Rozelle interchange was used to assess potential changes in flood behaviour under the various climate change scenarios. The climate change assessment has been based on the proposed design conditions. Peak flood levels at key locations for present day (2016) as well as for the assessed climate change scenarios are summarised in **Appendix Q** (Technical working paper: Surface water and flooding).

Potential impacts are as follows:

- Potential increases in rainfall intensities by up to 10 per cent would lead to flood level increases of around 0.06 metres for areas that are not affected by sea level rise in the 100 year ARI event. Increases in rainfall intensities by up to 30 per cent would lead to flood level increases of up to 0.15 metres. This means that more properties could be affected by flooding or experience more frequent flooding under future climate change conditions around Rozelle Bay and the Rozelle Rail Yards

- At the new bridge over Whites Creek at The Crescent, sea level rise would lead to increases in peak flood levels of between 0.26 metres and 0.82 metres in the 100 year ARI event. This would reduce the freeboard to the underside of the bridge. This means that properties adjacent to Whites Creek, particularly along Railway Parade could experience much more frequent flooding under future climate change conditions
- At the tunnel portal, the effect of sea level rise would be less pronounced than at The Crescent. Sea level rise would lead to increases in peak flood levels of between 0.1 metres and 0.67 metres in the 100 year ARI event. This would reduce the freeboard to the portal, but peak flood levels would still be more than 0.5 metres below the PMF level
- At the new culverts under City West Link, sea level rise would lead to increases in peak flood levels of between 0.1 metres and 0.66 metres in the 100 year ARI event. Peak flood levels would still be more than 0.5 metres below the PMF level which would set the minimum level for the tunnel portal
- Neither potential increases in rainfall intensities nor sea level rise would lead to overtopping of The Crescent or City West Link in the 100 year ARI event
- At the tunnel portal, sea level rise would lead to minor increases in peak flood levels of between 0.01 metres and 0.04 metres in the PMF. Peak PMF flood levels at the tunnel portal are therefore not very sensitive to a sea level rise of up to 0.9 metres
- Flood behaviour with potential increases in rainfall intensities and sea level rise in a 100 year ARI and PMF events are shown in **Appendix Q** (Technical working paper: Surface water and flooding).

Iron Cove Link

Iron Cove Link would be situated at a level that is above the influence of any sea level rise associated with climate change. Therefore, only the influence of increases in rainfall intensities was considered as part of the climate change assessment. Design rainfall intensities for the 200 and 500 year ARI events were adopted as being similar to the 100 year ARI design rainfall intensity, being increased by 10 per cent and 30 per cent respectively.

The peak flood levels at Iron Cove Link or surrounding roads did not vary significantly under the higher rainfall intensity scenarios of the 200 year and 500 year ARI events. Along roads and other areas with reasonable hydraulic gradients and shallow depths, the increase in flood level would only be between 0.01 metres and 0.05 metres.

Darley Road

Darley Road is near Hawthorne Canal, which would be influenced by sea level rise as well as increased rainfall intensities and frequencies.

The climate change assessment at Darley Road involved determining the potential influence on flood levels as a consequence of higher rainfall intensity. Design rainfall intensities for the 200 year and 500 year ARI events were adopted as being similar to the 100 year ARI design rainfall intensity, being increased by 10 per cent and 30 per cent respectively.

The peak flood levels at Darley Road did not vary significantly under the higher rainfall intensity scenarios of the 200 year and 500 year ARI events. Along roads and other areas with reasonable hydraulic gradients and shallow depths the increase in flood level would only be between 0.01 metres and 0.05 metres. In ponding areas, flood levels could rise by up to 0.16 metres under future climate conditions.

17.4.4 Impact on existing drainage infrastructure

There is limited existing drainage infrastructure at many of the project sites that would be impacted or need to be modified. For the operational sites, the surface water runoff would be managed to minimise flood impacts on adjoining properties. Where the operational sites propose to connect directly to existing drainage infrastructure, flow rates from the sites would match existing flow rates where possible so as not to overload the existing drainage system or cause adverse flood impacts on adjoining properties. Further details on the relocation and adjustments to drainage infrastructure can be found in **Appendix F** (Technical working paper: Utility Management Strategy). The impacts the project may have on the social and economic costs to the community as consequence of flooding are considered to be minimal with the adoption of the mitigation measures provided in **section 17.5**.

17.4.5 Hydrological impacts

Surface water balance

Stormwater runoff volumes generated within the project footprint would increase as a result of an increase in impervious surfaces associated with surface road widenings, ramps and ancillary surface infrastructure. The footprint included within the modelling and the change in impervious area is provided in **Appendix Q** (Technical working paper: Surface water and flooding).

Modelling was undertaken to estimate changes in annual stormwater runoff volume to receiving waterways caused by the project. The modelling results are provided in **Appendix Q** (Technical working paper: Surface water and flooding). The results indicate that annual runoff volumes would be slightly increased as a result of the project, with increases occurring at Rozelle Bay and White Bay with no change to Whites Creek. A slight decrease in runoff volume would occur at Iron Cove.

Treated tunnel water flows from the operational water treatment plants at Darley Road (MOC1) and Rozelle would ultimately discharge to Hawthorne Canal and Rozelle Bay respectively, leading to an increase in base flow rate to those waterways. It is estimated that up to 725 megalitres per year and 693 megalitres per year of treated groundwater would be discharged to Hawthorne Canal and Rozelle Bay respectively.

It is estimated that up to 50 megalitres per year of tunnel drainage from about one kilometre of the northbound and 600 metres of southbound tunnel would be captured by the New M5 drainage system and conveyed to the New M5 operational water treatment plant at Arncliffe, prior to discharge to the Cooks River. A post development mean annual water balance is provided in **Appendix Q** (Technical working paper: Surface water and flooding).

Discharges

The flow variability within the receiving waterways is dominated by tides at the discharge locations. Therefore, the minor increases in stormwater flow within Rozelle Bay and Whites Bay and increase in base flow to Hawthorne Canal and Rozelle Bay is not considered to pose a material impact on the flow variability or natural processes within the receiving waterways. As Hawthorne Canal is hard-lined, increased discharge volumes would not impact on bed or bank stability or the geomorphology of the waterway. Scour and/or dissipation measures would minimise any sediment disturbance impacts at the outlets to the receiving bays and waterways. Further information on scour impacts and proposed management measures is discussed in **Chapter 15** (Soil and water quality).

The impacts associated with discharges from the Arncliffe operational water treatment plant were assessed as part of the New M5. The additional tunnel drainage flow (around 1.6 litres per second) associated with the project would be negligible compared to flows within the Cooks River. It is therefore considered that impacts on levels and velocities in the Cooks River would be negligible. The existing scour protection and/or energy dissipation measures would minimise any sediment disturbance impacts near to the outlet.

Environmental water availability

No surface water is proposed to be extracted directly from adjacent waterways or bays during the operational phase. Discharge volumes are likely to slightly increase as a result of the project. All operational discharges would be to unregulated, artificial and tidally influenced waterways or bays. Therefore, no impacts on environmental water availability or flows are likely to occur.

17.5 Management of impacts

The flood mitigation standards established for the project infrastructure have been achieved by demonstrating that there is no impact on properties in the 100 year ARI. Therefore, it is not anticipated that floor level impacts would occur, however this would be confirmed during detailed design. If changes to flooding in larger events such as the PMF were found to impact tunnels or critical infrastructure, further flood mitigation measures would be adopted.

Public safety is one of the driving factors for assessing and mitigating flood impacts. This is reflected in the hydrologic standards that have been set for both construction and operation of the project as set out in **section 17.1.3**. In terms of flooding, public interest has specifically been taken into account by:

- Providing PMF flood immunity to tunnel portals and other critical infrastructure such as motorway control centres and substations
- Providing drainage channels within the Rozelle Rail Yards that have 100 year ARI capacity, leaving the overbank areas flood free up to the 100 year ARI and opening the area up to recreational uses
- Widening of Whites Creek which reduces 100 year ARI flood levels along Whites Creek.

Environmental management measures relating to flooding and drainage for the construction and operation of the project are provided in **Table 17-5**. Specific management measures for each construction ancillary facility are provided in **Appendix Q** (Technical working paper: Surface water and flooding). The environmental management measures listed in **Table 17-5** should be read in conjunction with the environmental management measures provided in **Chapter 15** (Soil and water quality).

Table 17-5 Environmental management measures – flooding and drainage

Impact	No.	Environmental management measure	Timing
Impacts on flood behaviour from construction and operation	FD01	A Flood Mitigation Strategy will be prepared by a suitably qualified and experienced person in consultation with directly affected landowners, DPI-Water, OEH, SES, Sydney Water and the relevant local councils. It will include but not be limited to: • Identification of flood risks to the project and adjoining areas, including consideration of local drainage catchment assessments and climate change implications on rainfall, drainage and tidal characteristics • Identification of design and mitigation measures to protect proposed operations and not worsen existing flooding characteristics during construction and operation, including soil erosion and scouring • Identification of drainage system upgrades • The 100 year ARI flood level will be adopted in the assessment of measures which are required to mitigate flood risk to the project, as well as any adverse impacts on surrounding property • Changes in flood behaviour under PMF conditions will also be assessed in order to identify impacts on critical infrastructure and significant changes in flood hazards as a result of the project • Consideration of limiting flooding characteristics to the following levels: - A maximum increase in inundation time of one hour in a 100 year ARI rainfall event - No inundation of floor levels which are currently not inundated in a 100 year ARI rainfall event - A maximum increase of 10 mm in inundation at properties where floor levels are currently exceeded in a 100 year ARI rainfall event	Construction

Impact	No.	Environmental management measure	Timing
		- A maximum increase of 50 mm in inundation at properties where floor levels will not be exceeded in a 100 year ARI rainfall event - Or else provide alternative flood mitigation solutions consistent with the intent of these limits • Consideration of the EIS documents.	
	FD02	Hydrologic and hydraulic assessments will be carried out for all temporary project components (including ancillary facilities) and permanent design features that have the potential to affect flood levels in the vicinity of the project. The results of the assessment will inform the preparation of the Flood Mitigation Strategy (FD01) as well as the design development of temporary and permanent works.	Construction
	FD03	Measures developed to manage potential flood impacts, as identified in the Flood Mitigation Strategy, will be incorporated into the design of temporary and permanent project components and construction and operational management systems as relevant.	Construction
	FD04	All entries (portals) into the tunnels will be designed so that they are located above the peak level of the PMF or the 100 year ARI design flood plus 0.50 metres, whichever is greater. The same hydrological standard will be applied to tunnel ancillary facilities such as tunnel ventilation and emergency response facilities, electrical substations and water treatment plants where the ingress of floodwaters will also have the potential to flood the tunnels.	Construction
	FD05	Bridge crossings over existing waterways and proposed drainage channels will be designed for the underside of bridge structure to be above the peak 100 year ARI design flood level.	Construction
	FD06	The need to maintain flood conveyance will be factored into construction planning associated with the new bridge structure over Whites Creek.	Construction
	FD07	Parts of the site that will be adversely affected by floodwaters, such as tunnel dive shafts, portals and cut and cover sections, will be protected from floodwater ingress during construction. The flood level adopted for design of temporary protection will be informed by consideration of both mainstream and local overland flows, the potential risk to the environment, safety and the potential disruption and damage to project works.	Construction
	FD08	The Pyrmont Bridge Road tunnel site (C9) will be designed with consideration of and to appropriately manage the existing surface water flow path on Bignell Road.	Construction
	FD09	The permanent surface water conveyance solution within the Rozelle Rail Yards will be implemented as soon as possible.	Construction

Impact	No.	Environmental management measure	Timing
	FD10	Flood contingency measures will be prepared and implemented where construction ancillary facilities and vulnerable temporary facilities (including fuel storages, water treatment plants and substations) are located in the 20 year ARI design flood extent.	Construction
Impacts on stormwater drainage systems	FD11	Further hydrological and hydraulic modelling based on the detailed design will be undertaken to determine the ability of the receiving drainage systems to effectively convey drainage discharges from the project once operational. The modelling must be undertaken in consultation with the relevant council(s). It will include, but not be limited to: • Confirming the location, size and capacity of all receiving drainage systems affected by the operation of the project • Assessing the potential impacts of drainage discharges from the project drainage systems on the receiving drainage systems • Identifying all feasible and reasonable mitigation measures to be implemented where drainage from the project is predicted to adversely impact on the receiving drainage systems.	Construction
	FD12	Where drainage systems are to be upgraded or replaced during the project, existing systems will be left in place and remain operational during the process wherever possible.	Construction
	FD13	Runoff generated from project construction and operational facilities will be managed to mitigate risk of overloading the receiving drainage system.	Construction
	FD14	Entry points to the stormwater used by or immediately downgradient from the project sites will be inspected regularly for blockages and cleaned as required to maintain performance.	Construction
Impacts on flood behaviour from future climate change	FD15	Hydrological and hydraulic assessments of the permanent design will consider the climate change related flood risk to the project and flood impacts from the project, and will confirm requirements for any management measures. The assessment will be undertaken in accordance with the *Practical Considerations of Climate Change – Floodplain Risk Management Guideline* (DECC 2007).	Construction
Impacts on property and infrastructure	FD16	Where peak levels in the 100 year ARI design flood are predicted to increase at any residential, commercial and/or industrial buildings due to construction or operation of the project, a floor level survey will be carried out. If the survey indicates flood impacts in excess of the limits set in FD01, further refinements will be made to the temporary or permanent designs as required to minimise impacts.	Construction

Impact	No.	Environmental management measure	Timing
	FD17	A flood review report will be prepared after the first defined flood event affecting the project works for any of the following flood magnitudes – the five year ARI event, 20 year ARI event and 100 year ARI event - to assess the actual flood impact against those predicted in the design reports or as otherwise altered by the FMS. The Flood Review Report(s) must be prepared by an appropriately qualified person(s) and include: • Identification of the properties and infrastructure affected by flooding during the reportable event • A comparison of the actual extent, level, velocity and duration of the flooding event against the impacts predicted in the design reports or as otherwise altered by the FMS • Where the actual extent and level of flooding exceeds the predicted level with the consequent effect of adversely impacting of property(ies), structures and infrastructure, identification of the measures to be implemented to reduce future impacts of flooding related to the M4-M5 Link project including the timing and responsibilities for implementation. Flood mitigation measures will be developed in consultation with the affected property, structure and/or infrastructure owners, OEH and the relevant council(s).	Construction and operation

18 Biodiversity

This chapter provides a summary of the biodiversity impacts associated with the M4-M5 Link project (the project). A detailed biodiversity assessment report (BAR), including an arboriculture impact assessment, has been prepared for the project and is included in **Appendix S** (Technical working paper: Biodiversity).

The Secretary of the NSW Department of Planning and Environment (DP&E) has issued environmental assessment requirements for the project. These are referred to as the Secretary's Environmental Assessment Requirements (SEARs). **Table 18-1** sets outs these requirements and the associated desired performance outcomes that relate to biodiversity, and identifies where they have been addressed in this environmental impact statement (EIS).

Table 18-1 SEARs – biodiversity

Desired performance outcome	SEARs	Where addressed in the EIS
1. Environmental impact assessment process The process for assessment of the proposal is transparent, balanced, well focused and legal.	2. It is the Proponent's responsibility to determine whether the project needs to be referred to the Commonwealth Department of the Environment for an approval under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The Proponent must contact the Commonwealth Department of the Environment immediately if it is determined that an approval is required under the EPBC Act, as supplementary environmental assessment requirements may need to be issued to ensure a streamlined assessment under the Bilateral agreement can be achieved.	An assessment of the project on matters of national environmental significance is included in **section 18.3**. A referral to the Australian Government Department of the Environment and Energy for an approval under the EPBC Act is not required for the project. The assessment process and determination that the project does not need to be referred to the Australian Government Department of the Environment and Energy is included in **Chapter 2** (Assessment process).
6. Biodiversity The project design considers all feasible measures to avoid and minimise impacts on terrestrial and aquatic biodiversity. Offsets and/or supplementary measures are assured which are equivalent to any remaining impacts of project construction and operation.	1. The Proponent must assess biodiversity impacts in accordance with the current guidelines including the Framework for Biodiversity Assessment (FBA) and be carried out by a person accredited in accordance with section 142B(1)(c) of the *Threatened Species Conservation Act 1995* (NSW).	The biodiversity assessment was undertaken by an accredited assessor, in accordance with the requirements of the FBA and relevant legislation (refer to **section 18.1** and **Appendix S** (Technical working paper: Biodiversity)).
	2. The Proponent must assess any impacts on biodiversity values not covered by the FBA. Impacts on species, populations and ecological communities that will require further consideration and provision of information specified in section 9.2 of the FBA include any identified through consultation with the Office of Environment and Heritage (OEH).	An assessment of biodiversity impacts which are not covered by the FBA is provided in **section 18.3** and **Appendix S** (Technical working paper: Biodiversity). The methodology adopted for, and the findings of the targeted species surveys are included in

Desired performance outcome	SEARs	Where addressed in the EIS
	Species specific surveys shall be undertaken for those species and in accordance with the survey requirements specified by the OEH.	**section 18.1**, **section 18.2** and **Appendix S** (Technical working paper: Biodiversity).
	The Proponent must identify whether the project as a whole, or any component of the project, would be classified as a Key Threatening Process (KTP) in accordance with the listings in the *Threatened Species Conservation Act 1995* (TSC Act), *Fisheries Management Act 1994* (FM Act) and *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).	A determination of whether the project would be classified as a Key Threatening Process is included in **section 18.3** and **Appendix S** (Technical working paper: Biodiversity).
	3. The Proponent must assess any impacts on trees within the project area. Impacts should be minimised; following the hierarchy of avoid, minimise and mitigate impacts on trees.	An assessment of the project's impact on trees is included in **section 18.3**. An arboricultural impact assessment is included as Annexure G of **Appendix S** (Technical working paper: Biodiversity).

18.1 Assessment methodology

18.1.1 Overview

The key components of the biodiversity assessment included:

- Desktop analysis to describe the existing environment and landscape features of the study area and to identify threatened terrestrial and aquatic values potentially affected by the project
- Field surveys to identify the biodiversity values of the project footprint and to determine the likelihood of threatened species and their habitats occurring in the project footprint or being affected by the project
- Qualitative assessment of potential impacts of the project on biodiversity values, including threatened species
- An arboricultural impact assessment, including a visual tree assessment for trees potentially affected by the project.

A summary of the tasks undertaken to inform the BAR is included in **section 18.1.3** and **section 18.1.4**. The arboricultural impact assessment is located in Annexure G of **Appendix S** (Technical working paper: Biodiversity).

Study area

The study area for the biodiversity assessment comprises a 550 metre buffer around the project footprint, as required by the *Framework for Biodiversity Assessment* (FBA) (NSW Office of Environment and Heritage (OEH) 2014b). The study area includes existing roads, motorways, residential areas, industrial areas, urban landscaped areas, and exotic vegetation and is shown in **Figure 18-1**.

Figure 18-1 also shows the corridor assessed for matters of national environmental significance (MNES), groundwater dependant ecosystems (GDEs) and riparian ecosystems. Riparian ecosystems are those associated with (and often located adjacent or close to) waterbodies, or dependent on surface or subsurface drainage. GDEs are defined and discussed in further detail in **section 18.2.6**.

Some desktop assessment tools for biodiversity have a minimum search area of a 10 kilometre radius. This area is referred to as the locality in this chapter (see **section 18.2**).

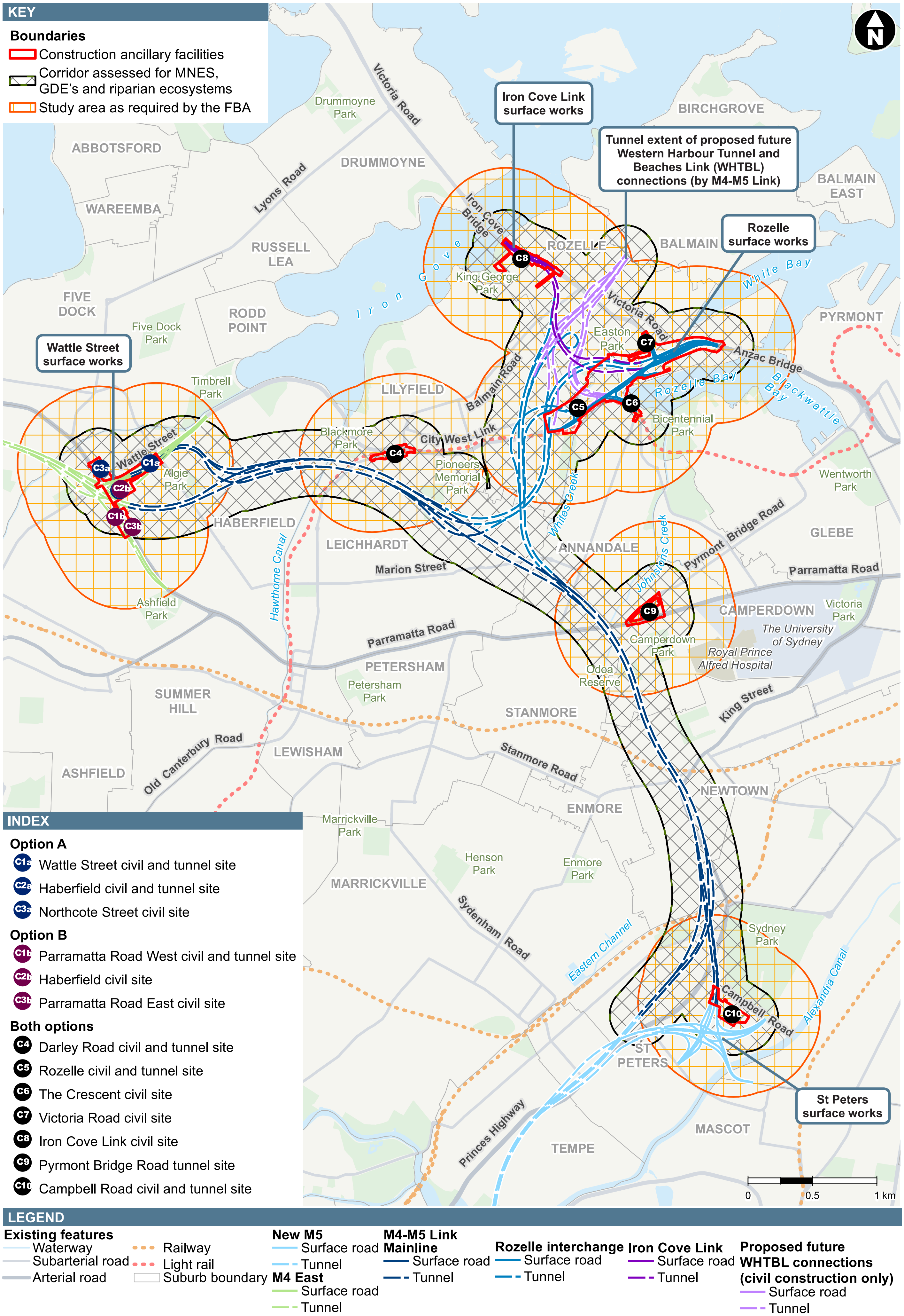


Figure 18-1 Biodiversity assessment study area

18.1.2 Legislation and policy framework

The BAR has been prepared to assess the impacts of the project in accordance with relevant legislation as described in **Table 18-2**.

Table 18-2 Legislation relevant to the biodiversity assessment of the project

Legislation	Relevance to project
Threatened Species Conservation Act 1995 (NSW) (TSC Act)	The TSC Act provides for listing of 'threatened species, populations and ecological communities', 'Key Threatening Processes', and the preparation and implementation of Recovery Plans and Threat Abatement Plans. As detailed in **section 18.3**, the project is not expected to have a significant impact on any species or communities listed under the TSC Act.
Fisheries Management Act 1994 (NSW) (FM Act)	The FM Act aims to conserve, develop and share the fishery resources of the state. It provides listings of 'threatened species, populations and ecological communities', 'Key Threatening Processes', and the preparation and implementation of Recovery Plans and Threat Abatement Plans. The FM Act has been considered for the purpose of this assessment with regard to aquatic biodiversity (including listed protected and threatened species and populations) and Key Threatening Processes. Sections 201, 205 and 219 of the FM Act require permits to be obtained for dredging or reclamation work (including any excavation of land submerged by water), harming marine vegetation and blocking of fish passage respectively. However, permits under the FM Act are not required for approved State significant infrastructure (in accordance with section 115ZG of the *Environmental Planning and Assessment Act 1979* (NSW) (EP&A Act). In accordance with Section 199 of the FM Act, notification to the NSW Department of Primary Industries (Fisheries) (DPI-Fisheries) is required if dredging or reclamation work are required in water land classed as key fish habitat (for example Rozelle Bay). Following detailed design, DPI-Fisheries would be notified regarding construction works at Rozelle Bay and their response would be considered (refer to **Chapter 2** (Assessment process)).
Native Vegetation Act 2003 (NSW) (NV Act)	The NV Act regulates clearing of native vegetation, remnant native vegetation and protected regrowth. The NV Act is intended to protect and promote the conservation of native vegetation, but excludes National Park, State Forest and urban areas. The project footprint does not include any remnant native vegetation that meets the definition in the NV Act. The NV Act is also not applicable to the Sydney metropolitan area.
Noxious Weeds Act 1993 (NSW) (NW Act)	The NW Act provides for the declaration of noxious weeds and the making of weed control orders specifying control measures that are to be used to control noxious weeds. Noxious weeds may be considered noxious on a national, state, regional or local scale. All private landowners, occupiers, public authorities and councils are required to control noxious weeds on their land under Part 3 Division 1 of the NW Act. Impacts of the project in relation to weeds are discussed in **section 18.3**.
Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth) (EPBC Act)	Under the EPBC Act, an action includes a project, undertaking, development, activity, series of activities or alteration. An action that 'has, will have or is likely to have a significant impact on a matter of national environmental significance' is a 'controlled action' and may not be undertaken without approval from the Australian Government Minister for the Environment. The project would not have a significant impact upon any MNES and therefore does not require approval from the Australian Government Minister for the Environment as outlined in **section 18.3**.

Policy and guidelines

The BAR has been prepared to assess the impacts of the project on biodiversity values in accordance with the requirements of the *NSW Biodiversity Offsets Policy for Major Projects* (OEH 2014a) (the Biodiversity Offset Policy) and the FBA.

The Biodiversity Offset Policy and the SEARs require the FBA to be applied to assess impacts on biodiversity. The FBA outlines the assessment methodology to quantify and describe the biodiversity values in the project footprint, and the biodiversity offsets required for any unavoidable impacts. The FBA applies predominantly to terrestrial biodiversity. The assessment of impacts of the project on aquatic environments and biodiversity has been undertaken in accordance with the *Policy and Guidelines for Fish Habitat Conservation and Management* (update 2013) (DPI 2013) which incorporates *Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings* (Fairfull and Witheridge 2003).

The BAR has also considered the following guidelines:

- *Risk Assessment Guidelines for Groundwater Dependent Ecosystems* (DPI 2012)
- *NSW Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities – Working Draft November 2004* (NSW Department of Environment and Conservation (DEC) 2004)
- *NSW Threatened species survey and assessment guidelines: field survey methods for fauna (Amphibians)* (NSW Department of Environment and Climate Change (DECC) 2009)
- *NSW Sustainable Design Guidelines Version 3.0* (Transport for NSW 2013)
- *Aquatic Ecology in Environmental Impact Assessment – EIA Guideline* (Marcus Lincoln Smith 2003)
- *Commonwealth Survey Guidelines for Australia's Threatened Frog* (Australian Government Department of the Environment, Water, Heritage and the Arts (DEWHA) 2010a)
- *Commonwealth Survey Guidelines for Australia's Threatened Bats* (DEHWA 2010b)
- *Matters of National Environmental Significance Significant Impact Guidelines 1.1 Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth of Australia 2013)
- *Referral guideline for management actions in Grey-Headed and Spectacled Flying-fox camps* (Commonwealth of Australia 2015).

18.1.3 Desktop assessment

A desktop review was undertaken to identify the potential presence of any threatened species, populations or ecological communities listed under the TSC Act and FM Act, as well as MNES listed under the EPBC Act within the study area. The desktop review included a review of the following databases:

- OEH Atlas of NSW Wildlife (OEH 2016a) (NSW Department of the Environment and Energy (DEE) 2016a)
- NSW Threatened Species Profile Database (OEH 2016b)
- EPBC Act Protected Matters Search Tool (PMST) (DEE 2016b)
- FM Act listed protected and threatened species and populations, including species profiles, 'Primefact' publications and expected distribution maps (Riches et al 2016)
- Online Zoological Collections of Australian Museums (OZCAM)
- Bureau of Meteorology Groundwater Dependent Ecosystems Atlas (searched 27 September 2016)
- *Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2011* - Appendix 2 (NSW Government 2011).

A number of documents were also reviewed to assist with identifying biodiversity values within the study area. These documents included:

- Rozelle Rail Yards Review of Environmental Factors (REF) – Biodiversity Assessment (Eco Logical Australia (ELA) 2016)
- WestConnex M4 East EIS – Biodiversity Impact Assessment (GHD Pty Ltd 2015)
- WestConnex New M5 EIS – Biodiversity Assessment Report (ELA 2015)
- WestConnex M4-M5 Geotechnical Investigations – Flora and Fauna Assessment (Niche 2016)
- Central Business District (CBD) Metro – Environmental Assessment (SKM 2010)
- Aerial photography of the study area
- Visual Information System online vegetation classification database (OEH 2016c)
- Native Vegetation Maps of the Sydney Metropolitan Catchment Management Authority Area (OEH 2013a)
- Soil Landscapes of the Sydney 1:100,000 Sheet (Chapman and Murphy 1989)
- Local council action plans or strategies:
  - The City of Sydney Urban Ecology Strategic Action Plan (2014)
  - City of Sydney Environmental Action 2016-2021 Strategy and Action Plan (2016)
  - Marrickville Council Biodiversity Action Plan 2011-2015 (2011)
  - Marrickville Council Biodiversity Strategy 2011-2021 (2011)
  - The Inner West Council Greenway Strategy including the Greenway Biodiversity Strategy (2012), Greenway Revegetation and Bushcare Plan (2011) and Greenway Flora and Fauna Literature Review (2010).

Likelihood of occurrence assessment

Based on the desktop assessment, further assessment was undertaken to determine how likely a particular species is to occur within the project footprint. A likelihood ranking was then assigned to each species, according to whether the species was 'known', 'likely', 'possible', 'unlikely' or 'absent'. The likelihood of occurrence assessment was used to guide and inform the field surveys that were undertaken for the project. Refer to Annexure A of **Appendix S** (Technical working paper: Biodiversity) for the likelihood of occurrence assessment and description of likelihood rankings.

18.1.4 Field surveys

Flora

The existing vegetation community mapping (OEH 2013a) within the study area was verified to confirm the presence or absence of native vegetation communities, including the presence of any threatened ecological communities (TECs). Vegetation communities were identified from a combination of floristic surveys and checked to see if a plant community type (PCT) could be assigned or whether they constituted non-native vegetation, by comparing the dominant canopy species, the general description of location, soil type and other attributes.

No biometric plots were completed as part of this assessment, as no PCTs were present within the study area.

Fauna

Fauna surveys were carried out over several nights between August and October 2016 within the Rozelle Rail Yards and at the confluence of Whites Creek and Rozelle Bay, as these areas were considered the only potential habitat for species within the project footprint. Details of the field surveys, survey extents and survey conditions are provided in **Appendix S** (Technical working paper: Biodiversity). In summary, these surveys included:

- Fauna habitat assessments to identify potential habitat for threatened fauna species (such as hollow-bearing trees, rock habitats, known food trees, presence of termite mounds and evidence of fauna usage)
- An assessment of aquatic habitat within Whites Creek and at the foreshore at Rozelle Bay.

Other waterways considered in the desktop assessment included Iron Cove (at the eastern abutment of Iron Cove Bridge and at Haberfield), Hawthorne Canal at Darley Road, Johnstons Creek at Camperdown and Alexandra Canal at St Peters.

Targeted surveys for threatened microbats were carried out within the Rozelle Rail Yards to inform the biodiversity assessment for site management works (see **section 18.2.1**). The results of these targeted surveys were used to assess the potential for any additional impacts of the M4-M5 Link project (such as the demolition of the Victoria Road bridge). The cumulative impacts of the site management works and the M4-M5 Link project on biodiversity values are assessed in **Chapter 26** (Cumulative impacts).

18.2 Existing environment

18.2.1 Rozelle Rail Yards

Roads and Maritime is separately carrying out site management works (that includes vegetation clearing) at part of the Rozelle Rail Yards site. The works are needed to manage the existing environmental and safety issues at the site and would also improve access to surface conditions, which would allow for further investigation into the location of utilities and the presence of contamination and waste. The works would benefit future uses of the site (including construction of the M4-M5 Link project if it is approved) because the works would remove material and redundant facilities associated with rail and rail related infrastructure from the site. The site management works were subject to a separate environmental assessment and are excluded from the scope of the project that is the subject of this EIS. The works were assessed in an REF which was approved by Roads and Maritime under Part 5 of the EP&A Act in April 2017.

Site management works will be carried out over a period of around 12 months and commenced in mid-2017. After completion of the works, the ‘finished site’ would be managed and maintained to ensure that the surface cover and stormwater controls are operating effectively. For the purposes of this EIS, it has been assumed that the site management works are completed prior to construction of the project commencing. **Chapter 2** (Assessment process) provides further information on the scope and timing of activities to be undertaken as part of the site management works at the Rozelle Rail Yards.

A biodiversity assessment was undertaken by ELA to support the REF for site management works at the Rozelle Rail Yards (Roads and Maritime 2016). As part of the assessment, targeted threatened fauna surveys were completed for the Green and Golden Bell Frog (*Litoria aurea*), Long-nosed Bandicoot (*Perameles nasuta* – endangered population) and threatened microchiropteran bats (microbats). The assessment concluded the following for the Rozelle Rail Yards site survey:

- No threatened flora species or listed ecological communities were identified, or are considered as having the potential to occur within the Rozelle Rail Yards
- The Eastern Bentwing-bat (*Miniopterus schreibersii oceanensis*) was recorded and may be roosting in the cavities under the Victoria Road bridge, or using it as a flyway. The Victoria Road bridge would not be impacted during site management works, however it would be demolished as part of the M4-M5 Link project (further discussion is provided in **section 18.3**)
- The Yellow-bellied Sheathtail-bat (*Saccolaimus flaviventris*) was recorded and may be using the site to forage

- The White-striped Freetail Bat (*Tadarida australis*) was recorded; however, this species is not threatened under NSW or Commonwealth legislation
- Grey-headed Flying-fox were observed feeding on fig trees immediately adjacent to the site and therefore were assumed to be present
- No other threatened fauna species were observed, or are considered present within the site (including the Green and Golden Bell Frog).

18.2.2 Landscape features

The landscape features of the study area have been determined in accordance with the requirements of the FBA. Landscape features contribute to the overall biodiversity value of the study area and are used to inform appropriateness of offsets where required. **Table 18-3** summarises the biodiversity landscape features of the study area. Figures showing landscape features of the study area are included in **Appendix S** (Technical working paper: Biodiversity).

Table 18-3 Biodiversity landscape features of the study area

Landscape feature	Description
Interim Biogeographic Regionalisation for Australia (IBRA) region and subregion	The study area is located within the Sydney Basin Bioregion which extends north to the Hunter Valley, west to Mudgee and south to Batemans Bay. The project footprint crosses two IBRA subregions; the Cumberland subregion and the Pittwater subregion. The study area is highly urbanised and surrounded by extensive areas of established urban development.
Mitchell landscapes	The majority of the study area occurs within the Mitchell landscape of Sydney – Port Jackson and Ashfield Plains. The Sydney–Newcastle Barriers and Beaches landscape also occurs within the study area.
Rivers and streams	Riparian corridors of three waterways occur within or adjacent to the project footprint; Whites Creek (first order stream), Rozelle Bay (Estuarine Area) and Iron Cove (second order stream). Whites Creek is not mapped as a key fish habitat, as defined in the *Fisheries Policy and Guidelines for Fish Habitat Conservation and Management – update 2013* (Fairfull 2013). Rozelle Bay is mapped as a key fish habitat and would be directly impacted by the project, which includes piling for a pedestrian and cyclist bridge and rock revetment work for the drainage outlet from the Rozelle Rail Yards to Rozelle Bay. A coffer dam would be required to carry out these works. Iron Cove is mapped as key fish habitat and would not be directly impacted by the construction of the Iron Cove Link (near the eastern abutment of Iron Cove Bridge). The bioretention facility at Manning Street at Rozelle would connect to an existing underground stormwater pipe that would discharge to Iron Cove via the existing outlet. Hawthorne Canal is mapped as a key fish habitat and would not be directly impacted by the project. A potential option for the discharge of treated water from the Darley Road water treatment facility would be to Hawthorne Canal via an existing outlet and would not require any works to the Hawthorne Canal. Notwithstanding the presence of areas mapped as key fish habitat, waterways within or adjacent to the project footprint are not suitable habitat for threatened fish species.
Wetlands	There are no coastal wetlands mapped under the State Environmental Planning Policy No. 14- Coastal Wetlands (SEPP 14) within the study area. Artificial waterbodies are scattered across the study area and surrounds as detention basins and ponds.

Landscape feature	Description
State or regionally significant biodiversity links (connectivity)	No formal regional or state biodiversity links recognised by the FBA methodology occur within the study area.
Vegetation cover	The assessment for the buffer area (550 metres from the project footprint in accordance with the FBA) recorded around 0.62 hectares of native vegetation cover. This represents 0.05 per cent native vegetation cover.
Patch size of vegetation	Vegetation within the study area comprises patches of urban native and exotic vegetation and is surrounded by extensive urbanised areas. These patches of vegetation do not meet the definition of native vegetation under the FBA.
Change in area to perimeter ratio	As the native vegetation within the study area does not meet the definition for native vegetation, the proportional change in area to perimeter ratio could not be assessed.

18.2.3 Terrestrial flora

Native vegetation communities

All vegetation in the study area is mapped as ‘urban exotic and native cover’ (OEH 2013a) and considered to be in a low ecological condition. No PCTs were recorded in the study area and thus no native vegetation as defined by the FBA is considered to be present.

Urban exotic and native cover within the study area consists of planted indigenous, non-indigenous native and exotic species within local parklands, urban backyards, riparian areas and the Rozelle Rail Yards. These areas often contain large expanses of exotic grasses and other weeds and generally occur where the soil profile has been extensively modified. Some areas, such as parklands, only contain large established trees (native and exotic) and exotic grasses, with no shrub layer or evidence of regenerating overstorey species.

The study area is entirely modified and disturbed and contains exotic species, weeds and planted native or non-indigenous species. The study area is generally characterised by urban parks, landscaped road verges, compacted soils, introduced fill, existing dwellings and other infrastructure, and is considered to be in a poor ecological condition, with little ecological value, and is unlikely to have any native resilience or recovery potential.

Threatened ecological communities

The desktop survey identified 16 threatened ecological communities (TECs) within the locality of the project. Of these, all are listed under the TSC Act and 11 are listed under the EPBC Act. An assessment of likelihood for these TECs occurring within the study area is provided in Annexure A of the **Appendix S** (Technical working paper: Biodiversity).

No TECs were recorded or assessed as likely to occur within the project footprint and no remnant native vegetation as defined by the FBA is mapped within the project footprint. Three TECs listed under the TSC Act and/or EPBC Act, previously mapped as being within around two kilometres of the project footprint are described in **Table 18-4**. Given this distance, impacts on these TECs would not occur as a result of the project.

Table 18-4 TECs within proximity to the project footprint

Common name	TSC Act listing	EPBC Act listing	Nearest occurrence
Coastal Saltmarsh	Endangered: Coastal Saltmarsh in the NSW North Coast, Sydney Basin and South East Corner bioregions	Vulnerable: Subtropical and Temperate Coastal Saltmarsh	Mapped within the study area around 300 metres southeast of the works associated with the widening of The Crescent and 600 metres southeast of the Rozelle Rail Yards. Occurs along the banks of Johnstons Creek at Bicentennial Reserve, and in small patches along the northern shores of Iron Cove.
Sydney Turpentine Ironbark Forest	Endangered: Sydney Turpentine Ironbark Forest	Critically endangered: Turpentine Ironbark Forest in the Sydney Basin Bioregion	Mapped at Five Dock Park and Russell Lea Infants School, around 900 metres and 1,800 metres north of the Wattle Street interchange.
Swamp Oak Floodplain Forest	Endangered: Swamp oak floodplain forest of the NSW North Coast, Sydney Basin and South East Corner bioregions	Not listed	Mapped along the banks of Iron Cove around 400 metres west of Victoria Road and the Iron Cove Link civil site (C8).

The FBA requires identification of ecosystem credit species (species that can be reliably predicted based on the PCT) and species credit species (species that generate species credits). In accordance with the requirements of the FBA, the identification of ecosystem credit species is required based on the PCT, IBRA subregion of the study area and the condition and patch size of vegetation to be impacted (see **Table 18-3**). If these factors are not present, ecosystem credit species present in the study area cannot be identified. As no PCTs were identified within the study area, no ecosystem credit species were predicted to occur.

Threatened flora

Desktop searches of the EPBC Act PMST and the Atlas of NSW Wildlife identified 38 threatened flora species listed under the TSC Act and/or EPBC Act as potentially occurring within the locality of the project. No threatened flora populations were identified. An assessment of likelihood for these threatened flora species to occur within the study area is provided in Annexure A of **Appendix S** (Technical working paper: Biodiversity).

No threatened flora was considered likely to occur within the study area, or was recorded opportunistically during the vegetation and fauna surveys. The study area is representative of a highly disturbed and degraded environment, dominated by exotic vegetation or native species that have been planted.

In accordance with the FBA requirements, a list of species credit species is generated based on an assessment of the IBRA sub region, past records and habitat elements (see **Table 18-3**). As no species credit species were identified, these species were not considered for further assessment.

Weeds

Weeds are common throughout the study area with some areas supporting weed infestations. Although some exotic weed species would be removed as part of the site management works at the Rozelle Rail Yards, weeds are also present in areas outside the site management works area. Weeds identified in the study area during the field surveys are summarised in **Table 18-5**.

Table 18-5 Noxious and environmental weed species recorded in the study area

Scientific name	Common name	Class of weeds for Inner West and City of Sydney local government area*	Weed of National Significance
Anredera cordifolia	Madeira Vine	-	X
Asparagus asparagoides	Bridal Creeper	5	X
Cenchrus echinatus	Spiny Burr Grass	5	
Cestrum parqui	Green Cestrum	3	
Cortaderia selloana	Pampas Grass	4	
Lantana camara	Lantana	4	X
Ligustrum lucidum	Broad-leaved Privet	4	
Ligustrum sinense	Small-leaved Privet	4	
Oxalis sp.	Oxalis	5	
Parietaria judaica	Pellitory	4	
Ricinus communis	Castor Oil Plant	4	
Rubus fruticosus	Blackberry	4	X

Notes:

* Noxious weeds classes as defined under the NW Act:

- Class 3: The plant must be fully and continuously suppressed and destroyed
- Class 4: The growth of the plant must be managed in a manner that reduces its numbers, spread and incidence and continuously inhibits its reproduction
- Class 5: The requirements in the NW Act for a notifiable weed must be complied with.

18.2.4 Terrestrial fauna

Threatened fauna and habitat

The EPBC Act PMST and the Atlas of NSW Wildlife identified 51 threatened fauna species (or their habitat) listed under the TSC Act or EPBC Act as potentially occurring within the locality of the project. A full list of these species is provided in **Appendix S** (Technical working paper: Biodiversity).

In accordance with the FBA, no candidate species were predicted to occur within the study area. However, some species have habitat requirements that are not predicted by PCTs, and require expert input, particularly those species that can use man-made or exotic environments. As such, a conservative list of eight final candidate species (including one population) was developed, as summarised in **Table 18-6**.

This list of candidate species is based on each species' likelihood of occurrence, which was informed from database searches, previous studies and specific habitat features present within the study area. The likelihood of occurrence assessment is detailed in Annexure A of **Appendix S** (Technical working paper: Biodiversity). The list of final candidate species was then used to determine whether or not the species requires further assessment in the form of targeted surveys.

Two threatened microbat species, the Eastern Bentwing-bat and Yellow-bellied Sheathtail-bat, were recorded during targeted surveys at the Rozelle Rail Yards. The Eastern Bentwing-bat was recorded within the Rozelle Rail Yards and may be roosting in the cavities under the Victoria Road bridge, or using it as a flyway. The Yellow-bellied Sheathtail-bat was also recorded (as a possible call) within the Rozelle Rail Yards and may be using the site to forage.

No targeted surveys were conducted for the Grey-headed Flying-fox as the species was assumed to be present within the study area. The Commonwealth survey guidelines (DEWHA 2010) indicate that surveys based on animal sightings for this species are unlikely to be reliable as this species is highly mobile and occupies most areas in its distribution in highly irregular patterns. A more effective survey method is to determine the likelihood of occurrence via desktop assessment and to conduct vegetation surveys to identify feeding habitat. It was assumed likely that the Grey-headed Flying-fox would use the study area on occasion for foraging.

It should be noted that the targeted surveys were undertaken to inform the biodiversity assessment for the Rozelle Rail Yards site management works, which targeted amphibian and mammalian species that may be present on this site. While the Rozelle Rail Yards would be mostly cleared following site management works, the M4-M5 Link project has the potential for additional impacts on these species (from additional vegetation removal and the demolition of the Victoria Road bridge), as assessed in **section 18.3**.

Migratory species

Forty migratory species listed under the EPBC Act were assessed for their likelihood of occurrence within the study area, including a number of predominantly marine species. The assessment considered it was unlikely for any migratory species to occur within the study area, primarily due to the lack of suitable habitat and the highly urbanised environment. Marine migratory species are not relevant to this assessment.

Table 18-6 Species and ecosystem credit species and their initial likelihood of occurrence within the study area

Species name	Species or ecosystem credit species	Likelihood of occurrence	Habitat assessment	Targeted survey required
Grey-headed Flying-fox *(Pteropus poliocephalus)*	Species (breeding camps) and ecosystem (foraging)	High	Potential feed trees scattered across the study area. However, these are limited in number and may occur as individual trees. Records exist close to the study area and are common in the locality. There are known breeding camps at the Royal Botanic Gardens, Sydney and at Turrella.	No – assumed to be present for foraging
Little Bentwing-bat *(Miniopterus australis)*	Species (breeding sites) and ecosystem (foraging)	Low	Uses caves, hollows and man-made structures as roost sites. Only one record exists for this species within the locality. This record is within 100 metres of Iron Cove bridge and over 20 years old. The record is noted as being dubious within the Atlas of NSW Wildlife, as the record is well outside the species known range.	Yes
Eastern Bentwing-bat *(Miniopterus schreibersii oceanensis)*	Species (breeding sites) and ecosystem (foraging)	Moderate	Uses caves, hollows and man-made structures as roost sites. A number of records exist for this species within the locality. This closest record is over 20 years old from an old Balmain power station. It occurs within 100 metres of Iron Cove Bridge. Other records are from Goat Island (10 years' old), 2.5 kilometres north of the study area within Sydney Harbour.	Yes

Species name	Species or ecosystem credit species	Likelihood of occurrence	Habitat assessment	Targeted survey required
Eastern Freetail-bat *(Mormopterus norfolkensis)*	Ecosystem	Moderate	Primarily uses hollows as roost sites, but can also use man-made structures. Nearest record is 10 years' old from Goat Island, 2.5 kilometres north of the study area in Sydney Harbour.	Yes
Southern Myotis *(Myotis macropus)*	Species (breeding sites) and ecosystem (foraging)	Low	Species has specific roost requirements, which primarily include tree hollows within riparian zones. Nearest record (10 years old) is from Goat Island, 2.5 kilometres north of the study area in Sydney harbour.	Yes
Yellow-bellied Sheathtail-bat *(Saccolaimus flaviventris)*	Ecosystem	Low	Primarily uses hollows as roost sites. No records for this species exist within the locality.	Yes

18.2.5 Aquatic biodiversity

The foreshore of Rozelle Bay near Whites Creek consists of reclaimed land, vertical seawalls, jetty structures, riprap (ie rocks used to armour shorelines) embankments and gently sloping intertidal land. At the lower end of Whites Creek, the marine environment is highly modified, consisting of a concrete channel around nine metres wide with vertical walls and a concrete base (Whites Creek channel). The subtidal substrate of Rozelle Bay is silty-sand covered with leaves and branches discharged from Whites Creek. Decomposition of this organic material likely results in anoxic conditions close to the sediment, providing unsuitable habitat for seabed fauna. This area is mapped as key fish habitat.

The Crescent crossing over Whites Creek channel is a low bridge, 46 metres wide by nine metres long. Sydney Water is planning to naturalise sections of Whites Creek further upstream of the crossing, which would be continued to the confluence with Rozelle Bay outfall as part of the M4-M5 Link project (refer to **Chapter 5** (Project description)).

The riparian vegetation in the study area is mapped as urban exotic and native cover, and represents planted and landscaped native and exotic species. Within the study area, both the Whites Creek and Hawthorne Canal riparian corridors are highly modified environments, consisting of a concrete channel with vertical walls and concrete base. This riparian vegetation does not contribute to the ecological functioning of the waterways. The vegetation provides little ecological value, and is of limited habitat for fauna species.

Immobile marine organisms have adapted to the concrete walls of Whites Creek, including the Sydney Rock Oyster (*Saccostrea commercialis*) and Honeycomb Barnacle (*Chamaesipho tasmanica*). The habitat is not suitable for mangroves and saltmarsh due to the low horizontal intertidal zone. The Whites Creek channel is covered with a thin layer of sediment and debris, but does not support seagrass or marine macroalgae. Woody debris and leaf litter has accumulated in Rozelle Bay at the discharge point immediately east of the road crossing. No marine algae or seagrass occurs near the outlet. Riparian vegetation upstream comprises a row of planted Swamp Oak (*Casuarina glauca*) and Canary Island Date Palm (*Phoenix canariensis*).

There are two existing large pipe culverts at the confluence of Easton Park drain and Rozelle Bay, partially below the high tide mark. This intertidal habitat is in poor condition with limited aquatic value comprising few oysters and marine molluscs. No seagrass or macroalgae are present. There are no aquatic ecology communities within the project footprint (NSW Department of Planning, Infrastructure and Natural Resources 2005). The following areas of aquatic biodiversity sensitivity are located within and near the study area:

- A patch of seagrass (*Halophila*) is located in the shallow subtidal zone at the opposite end of Rozelle Bay, around two kilometres northeast of the project footprint (near Ewenton Park in Balmain)
- A small patch of mangroves is located around 800 metres east of the Rozelle interchange at Rozelle Bay (Creese et al 2009)
- A small mangrove/saltmarsh restoration zone is located 250 metres east of the Rozelle interchange at Bicentennial Park in Glebe.

As Whites Creek is concrete lined, it is not considered key fish habitat and does not receive a waterway crossing classification for fish passage in accordance with the *Fisheries Policy and Guidelines for Fish Habitat Conservation and Management – update 2013* (Fairfull 2013). Rozelle Bay is classed as key fish habitat, however this location does not provide suitable habitat for fish life.

Johnstons Creek also flows into Rozelle Bay, and like Whites Creek, it is concrete lined and does not have any valuable aquatic habitat mapped by DPI-Fisheries and the Sydney Harbour – Foreshores and Waterways Area Development Control Plan: Ecological Communities and Landscape Characters and Wetlands Protection Map (SHFWDCP). Sydney Water has plans to naturalise sections of Johnstons Creek.

Dobroyd Canal (Iron Cove Creek) and Hawthorne Canal are first order tributaries of Iron Cove estuary. Both waterways are concrete lined channels, transitioning from freshwater to estuarine where they are mapped as key fish habitat. These provide limited value aquatic habitat with limited opportunities for water quality improvement before water reaches Rozelle Bay. The SHFWDCP map does not identify the creeks within/near the project footprint as having any notable aquatic ecological community, besides being ‘Rivers and Creeks’.

Iron Cove estuary is a narrow arm of Sydney Harbour. The foreshore is heavily developed, with extensive areas of habitat lost to reclamation and seawalls. The SHFWDCP map identifies the area beneath Victoria Road at Iron Cove Bridge as ‘Grassland’, ‘Mixed Rock Intertidal and Mudflats’, ‘Water’ and ‘Area not mapped – site specific investigations required’. Mapping by DPI-Fisheries (Creese et al 2009) shows a narrow band of *Zostera/Halophila* seagrasses about 400 metres west of the project footprint and a small patch of *Zostera* around 500 metres east of the project footprint.

The Alexandra Canal, near the St Peters interchange, is a realigned waterway flowing to Botany Bay. The channel has limited habitat variety, with similar depth, width, stone lined banks and poor riparian vegetation. It is mapped as key fish habitat, which would provide optional open water habitat for fish navigating Wolli Creek and Cooks River. This canal does not provide habitat for threatened aquatic species. The nearest seagrass beds are several kilometres downstream in Botany Bay.

It is considered unlikely that there would be valuable or specific aquatic habitat for threatened aquatic/estuarine species (including fish, sharks, rays, aquatic mammals and birds), populations or communities listed under the FM Act, TSC Act or EPBC Act present within the study area. It is possible some species may opportunistically pass near the study area at Whites Creek, given the connectivity to the broader harbour and coastal habitats, but those species are unlikely to depend on the habitat within Whites Creek.

18.2.6 Groundwater dependent ecosystems

GDEs are defined as ecosystems whose current species composition, structure and function are reliant on a supply of groundwater, as opposed to surface water supplies from overland flow paths. In Australia, many ecosystems are dependent on groundwater, although a complete understanding of the role of groundwater in maintaining ecosystems is generally poor. Most wetland communities and many river systems have some degree of dependence on groundwater.

The most likely GDE types in the Sydney region are terrestrial vegetation communities with deep roots that use groundwater, wetlands and river baseflow systems. A search of the GDE Atlas (Bureau of Meteorology) and the *Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources* (2011) indicated that there are no ecosystems within the study area that are likely to be dependent on groundwater.

18.3 Assessment of potential impacts

18.3.1 Terrestrial flora

Loss of vegetation (including native vegetation)

There is no native vegetation (as defined by the FBA) located within the project footprint. Around 1,675 trees would potentially require removal to facilitate the project. Based on the current concept design for the project, it is unlikely these trees could be retained. Of these trees, around 107 have been identified has having a high retention value in accordance with the Institute of Australian Consulting Arboriculturists Significance of a Tree, Assessment Rating System (refer to Annexure G of **Appendix S** (Technical working paper: Biodiversity)).

The majority of trees to be removed are located at Rozelle around the Rozelle Rail Yards and associated surface road upgrades and active transport connections. This includes trees within the Rozelle Rail Yards and Ports Authority land (those remaining following site management works), along City West Link and Lilyfield Road, and areas adjacent to Whites Creek at The Crescent and Brenan Street.

Around 355 trees were identified to be investigated further during detailed design to determine their suitability for retention, 34 of which were identified as high retention value. These trees include groups of trees along Lilyfield Road and on the approaches to Anzac Bridge that may offer visual screening.

Trees to be retained would be protected in accordance with Australian Standard (AS) 4970-2009 Protection of trees on development sites and suitable ground protection measures to protect the tree protection zone. Tree removal would be carried out by a suitably qualified arborist and in accordance with AS 4373-2007 Pruning of Amenity Trees and the NSW WorkCover Code of Practice for the Amenity Tree Industry (1998).

This assessment has been based on the current project footprint and concept design for the project. Further opportunities to retain trees may emerge during detailed design. All opportunities for retaining additional trees through tree sensitive design and construction methods would be considered. Where retention of trees is not possible, compensatory planting would be carried out. Replacement trees should be planted within, or close to, the project footprint where feasible and practicable.

Compensatory planting would seek to use opportunities presented by the new open space at the Rozelle Rail Yards, including along Lilyfield Road and City West Link and the remaining project land at Iron Cove Link, to be consistent with the Urban Design and Landscape Plan (see **section 18.5**) to be developed for the project.

Removal of threatened flora

The project would not involve the removal of any threatened flora species listed under the TSC Act or EPBC Act.

Spread of weeds

As part of the site management works, most of the weeds within the Rozelle Rail Yards would be removed. Weeds throughout the remainder of the study area (and in other parts of the Rozelle Rail Yards east of Victoria Road) are intermittent. Given the presence of weeds in the study area, there is potential for disturbance of vegetation to lead to the spread and/or intensification of weeds. If not appropriately managed, this may indirectly affect native flora and fauna in adjoining areas by further reducing habitat quality, altering the structure and composition of vegetation and increasing competition for resources.

The implementation of management measures outlined in **section 18.5** would minimise the potential for the spread of weeds from construction activities.

18.3.2 Terrestrial fauna

Edge effects

With regard to biodiversity, edge effects are changes in population or community structures that occur at the boundary of two habitats. No remnant native vegetation occurs within the study area. Therefore, edge effects on native vegetation are not considered likely to occur as a result of the project. Habitat for native species within the study area includes non-remnant native and exotic vegetation (such as planted street trees and exotic species). Edge effects on these areas are likely to occur, but would be limited through the implementation of mitigation measures outlined in **section 18.5**.

Fauna injury and mortality of fauna

Fauna injury or mortality could occur during construction of the project, as a result of direct collision with vehicles and equipment within the project footprint. Mobile species (such as birds) may be able to move away quickly and easily, but other less mobile species, or those with high fidelity with their home range, may be slower to move away or may not relocate at all, potentially resulting in injury or mortality of the individual.

During construction at the Rozelle Rail Yards (including demolition of the Victoria Road bridge), there is potential for the Eastern Bentwing-bat to be injured or stressed due to disturbances associated with noise, dust or light while roosting in the cavities of the bridge. Direct mortality or injury is unlikely to occur to the Grey-headed Flying-fox as a result of the works, as the species is highly mobile. Individuals are likely to actively avoid the area during construction.

Although there is potential for some injury or mortality of fauna species, the project is unlikely to result in a large number of fauna injury or mortality incidents, as the majority of the project would be constructed underground. Where temporary and permanent ancillary facilities and infrastructure occur, the surrounding land is highly urbanised.

Implementation of management measures outlined in **section 18.5** would reduce the chances of injury or mortality of fauna. Measures to manage potential impacts on bats would be included in the Construction Flora and Fauna Management Plan, which would include specific measures identified for the Victoria Road bridge.

Impact on migratory species

No migratory species are expected to occur in the project footprint, given the absence of suitable habitat and the highly urbanised environment. A total of 40 migratory species are either known to occur, or have been assessed as likely to occur, within the study area, however outside of the project footprint. The project is therefore unlikely to impact migratory species (refer to **Appendix S** (Technical working paper: Biodiversity)).

Threatened fauna and loss of habitat

There is potential for direct and indirect impacts on the Grey-headed Flying-fox, Eastern Bentwing-bat and Yellow-bellied Sheathtail-bat as a result of the project.

Grey-headed Flying-fox impact

The Grey-headed Flying-fox is listed as 'vulnerable' under the EPBC Act and is therefore considered a MNES. This species is considered likely to forage on around 4.49 hectares of mapped urban exotic and native cover comprising feed trees around that would be removed by the project (foraging habitat). This area does not include vegetation within the Rozelle Rail Yards that will be removed as part of the site management works. This loss of foraging habitat is considered negligible in the context of similar available habitat within the foraging range for this species. A cumulative assessment of the impact on biodiversity, including the Grey-headed Flying-fox, is included in **Chapter 26** (Cumulative impacts).

While the species was not sighted during targeted field surveys for other species, known records exist close to the study area. The project would not impact roosting sites or known breeding camps located at the Royal Botanic Gardens in Sydney, around three kilometres east of the Rozelle interchange and at Turrella, around four kilometres southeast of the St Peters interchange.

Indirect impacts of the project also have the potential to affect the Grey-headed Flying-fox. Construction noise and vibration would be generated by the works, and lighting would be required during standard construction hours (to brighten dark areas such as under the Victoria Road bridge) and during out-of-hours (night) works. These types of indirect impacts are already widespread within the highly urbanised study area, and any exacerbation of these impacts would be managed by the implementation of mitigation measures outlined in **section 18.5**.

Furthermore, night construction works would likely deter Grey-headed Flying-fox individuals from foraging within or immediately adjacent to the project footprint. Construction noise, vibration and lighting impacts would be temporary and are not expected to significantly impact the Grey-headed Flying-fox.

An assessment in accordance with criteria under the *Matter of National Environmental Significance Significant Impact Guidelines* (Commonwealth of Australia 2013) for this species was undertaken and is provided in Annexure E of **Appendix S** (Technical working paper: Biodiversity). This assessment concluded that a significant impact on the Grey-headed Flying-fox is unlikely to occur as a result of the project.

Impact on microbats (Eastern Bentwing-bat and Yellow-bellied Sheathtail-bat)

The project would require the demolition of Victoria Road bridge. The cavities of the bridge have been identified as a potential roosting site for the Eastern Bentwing-bat (non-breeding / maternal roost). No maternity colonies for the Eastern Bentwing-bat are known within the Sydney Metropolitan Catchment Management Authority area (OEH 2016a). This species breeds at maternal roosting sites within limestone caves and migrates to Sydney and other areas for winter, returning to maternal roosts in summer.

The Eastern Bentwing-bat is most at risk from indirect impacts associated with noise, vibration, light and dust during construction. The works for the Rozelle interchange would occur during standard construction hours and out-of-hours (night) works, and the impacts of noise, dust and vibration are expected to occur continuously during this time. However, separation distances from these activities to the Victoria Road bridge where potential roost sites exist (before its demolition), would minimise these impacts.

There is potential for noise, light and/ or vibration impacts on the Eastern Bentwing-bat to occur at the new Victoria Road bridge during operation as a result of additional surface road traffic and associated increases in lighting and noise impacts. These potential impacts are not expected to be significant as the Eastern Bentwing-bat is a highly mobile species and the bridge has been identified as only providing a potential non-breeding/maternal roost site.

Whites Creek bridge was also assessed for potential microbat habitat. No microbats were considered likely to occur at Whites Creek bridge. Of the 4.49 hectares of vegetation being removed for the project and comprising potential foraging habitat for the Grey-headed Flying-fox, around 3.78 hectares of vegetation has been identified as potential foraging habitat for the Eastern Bentwing-bat. This small loss of foraging habitat would have a minor impact on the Eastern Bentwing-bat.

Construction noise, vibration, light and dust are not expected to have a significant impact on the Yellow-bellied Sheathtail-bat as it is considered likely that this species only visits this area for foraging habitat and does not rely on this area as a roosting site.

18.3.3 Loss of aquatic biodiversity

The surface water and flooding assessment for the project (refer to **Appendix Q** (Technical working paper: Surface water and flooding)) has determined that the project would have no adverse surface water quality impacts (including Whites Creek), based on the implementation of appropriate management measures and the fact that the residual risk to the environment is low (refer to **Chapter 15** (Soil and water quality)).

Suitable habitat for marine species is not considered present, or is unlikely to be present, within the study area. Further, impacts on aquatic habitat downstream of the project are not expected. Water quality impacts such that they would affect marine species, or their habitat, are not expected at Dobroyd Canal (Iron Cove Creek), Hawthorne Canal, Iron Cove estuary, Whites Creek, Johnstons Creek or Alexandra Canal. These receiving waterways are highly disturbed ecosystems and the project would generally reduce the mean annual stormwater pollutant loads being discharged to receiving waterways when compared to the existing conditions. Further details regarding water quality are provided in **Chapter 15** (Soil and water quality).

The project would not directly harm marine vegetation or habitat of threatened species, communities or populations. Removal of planted riparian vegetation (non-marine) along the edges of the Whites Creek concrete channel would be required for the upgrade of the intersection of The Crescent and City West Link and the widening and improvement works to Whites Creek. Following these works, a section of the riparian corridor of Whites Creek between The Crescent and the Rozelle Bay confluence would be improved as part of the integration of the Whites Creek naturalisation works planned by Sydney Water. These naturalisation works would be carried out in consultation with Sydney Water.

The new infrastructure proposed over Whites Creek would shade the aquatic habitat within the concrete channel of Whites Creek, creating less favourable conditions for barnacles and oysters attached to the wall. This reduction in light is unlikely to change water temperature given the constant tidal movement in and out of the crossing. The increased bridge width is unlikely to act as a behavioural barrier to fish passage (as is the case with small dark culverts). The passage is considered to have adequate clearance (two to three metres above water), depth (one to two metres) and width (nine metres) to encourage fish movement.

During construction, the proposed works may temporarily obstruct fish passage during the use of a floating boom and silt curtain near the Whites Creek outlet across Rozelle Bay. A coffer dam would also be required within Rozelle Bay to facilitate piling for a pedestrian bridge and rock revetment works for the drainage outlet to Rozelle Bay. This impact would be minimal given the poor creek habitat in Whites Creek and Rozelle Bay intertidal and subtidal area. Fish passage would be restored during operation.

As part of the project, Easton Park drain would be decommissioned with flows diverted into a new channel to convey flows through the Rozelle Rail Yards. An upgraded culvert would be provided to discharge flows into Rozelle Bay. This culvert upgrade would result in the removal of around 27 metres of intertidal rock revetment wall. This intertidal habitat is in poor condition with limited aquatic value comprising few oysters and marine molluscs. A rock spillway and scour protection rock apron would replace the existing rock wall, providing a similar scale and type of intertidal habitat. There is no marine vegetation present at this location that could be affected by changes in salinity due to freshwater discharge. The nearest sensitive vegetation is Coastal Saltmarsh, located around 300 metres east of The Crescent, which is unlikely to be affected due to its distance and mixing with tidal water. The project would not result in a net loss of key fish habitat. No direct impacts would occur to Dobroyd Canal (Iron Cove Creek), Hawthorne Canal, Iron Cove estuary, Johnstons Creek or Alexandra Canal.

Indirect impacts on aquatic habitat may occur as a result of impacts on water quality. Water quality could potentially be impacted by sediment runoff and deposition, polluted road runoff, high velocity runoff/discharge, and oil and pollutant spills entering the waterway. Uncontrolled runoff or discharge can influence the water quality in waterways, such as water temperature, turbidity, pH, salinity and alkalinity. These impacts may reduce water quality, reduce light penetration through the water column, and smother benthic habitat with sediment. This could alter primary (plant) and secondary (animal) production that supports or regulates the aquatic food web.

However, the receiving waterways are highly disturbed ecosystems and the project would generally reduce the mean annual stormwater pollutant loads being discharged to receiving waterways when compared to the existing conditions. Impacts on aquatic habitat as a result of water quality impacts during construction would be short term and would be minimised through the implementation of appropriate management measures as identified in **section 18.5** and in **Chapter 15** (Soil and water quality). There would be no net loss of aquatic habitat in the medium to long term.

18.3.4 Impact on groundwater dependent ecosystems

No priority GDEs were identified in the study area and therefore the project is considered unlikely to have an impact on GDEs. Long term dewatering caused by tunnel drainage could lower the water table, reducing the amount of groundwater available for shallow rooted plants. The minimum depth of the water table underlying the majority of the project is around two metres below ground surface and therefore existing plants are unlikely to be completely dependent on groundwater. Further information on groundwater is provided in **Chapter 19** (Groundwater).

18.3.5 Introduction and spread of exotic species

Animal pests

Given the majority of the study area is disturbed and within a highly urbanised setting, it is likely that animal pests are present within the study area. The following species were recorded during field surveys at the Rozelle Rail Yards as part of the site management works investigations:

- European Red Fox (*Vulpes vulpes*)
- European Rabbit (*Oryctolagus cuniculus*)
- Feral Cat (*Felis catus*)
- Common Myna (*Acridotheres tristis*).

Given the highly urbanised nature of the remainder of the study area, these species are also considered likely to occur in other parts of the study area. The project is not likely to exacerbate the impacts of the European Red Fox or European Rabbit on native fauna, due to their existing presence in the study area, the highly urban context and the lack of native fauna. Further, the project is unlikely to increase the abundance of cats, introduce them into new areas (given the abundance of cats in the study area), or increase predation pressure on native fauna.

Pathogens

A number of pathogens of concern in NSW have the potential to impact native flora and fauna. Activities that involve movement of equipment over large areas are of particular concern, given the high potential to spread pathogens over large areas. Although no sign of pathogen infection was identified during the field surveys at the Rozelle Rail Yards as part of the site management works investigations, key pathogens of concern include:

- Myrtle rust (*Uredo rangelli*)
- Chytrid fungus (*Batrachochytrium dendrobatidis*)
- Phytophthora (*Phytophthora cinnamomi*).

Given the highly urban context and lack of existing remnant native vegetation within the study area, it is unlikely that Phytophthora is present. Myrtle rust, if present, would be limited to any landscaped or planted Eucalypts. It is considered unlikely that the Chytrid fungus (an infectious disease in amphibians) is present within the study area given the absence of frog species.

The implementation of appropriate mitigation measures listed in **section 18.5** would reduce the potential for introduction of Myrtle rust and Phytophthora to be introduced into the study area during construction of the project. Where required, these pathogens would be managed through the implementation of the management measures detailed in **section 18.5**.

18.3.6 Impact on matters of national environmental significance

The only MNES that was considered likely to be impacted by the project is the Grey-headed Flying-fox, listed as Vulnerable under the EPBC Act. This species was considered likely to forage on a limited number of feed trees within up to 4.49 hectares of mapped urban and exotic native cover to be removed by the project. Potential impacts of the project on this species include:

- Removal of up to 4.49 hectares of potential foraging habitat within the study area
- Disturbance from construction noise, vibration and lighting.

An assessment in accordance with criterion under the *Matter of National Environmental Significance Significant Impact Guidelines* (Commonwealth of Australia 2013) for this species was undertaken and is provided in Annexure E of **Appendix S** (Technical working paper: Biodiversity). This assessment concluded that a significant impact on the Grey-headed Flying-fox is unlikely to occur as a result of the project. No impacts on a known camp would occur as a result of the project and no species offsets are required.

As no significant impact would occur on any MNES, a referral to the Commonwealth Department of the Environment is not required and the EPBC Act assessment bilateral agreement has not been triggered for this project. Further detail is provided in **Chapter 2** (Assessment process).

18.3.7 Impacts on relevant key threatening processes

The project has the potential to contribute to key threatening processes as defined by the EPBC Act, TSC Act and FM Act in relation to threatened species, communities, populations and their habitats. These are summarised in **Table 18-7**. With the implementation of appropriate mitigation measures, the risk of exacerbating these key threatening processes is considered to be low.

Table 18-7 Potential impacts of key threatening processes on biodiversity

Key threatening process	Statutory listing	Relevance to the project	Potential or known
Infection of native plants by *Phytophthora cinnamomi* Dieback caused by the root-rot fungus* *Phytophthora cinnamomi*	TSC Act EPBC Act	Movement of vehicles, equipment and people during the construction phase carries a risk of introduction and spread of the plant pathogen *Phytophthora cinnamomi*. Presence of the plant pathogen within the study area is unknown.	Potential
Introduction and establishment of Exotic Rust Fungi of the order Pucciniales pathogenic on plants of the family Myrtaceae	TSC Act	Movement of vehicles, equipment and people during the construction phase carries a risk of introduction and spread of Myrtle rust. Presence of Myrtle rust within the study area is unknown, but would likely be limited to any landscaped or planted Eucalypts.	Potential
Invasion and establishment of exotic vines and scramblers	TSC Act	Exotic vines and scramblers are present within the study area including areas along road and track edges. Movement of vehicles, equipment and people during the construction phase carries a risk of introduction and spread of these exotic vines and scramblers.	Potential
Invasion, establishment and spread of *Lantana camara*	TSC Act	*L. camara* is present within the Rozelle Rail Yards. Movement of vehicles, equipment and people carries a risk of introduction and spread of *L. camara* into unaffected areas.	Known

Key threatening process	Statutory listing	Relevance to the project	Potential or known
Human-caused climate change	TSC Act, EPBC Act and FM Act	During construction, machinery and production and transport of materials would emit carbon-dioxide into the atmosphere, which is known to increase greenhouse gases responsible for climate change. However, the results of the greenhouse gas assessment for the project demonstrates the benefits of road tunnel usage in urban areas, where travel along a more direct route at higher average speeds results in fewer greenhouse gas emissions being generated by road users, as reduced congestion and stop-start driving reduces the fuel used by vehicles. Further detail is provided in **Chapter 22** (Greenhouse gas).	Known

Note: *It is now understood that *P. cinnamomi* is not a fungus. This was the name of the key threatening process when it was registered under the EPBC Act.

18.4 Biodiversity offsets

Consistent with the SEARs, the project has been assessed using the FBA. The FBA was developed by OEH and includes a standardised methodology for the calculation of offsets. The outcome of this assessment is that no biodiversity offsets are required for this project. Details of this assessment can be found in **Appendix S** (Technical working paper: Biodiversity).

Replacement planting would be undertaken for the trees that would be removed by the project, as outlined in **section 18.3.1** and **section 18.5**.

18.5 Environmental management measures

Environmental management measures relating to biodiversity during construction and operation are provided in **Table 18-8**. Additional mitigation and management measures relevant to biodiversity are also described in the following sections of this EIS:

- Noise and vibration management measures in **Chapter 10** (Noise and vibration)
- Lighting management measures in **Chapter 13** (Urban design and visual amenity)
- Erosion and sediment control management measures in **Chapter 15** (Soil and water quality)
- Flooding and drainage management measures in **Chapter 17** (Flooding and drainage).

Table 18-8 Environmental management measures – biodiversity

Impact	No.	Environmental management measure	Timing
Construction			
Impact on biodiversity values	B1	A Construction Flora and Fauna Management Plan (CFFMP) would be developed and implemented during construction. The CFFMP would include the following: • Identification of guidelines relevant to construction, the matters they apply to and what is required to ensure compliance • Pre-disturbance inspection requirements to identify features of biodiversity conservation significance and select appropriate management measures and environmental controls • Management measures and environmental controls to be implemented before and during construction including: – An unexpected threatened species finds procedure – Section 3.3.2 Standard precautions and mitigation	Construction

Impact	No.	Environmental management measure	Timing
		measures of the *Policy and guidelines for fish habitat conservation and management Update 2013* (DPI-Fisheries NSW 2013) – Tree assessment and management protocols consistent with AS 4970-2009 Protection of trees on development sites – Weed management protocols.	
Disturbance of threatened microbats	B2	Prior to the commencement of any works associated with the modification of the Victoria Road bridge, an inspection would be carried out by a suitably qualified and experienced ecologist to confirm the presence of roosting microbats. If roosting microbats are identified, measures to manage potential impacts would be developed in consultation with an appropriate microbat expert and included in the CFFMP prior to the commencement of any work with the potential to disturb the roosting locations (as confirmed by the microbat expert). The plan would include management measures outlined in Appendix S (Technical paper: Biodiversity assessment report) and from any additional assessments carried out during detailed design and project delivery as relevant.	Construction
Aquatic impacts	B3	The proposed road bridge at Whites Creek would be designed with consideration of *Policy and Guidelines for Fish Habitat Conservation Update 2013* (DPI, 2013) and *Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings* (NSW Fisheries 2003).	Construction
	B4	Site-specific Erosion and Sediment Control Plans (ESCPs) would be prepared for each work location associated with or in the vicinity of waterways and culverts that would be modified as part of the project. The ESCPs would contain measures to stabilise all surfaces disturbed as a result of the project as soon as possible following the disturbance to prevent erosion and to minimise sedimentation in adjacent aquatic environments.	Construction
Loss of trees	B5	The CFFMP will include measures to manage potential impacts on trees. Measures will include: • The establishment of tree protection zones • Ground protection measures for trees to be retained.	Construction
	B6	As many trees as possible will be retained during construction. In the event that tree removal cannot be avoided, a tree replacement strategy will be prepared. Replacement trees will be included in the Urban Design and Landscape Plan to be developed and implemented for the project.	Construction
	B7	The CFFMP will include tree management protocols and provision for the development of tree management plans (in accordance with the requirements of AS 4970-2009) where required for specific trees. Protection of trees on development sites will be carried out in consultation with an arborist with a minimum Australian Qualifications Framework (AQF) Level 5 qualification in arboriculture for each tree proposed for retention where works associated with the project have the potential to impact on the tree root zone.	Construction

Impact	No.	Environmental management measure	Timing
	B8	Tree removal, pruning and maintenance work will be carried out by an arborist with a minimum AQF Level 3 qualification in accordance with AS 4373-2007 Pruning of Amenity Trees and the NSW WorkCover Code of Practice for the Amenity Tree Industry (1998) and advice provided by an arborist with a minimum AQF Level 5 qualification in arboriculture (or equivalent).	Construction
Operation			
Loss of trees	OB9	An Urban Design and Landscape Plan will be prepared and implemented to guide the compensatory planting for trees removed by the project. The plan will include: • A tree replacement strategy • Species recommendations for the landscape design to consider, including foraging trees for the Grey-headed Flying-fox • Relevant project specific rehabilitation and revegetation measures associated with the M4 East and New M5 projects, where there is an overlap in use of project footprint.	Operation
Loss of aquatic habitat	OB10	Consultation would be undertaken with Sydney Water regarding integration of naturalisation works at Whites Creek, including re-establishment of vegetation where possible following construction activities. Vegetation re-establishment will be undertaken in accordance with Guide 3*: Re-establishment of native vegetation of the Biodiversity Guidelines: Protecting and management biodiversity on RTA project* (NSW Roads and Traffic Authority 2011).	Operation

19 Groundwater

This chapter outlines the potential groundwater impacts associated with the M4-M5 Link project (the project). A detailed groundwater assessment has been undertaken for the project and is included in **Appendix T** (Technical working paper: Groundwater).

The Secretary of the NSW Department of Planning and Environment (DP&E) has issued environmental assessment requirements for the project. These are referred to as Secretary's Environmental Assessment Requirements (SEARs). **Table 19-1** sets out these requirements and the associated desired performance outcomes that relate to groundwater and identifies where they have been addressed in this environmental impact statement (EIS).

Table 19-1 SEARs - groundwater

Desired performance outcome	SEARs	Where addressed in the EIS
3. Health and safety The project avoids, to the greatest extent possible, risk to public safety.	2. The assessment must: (e) assess the likely risks of the project to public safety, paying particular attention to pedestrian safety, subsidence risks, bushfire risks and the handling and use of dangerous goods;	Subsidence risks are discussed in **section 19.3.8**.
10. Water - Hydrology Long term impacts on surface water and groundwater hydrology (including drawdown, flow rates and volumes) are minimised. The environmental values of nearby, connected and affected water sources, groundwater and dependent ecological systems including estuarine and marine water (if applicable) are maintained (where values are achieved) or improved and maintained (where values are not achieved). Sustainable use of water resources.	1. The Proponent must describe (and map) the existing hydrological regime for any surface and groundwater resource (including reliance by users and for ecological purposes) likely to be impacted by the project, including stream orders, as per the FBA.	The existing hydrological regime for groundwater is described (and mapped) in **section 19.2**.
	2. The Proponent must prepare a detailed water balance for ground and surface water including the proposed intake and discharge locations, volume, frequency and duration for both the construction and operational phases of the project.	**Section 19.3.9** and **section 19.4.9** detail a project construction and operational water balance respectively.
	3. The Proponent must assess (and model if appropriate) the impact of the construction and operation of the project and any ancillary facilities (both built elements and discharges) on surface and groundwater hydrology in accordance with the current guidelines, including:	Refer below
	(a) natural processes within rivers, wetlands, estuaries, marine waters and floodplain that affect the health of the fluvial riparian estuarine or marine system and landscape health (such as modified discharge volumes, durations and velocities), aquatic connectivity and access to habitat for spawning and refuge;	Impacts on natural processes are assessed in **Chapter 15** (Soil and water quality), **Chapter 17** (Flooding and drainage) and **Chapter 18** (Biodiversity).
	(b) impacts from any permanent and temporary interruption of groundwater flow, including the extent of drawdown, barriers to flows, implications for groundwater dependent surface flows, ecosystems and species, groundwater users and the potential for settlement;	**Section 19.3** and **section 19.4** outline potential impacts on groundwater flow during the construction and operation of the project respectively.

Desired performance outcome	SEARs	Where addressed in the EIS
	(f) water take (direct or passive) from all surface and groundwater sources with estimates of annual volumes during construction and operation;	Groundwater intake assessed in section **19.3.2** and section **19.4.2**.
	5. The assessment must include details of proposed surface and groundwater monitoring.	**Section 19.5** outlines the proposed groundwater monitoring for the project and surface water monitoring is described in **Chapter 15** (Soil and water quality).
	6. The proposed tunnels should be designed to prevent drainage of alluvium in the palaeochannels.	As described in **section 19.4.2** the project tunnels have been designed to avoid palaeochannels where possible. At the Rozelle Rail Yards tunnels intersecting the alluvium are to be fully lined to prevent direct inflow of groundwater from the alluvium. A specific management measure to this effect for the detailed design stage is included in **section 19.5**.
11. Water - Quality The project is designed, constructed and operated to protect the NSW Water Quality Objectives where they are currently being achieved, and contribute towards achievement of the Water Quality Objectives over time where they are currently not being achieved, including downstream of the project to the extent of the project impact including estuarine and marine waters (if applicable).	1. The Proponent must: (i) identify proposed monitoring locations, monitoring frequency and indicators of surface and groundwater quality.	**Section 19.1.3** outlines the field investigations and groundwater monitoring undertaken to inform groundwater modelling for the project. **Section 19.5** outlines the proposed groundwater monitoring for the project. Surface water monitoring is described in **Chapter 15** (Soil and water quality).

Desired performance outcome	SEARs	Where addressed in the EIS
13. Soils The environmental values of land, including soils, subsoils and landforms, are protected. Risks arising from the disturbance and excavation of land and disposal of soil are minimised, including disturbance to acid sulfate soils and site contamination.	5. The Proponent must assess the impacts of the project on soil salinity and how it may affect groundwater resources and hydrology.	Impacts to groundwater from the project related to soil salinity are discussed in **section 19.3.4**.
	7. The Proponent must assess the impact of any disturbance of contaminated groundwater and the tunnels should be carefully designed so as to not exacerbate mobilisation of contaminated groundwater and/or prevent contaminated groundwater flow.	Potential impacts related to the disturbance of contaminated groundwater are discussed in **section 19.3.4**, including an outline of tunnel design measures which aim to avoid the mobilisation of contaminated groundwater.

19.1 Assessment methodology

A groundwater assessment has been undertaken to address the relevant SEARs outlined in **Table 19-1**. The assessment describes the existing groundwater environment and determines the potential impacts of the construction and operation of the project on groundwater flows, groundwater levels and water quality. A summary of the groundwater assessment is provided in this chapter. The full assessment is included in **Appendix T** (Technical working paper: Groundwater).

The assessment includes:

- Consideration of the existing environment that the project would interact with, including the hydrogeological conditions and environmental values of the surrounding environment
- An impact assessment, which characterises the impacts of the tunnels on groundwater dependant systems and surrounding environment using numerical modelling techniques to quantify impacts
- Groundwater management and monitoring measures required to mitigate impacts and manage tunnel inflows.

The assessment has been undertaken with consideration of relevant legislation, policies, guidelines and water sharing plans listed below and in **Table 19-2**.

Table 19-2 Relevant groundwater assessment legislation and guidelines

Policy/guidance	Relevance
Water Management Act 2000 (NSW)	• State significant development and State significant infrastructure projects are exempt from requiring some water supply works approvals and controlled activity approvals • Aquifer interference activity approval provisions have not yet commenced but are administered under the *Water Act 1912* (NSW) • Water sharing plans are administered under this Act.
Water Act 1912 (NSW)	• Administration of water access licences and the trade of water licences and allocations.

Policy/guidance	Relevance
NSW Aquifer Interference Policy (NSW Office of Water (NoW) 2012)	• Manages the impacts of aquifer interference activities in accordance with the *Water Act 1912* (NSW) and water sharing plans • Aquifer interference activities must address minimal impact considerations as outlined in the policy • In the event that actual impacts are greater than predicted, the policy requires that sufficient monitoring be put in place.
Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2011	• Water sharing plans (regulations under the *Water Management Act 2000* (NSW)) manage the long-term surface and groundwater resources of a defined area • The plan outlines rules for the sharing and sustainable use of water between various uses such as town water supply, stock and domestic, industry and irrigation.

The project's compliance with the legislation and guidelines outlined in **Table 19-2** is demonstrated in detail in **Appendix T** (Technical working paper: Groundwater).

The groundwater assessment has been prepared with reference to the following additional applicable documents:

- NSW Groundwater Policy Framework Document (NSW Department of Land and Water Conservation (DLWC) 1998)
- NSW Groundwater Quality Protection Policy (DLWC 1998)
- NSW Groundwater Dependent Ecosystems Policy (DLWC 2002)
- NSW Groundwater Quantity Management Policy (DLWC undated)
- Risk assessment guidelines for groundwater dependent ecosystems (NoW 2013)
- Australia and New Zealand Environment and Conservation Council (ANZECC) and Agriculture Resource Management Council of Australia and New Zealand (ARMCANZ) National Water Quality Management Strategy Australian Guidelines for Fresh and Marine Water Quality (ANZECC & ARMCANZ 2000)
- *NSW Water Extraction Monitoring Policy* (Department of Water and Energy (DWE) 2007)
- *NSW Aquifer Interference Policy* (NoW 2012)
- Guidelines for riparian corridors on waterfront land (NSW Department of Primary Industries (DPI) 2012)
- Water Sharing Plan, Greater Metropolitan Regional Groundwater Sources Background Document, Sydney (NoW 2011).

19.1.1 Study area

A three-dimensional numerical groundwater model was developed to predict future groundwater conditions and potential impacts related to the project (see **section 19.1.5**).

For the purposes of the groundwater impact assessment, the study area is the domain considered by the groundwater model. The model domain (study area) extends over an area of about 11 by 11 kilometres and is centred on the mainline tunnel alignment and partially includes the neighbouring M4 East and New M5 projects. The northern boundary of the study area is represented by the central channel of the Parramatta River/Sydney Harbour. The study area is shown in **Figure 19-1**.

19.1.2 Desktop review

The following database searches were conducted to inform a review of the existing environment:

- Australian Soils Resource Information System acid sulfate soils, accessed May 2016
- Bureau of Meteorology (BoM) 2016 Australian Groundwater Explorer (formerly DPI-Water groundwater database), accessed December 2016
- Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources (2011). Schedule 4 of the Plan identifies high priority groundwater dependent ecosystems (GDEs) and Appendix 2 identifies GDEs
- BoM 2016 Atlas of Groundwater Dependent Ecosystems, accessed October 2016
- BoM 2017 online climate data, accessed March 2017
- NSW Environment Protection Authority (NSW EPA) Contaminated Land Record, accessed November 2016.

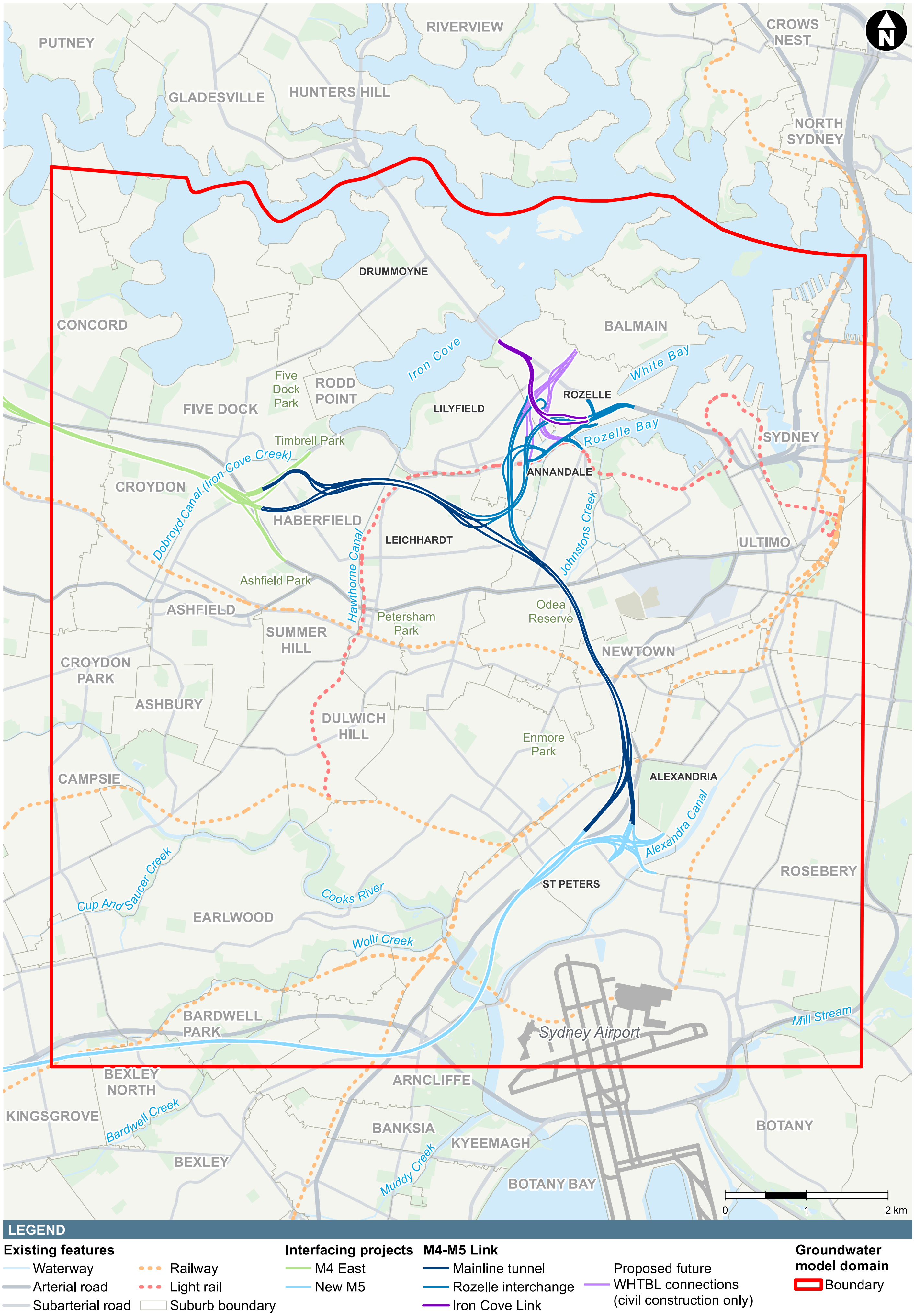


Figure 19-1 Groundwater assessment study area

19.1.3 Field investigation

Groundwater field investigations, including drilling boreholes, packer tests, groundwater gauging, groundwater sampling and hydrogeochemical analysis, were conducted across the study area between June 2016 and May 2017. During investigations, 58 boreholes were converted to monitoring wells. The locations of monitoring wells used in this investigation are presented in **Figure 19-2**. The selection of monitoring well locations was based on the initial project design and subsequent changes during concept design development. Consequently, some monitoring wells have become redundant as the alignment has changed during the development of the concept design.

Groundwater data collected included:

- Hydraulic conductivity (ie the rate at which groundwater naturally moves through the rock or sediments)
- Groundwater levels (including fluctuations), determined through groundwater gauging (ie monitoring levels in groundwater wells) and data loggers
- Groundwater quality, determined through hydrogeochemical sampling and analysis.

Hydraulic conductivity

Hydraulic conductivity is a fundamental aquifer property that assists in understanding the tunnel water inflows or the local drawdown (ie the reduction in the water level) that may be imposed on the local hydrogeological regime. Hydraulic conductivity is measured in metres per day and is a calculation of how easily groundwater flows through a porous medium (soil matrix or rock mass) under natural conditions. The higher the value of hydraulic conductivity, the greater the movement of groundwater expected (including into unsealed underground structures such as road tunnels).

Packer tests (or water pressure tests) were conducted to measure the hydraulic conductivity of selected rock mass intervals. Packer tests involve injecting water under pressure into a rock mass interval and measuring the water ingress over a given time period. The amount of water injected is proportional to the hydraulic conductivity. The packer test results provide a bulk hydraulic conductivity for the intervals measured.

Tests undertaken in the field, such as packer tests, primarily measure the horizontal hydraulic conductivity, and consequently laboratory testing was undertaken to also assess vertical hydraulic conductivity. Selected core samples (63.5 millimetre diameter and about 0.25 metres long) were collected during the field program for laboratory testing of hydraulic conductivity and porosity (a measure of the void (empty) spaces within a material that water can flow through). The data was used to support the groundwater modelling.

Groundwater levels

Groundwater gauging was conducted throughout the field program that commenced in June 2016, taking monthly measurements of standing groundwater levels using an electronic dipper. Data loggers were installed in most of the monitoring wells to automatically measure groundwater levels at one-hour intervals, to monitor both short-term and long-term groundwater level fluctuations. The loggers were suspended in each monitoring well at a depth of about five metres below the standing water level.

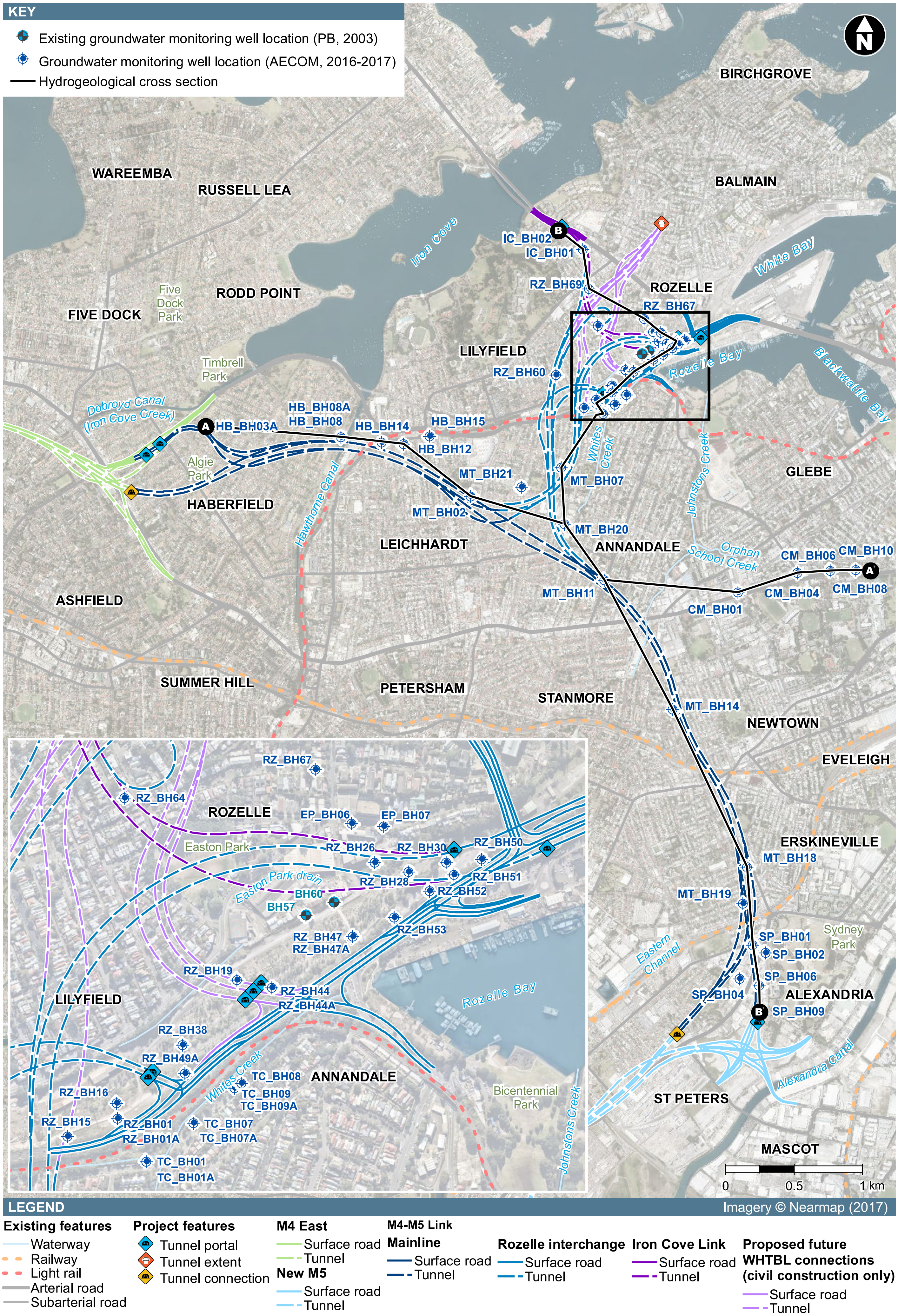


Figure 19-2 Locations of monitoring wells constructed for groundwater field investigations

Groundwater quality

Groundwater samples were collected from the monitoring well network for laboratory analysis. Groundwater was sampled and analysed to characterise the local groundwater quality of each of the main hydrogeological units; specifically to identify any spatial and temporal variability, and to identify potential groundwater contamination.

Groundwater quality samples were tested for the following components:

- Heavy metals and metalloids (including arsenic, cadmium, chromium, copper, iron, lead, magnesium, manganese, mercury, nickel and zinc)
- Benzene, toluene, ethylbenzene, xylene and naphthalene (BTEXN)
- Total recoverable hydrocarbons (TRHs)
- Polycyclic aromatic hydrocarbons (PAHs)
- Inorganics (including major anions and cations, alkalinity, ammonia, electrical conductivity, ionic balance, total dissolved solids, pH and hardness)
- Organochlorine pesticides (OCPs)
- Organophosphate pesticides (OPPs)
- Semi-volatile organic hydrocarbons (SVOCs)
- Volatile organic compounds (VOCs)
- Sulfate reducing bacteria (which promotes the increased corrosion of metals).

Groundwater aggressivity was also assessed, to gauge the extent to which the natural groundwater may corrode or degrade materials such as steel and concrete, which may be used in the construction of tunnel infrastructure.

The monitoring wells were sampled monthly using low flow sampling or a double valve stainless steel bailer (a hollow tube used to retrieve groundwater samples from below the ground surface). Sampling was typically scheduled for the middle of the month. During groundwater sampling, discharge water was directed through a flow cell to measure field parameters including dissolved oxygen, electrical conductivity, pH, temperature and oxidation-reduction conditions.

19.1.4 Groundwater dependant ecosystems

GDEs are communities of plants, animals and other organisms whose extent and life processes are dependent on groundwater, such as wetlands and vegetation on coastal sand dunes. Priority GDEs are ecosystems with a high ecological value which are considered high priority for management action as defined in the *Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources* (2011). Sources reviewed to understand potential GDEs that may be affected by the project include:

- *Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources* (2011). Schedule 4 of the Plan identifies high priority GDEs and Appendix 2 identifies GDEs
- BoM Atlas of GDEs
- Threatened species database (NSW Office of Environment and Heritage (OEH))
- The Biodiversity Assessment Report for the project as contained in **Appendix S** (Technical working paper: Biodiversity).

19.1.5 Groundwater modelling

A three-dimensional numerical groundwater model was developed to simulate existing groundwater conditions, proposed tunnel alignments, caverns and associated subsurface ancillary infrastructure. The groundwater model was used to predict future groundwater conditions and potential impacts related to the project.

The groundwater model was prepared by HydroSimulations (HydroSimulations 2017) and developed in accordance with the Australian Groundwater Modelling Guidelines (Barnett et al. 2012). The model was developed broadly as follows:

- Review of appropriate modelling platforms best suited to the required predictive modelling along a linear feature
- Desktop review of relevant geological and hydrogeological reports within the Sydney Basin
- Desktop review of recent tunnelling projects within the Sydney region
- Collation of data and analysis of aquifer parameters
- Development of a hydrogeological conceptual model
- Model development including setting model boundaries, layers, model discretisation and selection of interfaces to simulate surface waterbodies and the interaction with groundwater
- Model calibration
- Sensitivity analysis
- Model predictions.

The numerical groundwater model was developed using MODFLOW-USG (2012). This version of MODFLOW was selected as it allows local grid refinement and is suited to simulating linear features such as road tunnels. MODFLOW is the industry standard groundwater modelling platform and was used for the M4 East and New M5 projects' groundwater impact assessments.

Both transient and steady state models were developed and calibrated:

- The transient model predicts groundwater drawdown that would occur while the groundwater system is establishing a new equilibrium (following the commencement of the construction of the project)
- The steady state model predicts groundwater drawdown that would occur in the long term, after a new equilibrium has been established (at some point in time following the completion of the construction of the project)
- The groundwater model has been used to predict influences on the project as well as the cumulative impacts (see **section 19.1.6**) for the other WestConnex projects as follows:
  - Scenario 1: A 'Null' run does not include any WestConnex projects but does include the existing drained M5 East tunnels
  - Scenario 2: The 'Null' run in Scenario 1, plus the approved WestConnex tunnel projects (M4 East and New M5)
  - Scenario 3: The 'Null' run in Scenario 1, plus the approved WestConnex tunnel projects (M4 East and New M5) in Scenario 2, and the M4-M5 Link project

  The impacts of the M4-M5 Link project were computed by the model by subtracting the Scenario 3 impacts from those of Scenario 2
- The groundwater model has provided outputs for the year 2023 (for predicted groundwater conditions representative of end of the construction of the project) and for the year 2100 (for groundwater conditions representative of the long term operation of the project).

Further details on the method used for the groundwater modelling is provided in **Appendix T** (Technical working paper: Groundwater).

19.1.6 Cumulative impact assessment

Cumulative impacts are those that act together with other impacts to affect the same resources or receptors such that the accumulation of the impacts is the sum of the individual impacts. Cumulative groundwater impacts include groundwater extraction, groundwater drawdown, and groundwater quality.

A quantitative cumulative impact assessment of the local hydrogeological regime, for the WestConnex M4 East and New M5 projects[1] has been undertaken by application of the groundwater modelling. A qualitative groundwater cumulative impact assessment has been undertaken for other infrastructure projects including the Sydney Metro City and Southwest project, proposed future Western Harbour Tunnel and Beaches Link and the proposed future F6 Extension and is provided in **Chapter 26** (Cumulative impacts).

The objectives of the cumulative impact assessment are to:

- Use the groundwater model to predict the cumulative impacts on groundwater due to the project in combination with other WestConnex tunnel projects (M4 East and New M5)
- Qualitatively assess the cumulative impacts of the project, other WestConnex projects and other proposed infrastructure projects (outlined in **section 19.2.1**).

19.2 Existing environment

The existing environment has been characterised based on available information and investigation data collected for the project, including:

- Topography and drainage
- Geological setting
- Hydrogeological setting, including groundwater levels and hydraulic conductivity
- Groundwater quality
- Groundwater users
- GDEs.

19.2.1 Existing and proposed infrastructure

The project footprint transects an urban environment that consists of established industrial, commercial, recreational and residential areas. In some areas, major existing or proposed infrastructure may influence the project or the local hydrogeological regime. Major existing infrastructure is listed below and shown in **Figure 19-3**:

- Former Alexandria landfill at St Peters
- Sydney Park at St Peters
- King George Park at Rozelle
- Easton Park at Rozelle
- Rozelle Rail Yards at Rozelle
- White Bay redevelopment precinct at Rozelle
- Bicentennial Park at Glebe
- Existing tunnels (M5 East motorway tunnels and Airport Link rail tunnel)
- Surface roads and rail (including the Princes Highway, Parramatta Road, Victoria Road, the Western Distributor, Inner West rail line, Bankstown rail line and Inner West Light Rail line).

[1] The project does not include consideration of the WestConnex M4 Widening and King Georges Road Interchange Upgrade component projects because they do not involve tunnelling and therefore are not associated with potential groundwater impacts.

A number of other infrastructure projects (including proposed and approved projects) in the vicinity of the proposed M4-M5 Link project have the potential to cause cumulative impacts on the local environment, (refer to **Chapter 26** (Cumulative impacts)) including:

- WestConnex New M5 project, which will consist of about nine kilometres of twin motorway drained tunnels between the existing M5 East Motorway (between King Georges Road and Bexley Road) and St Peters
- WestConnex M4 East project, which will extend from the existing M4 Motorway at Homebush to Haberfield, consisting of 5.5 kilometres of three-lane twin drained tunnel
- Sydney Metro City and Southwest, which is a proposed rail alignment comprising two stages, with Stage 1 linking Chatswood to Sydenham and Stage 2 linking Sydenham to Bankstown. The alignment would consist of 15.5 kilometre twin railway tunnels
- Western Harbour Tunnel and Beaches Link, which is a proposed future project that would, via the Western Harbour Tunnel component, provide a further tunnel crossing of Sydney Harbour to the west of Sydney Harbour Bridge which, together with WestConnex, would act as a western bypass of the Sydney CBD
- F6 Extension, which is a proposed future connection linking the F6 Motorway to the New M5 Motorway at Arncliffe
- Sydney Gateway, which is a proposed future connection linking the New M5 at the St Peters interchange with the Sydney Airport and the Port Botany precinct
- White Bay Power Station redevelopment, which is proposed in accordance with The Bays Precinct Transformation Plan.

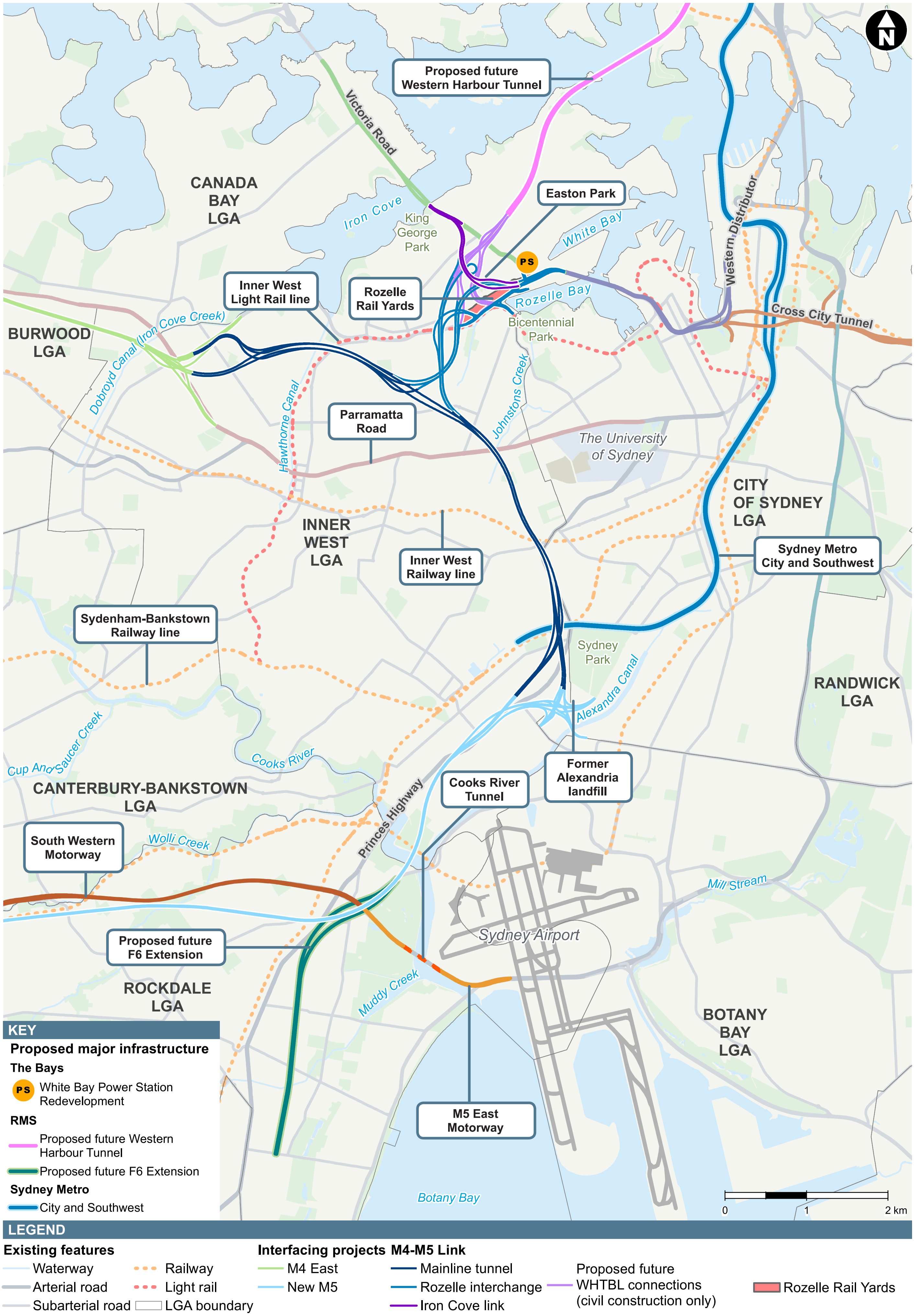


Figure 19-3 Existing and proposed major infrastructure

19.2.2 Topography and drainage

The project footprint extends from the M4 East at Haberfield, through the proposed interchange at Rozelle, emerging at the St Peters interchange. The topography of the project footprint is relatively flat and low lying, ranging from sea level (adjacent to Sydney Harbour at White Bay, Rozelle Bay, Iron Cove and the Alexandra Canal) up to 33 metres Australian Height Datum (AHD) at Lilyfield, where the Hawkesbury Sandstone outcrops.

The majority of the project footprint is located in a heavily urbanised area and is drained by the stormwater network. The primary surface water features in the groundwater assessment study area (see **Figure 19-4**) are the creeks, infilled creeks and canals. The footprint is covered by five catchments that discharge into Sydney Harbour and Botany Bay, as shown in **Figure 19-4**.

Dobroyd Canal (Iron Cove Creek) is a lined channel that drains Haberfield, discharging into Iron Cove on the Parramatta River. The lower tidal section of Iron Cove Creek is known as Dobroyd Canal. Draining Haberfield and Leichhardt is Hawthorne Canal, a lined channel that discharges into Iron Cove. Johnstons Creek is a lined channel that drains Annandale and Glebe, discharging into Rozelle Bay. Similarly, Whites Creek is a brick and concrete-lined channel that flows through the suburbs of Leichhardt and Marrickville, discharging to Rozelle Bay. Easton Park drain is located south of Easton Park.

Patches of coastal saltmarsh occur along the edge of Rozelle Bay and Johnstons Creek to the south of the project footprint. To the south, the suburbs of Newtown, Enmore and St Peters are drained by the lined Eastern Channel that discharges to the Cooks River. Wolli Creek, Bardwell Creek and Mill Stream are unlined and are outside the immediate project footprint, but are included in the groundwater study area to identify potential impacts associated with groundwater drawdown. Further to the south, Alexandra Canal drains into the Cooks River.

The majority of the creeks and canals in the model domain are concrete lined. In the concrete lined creeks, seepage to groundwater is limited to water flowing through fractures within the concrete lining, and along unlined stretches or naturalised areas. Lower reaches of the concrete lined channels are expected to leak more where the channels are tidally influenced and receive more water than the upper reaches.

Sydney Water is in the process of naturalising some creeks and canals (to replace the concrete lining with a natural permeable stream base, planting natural vegetation and re-contouring river banks). Parts of the Cooks River have been naturalised and it is proposed to naturalise parts of Johnstons Creek, Whites Creek and Dobroyd Canal (Iron Cove Creek) in the near future. No natural wetlands have been identified within the project footprint or area of predicted drawdown impact (see **section 19.3.3** and **section 19.4.3**). No natural springs have been identified within the project footprint.

Surface water and groundwater in the Sydney Basin is described at a large scale in the Water Sharing Plan for the Greater Metropolitan Region (NoW 2011). Within the porous rock aquifer, the level of connection between groundwater and surface water is stated as low to moderate, with the estimated travel time between groundwater and unregulated rivers being in the order of years to decades.

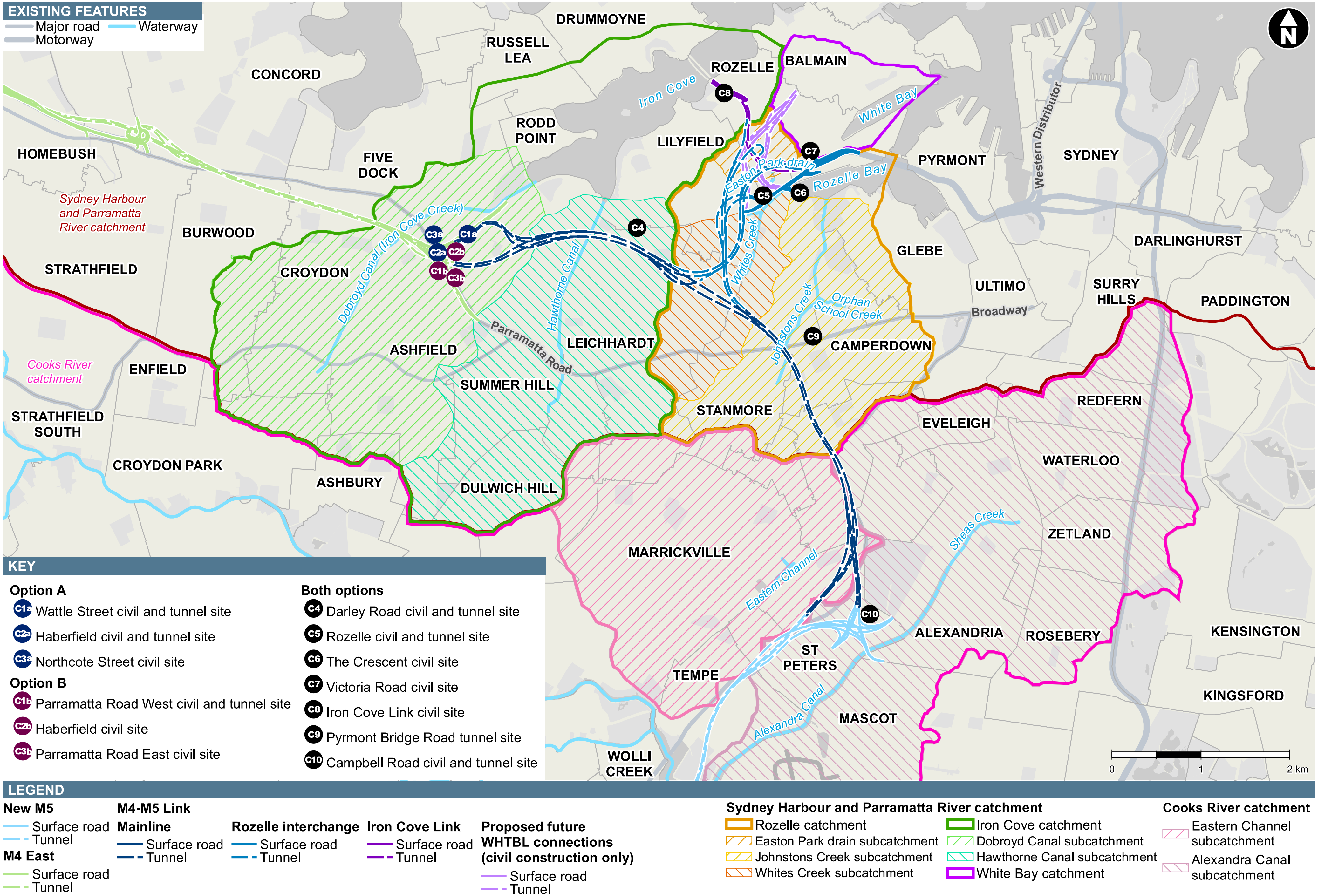


Figure 19-4 Surface water catchments within study area

19.2.3 Geological setting

Regionally, the project footprint is located within the Permo-Triassic Sydney Basin, which is characterised by sub-horizontal sedimentary sequences, mainly sandstone and shale. The project footprint is underlain by two main geological units (bedrock units), Ashfield Shale and Hawkesbury Sandstone. These are sometimes separated by the transitional Mittagong Formation. To the east of the project footprint, the unconsolidated Quaternary-aged Botany Sands overlap the Sydney Basin and the bedrock.

The main stratigraphic units that have been encountered within the study area, from youngest to oldest, are:

- Anthropogenic fill
- Quaternary alluvium (recent beneath rivers, palaeochannels and Botany Sands)
- Jurassic intrusions (ie dykes, which are basaltic intrusive rocks)
- Triassic Ashfield Shale (Wianamatta Group)
- Triassic Mittagong Formation
- Triassic Hawkesbury Sandstone Formation.

The geology of the study area is shown in **Figure 19-5**. Further detail on the stratigraphic units, including weathering profiles and implications for hydraulic conductivity, is provided in **Appendix T** (Technical working paper: Groundwater).

19.2.4 Groundwater recharge

The project is located in an urbanised part of Sydney where rainfall recharge to groundwater has been reduced by hardstand captured runoff and roof runoff being directed to stormwater. The majority of groundwater recharge occurs in parks, gardens, bushland and creeks prior to discharge into Sydney Harbour.

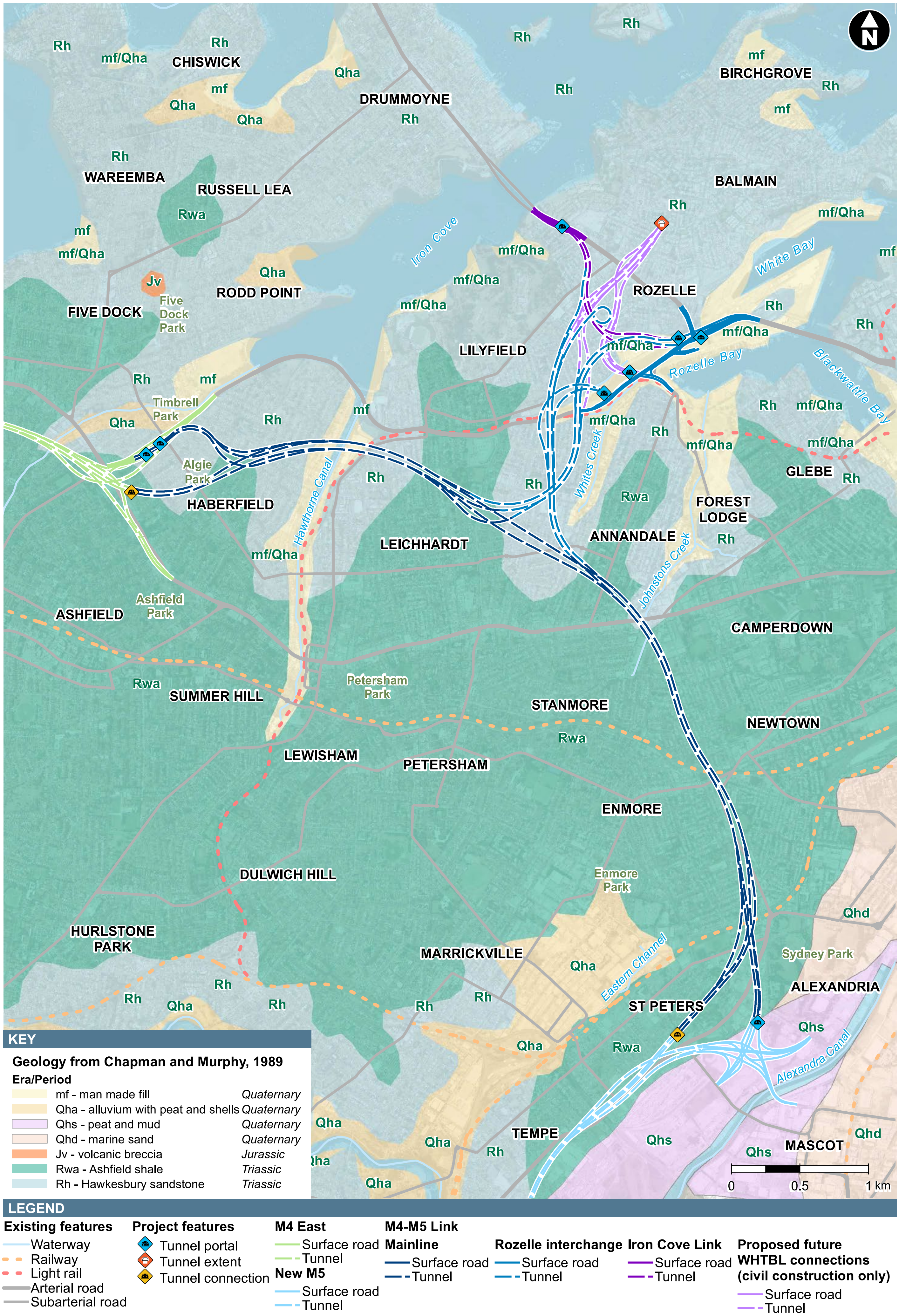


Figure 19-5 Geology in the study area

19.2.5 Hydrogeological setting

Across the study area the groundwater levels are typically deeper beneath hills and shallowest beneath creeks and gullies. Groundwater within the project footprint is recharged by rainfall runoff and infiltration. Groundwater is present within the following hydrogeological units:

- Quaternary alluvium
- Botany Sands aquifer
- Ashfield Shale
- Mittagong Formation
- Hawkesbury Sandstone.

Quaternary alluvium

Modern alluvium outcrops around the edge of the harbour at Rozelle Bay and is present beneath fill, together with slightly older alluvium infilling palaeochannels (these are ancient river systems eroded deeply into the landscape and subsequently infilled with saturated alluvial sediments), forming an unconfined aquifer. The alluvium surrounding creeks is generally of high permeability and the groundwater within the alluvium can be a source of either recharge or discharge, depending on whether upward or downward hydraulic gradients are present.

As the alluvium is hydraulically connected to the creeks, the groundwater levels are shallow and typically within one metre of the ground level. Hawthorne Canal, Whites Creek, Johnstons Creek and Dobroyd Canal (Iron Cove Creek) are concrete lined, thereby limiting the hydraulic connection between surface water and groundwater.

The palaeochannels that occur beneath some of the major watercourses or valleys in the study area extend to depths of up to 25 metres and are saturated with groundwater. Groundwater within the palaeochannels is typically saline, due to recharge from the Ashfield Shale and leakage from tidally flushed rivers and tributaries. The alluvium infilling the palaeochannels is highly transmissive due to the coarse clean sands and gravels present.

Botany Sands aquifer

Groundwater is present within the Botany Sands as a shallow unconfined aquifer. Groundwater levels are variable but are typically within five metres of the ground surface when not influenced by localised pumping. Regionally, groundwater flow is eastward, discharging into Botany Bay and Alexandra Canal. The Botany Sands aquifer naturally contains low salinity groundwater and is moderately acidic, but in many areas has been contaminated by industrial activities, most notably in the southern portion of the aquifer near the Botany Industrial Park.

Groundwater from the Botany Sands aquifer has historically been used beneficially for a number of purposes including irrigation, watering market gardens and domestic use. Groundwater is typically extracted via vacuum extraction systems, at groundwater yields typically up to two litres per second. DPI-Water advises that the whole Botany Sands hydrogeological unit is over allocated and domestic use has been embargoed since 2007 due to groundwater contamination.

While the Botany Sands are not intersected by the project, groundwater from the Botany Sands may be hydraulically linked with the drained M4-M5 Link tunnels. The residual alluvial clay that separates the sands from the underlying bedrock forms a hydraulic seal that would reduce groundwater drawdown due to the project. Groundwater flow to the Ashfield Shale is also expected to be low due to the shale’s low hydraulic conductivity.

Ashfield Shale

Groundwater flow within the Ashfield Shale is low due to the limited pore space and poor connectivity of the bedding planes. The majority of groundwater flow is via saturated fractures and joints, although these features can also reduce groundwater flow locally, if infilled with secondary mineralisation. The bulk hydraulic conductivity is typically low. Regionally, the Ashfield Shale reduces groundwater infiltration to the underlying Mittagong and Hawkesbury Sandstone Formations.

Groundwater quality within the shale is highly variable but is typically brackish or saline, due to the marine salts contained within it. The shale aquifer is characterised by low yields, limited storage and poor groundwater quality. Due to elevated salinity, low pH and the presence of sulphides, the groundwater can be corrosive to tunnel and infrastructure building materials.

Mittagong Formation

The Mittagong Formation is a relatively thin transition unit, where present, between the Ashfield Shale and Hawkesbury Sandstone. Although the Mittagong Formation is siltier than the Hawkesbury Sandstone, the hydraulic properties of the two formations are similar. The Hawkesbury Sandstone and Mittagong Formation are hydraulically connected. Groundwater quality is generally poor, due to leakage from the Ashfield Shale and the high clay content of the Mittagong Formation.

Hawkesbury Sandstone

The Hawkesbury Sandstone is characterised as a 'dual porosity aquifer', which means that groundwater is transmitted by both the primary porosity – or interconnected void space between grains of the rock matrix – and the secondary porosity, which is due to secondary structural features such as joints, fractures, faults, shear zones and bedding planes.

The Hawkesbury Sandstone is not one aquifer but several 'stacked aquifers', due to the heterogeneous and layered nature of the unit. Interbedded shale lenses can provide local or extensive confining layers, creating separate aquifers with different hydraulic properties including hydraulic heads (ie the elevation of groundwater in a monitoring well that the column of water would naturally attain).

The hydraulic conductivity of the Hawkesbury Sandstone is low, which means the groundwater flow through the sandstone is in the order of millimetres to centimetres per year. High groundwater yields can sometimes be pumped from the Hawkesbury Sandstone, particularly when saturated fractures are intersected (Hawkes *et al* 2009). Increased groundwater flow to tunnels is typically associated with the intersection of such major joints or fractures.

Groundwater flow within the Hawkesbury Sandstone is dominated by secondary fracture flow. Regionally, groundwater flow is eastward, discharging into the Tasman Sea. Recharge is via rainfall infiltration on fractured outcrops and through the soil profile and alluvium. Discharge is via seepage to cliffs, such as the exposed quarried sandstone cutting at the Rozelle Rail Yards, and via creeks and evapotranspiration.

Groundwater quality within the Hawkesbury Sandstone is generally acidic but of low salinity. The salinity of the upper part of the aquifer, however, can be elevated due to leakage from the Ashfield Shale. Elevated concentrations of dissolved iron and manganese naturally occur within the Hawkesbury Sandstone, which can cause staining when discharged and oxidised. In tunnels, groundwater ingress becomes oxidised, causing the dissolved iron and manganese to precipitate and form sludge in drainage lines.

Groundwater levels and movement

Natural groundwater levels are influenced by topography, creeks, rainfall, recharge and manmade structures. Groundwater levels are related to the position of a well in the landscape, with the groundwater table generally displaying gentler gradients but similar flow directions to the surface topography. Locally, the water table can be impacted by infrastructure such as pumping (for example, leachate pumping from landfills), groundwater resource pumping or localised temporary dewatering. Conversely, in some areas the local water table may be elevated above natural conditions due to irrigation, such as at Sydney Park or Bicentennial Park, or by subsurface structures including infrastructure or building foundations that restrict groundwater flow and cause localised groundwater 'mounding'.

Baseline groundwater level data has been collected in the groundwater monitoring network installed within the study area. The monitoring network consists of 58 monitoring wells intersecting groundwater from the alluvium, Ashfield Shale and Hawkesbury Sandstone.

Alluvium

Groundwater levels within the alluvium are monitored at 10 monitoring wells installed for the project. Groundwater levels are primarily controlled by local recharge and discharge conditions.

Since the alluvium is typically low-lying and connected to surface water within creeks or Sydney Harbour, the elevation of the water table within the unconfined aquifers is typically less than five metres AHD. Groundwater levels measured within the shallow alluvium (around The Crescent at Annandale) measured from 0.47 metres AHD to 1.08 metres AHD. Similarly, the groundwater levels measured within the deep palaeochannel (within the Rozelle Rail Yards at Rozelle) range from 1.11 metres AHD to 2.04 metres AHD.

Comparison of the two sets of groundwater levels indicate the water levels in the palaeochannel are higher by about 0.5 metres than the shallow alluvium, indicating there is upward pressure from the palaeochannel into the shallow alluvium, and groundwater from the palaeochannel may be discharging into the shallow alluvium. In each case, groundwater within the alluvium is flowing eastward, discharging into Rozelle Bay.

Ashfield Shale

Groundwater levels within the Ashfield Shale are monitored within the Camperdown and St Peters precincts of the project at eight monitoring wells. At St Peters, groundwater levels are influenced by ongoing leachate pumping from the former Alexandria Landfill (Hawkes and Evans 2016). As part of the landfill rehabilitation plan the former landfill will be capped to reduce rainfall infiltration and leachate generation. A cut-off wall along the eastern perimeter of the landfill is also proposed to be constructed to reduce groundwater inflow from the Botany Sands.

The highest groundwater level measured in the Ashfield Shale was measured at Camperdown, at an elevation of 22.1 metres AHD, where the topography along the alignment is at a high point. At the southern part of the proposed alignment next to the St Peters interchange, groundwater flows towards the western part of the landfill due to ongoing leachate pumping. This radial flow pattern and reversed hydraulic gradients prevent leachate contamination from dispersing into the Ashfield Shale.

Hawkesbury Sandstone

Groundwater levels within the Hawkesbury Sandstone are monitored at 40 monitoring wells within the study area. The elevation of measured groundwater levels ranges from 0.63 metres AHD beneath the Rozelle Rail Yards to 20.27 metres AHD beneath Camperdown. Artesian groundwater (groundwater under pressure) within the Hawkesbury Sandstone has been intersected at two monitoring wells in the low-lying areas beneath Hawthorne Parade. At this location the groundwater is under pressure and would flow from the well if a well cap is not in place.

At Haberfield, measured groundwater levels within the Hawkesbury Sandstone are variable and range from 0.5 metres to eight metres AHD. The groundwater elevation tends to reflect the position of the monitoring well in the landscape, with the hydraulic head increasing with distance from Rozelle Bay and Iron Cove.

Geological structural features

The solid geology within the project footprint is cross cut by a number of geological structural features that may impact groundwater flow. These include:

- Dykes, such as those identified within the sandstone cutting north of the Rozelle Rail Yards and 150 metres east of the Rozelle Rail Yards and beneath the Hawthorne Canal palaeochannel
- Geological faults (a fracture within rock where displacement may have occurred), which are typically found within the Hawkesbury Sandstone. The presence of geological faults is associated with increased groundwater inflows.

Hydraulic conductivity

Hydraulic conductivity and porosity testing was conducted during the field investigation program to provide parameters to support the groundwater modelling. Packer test results are summarised in **Table 19-3**. Results of the packer tests are expressed as Lugeon units, where one Lugeon unit is equivalent to a hydraulic conductivity of $1x10^{-7}$ metres per second (8.8×10^{-3} metres per day).

The distribution of packer test results for all hydrogeological units is presented in **Appendix T** (Technical working paper: Groundwater). **Table 19-3** shows the majority of the rock mass results are of low permeability, suggesting that inflows along the majority of the tunnels would be low. To provide an understanding of the measured bulk hydraulic conductivity within the Ashfield Shale and Hawkesbury Sandstone, statistics including mean, maximum, minimum and standard deviation are presented in **Table 19-3**. No site specific data was collected during the groundwater investigations for the hydraulic conductivity of the alluvium. Typical hydraulic conductivity values for similar lithologies across the Sydney Basin would be expected to range from 0.001 metres per day for clayey alluvium up to 1 metre per day for sandy alluvium.

Table 19-3 Monitored hydraulic conductivity for each hydrogeological unit

Relative permeability (metres per day)	Ashfield Shale	Hawkesbury Sandstone
Mean	0.017	0.10
Minimum	0.010	0.012
Maximum	0.12	1.17
Standard deviation	0.024	0.21
Number of samples	24	181

The majority (86 per cent) of packer tests were conducted within the Hawkesbury Sandstone, which is reflective of the majority of the tunnels being located within this stratigraphic unit. For comparison, hydraulic conductivity values within the Hawkesbury Sandstone across the whole Sydney Basin were compiled by McKibbin and Smith (2000) from the DPI-Water groundwater database, with results ranging between 0.01 and 0.15 metres per day. The range identified by McKibbin and Smith (2000) is higher than the packer test results obtained for the groundwater investigations, which is attributed to the majority of results being derived from test pumping results data, obtained from successful production bores that intersect highly permeable faults and fractures.

Groundwater inflow in existing Sydney tunnels

Within the Hawkesbury Sandstone, Mittagong Formation and Ashfield Shale, water inflow is dependent upon the number and aperture of saturated secondary geological structural features intersected. Rates of water inflows have been monitored in recent years from several unlined tunnels in the Sydney area with similar geology, hydrogeology and construction to that proposed by the M4-M5 Link project. These inflow rates are considered long-term flow rates throughout the operational life of the infrastructure, and are summarised in **Table 19-4** (after Hewitt 2005).

Drainage inflow varies from 0.6 litres per second per kilometre to up to 1.7 litres per second per kilometre.

Table 19-4 Measured drainage rates from other Sydney tunnels

Tunnel	Opened	Type	Width (m)	Length (km)	Drainage inflow (L/sec/km)
Eastern Distributor	1999	Three-lane road	12 (double deck)	1.7	1
M5 East Motorway	2001	Twin two-lane road	8 (twin)	3.8	0.9
Epping to Chatswood	2009	Twin rail	7.2 (twin)	13	0.9
Lane Cove Tunnel	2007	Twin three-lane road	9 (twin)	3.6	0.6/1.7*
Cross City Tunnel	2005	Twin two-lane road	8 (twin)	2.1	>3

Note:

* Measured inflow in Lane Cove Tunnel varied from 1.7 L/s/km (2001 – mid 2004) to 0.6 L/s/km (2011).

Predicted inflows to the M4 East and New M5 project tunnels have been calculated by numerical modelling published in the respective environmental impact statements for those projects which have obtained planning approval and are currently under construction.

For the New M5 project, groundwater modelling over a modelled length of about 20 kilometres (including the combined length of the mainline tunnels as well as tunnel ramps) predicted an inflow rate of 0.63 litres per second per kilometre of tunnel along the eastbound tunnel and 0.67 litres per second per kilometre of tunnel along the westbound tunnel (CDM Smith 2015).

Similarly, for the M4 East project, groundwater modelling was undertaken to predict inflows to the drained tunnels. The M4 East tunnels extend over a combined length of about 12 kilometres (including the combined length of the mainline tunnels as well as tunnel ramps). Groundwater modelling predicted inflow rates between 0.3 and 0.9 litres per second per kilometre of tunnel (WestConnex Delivery Authority 2015).

19.2.6 Groundwater quality

Table 19-5 provides a baseline for the existing groundwater quality within the study area. The groundwater quality criteria for the project have been developed in accordance with guidelines from ANZECC (2000). For analytes not covered by the ANZECC (2000) guidelines the amended National Health and Medical Research Council (NHMRC) Australian Drinking Water Guidelines (2015) have been adopted.

Table 19-5 Groundwater quality within the study area

Parameter	Alluvium	Ashfield Shale	Hawkesbury Sandstone
Groundwater temperature	Measured groundwater temperatures varied over a narrow range between 14 and 26.5°C. Seasonally, groundwater temperatures tended to vary by one or two degrees, although there was no variation between lithologies.	Measured groundwater temperatures varied over a narrow range between 14 and 26.5°C. Seasonally, groundwater temperatures tended to vary by one or two degrees, although there was no variation between lithologies.	Measured groundwater temperatures varied over a narrow range between 14 and 26.5°C. Seasonally, groundwater temperatures tended to vary by one or two degrees, although there was no variation between lithologies.
Electrical conductivity	Variable, ranging from 328 to 34,900 µS/cm	2860 µS/cm	1700 µS/cm
pH	Weakly acidic (pH 6.5)	Acidic (pH 5 to 6.5)	Acidic (pH 5 to 6.5)
Major cations (calcium, magnesium, sodium and potassium) and major anions (chloride, sulfate, carbonate and bicarbonate)	Groundwater within the alluvium is dominated by sodium, magnesium, chloride and bicarbonate. The dominance of sodium and chloride is attributed to tidal influences and interaction with sea water in Rozelle Bay.	The hydrogeochemical signature of groundwater from the Ashfield Shale is highly variable, which may be due to the intermittent development of secondary mineralisation such as calcite (calcium carbonate) and siderite (iron carbonate) and the variable flushing of salts of marine origin.	Groundwater derived from the Hawkesbury Sandstone is dominated by sodium and chloride, which may be in part due to the influence of saline harbour water.
Heavy metals (arsenic, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel and zinc)	The maximum recorded values of these metals exceeded the guideline concentration values for all but cadmium and nickel. In most cases the exceedance is marginal, indicating that background levels are already elevated.	The maximum recorded values exceeded the guideline concentration values for chromium, copper, iron, manganese, nickel and zinc. Iron and manganese are commonly elevated within the Ashfield Shale.	The maximum recorded values exceeded the guideline concentration values for chromium, copper, iron, lead, manganese, nickel and zinc. In most cases the guidelines have been marginally exceeded; however, the groundwater consistently has elevated iron and manganese.
Nutrients (including nitrite as N, nitrate as N, reactive phosphorus), and ammonia	Nitrite and nitrate concentrations ranged from below detection limits to 0.31 and 2.38 mg/L respectively, indicating background nutrient levels are low. Reactive phosphorous as P ranged from below detection limits to 0.04 mg/L, indicating phosphorous levels are also low. Ammonia values ranged from 3.81 to 5.76 mg/L, exceeding the guideline value	Nitrite and nitrate concentrations ranged from below detection limits to 0.1 and 1.17 mg/L respectively, indicating background nutrient levels are low. Reactive phosphorous as P ranged from below detection limits to 0.67 mg/L, indicating reactive phosphorous levels are low. Ammonia values ranged from 0.2 to 3.19 mg/L, averaging 1.2 mg/L,	Nitrite and nitrate concentrations ranged from below detection limits to 1.18 and 1.31 mg/L respectively, indicating background nutrient levels are low. Reactive phosphorus as P ranged from below detection limits to 0.16mg/L indicating reactive phosphorus levels are very low.

Parameter	Alluvium	Ashfield Shale	Hawkesbury Sandstone
	of 0.91 mg/L.	exceeding the guideline value of 0.91 mg/L.	Ammonia values ranged from 0.2 to 3.41 mg/L, averaging 0.93 mg/L, marginally exceeding the guideline value of 0.91 mg/L.
Sulfate reducing bacteria (measured as a colony forming unit (CFU) per 100 ml)[1]	Sulfate reducing bacteria was not assessed for alluvium.	No pattern with hydrogeological units was assessed for sulfate reducing bacteria because many samples were above the measurement limit (500,000 CFU/ml). Seawater is a known prime habitat for sulfate reducing bacteria, and it is possible that the dissolution of marine salts from the Ashfield Shale into the Hawkesbury Sandstone makes the groundwater prone to sulfate reducing bacteria growth.	No pattern with hydrogeological units was assessed for sulfate reducing bacteria because many samples were above the measurement limit (500,000 CFU/ml). Seawater is a known prime habitat for sulfate reducing bacteria, and it is possible that the dissolution of marine salts from the Ashfield Shale into the Hawkesbury Sandstone makes the groundwater prone to sulfate reducing bacteria growth.
Soil salinity	Salt concentrations within the alluvium are variable, and impacted by tidal influences.	Ashfield Shale typically has a high salt content due to the presence of connate marine salts.	Salt concentrations within the Hawkesbury Sandstone are variable.
Groundwater aggressivity[1]	Groundwater aggressivity was not assessed for alluvium.	Groundwater within the Ashfield Shale is: • Non-aggressive towards concrete piles for average concentrations of chloride, pH and sulfate • Non-aggressive towards steel piles for average concentrations of chloride and pH • Moderately aggressive towards steel pipes for groundwater with low conductivity.	Groundwater within Hawkesbury sandstone is: • Mildly aggressive towards concrete piles for average concentrations of chloride, pH and sulfate • Mildly aggressive towards steel piles for average concentrations of chloride and pH • Severely aggressive towards steel piles for groundwater with low conductivity.

Note:

1 Further assessment of the risk posed by the presence of sulfate reducing bacteria and groundwater aggressivity would be undertaken prior to construction. A corrosion assessment would be undertaken by the construction contractor to assess the impact on building materials that may be used in the tunnel infrastructure such as concrete, steel, aluminium, stainless steel, galvanised steel and polyester resin anchors.

19.2.7 Contamination

An assessment of contaminated land risk is provided in **Appendix R** (Technical working paper: Contamination) which is summarised in **Chapter 16** (Contamination). Areas within the project footprint that may contain contaminated soil and/or groundwater due to past or present land use practices have been investigated. During routine monthly groundwater monitoring as part of the hydrogeological investigation a suite of contaminants was assessed for laboratory analysis including cations and anions, heavy metals and nutrients. Groundwater contamination monitoring was conducted in September and November 2016 to support the site contamination investigation as summarised in **Chapter 16** (Contamination). Key sites investigated are discussed below.

Rozelle Rail Yards

The Rozelle Rail Yards are located to the north and northwest of Rozelle Bay. Roads and Maritime is planning to carry out a limited suite of site management works on part of the Rozelle Rail Yards site which include the removal of rail and rail-related infrastructure including vegetation, buildings and stockpiles. The works are needed to manage the existing environmental and safety issues at the site and would also improve access to surface conditions, which would allow for further investigation into the location of utilities and the presence of contamination and waste. The works would benefit future uses of the site (including construction of the M4-M5 Link project if it is approved).

The site management works were subject to a separate environmental assessment. The works were assessed in a review of environmental factors (REF) which was approved by Roads and Maritime under Part 5 of the *Environmental Planning and Assessment Act 1979* (NSW) in April 2017. The works commenced in mid-2017 and are anticipated to be conducted over a period of 12 months.

Contamination investigations undertaken at the Rozelle Rail Yards as part of the REF and for this EIS have confirmed varying concentrations and types of contamination at a number of locations across the site. The contamination is considered likely to be related to historical land uses and the importation of fill materials of unknown origin. This has resulted in the presence of variable concentrations of heavy metals, PAHs, TRHs, and bonded and friable asbestos in the soils, fill, ballast and existing stockpiles. However, elevated concentrations of these contaminants are not found in all locations across the site. Further investigation of the site would be completed once infrastructure and vegetation has been cleared as part of the site management works.

Contaminated groundwater has also been identified; however, this contamination is relatively minor and limited to exceedances of:

- Zinc and copper in one location
- Zinc in one other location
- TRHs, naphthalene and Bis(2-ethylhexyl) phthalate in one location.

The excavation of low lying natural soil during the tunnel excavation program may also uncover potential acid sulfate soils (PASS). Consequently, the risks associated with PASS and other contaminants of concern would be managed under a Construction Soil and Water Management Plan (CSWMP), which would outline requirements for the management of potential acid sulfate soils.

The primary risk to groundwater is the migration of contaminated groundwater due to altered groundwater flow paths from tunnel construction. The tunnel and cut-and-cover sections through the Whites Creek alluvium beneath the Rozelle Rail Yards would be constructed as undrained (tanked) (ie lined) to avoid the ingress of groundwater from the palaeochannels, minimising the potential for contaminated groundwater migration.

Leichhardt

The Hawthorne Canal and Leichhardt North area has undergone historic, widespread land reclamation with fill from unknown sources, indicating that subsurface soil contamination could be present in some areas. Other potential soil contamination sources include the storage and use of chemicals, pesticides, fuels and oils, and hazardous building materials at the former Public Works Depot and the former Ordnance Depot within Blackmore Park. There are potentially pockets of soil contamination present across these areas that could contaminate groundwater within the underlying palaeochannels. The tunnels are to be constructed at depth to extend beneath the palaeochannel associated with the Hawthorne Canal so groundwater from the alluvium would not directly flow into the tunnels. PASS have been mapped across the majority of this area. At The Crescent, shallow alluvial groundwater may have become contaminated with hydrocarbons via hydraulic connection with Whites Creek or activities associated with the light rail line and former freight line.

Haberfield and St Peters

Contamination investigations undertaken for the M4 East and New M5 projects have been reviewed to provide an understanding of potential groundwater contamination in the vicinity of the Wattle Street interchange at Haberfield and the St Peters interchange at St Peters, respectively.

Wattle Street interchange

It was determined that the risk of potential groundwater contamination in the vicinity of the Wattle Street interchange at Haberfield is low. Potential contaminating land uses were identified as being located topographically down-gradient of the project and therefore would be unlikely to impact groundwater within the project footprint.

St Peters interchange

The St Peters interchange is to be constructed on a rehabilitated Alexandria Landfill as part of the New M5 project. Leachate is still generated from the former landfill and will continue to be pumped and treated on site before disposal off site. Leachate generation will be reduced by improving internal drainage and capping of the landfill. A cut-off wall is to be constructed along the eastern perimeter of the landfill to reduce groundwater inflow from the Botany Sands aquifer as part of the New M5 project.

The New M5 tunnels and access portals through the former landfill are to be undrained (tanked), preventing the ingress of contaminated groundwater into the tunnel drainage system. The deeper tunnels constructed in the Hawkesbury Sandstone or Ashfield Shale are to be drained, but are unlikely to intersect contaminated groundwater. The risk of contaminated groundwater entering the project tunnels at St Peters from leachate derived from the landfill is low, because leachate will continue to be pumped, collected and treated in a newly constructed water treatment plant as part of the New M5 project, drawing groundwater away from the tunnels. Leachate generation is to be reduced due to the cut-off wall that is to be constructed along the eastern perimeter of the landfill to reduce groundwater inflow and capping the former landfill to reduce rainfall infiltration.

Hydrocarbon contamination identified within the weathered clay and residual shale is attributed to fuel leaks and spills from the nearby service station.

19.2.8 Existing groundwater users

A review of bores registered with DPI-Water and accessed through the BoM (on 9 May 2016) identified 197 boreholes within a two kilometre radius of the project footprint. There may also be other private bores present within the two kilometre radius that have not been registered with DPI-Water. The distribution of registered boreholes extracted from the database is shown in Annexure B of **Appendix T** (Technical working paper: Groundwater). In analysing the data, there are two distinct types of bores: bores with recorded hydrogeological data (66), and bores with only the borehole number and coordinates recorded (131).

Typically, boreholes with only coordinates recorded are monitoring wells constructed as part of contamination investigation programs. In most cases these monitoring wells would no longer be monitored, as the site investigation or remediation programs are completed and the sites have been redeveloped. Analysis of the remaining data indicates that the majority of registered wells are constructed for monitoring purposes, with the minority developed for recreation and domestic water supply (see **Table 19-6**).

Table 19-6 Summary of DPI-Water registered bores within two kilometres of the project footprint

Purpose	Number of bores	Predominant lithology	SWL* min (mbgl)	SWL max (mbgl)	Bore depth min (mbgl)	Bore depth max
Recreation	1	sandstone	11.6	11.6	180	180
Domestic	4	sand	4	31	2.5	210
Monitoring	61	shale/sandstone	0.4	7.7	1.3	48

Note:

* SWL = Standing Water Level
* mbgl = meters below ground level

Review of the lithological data indicates that the majority of boreholes are shallow (less than 10 metres below ground surface) and monitor groundwater in the sand, clay, shallow sandstone or shale. The majority of monitoring wells are clustered at various investigation sites within the study area. A 180 metre deep recreation bore is located at Redfern Park within the Hawkesbury Sandstone, and is used to irrigate Redfern Oval. Four domestic bores are located within the study area, ranging in distance between 210 metres and 1,480 metres from the tunnel corridor. It is not known if these bores are still used for domestic use or have been abandoned. A 210 metre deep bore (GW110247) at the University of Sydney at Camperdown extracts groundwater from the Hawkesbury Sandstone and is registered for domestic use.

Even though groundwater quality is generally good within the Hawkesbury Sandstone, groundwater use across most of the study area is low, as bore yields are typically low and the area has access to reticulated water. At Rozelle Rail Yards, there are few registered monitoring wells, suggesting that there have been limited historical groundwater investigations undertaken at this former industrial site (prior to the investigations undertaken for this assessment), or that monitoring wells have not been registered.

19.2.9 Groundwater dependent ecosystems

A review of the *Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources* (2011) and the *National Atlas of Groundwater Dependent Ecosystems* (viewed 22 August 2016) indicated there are no high priority GDEs within the study area (as identified in **Chapter 18** (Biodiversity)). The nearest high priority wetlands are the Botany Wetlands and Lachlan Swamps within the Botany Sands, located at Centennial Park, around five kilometres east of the easternmost point of the project footprint, and beyond the range of potential impact.

19.3 Assessment of potential construction impacts

Construction works and operational infrastructure have the potential to change groundwater behaviour and impact on the surrounding environment. An assessment of potential impacts has been undertaken in accordance with the guidelines outlined in **Table 19-2**.

Groundwater within parts of the study area has the potential to be impacted during the construction phase of the project. The potential impacts that have been identified are:

- Reduced groundwater recharge
- Tunnel inflow
- Groundwater level decline including potential impacts on:
  - GDEs
  - Surface water and baseflow (the groundwater that discharges to a creek or river)
  - Existing groundwater users
- Changes in groundwater quality
- Groundwater drawdown which may result in ground movement (settlement).

A detailed groundwater balance has been calculated for the construction of the project. This is discussed further in **section 19.3.9** and in **Appendix T** (Technical working paper: Groundwater).

19.3.1 Reduced groundwater recharge

Surface disturbance due to the project construction would include paved construction ancillary facilities, acoustic sheds, cut-and-cover sections leading to the tunnel portals, and approach roads. Construction ancillary facilities would create additional temporary impervious surfaces during construction. The impacts of these surfaces, however, are considered minor and would not significantly reduce groundwater recharge during construction. In many instances construction ancillary facilities would be located on existing impervious surfaces and would therefore not impact local groundwater recharge during construction.

The risks during construction would be that access roads, tracks and the bunded isolation areas for stockpiling of construction materials could alter or reduce groundwater recharge. These impacts are considered minimal, as the affected area is small compared to the overall project footprint, and temporary, as the various structures would be removed at the end of the construction phase.

19.3.2 Tunnel inflow

The short term inflow during construction would be dependent upon a number of factors including tunnelling progress, tunnelling construction methodology (including tunnel lining methods and locations and the success of pre-grouting), fractured zones intersected, localised groundwater gradients and storativity (the volume of water released from storage per unit decline in hydraulic head in the aquifer, per unit area of the aquifer). Pre-grouting is the process of pumping grout into the sandstone or shale in pre-determined areas by drilling and injection to reduce the bulk rock permeability before tunnel advancement.

Initial inflows to tunnels can be large, because of the large hydraulic gradients that initially develop near the tunnel walls; however, these gradients would reduce in time as drawdown impacts extend to greater distances from the tunnels and inflows approach steady state conditions. Higher inflow rates are likely from zones of higher permeability, where saturated geological structural features are intersected by the tunnels. During construction these high inflow zones would be grouted to reduce the inflow rate. Groundwater from the Botany sands aquifer is likely to enter the tunnel indirectly through hydraulic connection with the Hawkesbury Sandstone, however a capture zone analysis undertaken as part of the groundwater modelling confirms the Botany Sands would not be a dominant source of water to the tunnels during construction.

The groundwater modelling has predicted groundwater inflows to the tunnels during construction. Initial groundwater inflows to the tunnels during construction are estimated to range between 0.45 megalitres per day and 2.87 megalitres per day. The maximum inflows are predicted to peak towards the end of construction in 2021 at 2.45 megalitres per day or 0.77 litres per second per kilometre, which remains below the overall WestConnex tunnel inflow criterion of one litre per second per kilometre for any kilometre length of the tunnel.

The predicted water take during construction (year 2023) from each of the Greater Metropolitan Regional resource due to tunnel inflows is compared to the long term average annual extraction limit (LTAAEL) and is summarised in **Table 19-7**. Comparison of predicted tunnel inflows indicates the reduction in the groundwater availability within the Botany Sands during construction will be reduced by 0.004 per cent of the LTAAEL. Similarly the predicted reduction in the groundwater availability during construction will be reduced by 661 megalitres per year (ML/year) or 1.4 per cent of the LTAAEL for the Sydney Basin Central groundwater resource. These predicted water ‘take’ represent a small proportion of the available water within the water sharing plan.

Table 19-7 Groundwater extraction from the Metropolitan Regional Groundwater Resources during construction (Year 2023)

Aquifer	LTAAEL (ML/year)	Water take (ML/year)	Percentage of LTAAEL
Botany Sands	14,684	0.62	0.004
Sydney Basin Central	45,915	661	1.4

Source: NoW, 2011 and HydroSimulations, 2017

During construction, groundwater would be intersected and managed by either capturing the water that enters the tunnels, caverns and portals, or by restricting inflow through temporary dewatering or the installation of cut-off walls (which limit the movement of groundwater) in cut and cover sections. The volume of groundwater and treatment requirements would differ depending on the depth of the tunnel to be constructed, and the geological units through which it passes. It is recognised that high groundwater inflow during excavation is possible in faulted or fractured zones such as beneath the Hawthorne Canal palaeochannel and in the alluvium. Groundwater intersected during the construction of the tunnels would be the primary source of wastewater. The wastewater management system would be designed to treat and discharge groundwater as well as stormwater and other intersected water streams.

During construction, long-term water management solutions, such as the installation of water proofing membranes, would also be installed as required. Groundwater inflows would be collected from the low points of tunnel excavations via a temporary drainage system and would be pumped to the surface for treatment and discharge. Water inflows, treatment and discharge would be managed in accordance with a CSWMP that would form part of the Construction Environmental Management Plan (CEMP) for the project.

Construction options at Wattle Street, Haberfield

The modelling has been undertaken for construction Option A at Haberfield, and therefore the modelling results reflect tunnelling from Wattle Street civil and tunnel site (C1a) and Haberfield civil and tunnel site (C2a). Refer to **Chapter 6** (Construction work) for further information regarding the construction ancillary facility options at this location.

If Option B for the construction configuration at Haberfield occurs where tunnelling would be undertaken from Parramatta Road West civil and tunnel site (C1b), there would likely be a slight increase in inflow volume due to the increased construction access tunnel length required. It is expected that the change to the rate of inflow (in litres per second per kilometre) would be low, as this additional tunnelling would be through good quality Hawkesbury Sandstone and would not intersect alluvium.

19.3.3 Groundwater level decline

Groundwater modelling has been used to predict groundwater levels at the end of the construction period (2023) within the alluvium, Ashfield Shale and Hawkesbury Sandstone. The degree of drawdown is dependent on a number of factors including the geology intersected, the hydrogeology and the tunnel configuration and depths. Within the alluvium, the groundwater levels are predicted to form a steep elongated cone of depression along the tunnel alignment due to downward leakage to the underlying Hawkesbury Sandstone. However, the depressed groundwater contours are localised, extending no further than about 500 metres from the tunnels, indicating localised changes to groundwater flow patterns with negligible impacts on the regional groundwater flow.

At the end of construction, steep localised cones of depression are predicted to develop beneath Newtown and St Peters within the Ashfield Shale. Local groundwater sinks are created at these locations due to the low hydraulic conductivity of the shale and the influence of the leachate pumping at the former Alexandria Landfill. In this case the groundwater level decline is due to leachate pumping from the landfill and not the project.

At the end of construction, the maximum drawdown is predicted to be 42 metres centred on the Rozelle interchange. Drawdown within the alluvium is predicted to be up to 10 metres but in some areas it would be limited by the thickness of the alluvium. The groundwater levels within the

Hawkesbury Sandstone are predicted to be depressed along the tunnels at the end of the construction period. While the impacts are localised, with two metres or more drawdown extending no further than around 600 metres from the tunnels, the groundwater sink predicted to develop would create a hydraulic barrier along the length of the tunnel alignment, reversing groundwater gradients. Below the base of the tunnel, groundwater flow would cease being drawn upwards into the tunnel and natural groundwater flow within the sandstone would continue uninterrupted below the tunnels.

The predicted groundwater elevations at the end of the construction phase (2023) for the project are presented **Figure 19-6**. The predicted groundwater elevations presented in **Figure 19-6** include the total drawdown for the alluvium, Ashfield Shale and Hawkesbury Sandstone.

Groundwater drawdown

Groundwater drawdown due to construction activities and temporary dewatering would impact the local water table, potentiometric pressures in the deeper Ashfield Shale and the Hawkesbury Sandstone, or surface water features where there is hydraulic connectivity. As the majority of the tunnel lengths are drained structures (ie not tanked), the tunnel inflows could impact the natural groundwater system and potentially alter regional hydrogeological conditions.

During construction, the regional extent of drawdown impacts due to tunnel construction would be minimal, even though groundwater inflows are high. This is due to the generally low hydraulic conductivity of the Ashfield Shale and the Hawkesbury Sandstone restricting the extent of drawdown during the relatively short construction timeframe.

As construction continues, drawdown would decrease as the cone of depression expands progressively outwards over time. As the depressurisation caused by the tunnel inflows propagates to the surface, causing the water table to decline, inflows would extend outwards to progressively greater distances until steady state conditions are reached, which is expected to be well after the completion of construction.

Groundwater levels would be monitored throughout the construction phase in accordance with a CSWMP. Additional groundwater modelling is proposed to be conducted by the contractors during construction using measured tunnel inflow rates and monitored groundwater drawdown to better calibrate the model and predict impacts.

The project does not propose to extract groundwater during the construction or operational phases for project purposes. Re-use of treated groundwater would be considered in accordance with the DPI-Water re-use policy, the National Water Quality Management Strategy (DPI-Water 2006).

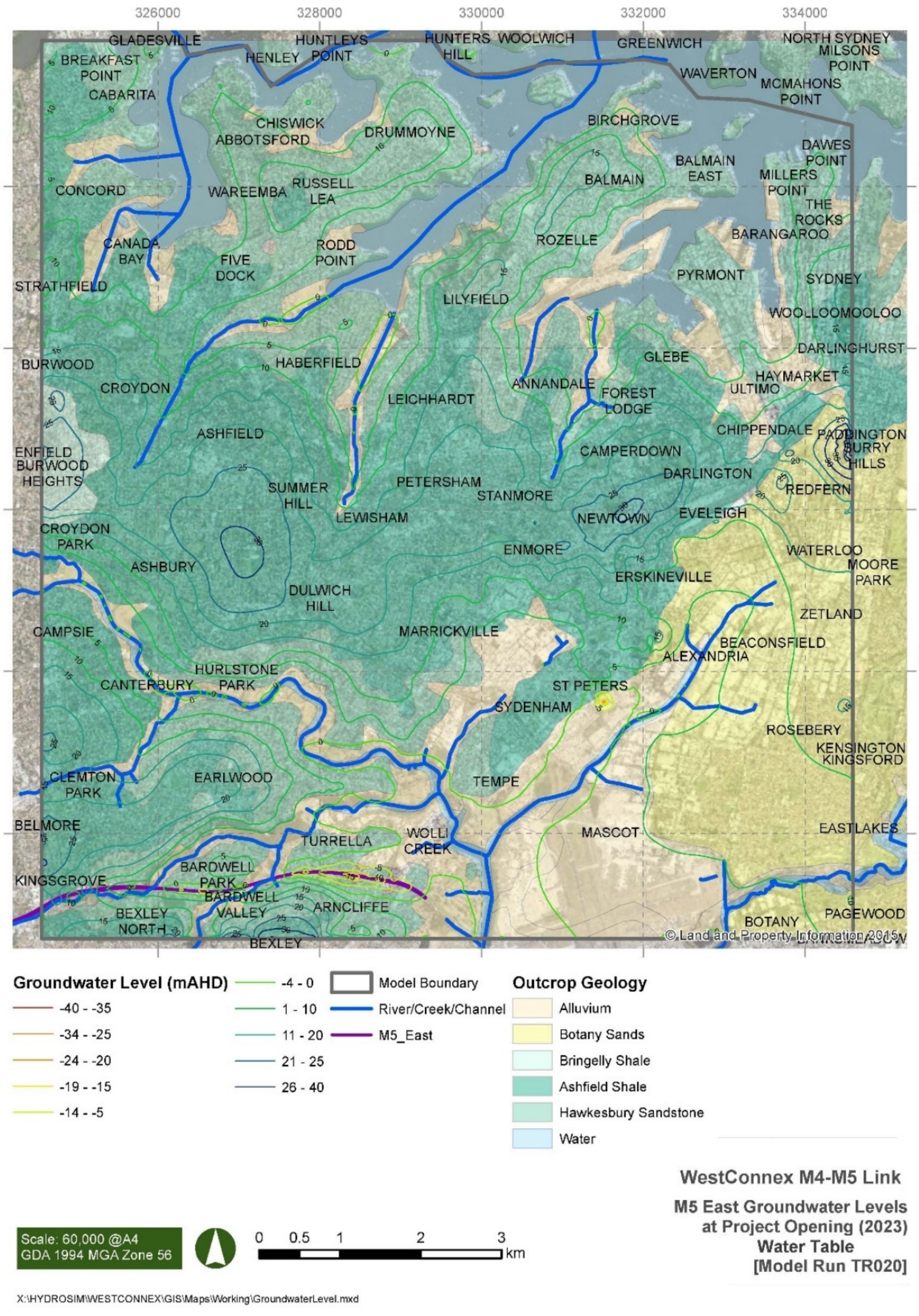


Figure 19-6 Water table elevations for the project at the end of construction (2023)

Potential impacts on groundwater dependent ecosystems

In accordance with the *NSW Aquifer Interference Policy*, groundwater drawdown must be within an allowable range of ten percent of baseline levels within 40 metres of a significant GDE. No priority GDEs have been identified within the project footprint. The closest priority GDEs are the Botany Wetlands and Lachlan Swamps within the Botany Sands, located at Centennial Park, around five kilometres east of the project footprint. These wetlands are at a sufficient distance from the project footprint not to be impacted by the project. Potential impacts on these wetlands and GDEs due to the New M5 project were assessed in the New M5 EIS.

There is a manmade wetland constructed at Whites Creek Valley Park at Annandale, immediately west of Whites Creek. This wetland is unlikely to have any groundwater dependence as it continually receives low flows from Whites Creek. Groundwater levels within the Whites Creek alluvium are unlikely to be adversely impacted during construction because the tunnels are below the alluvium. Groundwater levels are predicted to be drawn down in the Hawkesbury Sandstone but are unlikely to have any groundwater dependence in this area.

Potential impacts on surface water and baseflow

Surface water features within the study area are described in **section 19.2.2**. Groundwater inflows to the tunnels that would have the potential to impact surface water levels are unlikely for the section of the tunnels that would be constructed through the Whites Creek alluvium beneath the Rozelle Rail Yards. This is because these sections of the tunnels would be undrained (tanked) and the majority of the creeks and canals are concrete lined. Consequently, the risk of surface water from creeks or canals seeping into the tunnels via leakage to the alluvium is considered low. There may be some seepage from the canals through cracks in the aged concrete.

The Sydney Water proposals to naturalise sections of Whites Creek, Johnstons Creek and Dobroyd Canal (Iron Cove Creek) are likely to increase groundwater recharge and may partially increase the baseflow to these creeks through the removal of sections of concrete-lined bases which would allow more groundwater and surface water interaction leading to a higher contribution of baseflow to surface water flow.

Surface water can only flow to the groundwater system when the groundwater levels are lower than the surface water levels, or when the alluvial water table falls below the surface water level in the creeks. In the lower catchment reaches, if brackish water from Whites Creek or Johnstons Creek replaces groundwater lost from the alluvium, the groundwater quality may become degraded. Under conditions where groundwater levels are higher than surface water levels and creeks are not concrete lined, groundwater would naturally discharge into Whites Creek or Johnstons Creek.

Where the channels are concrete lined, groundwater would be expected to flow within the alluvium surrounding the channel, discharging downstream directly into Rozelle Bay or Parramatta River. However, if groundwater levels are lowered due to tunnel inflows, then the direction of groundwater flow could be altered or reversed. Therefore, there is potential for groundwater quality to decline as a result of the groundwater drawdown of the brackish water. The natural groundwater is already known to be brackish in the lower lying reaches of the catchment where there is natural tidal interaction. Higher in the catchments, any groundwater loss from the creeks to groundwater via leakage should not degrade groundwater quality, as the surface water would be of lower salinity.

Predicted impacts of construction on baseflow for major watercourses have been modelled (refer to **Appendix T** (Technical working paper: Groundwater)). Baseflow is simulated in the model only when groundwater reaches the ground surface and enters the drainage system. It is expected that the majority of river flow would be derived from stormwater runoff rather than baseflow.

Predicted changes in baseflow at the end of construction are summarised in **Table 19-8**.

Table 19-8 Predicted changes to baseflow at the end of construction

Mid 2023	Hawthorne Canal	Dobroyd Canal (Iron Cove Creek)	Whites Creek	Johnstons Creek
Base case (m^3/day)	298	281	177	289
Reduction in baseflow (m^3/day)	96	14	132	59
Percentage reduction (%)	32	5	75	20

During construction, the baseflow to major watercourses is reduced by between five and 75 per cent. These predicted baseflow reductions are not considered likely to impact the local environment, as the majority of baseflow is anticipated to be derived from surface water runoff. Consequently, groundwater is unlikely to sustain ecosystems before discharging into Rozelle Bay or the Parramatta River.

At Whites Creek, there may be some leakage through the aged cracked concrete that could contribute to baseflow, however this leakage would be minor. Although the baseflow component of streamflow in Whites Creek would be substantially reduced, it is expected that the overall contribution to river flow from groundwater input is relatively small due to Whites Creek being lined and tidally influenced and the catchment being heavily urbanised. There is no predicted impact due to project construction activities on other major watercourses near the New M5 project, including Cooks River, Wolli Creek and Bardwell Creek.

Potential impacts on existing groundwater users

A review of current groundwater use has been conducted to identify registered groundwater users within two kilometres of the project footprint (see **section 19.2.8**).

The groundwater model has been used to assess the potential groundwater level drawdown at sensitive areas and for registered groundwater users. Where the impacts are expected to exceed minimal impact considerations as specified in the *NSW Aquifer Interference Policy* (NoW 2012), mitigation measures have been recommended (see **section 19.5**). Potential impacts on existing users during construction include drawdown in registered bores due to the drawdown of groundwater during tunnelling. The groundwater model predicted that no registered bore within two kilometres of the project footprint would be drawn down more than two metres (the minimum impact criterion under the *NSW Aquifer Interference Policy*) during the project construction program.

In the event that groundwater users experience a decline in groundwater levels in existing bores in excess of two metres as a result of the project, provisions would be implemented to ‘make good’ the supply by restoring the water supply to pre-development levels. The measures taken would be dependent upon the location of the impacted bore, but could include deepening the bore, providing a new bore, providing an alternative water supply, or alternatively providing appropriate monetary compensation.

19.3.4 Groundwater quality

Groundwater quality risks from construction activities include potential groundwater contamination from fuel, oil or other chemical spills and from the captured groundwater intersected during tunnelling. There is also potential to intersect acid sulfate soils and contaminated groundwater associated with previous industrial land use. Contaminants within soils at the Rozelle Rail Yards could be mobilised by altered groundwater flow paths. As groundwater drawdown increases due to tunnel inflows, there is the potential for tidal waters to be drawn towards the tunnels, causing saltwater intrusion. Groundwater quality from monitoring wells and groundwater collected during tunnelling would be monitored throughout the construction phase in accordance with a CSWMP. These potential risks to groundwater quality are discussed further in the following sections.

Spills and incidents

There is potential to contaminate groundwater through incidents within the construction ancillary facilities associated with the storage of hazardous materials or refuelling operations. Groundwater could become contaminated via fuel and chemical spills, petrol, diesel, hydraulic fluids and lubricants, particularly if a leak or incident occurs over the alluvium, a palaeochannel or fractured sandstone. Stockpiling of construction materials may also introduce contaminants to the project footprint that could potentially leach into and contaminate local groundwater.

The risks to groundwater as a result of such incidents would be managed through standard construction management procedures in accordance with site specific environmental management plans developed for the project as outlined in **Chapter 16** (Contamination) and **Chapter 25** (Hazard and risk). Runoff from high rainfall events during construction would be managed in accordance with the measures outlined in **Chapter 15** (Soil and water quality). Following high rainfall events, groundwater quality impacts would be minor, as the majority of runoff would discharge to receiving waters.

Intercepting contaminated groundwater

A number of sites with the potential for groundwater contamination due to various current and historical land uses are located along the project footprint, as outlined in **section 19.2.7**. A potential contamination risk would be associated with the migration of contaminated groundwater plumes towards the tunnels.

The majority of the tunnels would be constructed within the Hawkesbury Sandstone at depths greater than 20 metres (at the western and eastern ends) and up to 50 metres beneath Newtown and parts of Leichhardt. In general, the risk of intersecting contaminated groundwater decreases the deeper the tunnel depth.

There is potential to intersect contaminated groundwater during construction while excavating the portals and dive structures that are constructed from the top down, although groundwater would typically be isolated from these structures by excavation support options such as diaphragm walls, sheet piled walls or secant piled walls.

Contaminant groundwater investigations have been conducted in the investigation phases of the EIS and have identified some areas where contaminated groundwater may occur, such as the Alexandria Landfill at St Peters, the Rozelle Rail Yards at Rozelle and former industrial sites in areas such as Alexandria and Haberfield. Contaminated groundwater, if intersected, would enter the tunnels and would be treated prior to discharge at one of the water treatment plants.

The primary risk to groundwater quality is the migration of contaminated groundwater along altered groundwater flow paths due to the tunnel construction. At the Rozelle Rail Yards, groundwater beneath the site within the alluvium is shallow and impacted by historical industrial land uses. Potential contaminants of concern include heavy metals (arsenic, cadmium, copper, lead, nickel and zinc) and hydrocarbons. Tunnel sections through the alluvium would be constructed as undrained (tanked), and cut-off walls would be installed to reduce the ingress of groundwater from the palaeochannels, minimising potential contaminated groundwater migration and addressing the requirements of DPI-Water. However, shallow groundwater is likely to be encountered and would require management during ground excavation works associated with the construction of the tunnel access decline.

Potential contaminated groundwater inflows could be derived from industrial sites that overlie the tunnels at Alexandria and St Peters, where the tunnels are relatively shallow (about 20 metres below ground surface) but constructed within the Ashfield Shale. This area historically contained potentially contaminating operations such as petrol stations, several vehicle service centres, dry cleaners, car manufacturing and mechanical workshops. The risk of intersecting shallow contaminated groundwater is considered low, because the tunnels would be constructed within the Ashfield Shale, where the hydraulic conductivity and groundwater leakage would be low.

At Hawthorne Canal and around Leichhardt North, the fill from unknown sources flanking Iron Cove deposited during historical land reclamation works is potentially contaminated and may have impacted local groundwater. Similarly, there are other potential soil contamination sources, such as the storage and use of chemicals, pesticides, fuels and oils and hazardous building materials in the former Public Works Depot at Blackmore Park, which may have impacted shallow groundwater quality within the alluvium and palaeochannels. The risk of intersecting shallow contaminated groundwater is considered low, because the tunnels are to be constructed below the potentially contaminated fill and alluvium within the Hawkesbury Sandstone.

Groundwater and surface water captured as a result of tunnelling are likely to be contaminated with suspended solids and increased pH due to tunnel grouting activities. These flows would be captured and treated prior to discharge via water treatment plants located at construction ancillary facilities. Where possible, the treated water would be reused during construction for purposes such as dust suppression, wheel washing and plant washing, rock bolting, earthworks or irrigation before discharge. Groundwater reuse would be undertaken in accordance with the policies of sustainable water use of DPI-Water. The volume of recycled water required for beneficial use would be variable and dependent on site conditions. The estimated total volume of water required during construction is estimated to be around 900 megalitres (refer to **Appendix Q** (Technical working paper: Surface water and flooding)). It is expected that there would be a water surplus during construction and recycled water for operational purposes would be used in preference to potable water.

At St Peters interchange there is known groundwater contamination, including elevated ammonia, associated with the former Alexandria Landfill. Geotechnical drilling as part of the project did not identify localised faulting or fracturing, which could provide leachate conduits to the tunnels. Although the tunnel depths are shallow near the portals, the risk of landfill contaminated groundwater being intersected by the tunnels is considered low as a cut-off wall is to be constructed along the eastern perimeter of the landfill to reduce groundwater inflow and continual leachate pumping from the former landfill will maintain internally directed groundwater gradients and pumped groundwater will be treated by the landfill water treatment plant.

Large portions of the Botany Sands are contaminated from a variety of sources, primarily related to previous industrial land use. Groundwater from the Botany Sands aquifer is likely to enter the tunnel indirectly through hydraulic connection with the Hawkesbury Sandstone. However, a capture zone analysis undertaken as part of the groundwater modelling confirms the Botany Sands would not be a primary source of groundwater to the tunnels during construction.

Given the tunnel depth, location of the tunnel in relation to the contaminant sources, and low inflow rates predicted, the risk of intercepting contaminated groundwater is considered to be low. All groundwater captured during construction would be directed to water treatment plants at the following construction ancillary facilities and treated to meet relevant discharge criteria prior to discharge:

- Haberfield civil and tunnel site (C2a)
- Parramatta Road West civil and tunnel site (C1b)
- Darley Road civil and tunnel site (C4)
- Rozelle civil and tunnel site (C5)
- Iron Cove Link civil site (C8)
- Pyrmont Bridge Road tunnel site (C9)
- Campbell Road civil and tunnel site (C10).

Groundwater treatment

The volume and treatment requirements for groundwater would vary for different geological units and tunnel depths. Groundwater and surface water captured as a result of tunnelling are likely to be contaminated with suspended solids and increased pH due to tunnel grouting activities. During construction, the wastewater generated in the tunnel (including collected groundwater) would be captured, tested and treated at a construction water treatment plant (if required) prior to reuse or discharge, or disposal offsite if required.

Based on the knowledge gained from the previous WestConnex projects (M4 East and New M5) it is likely that the water treatment plants would be required to include pH correction as well as the ability to remove iron, manganese, suspended solids and hydrocarbons. The existing groundwater quality within the study area (refer to **section 19.2.6**) indicates that groundwater in the study area may also be impacted by elevated levels of ammonia, total nitrogen and total phosphorus compared to ANZECC (2000) guideline levels (marine, freshwater and recreational protection levels). Other metals including copper, chromium, lead, nickel and zinc have been recorded at elevated levels on a limited number of occasions. The type, arrangement and performance of construction water treatment facilities would be developed and finalised during detailed design.

The receiving waterways and ambient water quality are all highly disturbed compared to the water discharge quality. The level of groundwater treatment would consider the characteristics of the discharge and receiving waterbody, any operational constraints or practicalities and associated environmental impacts and be developed in accordance with ANZECC (2000) and with consideration of the relevant NSW Water Quality Objectives. Ultimately the water quality objectives would be set by the catchment manager of the receiving waters in consultation with the NSW EPA.

The assessment of the potential impacts of the quality of water discharged from the water treatment plants during construction is discussed in **Chapter 15** (Soil and water quality).

Acid sulfate soils

PASS have been identified within natural alluvium beneath the Rozelle Rail Yards and possibly within the alluvium along Hawthorne Canal. When exposed to air (through actions such as excavation or dewatering), the iron sulphides (commonly pyrite) within acid sulfate soils can oxidise, producing sulphuric acid.

Acid sulfate soils could be disturbed by the project and may cause the generation of acidic runoff and/or the increased acidity of groundwater. At Rozelle Rail Yards, the excavation of low-lying natural soil for tunnel infrastructure may uncover PASS, which will require treatment and removal under the CEMP. The risks associated with PASS would be managed under an ASSMP as discussed in **Chapter 15** (Soil and water quality).

Soil salinity

Salts naturally present in soil and rock are mobilised in the subsurface by the movement of groundwater. The concentration of salts within the soil is related to the geological unit from which the soil is derived.

Within the study area, the Ashfield Shale typically has a high salt content due to the presence of marine salts. Salt concentrations within soils derived from the Hawkesbury Sandstone and alluvium are variable, and within the alluvium are impacted by tidal influences. Under shallow groundwater conditions, saline groundwater may be drawn to the ground surface by capillary action or altered recharge/discharge conditions, precipitating the salts as the water evaporates.

'Urban salinity' becomes a problem when the natural hydrogeological balance is disturbed by human interaction through the removal of deep rooted trees (causing groundwater levels to rise and potentially dissolve and mobilise salts from the soil profile) or construction of structures that intersect the water table. Since the majority of deep rooted trees were removed from the project footprint over 150 years ago a new equilibrium has been established and the removal of any further remaining trees on the new equilibrium would not be substantial. The development of urban salinity may cause corrosion of building materials, degrade surface water quality or prevent the growth of all but highly salt-tolerant vegetation.

During construction of the project, there is potential for salts within the alluvium to be mobilised by local dewatering or associated with the tunnel construction program. Tunnels constructed within the alluvium are to be tanked, and consequently could alter local flow paths, creating groundwater mounding and causing the dissolution of soil salts. Beneath the Rozelle Rail Yards, where the undrained (tanked) tunnels are to be constructed in the Whites Creek alluvium, saline groundwater reaching the ground surface would be directed towards the modified drainage system, thereby removing the mobilised salts from the system. It is unlikely the salts within the Ashfield Shale would become mobilised, as the drained tunnels are expected to draw down the water table, preventing the groundwater reaching the ground surface. The impact of the project on groundwater resources or hydrology, based on the mobilisation of saline soils, is therefore likely to be negligible.

Saltwater intrusion

During construction there are unlikely to be any impacts associated with saline groundwater entering the tunnels. Saltwater intrusion would commence as soon as the hydraulic pressure within the aquifer declines due to groundwater drawdown via the tunnels causing the displacement of fresher water along the shoreline with more saline tidal water. During construction, saline groundwater inflow to the tunnels from tidal areas would be negligible because of the considerable distance of the tidal surface waterbodies are from the tunnels and the slow calculated groundwater travel times. Close to the shoreline, groundwater quality would become slightly more saline during the construction period due to saltwater intrusion. However, the low salinity increase would be unlikely to impact the environment since the groundwater along the tidal fringe is naturally saline due to tidal mixing. In addition, there are no registered water supply wells or priority groundwater dependent ecosystems along this tidal fringe.

19.3.5 Groundwater monitoring

Groundwater monitoring would be carried out during construction for monitoring wells and groundwater collected during tunnelling. The monitoring program would be designed to monitor:

- Groundwater levels (manual monitoring and automatic monitoring by data loggers)
- Groundwater quality (within key boreholes and tunnel inflows)
- Groundwater inflows to the tunnels.

The monitoring program would identify groundwater monitoring locations, performance criteria in relation to groundwater levels, quality and inflows and potential remedial actions that would be considered to address any non-compliances with performance criteria.

Groundwater levels and quality would be monitored in the alluvium, Hawkesbury Sandstone and Ashfield Shale. The monitoring wells in the monitoring program used to inform this assessment would be used as required for monitoring. It may be necessary to construct additional monitoring wells if some of the existing wells are damaged during construction or other key areas are identified during the detailed design phase where monitoring is required.

It is expected that manual groundwater level monitoring and groundwater quality monitoring would be undertaken monthly. The quality and volume of tunnel inflows are expected to be monitored weekly.

The following analytes are likely to be sampled:

- Field Parameters (pH, electrical conductivity, dissolved oxygen, temperature and redox conditions)
- Metals (arsenic, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel and zinc)
- Nutrients (nutrients (nitrate, nitrite, Total Kjeldahl Nitrogen (TKN), ammonia and reactive phosphorous)
- Major cations (sodium, potassium, calcium, magnesium) and anions (chloride, sulphate, carbonate, bi-carbonate).

The analytes to be sampled and the frequency and type of reporting would be confirmed by the construction contractors. The groundwater monitoring program would be developed in consultation with the NSW EPA, DPI-Fisheries, DPI-Water and the Inner West and City of Sydney councils and documented in the CSWMP to satisfy the project conditions of approval.

19.3.6 Ancillary infrastructure

Ancillary infrastructure to be constructed to support the project includes the following:

- Operational facilities for electronic tolling and traffic control
- Fire safety systems and emergency access and evacuation
- Utilities including power supply and water supply
- Buildings such as water treatment facilities and electrical substations
- Ventilation tunnels and systems
- Tunnel portals
- Construction ancillary facilities

- Five motorway operation complexes. The type of facilities constructed at each of these complexes would include substations, water treatment facilities, ventilation facilities, offices, on-site storage and parking for employees.

The majority of these features are above ground and would not impact the hydrogeological regime. Activities that may impact groundwater during construction include:

- Tunnel portals
- Ventilation tunnels and systems
- Water treatment facilities
- Construction ancillary facilities
- Drainage channels and wetland areas.

During the construction of below ground tunnel ancillary infrastructure such as ventilation shafts or tunnel portals, sheet piling may be installed to assist temporary dewatering. Groundwater levels would be restored after the barriers are removed.

19.3.7 Utility works

The project would involve utility works that would include the protection of existing utilities, construction of new utilities and relocation of existing utilities. The majority of the utility works would occur in new utility service corridors at the Iron Cove Link, parallel to Victoria Road and within and surrounding the Rozelle Rail Yards. The utilities to be impacted include:

- Sewer mains
- Water mains
- Electricity cables
- Telecommunications including fibre optic cables
- Gas mains
- Sydney trains electrical infrastructure.

These works would involve excavating trenches to varying depths and may intersect the water table. At the Iron Cove Link impact on groundwater is expected to be minimal as the groundwater level is typically below the estimated depth of utility trenches. In contrast, at the Rozelle Rail Yards the water table is shallow and within one metre of the ground surface indicating that utility trenches are likely to intersect the groundwater. During trench excavations sheet piling may be required to temporarily provide support in the alluvium and to restrict groundwater inflows to the trench. Once the sheet piling is removed, groundwater levels would return to pre-excavation levels. The trenches may be encased in concrete or plastic pipes to water proof the utility service corridors. Deeper trenches or excavations may require temporary dewatering during the construction phase.

Where feasible, the new utility corridors are designed to contain multiple utilities to minimise the construction footprint. These works would be undertaken in accordance with the Utilities Management Strategy and the CSWMP.

19.3.8 Ground movement (settlement)

Ground movement (settlement) or subsidence can be caused by volume loss due tunnel excavation or due to the compression of the soil structure due to groundwater drawdown. This discussion relates to groundwater movement due to groundwater drawdown.

When groundwater levels are drawn down, the unconsolidated sediments hosting the groundwater are subjected to an increase in effective stress (the force that keeps soil particles together), and the sediment may experience settlement. If the degree of settlement is sufficient, it can result in damage to structures within the groundwater drawdown zone of influence. Settlement associated with construction tunnelling occurs within a shorter timeframe compared to settlement associated with groundwater drawdown, which occurs over a longer timeframe.

Within the M4-M5 Link project footprint, residual soil profiles developed on the weathered sandstone and shale bedrock are typically relatively thin, stiff and of low compressibility and as such would be less susceptible to ground settlement. Settlement within the alluvium would be dependent on the amount of groundwater drawdown and would be expected to be greater than that within the Hawkesbury Sandstone and Ashfield Shale, due to the competent nature and geotechnical properties these bedrock units. Monitoring of settlement throughout the construction program would be included as part of the CEMP.

Since ground settlement due to groundwater drawdown would be more likely to occur within the alluvium, the tunnels would be constructed in accordance with design measures to minimise settlement within the alluvium. Design measures include constructing tanked tunnels through the alluvium to minimise groundwater drawdown. Below Hawthorne Canal and Johnstons Creek, the tunnels have been designed to dive beneath the alluvium to reduce groundwater ingress, which would reduce potential settlement. During tunnel construction, the bulk hydraulic conductivity of the Hawkesbury Sandstone would be decreased by grouting off the tunnel faces, decreasing groundwater inflow and thereby reducing potential settlement.

Small scale dewatering of the alluvium and Hawkesbury Sandstone may be required during construction. This could result in an increase in effective stress, leading to ground settlement. Movement in clay soils between hydrogeological units would cause both consolidation settlement and creep settlement, which may result in settlement continuing over a long period of time.

Although the groundwater model has predicted groundwater drawdown within the alluvium and Botany Sands, it is not considered appropriate to use these regional results to calculate localised ground settlement. The model is a regional groundwater model and is not considered appropriate for use in estimating groundwater induced settlement at a more localised level. A preliminary assessment based on geotechnical conditions has been carried out to assess the potential for ground movement as a result of the project and the results of this assessment are provided in **Chapter 12** (Land use and property).

A geotechnical model of representative geological and groundwater conditions would be prepared by the construction contractor prior to excavation and tunnelling for the project. The model would be used to assess predicted settlement impacts and ground movement caused by excavation and tunnelling on adjacent property and infrastructure. Management measures to control groundwater inflows (which influence groundwater drawdown and therefore ground movement) during construction are outlined in **section 19.5**.

Pre-construction condition surveys of potentially impacted property and infrastructure would be undertaken before the commencement of construction activities that would pose a settlement risk, to determine appropriate settlement criteria to prevent damage. In the event that the geotechnical model identifies potential exceedances of settlement criteria, management measures such as appropriate support and stabilisation structures would be implemented to minimise settlement impacts on property and infrastructure.

A settlement monitoring program would be carried out during construction (in accordance with a Settlement Monitoring Plan) and would include a quantitative assessment to develop settlement criteria for tunnel excavation works. In the event that settlement criteria are exceeded during construction for property and infrastructure, measures would be taken to ‘make good’ or to manage the impact.

Further details regarding settlement are provided in **Chapter 12** (Land use and property).

19.3.9 Groundwater balance

The groundwater model was used to quantify potential impacts for the project. The simulated groundwater balance computed for the end of the construction phase (2023) is summarised in **Table 19-9** and is based on the detailed water balance presented in **Appendix T** (Technical working paper: Groundwater).

Table 19-9 Simulated water balance – construction (2023)

Water balance component	Inputs (recharge) (ML/day)	Output (discharge) (ML/day)
Rainfall infiltration	9.52	0.00
Evapotranspiration	0.00	1.53
River inflow/outflow	1.60	12.44
Project tunnels	0.00	2.87
Pumping wells	0.00	0.05
Regional boundary flow	24.95	21.40
Tidal seepage	1.43	0.88
Storage	3.26	1.59
TOTAL	**40.76**	**40.76**

Additional detail on the water balance is provided in **Appendix T** (Technical working paper: Groundwater), including a hydrogeological conceptual model which provides further detail on the components of the water balance.

The water balance confirms that the major water inflows during the construction phase would be derived from regional boundary flow and rainfall infiltration. Conversely, major outflows are regional boundary flow and river outflow. The total inputs and outputs indicate that the water components are balanced.

At the completion of construction in 2023 there would be a net loss in storage of 1.67 megalitres per day (3.26 megalitres per day storage input and 1.59 megalitres per day storage discharge), indicating that water is being drained from the system. In the context of the Sydney Basin, 1.67 megalitres per day is negligible (less than 0.3 per cent of the annual recharge rate of 229,223 megalitres per year for the Sydney Basin Central) (NoW 2011).

19.4 Assessment of potential operation impacts

Groundwater within the study area has the potential to be impacted during the operational phase of the project. The potential impacts that have been identified are:

- Reduced groundwater recharge
- Tunnel inflow
- Groundwater level decline including impacts on:
  - Long term groundwater inflow
  - Groundwater drawdown
  - GDEs
  - Existing groundwater users
  - Baseflow
  - Ground settlement
- Groundwater quality
- Barriers to groundwater flows from operational infrastructure.

A detailed water balance has been calculated to predict the long-term impacts from operation of the project.

19.4.1 Reduced groundwater recharge

The Rozelle Rail Yards are underlain by alluvium, where groundwater recharge would be expected to be higher than in areas underlain by sandstone and shale. The Rozelle Rail Yards currently behave as a flood storage area where much of the floodwaters would recharge the alluvium. Post construction of the project, the area would be drained by flood channels to minimise flooding, which may result in a reduction of natural groundwater recharge. Parts of the Rozelle Rail Yards not used for road infrastructure would be converted to new open space. These areas would continue to receive rainfall recharge.

Following the completion of construction, construction ancillary facility sites would be rehabilitated. In the event that sites previously used for construction ancillary facilities are used for open space or project landscaping, rainfall recharge in these areas would increase; however, recharge quantities would be minor. The majority of the project is below ground and is unlikely to directly impact groundwater recharge (see **section 19.4.6**). Above ground, the surface area of the road network would slightly increase with additions in some key areas such as City West Link, Victoria Road, Anzac Bridge and The Crescent.

Given the limited increase in surface area of the surface road infrastructure including operational infrastructure such as the motorway operations complexes, ventilation infrastructure, substations and water treatment plants, the reduction in rainfall recharge across the project footprint is considered negligible.

19.4.2 Tunnel inflow

Inflow to the drained tunnel is influenced by the construction methods selected, as well as the geology and hydrogeological features of the intersected lithologies such as hydraulic conductivity, storativity and hydraulic connectivity.

The project tunnels are to be constructed predominantly through the Hawkesbury Sandstone and, to a lesser extent, through the Mittagong Formation and Ashfield Shale. To minimise groundwater inflow, the tunnels are designed to avoid the palaeochannels present by diving beneath Hawthorne Canal and tanking (ie lining to prevent groundwater ingress) sections of the tunnel through the Whites Creek alluvium beneath the Rozelle Rail Yards.

Conservative estimates of tunnel inflows can be made by assuming a maximum groundwater inflow rate of one litre per second per kilometre along the whole drained tunnel length during operation of the project, although inflow rates in some sections of the tunnels would be less than the maximum allowed rate. The total combined length of the mainline tunnels, Iron Cove Link and Rozelle interchange tunnels is around 47,940 metres. The total tunnel length of drained tunnel is 44,950 metres.

Assuming a worst case scenario of a uniform groundwater inflow rate of one litre per second per kilometre for any kilometre length of the tunnel along the whole drained tunnel length, a groundwater inflow of around 44.95 litres per second (3.9 megalitres per day) would be expected, although (as explained above) this is an overestimate.

At the Rozelle interchange, groundwater inflows in each tunnel would be further restricted due to the number of tunnels close to each other and the associated interference of available groundwater flowing into these multiple tunnels.

The regional impact on the Sydney Basin Central of long-term groundwater tunnel inflows (or ‘take’) as a result of the project is estimated to vary from 1.74 megalitres per day (635 megalites per year) in 2023 reducing to 0.99 megalitres per day (361 megalitres per year) in 2100. The total regional recharge across the Sydney Basin is 229,223 megalitres per year. Consequently, the groundwater ‘take’ due to long-term groundwater inflow to the tunnels represents 0.27 per cent of the annual recharge across the Sydney Basin in 2023 and 0.15 per cent in 2100.

Groundwater inflow from the Hawkesbury Sandstone is expected to be low due to low bulk hydraulic conductivity values (typically 0.008 metres per day). The Ashfield Shale overlying the Hawkesbury Sandstone typically has an even lower hydraulic conductivity, in the order of 0.001 metres per day (Hewitt 2005), indicating groundwater inflow is expected to be lower in the Ashfield Shale compared to the Hawkesbury Sandstone. The tunnels do not pass through the Botany Sands or Zone 2 of the

Botany Sands Source Management Zone, so there would be no direct inflow of groundwater from the Botany Sands into the drained tunnels.

Alluvium associated with the creeks, canals and edge of the Sydney Harbour and Parramatta River in the study area is partly saturated. Since the alluvium is hydraulically connected to surface waterbodies, water can potentially flow from Rozelle Bay or the Parramatta River via the alluvium and fractured sandstone or shale into the project footprint. Although the majority of the creeks and canals are concrete lined, there remains good hydraulic connection with the groundwater within the alluvium outside the main channels. There is no direct inflow to the tunnels from the alluvium since the tunnels are designed as undrained (tanked) where the alluvium is intersected.

The overall impact of tunnel inflow on groundwater is considered to be minor.

19.4.3 Groundwater level decline

Long-term groundwater inflow

Previous tunnelling in the Hawkesbury Sandstone in the Sydney region has shown that groundwater inflow is typically highest during construction and then is reduced as the cone of drawdown expands and equilibrium or a steady state condition is reached. This equilibrium is achieved when the tunnel inflow is matched by rainfall recharge via infiltration and/or surface water inflows. Long-term groundwater inflows to the tunnels are influenced by the geology intersected and the tunnel construction methods used to reduce the bulk hydraulic conductivity. Long-term groundwater inflow rates are expected to be lower than construction inflow rates for the project.

The reduction in long-term inflow rates is due to the ‘cone’ of drawdown depression expanding laterally at a rate that is proportional to the log of time. As the cone of depression expands further, the hydraulic gradients towards the tunnels reduce. Drawdown is derived from storage depletion but would be partly offset by recharge, both in the short term and long term.

Based on historical groundwater inflows to other drained Sydney tunnels (**section 19.2.5**), the long-term inflow rate into the project tunnels is expected to be below the one litre per second per kilometre design criterion for any kilometre tunnel length. Specific zones capable of higher rates of inflow identified during construction would be treated to reduce inflow rates to meet this criterion.

Groundwater modelling has calculated inflows for the construction and operations phases of the project. At project opening (2023), tunnel inflows are estimated to be 441 megalitres per year, declining to 267 megalitres per year at the end of the model simulation in 2100. As observed in other Sydney tunnels, the inflow rate is likely to decrease with time.

Groundwater drawdown

Construction of drained tunnels beneath the water table is expected to cause long-term, ongoing groundwater inflow to the tunnels, inducing groundwater drawdown along the tunnel alignment. Actual groundwater drawdown of the water table would be dependent on a number of factors, including proximity to the tunnel alignment and the specific geological conditions present. Immediately after tunnelling is completed, groundwater inflows would be at their highest, but with time, groundwater inflow to the tunnel would decrease while the water table decline would continue to gradually expand outwards from the tunnels until equilibrium is reached.

In zones where the inflow rates are likely to exceed one litre per second per kilometre for any kilometre length of tunnel, water bearing fractures/rock defects would be pre-grouted during construction to reduce ongoing groundwater inflow. This grouting would also reduce long-term drawdown impacts. Groundwater movement is restricted in Hawkesbury Sandstone because it is interbedded with shale lenses that discourage groundwater movement. Groundwater drawdown within the palaeochannels and river alluvium within the project footprint would be low because the tunnel sections that intersect the alluvium are to be undrained (tanked). In addition, groundwater levels may be partly maintained by direct hydraulic continuity with surface water.

The predicted drawdown at the various creeks varies depending on local geology, horizontal distance from the tunnel, depth to the tunnel and tunnel design. For some sections, the tunnels have been designed so there would be no direct inflow from the alluvium into the tunnels. This would be achieved by:

- Tanking the tunnels where the alluvium is intersected, such as beneath the Rozelle Rail Yards
- Designing the tunnels to dive beneath the alluvium, such as at Hawthorne Canal
- Constructing cut-off walls where the portals and cut-and-cover sections intersect alluvium, such as at Haberfield.

Drawdown within the alluvium would be variable as it is dependent on a number of factors including leakage to the underlying Hawkesbury Sandstone, rainfall recharge and surface water interaction.

Potential groundwater drawdown due to the project for the long term (2100) has been calculated and is presented in **Figure 19-7**. The drawdown presented in **Figure 19-7** is the total drawdown for the alluvium, Ashfield Shale and Hawkesbury Sandstone.

While the tunnels constructed within the alluvium are proposed to be undrained (tanked), groundwater is predicted to leak from the alluvium into the underlying sandstone, resulting in a decline in the water table within the alluvium. When there is insufficient rainfall recharge or surface water inflow at locations where the alluvium is shallow, the alluvium may be drawn down due to the induced tunnel leakage.

Long-term drawdown (Year 2100) within the Ashfield Shale and Hawkesbury Sandstone extends to the tunnel invert and continues to spread laterally over time. Predicted drawdown in the Hawkesbury Sandstone at Rozelle is a maximum depth of 55 metres, extending laterally 1.4 kilometres either side of the tunnel to the two-metre drawdown contour.

Similarly near St Peters interchange within the Ashfield Shale, groundwater is predicted to be drawn down to the tunnel invert to a depth of 44 metres, with the drawdown extending laterally 0.5 kilometres either side of the tunnel to the two-metre drawdown contour. The reduction in the lateral extent of drawdown within the Ashfield Shale compared to the Hawkesbury Sandstone is due to the sandstone being more permeable than the shale.

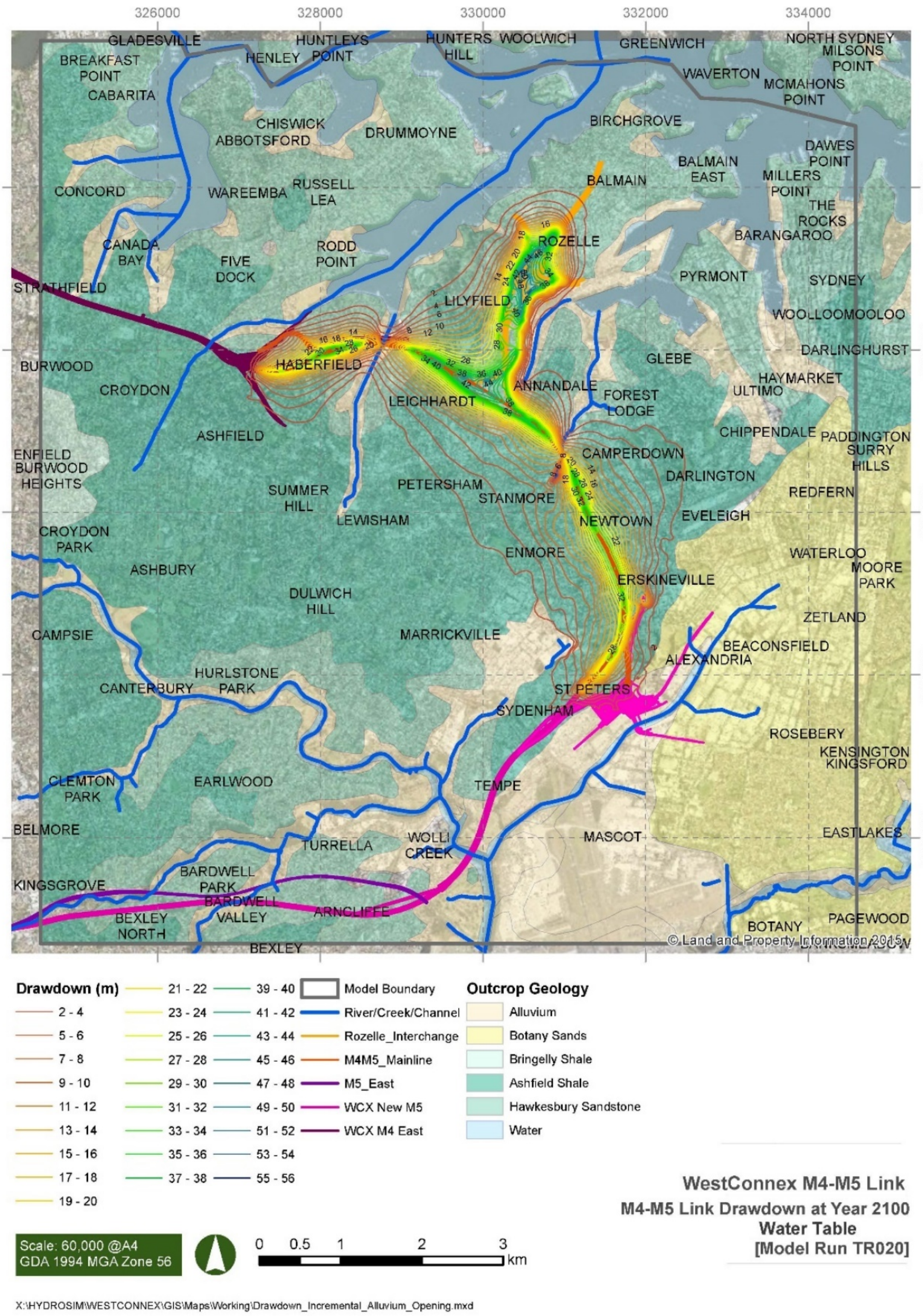


Figure 19-7 Predicted groundwater drawdown for the project during operation (2100)

Potential impacts on groundwater dependent ecosystems

As identified in **section 19.2.9**, there are no priority GDEs identified in the Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources within five kilometres of the project footprint. Consequently, no priority GDEs are likely to be impacted by groundwater level decline associated with the long-term operation of the project. The closest priority GDEs are the Botany Wetlands and Lachlan Swamps within the Botany Sands, located at Centennial Park, around five kilometres east of the project footprint. These wetlands are at a sufficient distance from the project footprint not to be impacted by the project. Potential impacts on these wetlands and GDEs due to the New M5 project were assessed in the New M5 EIS.

Long-term dewatering caused by tunnel drainage could lower the water table and hydraulic heads within the Hawkesbury Sandstone, reducing the amount of groundwater available for non-priority GDE shallow rooted plants. The minimum depth of the water table underlying the majority of the alignment is on average two metres below ground surface. Areas where the water table is shallow, such as at the Rozelle Rail Yards, are typically subjected to periodic flood inundation, which would provide water for shallow rooted plants that may have some groundwater dependence. Continued flood inundation would recharge to the alluvium, although flows would be reduced due to the installation of flood mitigation measures as part of the project (see **Chapter 17** (Flooding and drainage)). At other more elevated topographic areas such as Rozelle, Leichhardt and Newtown, the water table is much deeper below ground surface and consequently flora is unlikely to be dependent on groundwater.

In low-lying areas, such as the Rozelle Rail Yards or close to Rozelle Bay the availability of water for plants is not expected to change, given the high permeability of the sandy soils in combination with frequent rainfall events and higher recharge than elevated sites.

Potential impacts on existing groundwater users

Long-term dewatering caused by tunnel drainage could impact existing groundwater users registered with DPI-Water. A review of the DPI-Water groundwater database indicates that of the registered bores within two kilometres of the proposed project footprint, the majority are registered as monitoring wells. Only five bores are registered for water supply or irrigation. Of these five wells, four are domestic wells and the fifth is registered for irrigation. Two of the domestic wells are located within the Botany Sands and are no longer permitted to be used for domestic purposes due to restrictions imposed by DPI-Water.

Groundwater modelling has been used to predict drawdown at the location of registered bores across the project footprint. Only one bore (GW110247) located in the University of Sydney grounds at Camperdown is registered for domestic use and is predicted to have a drawdown in excess of two metres that is directly attributable to the project. This bore is predicted to have a drawdown of about 2.4 metres to the hydraulic head in Hawkesbury Sandstone by the end of the long-term simulation in 2100. Given the standing water level is recorded as 31 metres below ground level and the bore is 210 metres deep, the drawdown is likely to have a negligible impact on the bore capacity, however the drawdown in excess of two metres triggers ‘make good provisions’ in accordance with the Aquifer Interference Policy. The impact on water quality in GW110247 due to saltwater intrusion is also anticipated to be negligible, since the bore is at least two kilometres from the nearest saltwater body at Rozelle Bay and predicted saline water travel times are in excess of 1,000 years.

Potential impacts on surface water baseflow

Within the Hawkesbury Sandstone (and to a lesser extent the Ashfield Shale), saturated secondary structural features can be hydraulically connected to the creeks and canals or their associated alluvium, providing a pathway for surface water to seep into the tunnels.

Losses to stream flows can occur either as a reduction in baseflow, or as streambed leakage from the creeks and canals, and are dependent on the hydraulic connection between the stream channel and alluvium, the underlying sandstone or shale, and the relative water levels of the creek and groundwater. Groundwater contributions to creek baseflow occur only when the water table elevation is above the creek bed, allowing groundwater to flow to the creek. Conversely, stream bed leakage occurs when the water table elevation is below the creek bed level and groundwater seeps into the underlying lithologies. The concrete lining of creeks would reduce stream bed leakage and baseflow.

Predicted long-term changes to baseflow from the groundwater modelling as a result of the project are summarised in **Table 19-10**. Although the baseflow component of river flow is significantly reduced in several of the watercourses, it is expected that the overall contribution to flow in these watercourses from groundwater is relatively small, since the watercourses are mostly lined channels. It is expected that the majority of flow would be derived from stormwater runoff.

Table 19-10 Predicted long term changes to baseflow

January 2100	Hawthorne Canal	Dobroyd Canal (Iron Cove Creek)	Whites Creek	Johnstons Creek
Base case (m^3/day)	291	274	174	282
Reduction in baseflow (m^3/day)	136	20	145	79
Percentage reduction (%)	47	7	83	28

A water quality objective outlined in **Chapter 15** (Soil and water quality) is to 'maintain groundwater within natural levels and variability that are critical to surface flows and ecosystems of the upper estuary' in the Sydney Harbour and Parramatta River Catchment. Potential groundwater drawdown due to the project for the long-term (2100) has been calculated and is presented in **Figure 19-7**. These figures show that groundwater drawdown would not extend as far to the north as Rozelle Bay and therefore the natural variability of groundwater levels adjacent to Sydney Harbour and the Parramatta estuary would not be impacted by the project.

Groundwater modelling has predicted the potential for varying decreases in creek base flow during the operation of the project, however under current conditions these creeks are concrete lined, restricting groundwater entering the surface water flow during high flow conditions. It is therefore expected that these reductions in base flow would not substantially impact the ecosystems of the upper estuary catchment. If sections of these creeks are naturalised, groundwater recharge would be enhanced, increasing the groundwater component available to surface water flows.

Long-term, the baseflow to major non-tidal creeks is predicted to be reduced by between seven per cent and 83 per cent as a result of the project operation. Although the predicted percentage reduction in baseflow in Hawthorne Canal and Whites Creek is substantial, this reduction represents a small reduction in stream flow, since baseflow, as simulated in the model, only represents the occasions when the groundwater reaches ground level and enters the channels. It is expected that the majority of stream flow would be derived from rainfall runoff and tidal inflow.

There is no impact predicted on the baseflow of other major creeks near the New M5 project footprint (including Cooks River, Wolli Creek and Bardwell Creek) due to the M4-M5 Link project.

Sydney Water is proposing to naturalise parts of creek channels within the project footprint, including sections of Whites Creek, Johnstons Creek at Annandale and Dobroyd Canal (Iron Cove Creek) in Haberfield. Removal of sections of the concrete-lined base would allow more groundwater and surface water interaction, leading to a higher contribution of baseflow to surface water flow in the creeks. Therefore, the impact of a reduction in surface water flow due to the project in these creeks would be in part balanced by the proposed naturalisation works, resulting in additional surface water recharge via bed leakage when the water table is below the creek bed.

Ground movement (settlement)

Impacts related to settlement during operation would be consistent with the impacts related to settlement outlined in **section 19.3.8.** Impacts related to settlement during operation would be from groundwater drawdown, which occurs over a longer timeframe as opposed to settlement impacts from tunnel construction.

A geotechnical model of representative geological and groundwater conditions would be prepared by the construction contractor during the detailed design phase prior to and the commencement of tunnelling. The model would be used to assess predicted settlement impacts and ground movement during the operation of the project. Management measures to control groundwater inflows (which influence groundwater drawdown and therefore ground movement) during the operation of the project are outlined in **section 19.5**.

A settlement monitoring program would be carried out during operation (in accordance with a Settlement Monitoring Plan) at properties and infrastructure where exceedances of the settlement criteria are identified. In the event that settlement criteria are exceeded during operation for property and infrastructure, measures would be taken to ‘make good’ the impact.

Further details regarding settlement are provided in **Chapter 12** (Land use and property).

19.4.4 Groundwater quality

Intercepting contaminated groundwater

There is a risk that contaminated groundwater within the study area (such as a hydrocarbon plume emanating from a former service station or industrial site, for example) could be intercepted during operation of the project, as groundwater is induced to flow towards the tunnel. Altered groundwater flow paths due to the tunnels and hydraulic gradient changes may locally cause existing contaminant plumes (if present) to migrate towards the tunnel alignment. Tunnel inflow quality and quantity would be routinely monitored prior to treatment to detect changes in water quality and treat as needed.

Leachate and elevated concentrations of ammonia are currently generated at the former Alexandria Landfill site. The risk of contaminated groundwater entering the project tunnels from leachate derived from this site is considered low, since the cut-off wall that is to be constructed along the eastern perimeter of the landfill would reduce groundwater inflow cut off walls, the landfill will be capped and ongoing leachate pumping system to be operated as part of the New M5 project will direct groundwater flow towards the leachate pumps and away from the project tunnels.

Contamination generated within the tunnels during operation is unlikely to impact the local hydrogeological regime as groundwater gradients are towards the tunnel. The contamination would be captured within the tunnel drainage system and removed during the treatment process prior to discharge.

At the Rozelle Rail Yards, there is a risk that the groundwater within the alluvium is contaminated from a variety of previous industrial activities. The risk of intersecting shallow contaminated groundwater during the operation of the project is considered to be low, because the tunnels intercepting the alluvium in this area would be undrained (tanked). However, there may be hydraulic connection between the Hawkesbury Sandstone and alluvium, through which potentially contaminated groundwater could enter the tunnel. Tunnel inflow quality and quantity would be routinely monitored prior to treatment to detect changes in water quality, in accordance with an OEMP or Environmental Management System (EMS).

Groundwater from the Botany Sands aquifer is likely to enter the tunnel through hydraulic connection with the Ashfield Shale and Hawkesbury Sandstone at Alexandria. However, analysis undertaken as part of the groundwater modelling indicates the Botany Sands would not be a dominant long-term source of water to the tunnels. Groundwater from the Botany Sands near Alexandria has the potential to be contaminated, but the groundwater entering the tunnel would be treated prior to discharge.

Captured contaminated groundwater through tunnel inflows would be treated in water treatment plants proposed at Rozelle and Darley Road Leichhardt in accordance with the discharge criteria outlined in **Chapter 17** (Flooding and drainage).

The quality of tunnel inflows would be monitored throughout the operational phase to allow the operation of the water treatment plants to be modified as required to meet the adopted discharge criteria. The monitoring strategy would be included in the OEMP or EMS. Other risks associated with contamination during the operation of the project would be managed in accordance with the measures outlined in **Chapter 16** (Contamination).

Groundwater treatment

Treated flows from the Rozelle water treatment plant would drain via a constructed wetland to Rozelle Bay. Treated flows from the Darley Road water treatment plant would be discharged to Hawthorne Canal. A small portion (around 1.6 kilometres) of M4–M5 Link tunnel would also drain to the New M5 operational water treatment plant at Arncliffe.

The existing groundwater quality within the study area (refer to **section 19.2.6**) is brackish with elevated metals and nutrients recorded during groundwater sampling. Total metal, nutrient and ammonia loading to Hawthorne Canal and Rozelle Bay would be likely to increase due to the addition of water from treated groundwater discharges. While the total loading of these contaminants would increase for both treated and non-treated groundwater discharge scenarios, the treatment of groundwater for the project would result in comparatively lower impacts due to the reduced concentration of contaminants after treatment. In order to prevent adverse impacts on downstream water quality within Rozelle Bay and Hawthorne Canal, water treatment facilities would be designed so that the effluent would be of suitable quality for discharge to the receiving environment. By adding additional water to Hawthorne Canal the mass of contaminants would increase (whether treated or not) but the concentration of contaminants in the receiving water would decline if the water is treated, which is beneficial.

The operational water treatment plant at Rozelle and Darley Road would have iron and manganese treatment capabilities. The proposed constructed wetland at Rozelle would remove a proportion of the nutrient and metal load. As no constructed wetland is proposed at Darley Road, opportunities to incorporate other forms of nutrient treatment (for example ion exchange or reverse osmosis) within the plant at Darley Road would be investigated during detailed design with consideration of other factors such as available space, increased power requirements and increased waste production and appropriate discharge criteria.

For groundwater quality, receiving water quality and proposed treatment, the concentration of the key constituents in the treated discharge to Rozelle Bay are unlikely to be significantly higher than the baseline concentration of the constituents in Rozelle Bay. Due to the mixing and dilution affect which would occur at the outlet to the receiving waters, impacts on ambient water quality are likely to be negligible and localised to near the outlet.

The level of groundwater treatment would consider the characteristics of the discharge and receiving waterbody, any operational constraints or practicalities and associated environmental impacts and would be developed in accordance with ANZECC (2000) and with consideration of the relevant NSW Water Quality Objectives. Ultimately, the water quality objectives would be set by the catchment manager of the receiving waters in consultation with the NSW EPA.

Saltwater intrusion

Saltwater intrusion would commence as soon as the hydraulic pressure within the aquifer declines due to groundwater drawdown via the tunnels causing the displacement of fresher water along the shoreline with more saline tidal water.

Over time, saline intrusion is expected to result in saline water reaching the tunnels. The proportion of saline water flowing into the tunnels, however, would be low. A capture zone analysis has been undertaken as part of the groundwater modelling to investigate salt water intrusion within the tunnel catchment areas. From this analysis it is not possible to quantify volumes or concentrations of saline water entering the tunnels and therefore the following discussion is based on a qualitative analysis.

Alexandra Canal and Whites Creek

Travel times for saline water to enter the tunnels within the alluvium have been tabulated for minimum, maximum and average times (refer to **Appendix T** (Technical working paper: Groundwater)). The minimum travel times for saltwater particles to enter the tunnels from Alexandra Canal and Whites Creek are predicted to be two days and eight days respectively, although these water particles would have a negligible impact on groundwater quality. Initially (minimum travel time), the saline water would be a small fraction of total groundwater entering the tunnel but this is expected to increase over time as water is drawn from further afield. Estimated travel times for saline water to enter the tunnel during operation according to the groundwater model would to be 30 years at Alexandra Canal and 13 years at Whites Creek, although the saline water entering the tunnels would be a minor component of total inflow and changes to groundwater quality are expected to be minimal.

Tidal zones

The capture zone analysis indicates that tidal water from the tidal zones associated with the Parramatta River would enter the project tunnels at the proposed Rozelle interchange. Similarly, groundwater from the alluvium associated with the Cooks River would enter the project tunnels near the St Peters interchange.

As groundwater levels are drawn down below sea level, saline waters from tidal waterbodies would start flowing towards the tunnels and would ultimately enter the tunnels via hydraulic connection with the alluvium. Initially, the saline water would be a small fraction of total groundwater entering the tunnels, but this is expected to increase over time, as groundwater is drawn from further afield. Average times for saline water to enter the tunnels are predicted to be more than 100 years and maximum times are in the order of thousands of years.

As a result, groundwater quality in the tunnel catchment zones would slowly become more saline over thousands of years. Since the operational lifetime for major infrastructure is in the order of 100 years, the slow salinity increase should have minimal impacts on the tunnels and infrastructure in the project’s operational lifetime. Similarly, while there is the potential to increase the salinity in registered water supply bores due to saltwater intrusion, the slow progress is expected to have a minimal impact on these bores over a period of 100 years.

Under natural conditions within the Hawkesbury Sandstone, a low salinity water layer towards the top of the aquifer is often present. Shallow rooted plants may have a partial dependency on the low salinity groundwater layer; however, it is expected that these plants would be sustained primarily through rainfall recharge and soil moisture.

In accordance with the OEMP or EMS groundwater quality and tunnel inflow would be routinely monitored and treated, as required, prior to discharge (refer below).

19.4.5 Groundwater monitoring

The groundwater monitoring program prepared and implemented during construction would be augmented and continued during the operational phase. Groundwater would be monitored during the operations phase for three years or as otherwise required by the project conditions of approval and would include trigger levels for response or remedial action based on monitoring results and relevant performance criteria.

At least three monitoring wells and vibrating wire piezometers (VWPs) should be constructed as close as possible to the tunnel centrelines to allow for the comparison of pore pressures and standing water levels. The wells could be constructed about 5-10 metres above the top of the tunnel crown to allow for groundwater drawdown monitoring in the Hawkesbury Sandstone.

The exact nature and frequency of the ongoing groundwater monitoring during operation would be determined by the project operator.

The operational groundwater monitoring program would be developed in consultation with the NSW EPA, DPI-Fisheries, DPI-Water and the Inner West and City of Sydney councils and documented in the OEMP or EMS.

19.4.6 Ancillary infrastructure

The following ancillary infrastructure may impact groundwater during operation of the project:

- Tunnel portals
- Ventilation tunnels and systems
- Water treatment facilities
- Utility works
- Drainage channels and wetland areas.

The tunnel portals and cut-and-cover structures are likely to be constructed in bedrock to prevent the ingress of groundwater into the tunnels. Ventilation tunnels are likely to be constructed as drained tunnels. This infrastructure has been included in the groundwater model, so impacts such as groundwater drawdown or groundwater ingress due to tunnel seepage are discussed in this chapter.

The water treatment facilities would be constructed to enable captured groundwater and surface water that enters the tunnels to be treated and discharged in accordance with *NSW Water Quality and River Flow Objectives* (NSW Department of Environment, Climate Change and Water 2006) (refer to **Chapter 15** (Soil and water quality) for further detail). The water treatment plants are not expected to impact groundwater, since it would be above ground level and have no interaction with the water table. Utility corridors, drainage channels and wetland areas are likely to impact groundwater at the Rozelle Rail Yards since groundwater levels are typically less than one metre below ground level. Temporary dewatering or the installation of temporary sheet piling may be required to manage groundwater during construction.

19.4.7 Barriers to groundwater flow from operational infrastructure

Below ground infrastructure, such as a tunnel below the water table, can create physical barriers that cause temporary or permanent interruptions to groundwater flow. Temporary impacts may be seen after heavy rainfall, when infiltration to the water table and lateral flow are slowed by the barrier, creating a build-up of groundwater behind the barrier. Permanent impacts may be caused by the compartmentalisation of an aquifer through the construction of a barrier boundary that alters groundwater flow patterns.

During the operation of the tunnels, physical barriers to groundwater flow are unlikely for a number of reasons. The majority of the tunnels (including ventilation tunnels) are designed to be drained, which would allow groundwater to seep into the tunnel rather than creating a physical barrier to groundwater flow. Only limited sections of the tunnels in the Whites Creek Alluvium beneath the Rozelle Rail Yards would be undrained (tanked) to prevent groundwater ingress. These sections of the tunnels would be constructed within alluvium and are unlikely to create a physical barrier, as the tunnels would not fully penetrate the alluvium water table, thus allowing groundwater to flow around (above or below) the tunnel.

Although the project tunnels are unlikely to create physical barriers, drained tunnels may create hydraulic barriers impacting local groundwater flow patterns. The hydraulic barrier is formed by lowering groundwater levels centred on the tunnel alignment and, in some cases, locally reversing the groundwater flow direction. Permanent drawdown around the drained tunnels is likely to occur as discussed in the sections above. The creation of this groundwater ‘sink’ would occur along the alignment and extend to a level beneath the tunnel invert. Below this level, there would be no discernible lowering of groundwater pressures, and the groundwater flow pattern would remain unchanged.

At tunnel portals or cut-and-cover sections, the potential interruption of groundwater and possible groundwater mounding caused by the installation of cut-off walls would be avoided by the inclusion of drainage blankets or drains in the detailed design.

19.4.8 Groundwater management

Where higher long-term groundwater inflows into the proposed tunnels are identified during construction, these could be reduced using methods such as pre-grouting and the installation of waterproofing. However, because the proposed tunnels are designed as drained tunnels, with groundwater being captured, treated and discharged at the surface, the need for this measure is likely to be minimal. Strip drains or similar would be installed behind wall panels to assist in dissipating groundwater.

Tunnel drainage and treatment infrastructure would be designed to accommodate groundwater ingress. Separate sumps would be provided at tunnel low points to collect tunnel drainage from separately from groundwater ingress.

Groundwater would be pumped from the sumps to a water treatment plant at the Darley Road motorway operations complex (MOC1) at Leichhardt, with treated flows ultimately discharged to Hawthorne Canal or to the sewer and at the Rozelle East motorway operations complex (MOC3) with treated flows discharged via a constructed wetland within the Rozelle Rail Yards to Rozelle Bay. Further information regarding tunnel drainage and treatment infrastructure is provided in **Chapter 5** (Project description).

The beneficial reuse of the treated water would also be considered, the most likely reuse option being the irrigation of parks and playing fields, for example at the proposed Rozelle interchange. Groundwater reuse would be in accordance with DPI-Water policies for sustainable water use.

19.4.9 Groundwater balance

A groundwater balance has been prepared for the transient simulation (see **section 19.1.5**) and was run to predict the long-term operations impacts. The estimated water balance is summarised in **Table 19-11** and is based on the detailed water balance presented in **Appendix T** (Technical working paper: Groundwater).

Table 19-11 Estimated water balance – project operation (year 2100)

Water balance component	Inputs (recharge) (ML/day)	Output (discharge) (ML/day)
Rainfall infiltration	10.80	0.00
Evapotranspiration	0.00	1.61
River inflow/outflow	1.44	12.8
Tunnels (M4-M5 Link)	0.00	0.67
Pumping wells (Alexandria Landfill)	0.00	0.08
Regional boundary flow	24.60	21.1
Tidal seepage	1.20	0.89
Storage	2.87	3.58
TOTAL	**40.9**	**40.7**

Additional detail on the water balance is provided in **Appendix T** (Technical working paper: Groundwater), including a hydrogeological conceptual model which provides further detail on the components of the water balance.

The transient water balance confirms that the regional boundary flows and rainfall infiltration are the primary recharge parameters, and the primary discharge parameters are river outflow and regional outflow. The total recharge and discharge components match within an acceptable margin of error, indicating the water components of the model balance.

19.5 Environmental management measures

Mitigation and management measures would be implemented during construction and operation of the project to reduce or eliminate the risks to the existing groundwater regime. These environmental mitigation measures, including management, engineering solutions and monitoring, are summarised in **Table 19-12**.

Table 19-12 Environmental management measures – groundwater

Impact	No.	Environmental management measure	Timing
Construction			
High groundwater inflows in excess of the one litre per second per kilometre design criterion, which would cause significant groundwater inflows and groundwater drawdown	GW1	Groundwater inflows within the tunnels will be minimised by designing the final tunnel alignment to minimise intersections with known palaeochannels and alluvium present in the project footprint.	Construction
	GW2	Appropriate waterproofing measures will be identified and included in the detailed design to permanently reduce the inflow into the tunnels to below one litre per second per kilometre for any kilometre length of the tunnel.	Construction
	GW3	Appropriate measures will be investigated and implemented at dive structures and shafts and for cut-and-cover sections of the tunnel to minimise groundwater inflow.	Construction
Corrosion of building materials by sulfate reducing bacteria	GW4	Further assessment of the risk posed by the presence of sulfate reducing bacteria and groundwater aggressivity will be undertaken prior to construction. A corrosion assessment will be undertaken by the construction contractor to assess the impact on building materials that may be used in the tunnel infrastructure such as concrete, steel, aluminium, stainless steel, galvanised steel and polyester resin anchors. The outcomes of the corrosion assessment will be considered when selecting building materials likely to encounter groundwater.	Construction
Groundwater drawdown impacting a water supply well water level by more than two metres	GW5	In accordance with the Aquifer Interference Policy, measures will be taken to 'make good' the impact on an impacted water supply bore by restoring the water supply to pre-development levels. The measures taken will be dependent upon the location of the impacted bore but could include, for example, deepening the bore, providing a new bore or providing an alternative water supply.	Construction
Alteration of groundwater flows and levels due to the installation of subsurface project components	GW6	Potential impacts associated with subsurface components of the project intercepting and altering groundwater flows and levels will be considered during detailed design. Measures to reduce potential impacts will be identified and included in the detailed construction methodology and the detailed design as relevant.	Construction
Actual groundwater inflows and drawdown in adjacent areas exceed expectations	GW7	A detailed groundwater model will be developed by the construction contractor. The model will be used to predict groundwater inflow rates and volumes within the tunnels and groundwater levels (including drawdown) in adjacent areas during construction and operation of the project.	Construction

Impact	No.	Environmental management measure	Timing
	GW8	Groundwater inflow within and groundwater levels in the vicinity of the tunnels will be monitored during construction and compared to model predictions and groundwater performance criteria applied to the project. The groundwater model will be updated based on the results of the monitoring as required and proposed management measures to minimise potential groundwater impacts adjusted accordingly to ensure that groundwater inflow performance criteria are met.	Operation
Operation			
Impacts on groundwater quality or groundwater levels	OGW9	A groundwater monitoring program will be prepared and implemented to monitor groundwater inflows in the tunnels and groundwater levels as well as groundwater quality in the three main aquifers and inflows during construction. The program will identify groundwater monitoring locations, performance criteria in relation to groundwater inflow and levels and potential remedial actions that will be considered to address any non-compliances with performance criteria. As a minimum, the program will include manual groundwater level and quality monitoring monthly and inflow volumes and quality weekly. The monitoring program will be developed in consultation with the NSW EPA, DPI-Fisheries, DPI-Water, City of Sydney Council and Inner West Council.	Operation
	OGW10	The groundwater monitoring program prepared and implemented during construction will be augmented and continued during the operational phase. Groundwater will be monitored during the operations phase for three years or as otherwise required by the project conditions of approval and will include trigger levels for response or remedial action based on monitoring results and relevant performance criteria. At least three monitoring wells and vibrating wire piezometers (VWPs) should be constructed as close as possible to the tunnel centrelines to allow for the comparison of pore pressures and standing water levels. The wells could be constructed about 5-10 metres above the top of the tunnel crown to allow for groundwater drawdown monitoring in the Hawkesbury Sandstone. The operational groundwater monitoring program will be developed in consultation with the NSW EPA, DPI-Fisheries, DPI-Water and the Inner West and City of Sydney councils and documented in the OEMP or EMS.	Operation

Impact	No.	Environmental management measure	Timing
Corrosive groundwater could adversely impact the tunnel and associated infrastructure	OGW11	Where the corrosion assessment that will be carried out prior to construction indicates potential issues, corrosion and other associated impacts of highly aggressive groundwater on the tunnel infrastructure will be monitored during operations. The monitoring program will be documented in the OEMP or EMS. Corroded or otherwise impacted infrastructure will be repaired or replaced as required to maintain operational integrity of the road infrastructure.	Operation
Groundwater drawdown due to the project may exceed two metres in registered bores or at other receptors	OGW12	In accordance with the Aquifer Interference Policy, measures will be taken to ‘make good’ the impact on an impacted water supply bore by restoring the water supply to pre-development levels. The measures taken will be dependent upon the location of the impacted bore but could include, for example, deepening the bore, providing a new bore or providing an alternative water supply.	Operation

Based on the above mitigation and management measures it is considered that potential groundwater impacts that may arise as a result of the construction and operation of the project can be effectively managed.

20 Non-Aboriginal heritage

This chapter outlines the potential non-Aboriginal heritage impacts associated with the M4-M5 Link project (the project). A detailed non-Aboriginal heritage impact assessment has been undertaken for the project and is included in **Appendix U** (Technical working paper: Non-Aboriginal heritage).

The Secretary of the NSW Department of Planning and Environment (DP&E) has issued environmental assessment requirements for the project; these are referred to as Secretary's Environmental Assessment Requirements (SEARs). **Table 20-1** sets outs these requirements and the associated desired performance outcomes that relate to non-Aboriginal heritage, and identifies where they have been addressed in this environmental impact statement (EIS).

Table 20-1 SEARs – non-Aboriginal heritage

Desired performance outcome	SEARs	Where addressed in the EIS
14. Heritage The design, construction and operation of the project facilitates, to the greatest extent possible, the long term protection, conservation and management of the heritage significance of items of environmental heritage and Aboriginal objects and places.	1. The Proponent must identify and assess any direct and/or indirect impacts (including cumulative impacts) to the heritage significance of listed heritage items inclusive of: (c) environmental heritage, as defined under the *Heritage Act 1977* (including potential items of heritage value, conservation areas, built heritage landscapes and archaeology);	Non-Aboriginal environmental heritage values, including conservation areas, built heritage landscapes and archaeology have been identified in **section 20.2**. The impacts of the project on these values are assessed in **section 20.3**. The cumulative impact assessment of the project on non-Aboriginal heritage is included in **Chapter 26** (Cumulative impacts).
The design, construction and operation of the project avoids or minimises impacts, to the greatest extent possible, on the heritage significance of environmental heritage and Aboriginal objects and places.	(d) items listed on the National and World Heritage lists; and	There are no items listed on the National and World Heritage lists within the study area.
	(e) heritage items and conservation areas identified in local and regional planning environmental instruments covering the project area.	Potential impacts of the project on non-Aboriginal heritage values, conservation areas, built heritage landscapes and archaeology have been assessed in **section 20.3**.
	2. Where impacts to State or locally significant heritage items are identified, the assessment must: (a) include a significance assessment and statement of heritage impact for all heritage items (including any unlisted places that are assessed of heritage value);	Assessments of heritage significance of State and local items are included in **section 20.2**. Statements of heritage impact are summarised in **section 20.3** and included in **Appendix U** (Technical working paper: Non-Aboriginal heritage).

Desired performance outcome	SEARs	Where addressed in the EIS
	(b) provide a discussion of alternative locations and design options that have been considered to reduce heritage impacts;	A discussion of the evolution of the project and alternative options considered is included in **Chapter 4** (Project development and alternatives).
	(c) in areas identified as having potential archaeological significance, undertake a comprehensive archaeological assessment in line with Heritage Council guidelines which includes a methodology and research design to assess the impact of the works on the potential archaeological resource and to guide physical archaeological test excavations and include the results of these excavations;	The archaeological potential within the study area is outlined in **section 20.2**. The methodology for the non-Aboriginal heritage assessment is outlined in **section 20.1**. An assessment of potential impacts of the project on archaeology is provided in **section 20.3**.
	(d) consider impacts to the item of significance caused by, but not limited to, vibration, demolition, archaeological disturbance, altered historical arrangements and access, increased traffic, visual amenity, landscape and vistas, curtilage, subsidence and architectural noise treatment (as relevant);	Potential impacts of the project on non-Aboriginal heritage have been assessed in **section 20.3.**
	(e) provide a comparative analysis to inform the rarity and representative value of any heritage places proposed for demolition;	A comparative analysis of the rarity and representative value of non-Aboriginal heritage items that may be impacted by the project is included in **Appendix U** (Technical working paper: Non-Aboriginal heritage).
	(f) outline measures to avoid and minimise those impacts in accordance with the current guidelines; and	Recommended management measures to minimise impacts on non-Aboriginal heritage are outlined in **section 20.4**.
	(g) be undertaken by a suitably qualified heritage consultant(s) (note: where archaeological excavations are proposed the relevant consultant must meet the NSW Heritage Council's Excavation Director criteria).	The non-Aboriginal heritage impact assessment has been prepared by suitably qualified heritage consultants GML Heritage Pty Ltd (refer to **Appendix U** (Technical working paper: Non-Aboriginal heritage).

20.1 Assessment methodology

20.1.1 Overview

The non-Aboriginal heritage impact assessment for the project identifies non-Aboriginal heritage values within the project footprint, assesses the potential impacts of the project on these values and identifies appropriate management measures to minimise these impacts. The methodology for the assessment included:

- Desktop review of statutory heritage lists including the State Heritage Register (SHR), heritage schedules on Local Environmental Plans (LEPs) and State Environmental Planning Policies (SEPPs) (including deemed SEPPs such as Sydney Regional Environmental Plans (SREPs)), Section 170 Heritage and Conservation Registers (S170 Registers), the National Heritage List (NHL) and the Commonwealth Heritage List (CHL)
- Review of previous heritage reports, archaeological zoning plans and archaeological assessments prepared for relevant items and areas within the study area. This informed the preparation of detailed land use histories, which formed the basis for identifying potential heritage sites and historical archaeological resources
- Field surveys of the study area to inspect listed heritage items, heritage conservation areas (HCAs) and potential archaeological sites, and to identify potential heritage items that may be affected by the project
- Desktop historical research to inform the impact assessment, including review of relevant conservation management plans (CMPs) and other plans of management
- Assessment of potential heritage impacts from construction and operation of the project. Cumulative impacts on non-Aboriginal heritage are assessed in **Chapter 26** (Cumulative impacts)
- Recommendation of appropriate environmental management measures to avoid, mitigate and/or manage potential impacts on relevant non-Aboriginal heritage values.

20.1.2 Legislation and policy framework

The methodology for the non-Aboriginal heritage assessment applies the NSW heritage criteria set out in *Assessing Heritage Significance, NSW Heritage Manual* (NSW Heritage Office 2001). The assessment has been undertaken in accordance with the requirements of the *Heritage Act 1977* (NSW), including identification of potential impacts on items of heritage value, HCAs, built heritage landscapes and archaeology. The following relevant legislation and guidelines have also been considered:

- *Environmental Planning and Assessment Act 1979* (NSW) (EP&A Act)
- *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth)
- Sydney Regional Environmental Plan (Sydney Harbour Catchment) 2005 (SREP SHC), a deemed SEPP
- Sydney Regional Environmental Plan No. 26 – City West (SREP 26), a deemed SEPP
- Sydney Local Environmental Plan 2012 (Sydney LEP 2012)
- Ashfield Local Environmental Plan 2013 (Ashfield LEP 2013)
- Leichhardt Local Environmental Plan 2013 (Leichhardt LEP 2013)
- Marrickville Local Environmental Plan 2011 (Marrickville LEP 2011)
- *Assessing Heritage Significance for Historical Archaeological Sites and 'Relics'* (Heritage Branch of the NSW Department of Planning 2009)
- *Historical Archaeology Code of Practice* (NSW Heritage Office 2006)
- *NSW Skeletal Remains: Guidelines for Management of Human Remains* (NSW Heritage Office 1998)

- *Criteria for the assessment of excavation directors* (Heritage Council of NSW 2011)
- *NSW Heritage Manual* (Heritage Office and Department of Urban Affairs and Planning 1994)
- *How to Prepare Archival Records of Heritage Items* (NSW Heritage Office 2003)
- *Assessing Heritage Significance*, NSW Heritage Manual update (Heritage Council of NSW 2002a)
- *Statements of Heritage Impact*, NSW Heritage Manual update (Heritage Council of NSW 2002b)
- *Archaeological Assessments: Archaeological Assessment Guidelines* (NSW Heritage Office 1996)
- *Historical Archaeological Sites: Investigation and Conservation Guidelines* (Heritage Council of NSW 1993)
- *The Burra Charter: the Australia International Council on Monuments and Sites (ICOMOS) Charter for Places of Cultural Significance 2013* (the Burra Charter) (ICOMOS 2013).

20.1.3 Previous reports

A review of archaeological and historical reports relevant to the project was completed and included the following:

- Rozelle Rail Yards Site Management Works review of environmental factors (REF) (Roads and Maritime 2016)
- M4 East EIS – Non-Aboriginal Heritage Impact Assessment (GML 2015)
- M4 East EIS (AECOM & GHD 2015a)
- New M5 EIS – Non-Aboriginal Heritage Impact Assessment (AECOM 2015a)
- New M5 EIS (AECOM 2015b)
- Various heritage reports including CMPs and archaeological assessments as referenced in **Appendix U** (Technical working paper: Non-Aboriginal heritage).

20.1.4 Field survey

Listed non-Aboriginal heritage items and areas identified as having the potential to be impacted (either directly or indirectly) by the project were subject to a targeted inspection to determine their current condition. Non-listed items of potential heritage significance were also identified during these inspections and assessed as having local significance. These inspections were used to inform an assessment of potential impacts on non-Aboriginal heritage values (potential impacts are assessed in **section 20.3**).

This process comprised:

- Review of known non-Aboriginal heritage listings to identify those properties with the potential to be directly or indirectly impacted during the construction or operation of the project
- Compilation of available information of potentially impacted non-Aboriginal heritage listings, including past inspection photographs, as a baseline reference
- Field inspections of the identified listings, which involved recording the current condition of each site. Each listed item was externally photographed and compared to past descriptions and photos. Interior features and/or conditions were determined based on the details provided within their respective database where relevant
- Field investigation of other potential non-listed items of non-Aboriginal heritage, in addition to those known heritage listings that may be impacted by the project
- Updates to existing background information with the results of the field inspections.

Field surveys were carried out between May 2016 and May 2017 and included a pedestrian and vehicle survey. Sites marked on parish plans or identified as part of the survey were inspected and:

- The structure and/or features identified at each site were recorded
- Photographs were taken of the structures/features with details maintained in a photo log
- The structures/features were then assessed for historical significance.

20.1.5 Study area

The study area for the non-Aboriginal heritage impact assessment comprises the project footprint and a buffer determined by the character and visual corridors surrounding the project footprint to ensure indirect impacts are appropriately assessed (ie visual impacts). The study area is separated into six areas that would be subject to surface disturbance as part of the project and the area above the mainline tunnel alignment. The six areas of surface disturbance comprise:

- Area 1 – Haberfield/Ashfield (Option A around Wattle Street, and Option B around Alt Street and Bland Street)
- Area 2 – Leichhardt (around Darley Road)
- Area 3 – Rozelle, Lilyfield and Annandale (around the Rozelle Rail Yards, The Crescent, Rozelle Bay and Victoria Road)
- Area 4 – Iron Cove (around Victoria Road)
- Area 5 – Annandale (around Pyrmont Bridge Road and Parramatta Road)
- Area 6 – St Peters (around the St Peters interchange).

Within the six areas of surface disturbance, 11 Historical Archaeological Management Units (HAMUs) have been identified to assess the level of archaeological potential within the study area, as outlined in **Table 20-2**. There are no HAMUs at Area 1 - Haberfield (for Option A[1] only) and Area 6 - St Peters as these areas have been previously assessed as part of the M4 East and New M5 projects. Option B at Haberfield/Ashfield contains construction ancillary facilities which have not previously been subject to assessment by the M4 East project. This area has therefore been included in the M4-M5 Link assessment.

[1] The EIS includes two possible combinations of construction ancillary facilities around Haberfield which have been grouped together in this EIS and are denoted by the suffix *a* (for Option A) or *b* (for Option B) (eg C1a Wattle Street civil and tunnel site, which is part of Option A).

Table 20-2 HAMUs within the study area

Area	HAMU number	HAMU name
Area 1 – Haberfield/Ashfield	HAMU 1	Haberfield/Ashfield
Area 2 – Leichhardt	HAMU 2	Darley Road
Area 3 – Rozelle, Lilyfield and Annandale	HAMU 3	Lilyfield Road and Gordon Street
	HAMU 4	Victoria Road/City West Link
	HAMU 5	Rozelle Rail Yards (West)
	HAMU 6	Rozelle Rail Yards (East)
	HAMU 7	White Bay Power Station
Area 4 – Iron Cove	HAMU 8	Iron Cove
	HAMU 9	Manning Street bioretention facility
Area 5 – Annandale	HAMU 10	Bignell Lane
	HAMU 11	Parramatta Road/Pyrmont Bridge Road
Area 6 – St Peters	None	N/A

The study area and HAMUs are presented in **Figure 20-1** to **Figure 20-6**.

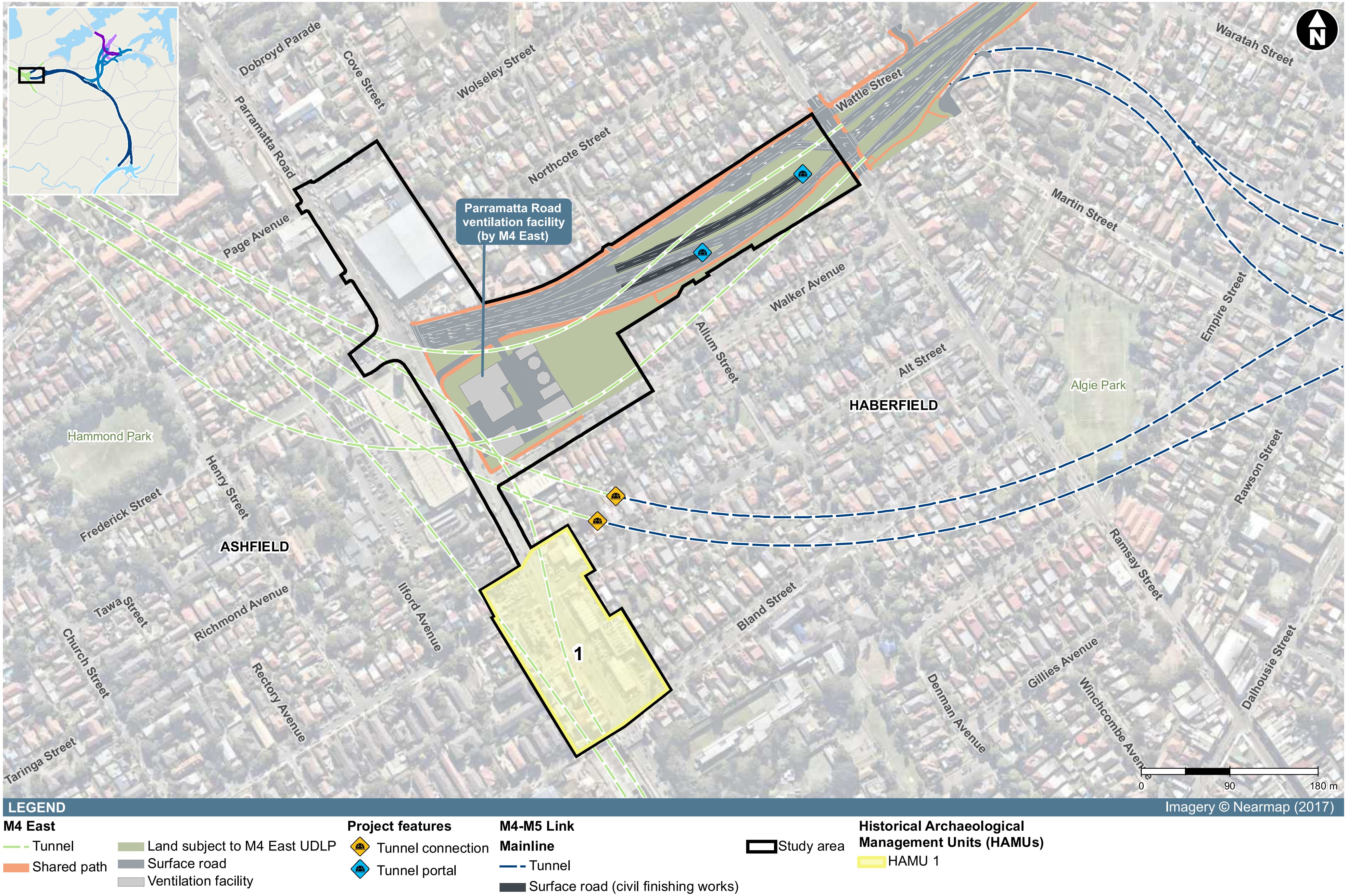


Figure 20-1 Area 1 - Haberfield/Ashfield and HAMUs

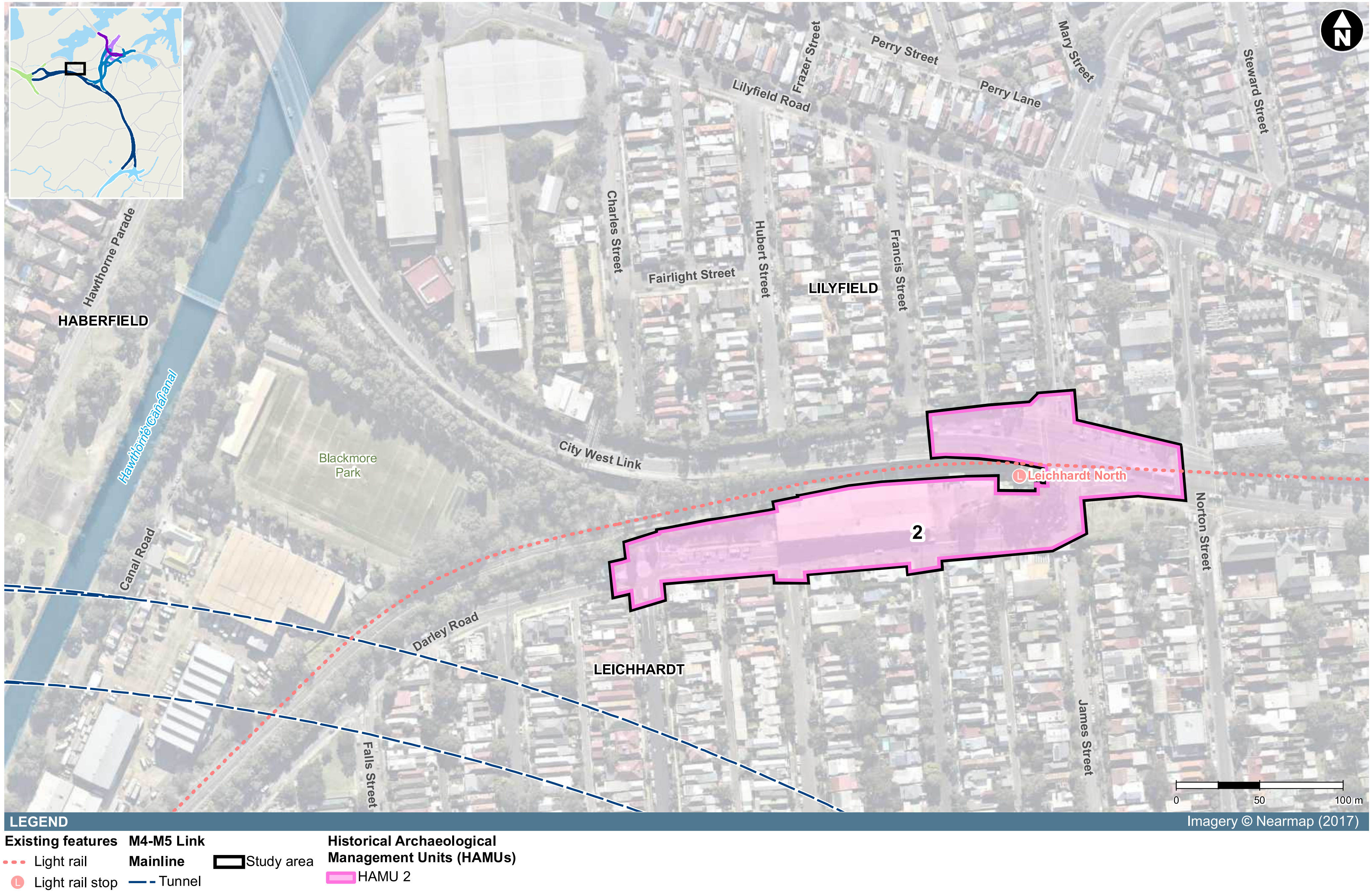


Figure 20-2 Area 2 - Leichhardt and HAMUs

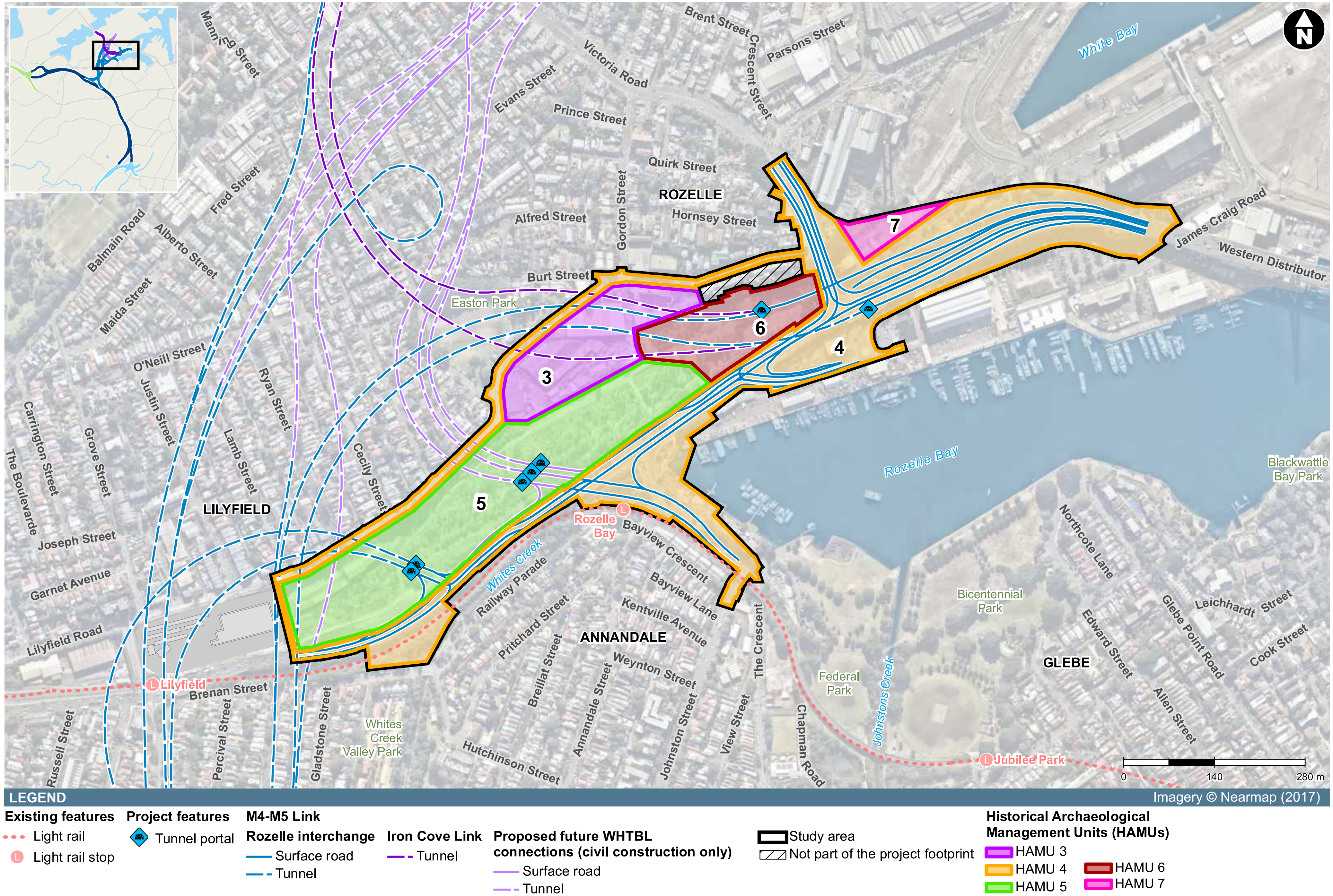
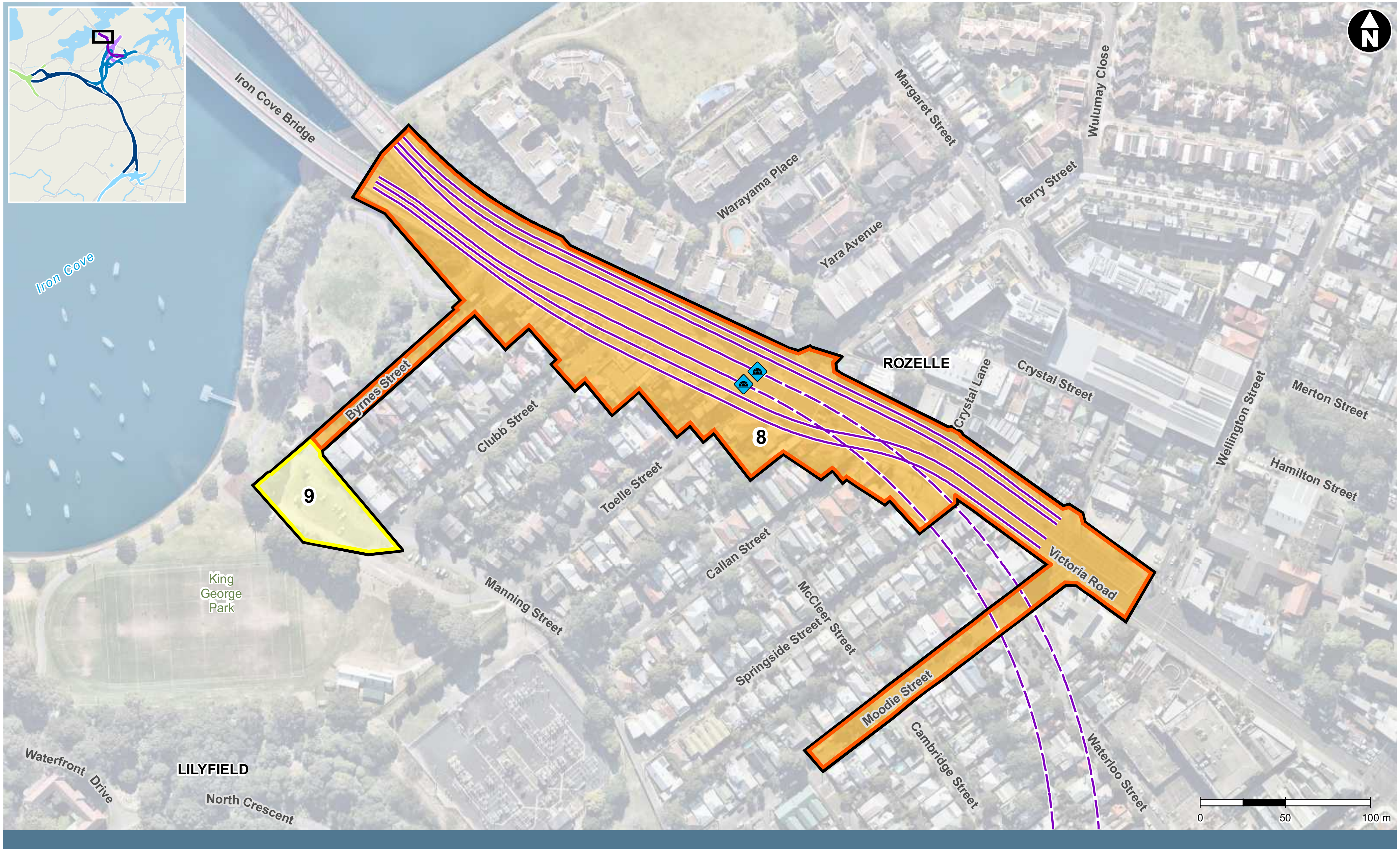


Figure 20-3 Area 3 - Rozelle, Lilyfield and Annandale and HAMUs



Project features

Tunnel portal

M4-M5 Link

Iron Cove Link

Surface road

Tunnel

Study area

Historical Archaeological Management Units (HAMUs)

HAMU 8

HAMU 9

Figure 20-4 Area 4 - Iron Cove and HAMUs

M4-M5 Link

Mainline

Tunnel

Study area

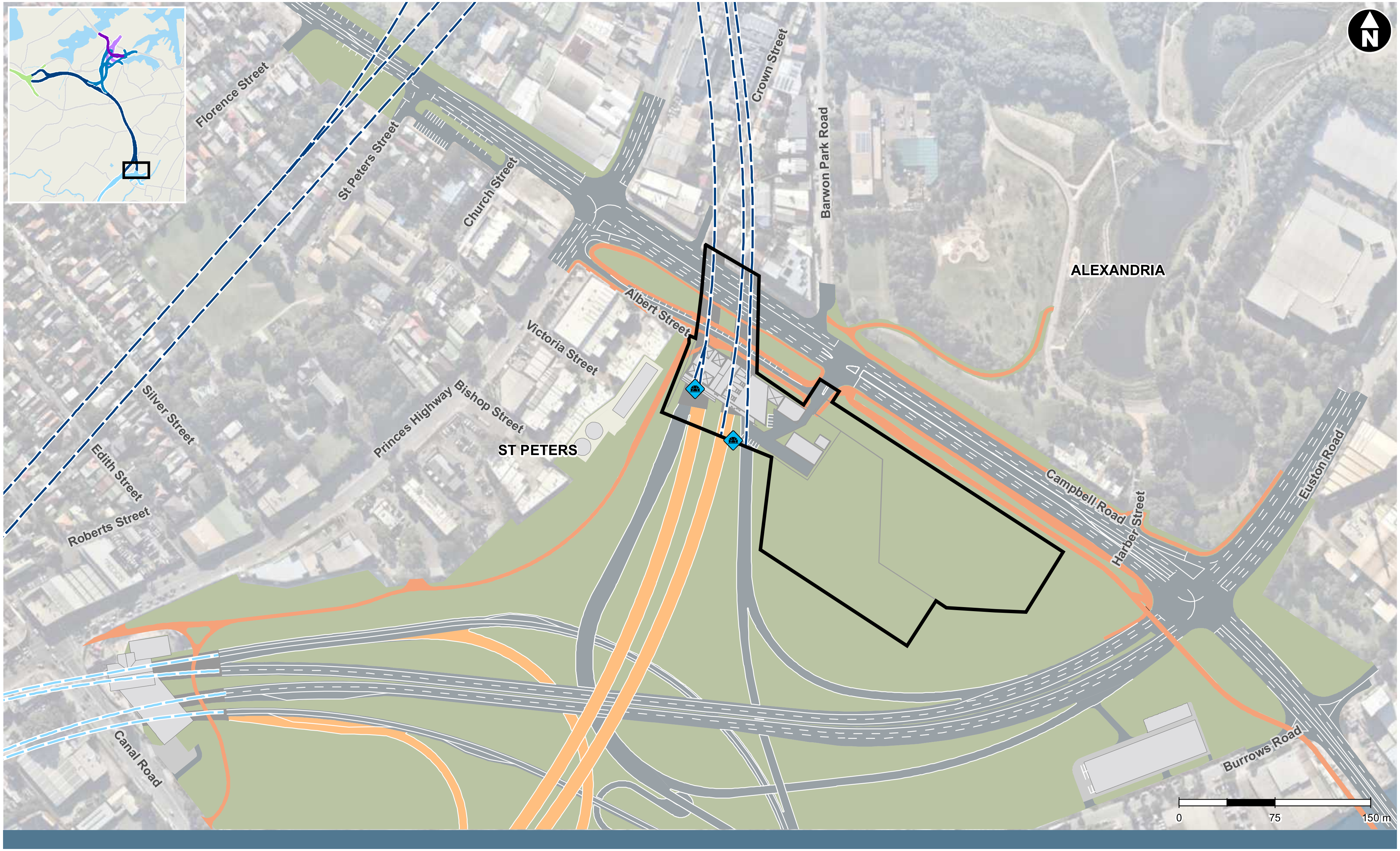
Not part of the project footprint

Historical Archaeological Management Units (HAMUs)

HAMU 10

HAMU 11

Figure 20-5 Area 5 - Annandale and HAMUs



New M5

- Tunnel
- Proposed future Sydney Gateway connections (non-operational as part of M4-M5 Link)
- Building
- Surface road
- Shared path
- Land subject to New M5 UDLP

Project features

- Tunnel portal

M4-M5 Link

Mainline

- Tunnel
- Study area

Historical Archaeological Management Units (HAMUs)

No HAMUs on this figure (previously assessed by New M5)

Figure 20-6 Area 6 - St Peters and HAMUs

20.1.6 Assessment of built heritage significance

An assessment of built heritage significance was carried out for each listed heritage item or potential heritage item identified within the study area. This included heritage items and HCAs that may be subject to demolition, visual, setting, vibration and/or settlement impacts from the project.

The statements of significance for the assessed built heritage items have been drawn from the relevant state and local statutory and non-statutory heritage registers listed in **section 20.1.1**. Additional information on significance, including heritage curtilages, has been drawn from conservation reports, such as CMPs, conservation plans and heritage impact statements, where available. This detail is included in **Appendix U** (Technical working paper: Non-Aboriginal heritage).

20.1.7 Archaeological assessment

The assessment of historical archaeological potential associated with various phases of history within the study area was based on consideration of the physical evidence observed during the field surveys, identified areas of previous disturbance, historical information about the development and occupation of the study area and previous archaeological assessments and investigations.

Each HAMU has been assessed for archaeological deposits. Based on this assessment the potential for archaeological remains within each HAMU has been designated as either nil, low, moderate or high. Following the assessment of potential archaeology for the individual HAMUs, a preliminary heritage significance assessment was completed for each HAMU. Each HAMU has been ascribed either nil, local or state heritage value in relation to its archaeological resources.

As the mainline tunnels would be generally located more than 20 metres below ground level, they are not likely to impact historical archaeology.

20.1.8 Approach to the assessment of potential impacts

Impact ratings have been established to rank the degree of impact (ie severity) on non-Aboriginal heritage, as outlined in **section 20.3**. These impact ratings have been used for previous similar projects including the CBD and South East Light Rail Heritage Impact Assessment (GML 2013) and M4 East Non-Aboriginal Heritage Impact Assessment (GML 2015). It should be noted that the impact severity is not related to the significance of the heritage item.

The assessment has assigned an impact type to each heritage item and HCA as follows:

- Settlement (above tunnel)
- Setting (including visual impacts)
- Vibration
- Partial demolition
- Full demolition.

Table 20-3 Non-Aboriginal heritage impact severity

Impact severity rating	Description
Major adverse	Severe, long-term and possibly irreversible impact on a heritage item that cannot be fully mitigated.
Moderate adverse	Adverse impact on a heritage item that could be reduced through appropriate mitigation measures.
Minor adverse	Minor adverse impact on a heritage item which may also be temporary and/or reversible.
Neutral	No heritage impact.
Minor positive	Minor benefit to a heritage item, such as removal of intrusive elements or fabric or a substantial improvement to the item’s visual setting.
Moderate positive	Moderate benefit to a heritage item, such as removal of intrusive elements or fabric or a substantial improvement to the item’s visual setting.
Major positive	Major benefit to a heritage item, such as reconstruction of significant fabric, removal of intrusive elements or reinstatement of an item’s visual setting or curtilage.

20.2 Existing environment

20.2.1 Rozelle Rail Yards

Roads and Maritime is carrying out a suite of site management works on part of the Rozelle Rail Yards site. The works are needed to manage the existing environmental and safety issues at the site and would also improve access to surface conditions, which would allow for further investigation into the location of utilities and the presence of contamination and waste.

The site management works were subject to a separate environmental assessment. The works were assessed in an REF which was approved by Roads and Maritime under Part 5 of the EP&A Act in April 2017.

Key features of the works relevant to this heritage assessment include removal of existing above ground rail infrastructure including gantries, railway lines, ballast, sleepers and buildings (excluding the southern penstock, switching station, transformer and rail infrastructure to the east of the Victoria Road bridge) generally to a depth of 500 millimetres below ground level, except where drainage channels and sediment basins are required. **Chapter 2** (Assessment process) provides further information on the scope and timing of activities to be carried out as part of the site management works.

Site management works will be carried out over a period of around 12 months and commenced in mid-2017. As the site management works will occur before the commencement of construction of the M4-M5 Link, the existing environment in this section is described as the finished site following completion of the site management works. In addition, potential cumulative impacts from the site management works and the construction and operation of the M4-M5 Link project have been assessed and are described in **Chapter 26** (Cumulative impacts).

A heritage impact assessment was undertaken to inform the REF for site management works at the Rozelle Rail Yards (Roads and Maritime 2016). The assessment concluded that the site management works would not impact any listed heritage or potential historical archaeology items within the Rozelle Rail Yards. Minor adverse impacts were identified to Rozelle Rail Yards as a whole, being removal of the lighting tower and the Port Authority Building. These items were considered to have potential local significance as representative of the operation of the Rozelle Rail Yards in the first part of the 20th century. Recommended management measures included the appropriate treatment of fabric, salvage and retention of some of the key elements where possible (being the lighting tower and the rail gantries) and the incorporation of historic values into the future urban design and interpretive works for the area.

20.2.2 Historical overview

This section provides an overview of the historical development of the land within the study area.

Area 1 – Haberfield/Ashfield

Haberfield and Ashfield located around seven kilometres west of the Sydney central business district (CBD). Haberfield retains a largely intact subdivision layout from the Federation era with many heritage listed items. Almost all of the suburb of Haberfield, from Dobroyd Canal (Iron Cove Creek) to Hawthorne Canal and northwest to Iron Cove (excluding the properties along Parramatta Road), is listed as an HCA of local (and nominated state significance) under the Ashfield LEP 2013.

Haberfield was Australia's first fully planned and developed 'garden suburb' and is largely intact, with the form, materials, scale and setbacks of the predominantly brick Federation and interwar period houses and their landscaped gardens. The tree-lined streets provide consistent and aesthetically significant streetscapes. Land on the northern side of Parramatta Road between Dobroyd Parade and O'Connor Street, Haberfield, originally formed part of the Dobroyd Estate granted to Nicholas Bayley in 1803, known as Sunning Hill Farm. Land opposite this on the southern side of Parramatta Road from Page Avenue to Ashfield Park was originally part of a grant to Augustus Alt.

A businessman names Simeon Lord purchased Sunning Hill in 1805 and renamed it 'Dobroyd'. His daughter Sarah Anne married Dr David Ramsay in 1825, and the couple were given the Dobroyd Estate as a component of Sarah's dowry. The Ramsay's built a timber cottage and garden on the property in 1826, named Dobroyd House. An additional house was constructed on the Dobroyd Estate west of Dobroyd House in 1855 called Yasmar.

The land from eastern side of Alt Street to eastern side of Bland Street was inherited by Mary Louisa Ramsay and contained Yasmar House. She sold the portion of land to Joseph and Albert Grace who subdivided it in 1905. This is the location of the proposed construction ancillary facilities containing the sites for the construction scenario Option B.

The block of land bound by Frederick, Henry, Alt Streets and Parramatta Road was purchased in 1859 by Thomas Wild from the Ashfield Estate subdivision. In the 1860s, Wild built a house on his land which he called 'Gordon'. In 1876 the entire site was purchased by Thomas Walker for the establishment of the Ashfield Infants Home. The Home's aim was for the shelter and care of foundling and orphaned children. This home remains on the site and the complex has, over the years, been enlarged with the construction of additional structures. No significant development was undertaken on the northern portion of the block fronting Parramatta Road.

The Parramatta Road frontage was developed in the early 1920s and was an early commercial strip. Businesses along this strip in 1924 included two grocers, a hairdresser, a motor garage (one of the earliest of many that would occupy parts of Parramatta Road), a timber yard, an electrician and a draper.

With the increasing ownership of cars in Sydney and the spreading suburbs, much of the land along Parramatta Road at Haberfield and Ashfield was redeveloped and now includes industrial sites including several car dealerships which remain the main business in this area. Within the project footprint for construction scenario Option B, most residential buildings have been replaced by open car parking or dealership showrooms. On the west side of Parramatta Road, this has included deep excavation into the slope of the site to the southwest. A row of early twentieth century buildings remain on the corner of Parramatta Road and Bland Street.

Within Area 1 at Haberfield for Option A, the following activities have already occurred as part of the M4 East project:

- Demolition of 53 properties within the Haberfield HCA for the construction of new motorway infrastructure, including dive structures, cut-and-cover tunnels, tunnels and noise barriers around the Wattle Street interchange

- Site clearing, levelling and installation of construction ancillary facilities for the M4 East project known as the Wattle Street and Walker Avenue civil sites and the Northcote Street tunnel site.

The heritage impacts of these works have been assessed as part of the M4 East EIS, including the construction of a ventilation facility near Parramatta Road (AECOM 2015). Cumulative impacts of the M4-M5 Link with other WestConnex component projects, including the M4 East project, are described and assessed in **Chapter 26** (Cumulative impacts).

Area 2 – Leichhardt

Leichhardt is located about six kilometres west of the Sydney CBD. Residential development along Darley Road and the surrounding area is characterised by a broad range of architectural styles and typologies dating from the Victorian era to the present day, with a high degree of alterations and modifications to most properties. The Darley Road civil and tunnel site (C4) would be located on land originally forming part of a 270 acre grant to Ensign Hugh Piper in 1811, which he named the 'Macquarie Gift'. His brother, Captain John Piper, was granted the 165 acres adjacent to Ensign Piper's grant in 1811, and named the land 'Piperston'. Captain Piper's land in Leichhardt was later sold off in four portions. Area 2 is located within the 92 acres purchased by Jean Charles Prosper de Mestre in 1832. De Mestre became insolvent in 1843 and died later that year. After his death, the land was purchased by Henry Alfred Hindson. Hindson kept the property for 11 years and sold it to James Henderson in February 1856, who six months later sold it to George William Lord.

The former Goods Line, a former freight railway line route that connected Sydney Yard and the Sydney-Parramatta railway line to the shipping port of Darling Harbour, also runs adjacent to the Darley Road civil and tunnel site (C4). Development of the Goods Line has resulted in significant development modifications to the landscape.

In 1871, the suburbs of Leichhardt, Lilyfield and Annandale were incorporated in the Municipality of Leichhardt. Leichhardt was already well serviced by horse-drawn buses but there was mounting public pressure for steam trams. The tram network was completed in 1884 and was further extended north along Norton Street in 1889. The Abbotsford line was opened in 1890 and the trams were electrified by 1905.

Other key historical developments in the area included:

- The Goods Line and Leichhardt Goods Yards (1910–1916)
- Construction of Darley Road (1919–1923)
- Operation of the Leichhardt Goods Yards for various uses including the Inner West Light Rail Extension and the Leichhardt North light rail stop (although outside the study area) (1916–present)
- City West Link (2000–present).

Area 3 – Rozelle, Lilyfield and Annandale

Rozelle, Lilyfield and Annandale (around the Rozelle Rail Yards, The Crescent, Rozelle Bay and Victoria Road) are located around three kilometres west of the Sydney CBD. This area includes the Rozelle Rail Yards, The Crescent, Rozelle Bay and Victoria Road. The area is characterised by light industrial development, interspersed with parkland constructed above areas of 19th century reclamation and bisected by a network of modern roads. Late 19th century residential developments surround the northern boundary of the area.

Rozelle was originally part of the 550 acre Balmain Estate granted to William Balmain in 1800. The southern portion of the area is reclaimed land which was once part of the estuary of Rozelle Bay. With the spread of industry, there was pressure to develop the land with housing for workers and by the 1880s, the basic street layout of the peninsula was established. Original housing from the 1890s saw terraces and freestanding houses built along Lilyfield Road and Gordon Street. A number of these buildings remain today.

Easton Park was partially reclaimed from five acres of low lying, probably flood-prone, land. It was resumed for recreation ground in 1889 and proclaimed as Easton Park in 1890. Located close to the foreshore, it was the sole public space for recreation in Rozelle until additional lands were reclaimed at Rozelle Bay, White Bay and Iron Cove, and parkland created in the early 1900s.

In the early 19th century, the waterfronts around White Bay and Blackwattle Bay became home to industries relocating from inner Sydney. The first of these was the abattoir established on Glebe Island in 1860, followed by other noxious industries. By the mid-late 1800s, the shoreline was well developed with a range of industries utilising the ready access to ships.

The closure of the abattoir in 1912 led to the larger scale industrialisation of the neighbourhood. The waterfront was levelled for the construction of wharves, including what became the Glebe Island container terminal, and the Rozelle Bay wharves. The White Bay Power Station was built by the NSW Rail Commissioners on a series of amalgamated residential lots and the reclaimed mudflats of White Bay. The power station was originally built to power the rapidly expanding tramway network, but after becoming fully operational in 1917, it gradually produced more and more power initially for the electrified rail network and then for general use. The White Bay Power Station is now listed on the SHR.

Closely associated with the White Bay Power Station is the southern penstock in the north-eastern part of the Rozelle Rail Yards, east of Victoria Road Bridge. The southern penstock formed part of the power station cooling water system, which was integral to the operation of the complex.

In 1916, the Rozelle Rail Yards (then known as the Rozelle Marshalling Yard) were created as part of the Goods Line. The Rozelle Rail Yards were created by filling in much of the Whites Creek estuary, and through the quarrying of the rugged sandstone outcrops along the foreshore. The Rozelle Rail Yards were a locomotive depot until World War II, with an engine shed, turntable, water columns and coal storage facilities. Two large brick overbridges, the Catherine Street overbridge and the Victoria Road overbridge, were constructed in the 1920s as part of a larger rollout of overbridges across the Goods Line network.

In 1988, the last train of export grain arrived from Parkes at the Rozelle Rail Yards. In 1996, the Goods Line from Pyrmont to Rozelle closed. In 2000, the light rail line to Lilyfield opened, using the tracks from the Rozelle Rail Yards near Brenan Street. For a few years the yards were used irregularly, including for the unloading of wheat and the storage of concrete, but were completely closed in 2007.

Area 4 – Iron Cove

Area 4 is oriented along Victoria Road, a major thoroughfare located around three to four kilometres to the west of the Sydney CBD. The residential development fronting Victoria Road and occupying the adjacent cross streets is predominantly late 19th century workers' housing. Iron Cove Bridge links the suburb of Rozelle to the suburb of Drummoyne to its northwest. The area is a small scale, irregular subdivision that exhibits a variety of building types and construction methods including single-fronted cottages, two storey terraces, and free-standing timber and stone single storey cottages, most with small front gardens.

The Iron Cove area is located in the south-western corner of the 550 acre Balmain Estate (also relevant to Area 3 above). In 1801, Balmain sold his entire holding for five shillings to John Bothwick Gilchrist in order to settle a debt. Balmain returned to England and this transaction remained unknown until after his death. The legality of the land transfer from Balmain to Gilchrist was challenged by Balmain's descendants and further development of the area was initially blocked. The first land was eventually sold in 1835.

From the 1830s to 1850s, Balmain developed as a suburb with a strong maritime industry. Along its coastline were boat yards, slipways, ships and wharves providing connections to the city via regular ferry services. In 1873, the government purchased Callan Park, located on the west of the Balmain boundary line, for the purpose of constructing a mental health hospital. The Callan Park Hospital was to provide relief from overcrowding and additional resources for the Gladesville Hospital for the Insane. The first patients from Gladesville were transferred to Callan Park in 1877 and housed in Garry Owen House.

Also in 1873, Iron Cove Bridge was being built to connect Drummoyne and Rozelle. The original bridge was constructed of wrought-iron lattice girders and opened in 1882. In 2009, works began constructing a second bridge over Iron Cove. The second bridge was completed and opened in 2011. The adjacent parkland was restored at the same time.

King George Park was the site of a United States' service-men encampment during World War II. Possibly related to the encampment, there appears to be air raid trenches on historical aerial photos, visible as a zig-zag to the south of Victoria Road dug into the headlands by Iron Cove (refer to Figures 4-49 and 4-50 of **Appendix U** (Technical working paper: Non-Aboriginal heritage).

The site of the proposed bioretention facility on Manning Street at Rozelle remained vacant during this period, however an aerial photograph from 1943 suggests that a stormwater drain ran through the area, and into the Iron Cove Bay.

Since the 1920s, there were discussions to widen Victoria Road to accommodate the rapidly increasing population. This did not occur until the 1882 Iron Cove Bridge was replaced in 1955 with the existing Art Deco steel truss bridge. In 1959, buildings 206 to 222 Victoria Road (between Callan Street and Springside Street) were purchased and demolished to make way for a petrol station and car park.

Area 5 – Annandale

Annandale is located around four kilometres south-west of the Sydney CBD and is characterised as a mixed use commercial/residential area oriented around Parramatta Road. The area is generally occupied by medium density development of predominantly industrial character. Buildings date primarily from the early to mid-20th century, punctuated by contemporary apartment developments.

The Annandale area is part of Governor William Bligh’s 240 acre grant, made to him by Governor Philip Gidley King in 1806. Bligh’s wife died in 1813 and he died in 1817. After his death, his landholdings were passed on to his six surviving daughters.

By the 1840s, the Camperdown Estate was in the ownership of Sir Maurice O’Connell, who had married Bligh’s widowed daughter, Mary Putland. In 1842, the Camperdown Estate was subdivided and sold. Most of the blocks were villa allotments, up to two hectares in size, but there were also smaller residential lots. New streets were also laid out, including a new alignment of George Street (present day Parramatta Road).

Parramatta Road was constructed in the first years of the colony to link the two European settlements of Sydney and Rose Hill (later renamed Parramatta). It is highly probable, although no written account confirms it, that the first European-made track between the two settlements followed an Aboriginal pathway. The creation date of the first European-made track also remains unknown, but was likely to have been sometime in 1790 or 1791.

By 1924, the residential cottages along Parramatta Road at Annandale were being replaced with factories, stores and shops. There have been minimal physical changes to the Annandale area since the 1940s. In 1937, the Bank of NSW purchased 164 Parramatta Road. The Bank of NSW was established by Governor Macquarie in 1817 and was Australia’s oldest financial institution. In 1982 the Bank of NSW merged with the Commercial Bank of Australia Ltd and changed its name to Westpac Banking Corporation.

Area 6 – St Peters

St Peters is located around five to six kilometres south of the Sydney CBD. Area 6 comprises a mostly cleared area south of Campbell Road. There are industrial areas to the east and west of the area, and Sydney Park to the north. Land comprising Area 6 formed part of a large parcel of land granted to William Hutchinson, who gave the area the name ‘Waterloo’. Subsequently during the 20th century, the area was used as a brickworks, and later as a landfill site.

While St Peters was subject to an early colonial land grant, the land was swampy and therefore remained undeveloped. Plans from the 1890s show Barwon Park as the Central Brick and Tile Company kilns. These kilns were used to manage and stockpile waste and were eventually demolished. It is unlikely that any deposits or material from the former Central Brick and Tile

Company remain in-situ, as these are likely to have been disturbed by activities associated with the subsequent waste facility established on the site.

The heritage impacts of these works have been assessed as part of the New M5 EIS (AECOM 2015b). Cumulative impacts of the M4-M5 Link with other WestConnex component projects, including the New M5 project, are described and assessed in **Chapter 26** (Cumulative impacts).

20.2.3 Historical archaeology

This section describes the historical archaeological potential of the study area. The heritage significance of each HAMU has been determined at the state or local level. This section also describes the potential impact on the archaeological resource resulting from construction of the project.

Area 1 – Haberfield/Ashfield

The archaeological potential and significance at Haberfield (Area 1) for Option A has been previously assessed as part of the M4 East project (GML 2015) and are being managed during construction of the M4 East project.

In this location, the construction works as part of the M4-M5 Link project comprise the internal fitout of the Parramatta Road ventilation facility, continued use of existing construction ancillary facilities, tunnelling of the mainline tunnels and tie-ins with the underground tunnel connections (constructed as part of the M4 East project). These works would not impact archaeological remains within this area, beyond the impacts already assessed and associated with the M4 East project.

The construction ancillary facilities at Haberfield/Ashfield for Option B have not been previously assessed by the M4 East project and have therefore been included in this assessment. These sites include the Parramatta Road West civil and tunnel site (C1b) and Parramatta Road East civil site (C3b). The Haberfield civil site (C2b) is within the same footprint as the ancillary facility for Option A (the Haberfield civil and tunnel site (C2a)) and has been assessed by the M4 East project. The two sites (C1b and C3b) are separated by Parramatta Road, which runs in a north–south direction. HAMU 1 is located in Area 1.

Table 20-4 summarises the past developments in the area and the nature, level and extent of previous disturbance. **Table 20-5** summarises the potential for archaeological remains to be present within HAMU 1, and the significance of those remains. HAMU 1 is assessed as having moderate or high potential to contain archaeological remains.

Table 20-4 Summary of previous disturbance at Haberfield/Ashfield (Area 1)

Past development	Nature of disturbance	Level of disturbance
Basement excavation of late 19th and early 20th century buildings	Disturbance of agricultural landscape features and fence lines.	Moderate to high
Building foundations, cutting and levelling of late 20th century buildings	Surface clearing and localised impacts resulting from excavation for building foundations.	Moderate to high
Services	Excavation for services (water, gas, sewage) would have completely removed any remains within the trench footprint.	Moderate
Construction of Parramatta Road	Construction and maintenance of road way.	Low to moderate

Table 20-5 Potential archaeological presence at Haberfield/Ashfield (Area 1)

HAMU	Listed archaeological items	Archaeological potential	Significance
HAMU 1 – Haberfield/ Ashfield	None	Moderate or high potential associated with late 19th to early 20th century building footings and services beneath road surfaces and footpaths.	Nil

Area 2 – Leichhardt

The Darley Road civil and tunnel site (C4) would be oriented around the former Goods Line, which has historically resulted in significant modifications to the landscape. The topography of this area slopes steadily downwards from east to west towards Hawthorne Canal. HAMU 2 is located in Area 2.

Table 20-6 summarises the past developments in the area and the nature, level and extent of previous disturbance. **Table 20-7** summarises the potential for archaeological remains to be present within HAMU 2, and the significance of those remains.

HAMU 2 is assessed as having no potential to contain archaeological remains.

Table 20-6 Summary of previous disturbance at Leichhardt (Area 2)

Past development	Nature of disturbance	Level of disturbance
Goods Line	Excavation of sandstone bedrock, and levelling of ground surface for construction of the railway Goods Line.	High
Early 20th century reclamation	Filling and levelling within waterfront and estuary areas.	Low to moderate
20th century warehouses	Excavation and levelling to create a level surface for construction of the existing building.	High
Stormwater drainage system	Excavation for the stormwater culvert and pipe trenches.	High
Construction of Hawthorne Canal	Reclamation for the construction of the Hawthorne Canal.	High
Services (excavation for service trenches)	Excavation for services (water, gas, sewage) would have completely removed any remains within the trench footprint.	Moderate

Table 20-7 Potential archaeological presence at Leichhardt (Area 2)

HAMU	Listed archaeological items	Archaeological potential	Significance
HAMU 2 – Darley Road	None	Nil	Nil

Area 3 – Rozelle, Lilyfield and Annandale

The majority of the Rozelle area has been modified by historical development. HAMUs 3, 4, 5, 6 and 7 are located in Area 3. **Table 20-8** summarises the past developments in the area and the nature, level and extent of previous disturbance. **Table 20-9** summarises the potential for archaeological remains to be present within the HAMUs identified in Area 3, and the significance of those remains.

HAMUs in Area 3 range from low to high degrees of archaeological potential. HAMU 3 and HAMU 6 have potential for locally significance archaeological remains, while HAMU 4 and HAMU 5 do not meet the threshold for significance. HAMU 7 is considered to have high potential for state significant archaeological remains associated with White Bay Power Station.

Table 20-8 Summary of previous disturbance at Rozelle, Lilyfield and Annandale (Area 3)

Past development	Nature of disturbance	Level of disturbance
Progressive reclamation	Multiple phases of filling and levelling within waterfront and estuary areas.	Moderate
Quarrying and cutting sandstone	Excavation of sandstone bedrock, and levelling of ground surface.	High
Construction of Victoria Road, City West Link and Western Distributor	Demolition of previous structures and any earlier deposits, and earlier street alignments for new, upgraded or wider roads.	High
18th and 19th century buildings	Surface clearing and some excavation for footings.	Low
20th century buildings (cutting and levelling)	Demolition of pre-existing buildings and complete removal of any earlier deposits.	Moderate to high
Infrastructure and services (excavation for service trenches)	Excavation for services (water, gas, sewage) and infrastructure (trams on Lilyfield Road) would have completely removed any remains within the trench footprint.	Moderate

Table 20-9 Potential archaeological presence at Rozelle, Lilyfield and Annandale (Area 3)

HAMU	Listed archaeological items	Archaeological potential	Significance
HAMU 3 – Lilyfield Road and Gordon Street	None	Moderate to high potential associated with early residential occupation on Gordon Street, previous phases of industrial activity and reclamation activities of the Rozelle foreshore prior to 1890. Most sites or features in this HAMU are likely to have been disturbed by the quarrying of the sandstone bedrock along the property boundary with Lilyfield Road.	Local
HAMU 4 – Victoria Road/City West Link	None. The southern penstock and associated subsurface elements of the White Bay Power Station cooling system are discussed in **section 20.2.4**.	Low to moderate potential associated with: • Early residential occupation on Weston Road and Abattoir Road • Early road alignments of Weston Road and Barnes Street predating the 1960s upgrades to Victoria Road • Alignment of Abattoir Road prior to construction of Rozelle Rail Yards and White Bay Power Station • Subsurface structural remains and the basement of the White Bay Hotel • Reclamation activities of the Rozelle foreshore prior to 1890, including early stages of bridging Glebe Island, and channelisation	Nil

HAMU	Listed archaeological items	Archaeological potential	Significance
		of Whites Creek. Most sites or features in this HAMU are likely to have been disturbed or destroyed by sandstone quarrying, late 20th century developments and road infrastructure development. Remains of the White Bay Hotel have likely been extensively disturbed by the fire which destroyed the hotel, and subsequent demolition.	
HAMU 5 – Rozelle Rail Yards (West)	None. The Lilyfield Road Stormwater Canal (listed under SREP 26) is located underground in this HAMU. While the above ground section of the canal is listed, the underground section is not listed and has potential archaeological significance.	Low to high potential associated with: • Early road alignments of Abattoir Road prior to construction of the Rozelle Rail Yards • Reclamation activities of the Rozelle foreshore during the 19th and 20th centuries • 19th century drainage infrastructure associated with channelising the creek, and early 20th century drainage infrastructure associated with the stormwater canal. Some sites or features in this HAMU are likely to have been disturbed by the quarrying of the sandstone bedrock along the northern boundary and levelling and subsequent modifications of the Rozelle Rail Yards.	Nil
HAMU 6 – Rozelle Rail Yards (East)	None	Low to high potential associated with: • Early industrial occupation on Lilyfield Road including structural remains and associated artefact deposits in areas which have been quarried and filled for the construction of the rail yards • Reclamation activities of the Rozelle foreshore during the 19th and 20th centuries. Some sites or features in this HAMU are likely to have been disturbed by the quarrying of the sandstone bedrock along the northern boundary and levelling and subsequent modifications of the Rozelle Rail Yards.	Local
HAMU 7 – White Bay Power Station	White Bay Power Station is a listed heritage item of state significance, with significant archaeological components of the system known to exist both within and outside the SHR curtilage. Impacts on this item are also discussed in **section 20.3.2**.	High potential for archaeological elements of White Bay Power Station water channels associated with the southern penstock (the specific location of the channels is unknown).	State

Area 4 – Iron Cove

The majority of the project footprint at Area 4 - Iron Cove has been heavily disturbed by historical developments which have likely impacted on earlier archaeological remains. HAMUs 8 and 9 are located in Area 4.

Table 20-10 summarises the past developments in the area and the nature and level of previous disturbance. **Table 20-11** summarises the potential for archaeological remains to be present within the two HAMUs identified in Area 4, and the significance of those remains.

HAMU 8 is considered to have no archaeological significance, while HAMU 9 is considered to have low potential for locally significance archaeological remains.

Table 20-10 Summary of previous disturbance at Iron Cove (Area 4)

Past development	Nature of disturbance	Level of disturbance
Construction of Iron Cove Bridge abutment	Excavation for the bridge head and adjacent construction ancillary facility.	High
Former petrol station underground tanks at 212–218 Victoria Road	Complete removal of earlier remains within the tank/s footprint.	High (localised)
Cutting and levelling for late 19th / early 20th century buildings	Excavation of bedrock to create level surfaces; areas of fill may have potentially buried remains.	Low to moderate
Construction of existing Victoria Road	Demolition of previous structures and any earlier deposits, and earlier street alignments for new, upgraded or wider roads.	High
Services (excavation for service trenches)	Excavation for services (water, gas, sewage) would have completely removed any remains within the trench footprint.	Moderate
Establishment of King George Park	Demolition of earlier buildings, and modification of the landscape including construction of new roads; areas of fill may have potentially buried remains.	Low to moderate

Table 20-11 Potential archaeological presence at Iron Cove (Area 4)

HAMU	Listed archaeological items	Archaeological potential	Significance
HAMU 8 – Iron Cove	None	Low potential associated with: • Remains of a quarry that may have extended into the study area within King George Park adjacent to Byrne Street • Remains of zigzag air-raid trenches visible on the 1943 aerial • Truncated footings and artefact scatters from 1890s houses at 212–218 and 224 Victoria Road • Earlier road surfaces, drainage features and services within adjoining side streets (including Byrnes, Clubb, Toelle and Callan streets). Sites or features in this HAMU are likely to have been heavily disturbed or removed by modern developments (ie construction of Iron Cove Bridge abutment and the ongoing upgrade of Victoria Road and intersections).	Nil
HAMU 9 – Manning Street bioretention facility	None	Moderate to high potential of truncated footings and deposits associated with 1890s houses. Although localised service excavation would have resulted in areas of disturbance, the introduction of fill to create the parkland may have buried earlier remains, which could survive intact beneath the modern ground surface.	Local

Area 5 – Annandale

The majority of the Annandale (around Pyrmont Bridge Road and Parramatta Road) area has been artificially modified by historical urban development. HAMUs 10 and 11 are located in Area 5.

Table 20-12 summarises the past developments in the area and the nature and level of previous disturbance. **Table 20-13** summarises the potential for archaeological remains to be present within the two HAMUs identified in Area 5, and the significance of those remains.

HAMU 10 encompasses those areas that have a moderate or high degree of archaeological potential. HAMU 11 contains areas that have a low potential for archaeological remains. Both HAMUs meet the threshold for local significance.

Table 20-12 Summary of previous disturbance at Annandale (around Pyrmont Bridge Road and Parramatta Road) (Area 5)

Past development	Nature of disturbance	Level of disturbance
20th century buildings (basement excavation)	Demolition of late 19th century buildings and excavation for basement levels.	Moderate to high
20th century buildings (building foundations, cutting and levelling)	Surface clearing and localised impacts resulting from excavation for building foundations.	Moderate
Services	Excavation for services (water, gas, sewage) would have completely removed any remains within the trench footprint.	Moderate
Construction of Bignell Lane	Construction and maintenance of road way.	Low

Table 20-13 Potential archaeological presence at Annandale (around Pyrmont Bridge Road and Parramatta Road) (Area 5)

HAMU	Listed archaeological items	Archaeological potential	Significance
HAMU 10 – Bignell Lane	None	Moderate to high potential associated with: • Western half of the c1860s Didliston House (building footings and deposits) • Footings and deposits associated with c1890s houses • Early 20th century services beneath Bignell Lane • Early to mid-19th century property boundaries and garden/agricultural remains • External structures and features associated with the Bignell and Clarke steam joinery works (the main building is outside this HAMU). Given the size of the 20th century buildings and the absence of basements within this HAMU, there is potential for archaeological remains to survive beneath the existing floor slabs and between building footings.	Local
HAMU 11 - Parramatta Road/ Pyrmont Bridge Road	None	Low potential associated with: Eastern half of the c1860s Didliston House (building footings and deposits) Footings and deposits associated with c1890s buildings Remains of the Bignell and Clarke Steam joinery works (main building) Early to mid-19th century property boundaries and garden/agricultural remains.	Local

Area 6 – St Peters

The archaeological potential and significance at St Peters (Area 6) has been previously assessed as part of the EIS for the New M5 project. Archaeological remains are being managed during the construction of the New M5. Archaeological remains are being managed during construction of the New M5. For the purpose of the non-Aboriginal heritage impact assessment, it has been assumed that the proposed construction works associated with the New M5 project within this area have been completed and mitigation measures relating to impacts on archaeological remains have been implemented.

20.2.4 Heritage items and conservation areas

This section identifies the existing listed heritage items and HCAs within or adjacent to the project footprint. Listed heritage items and HCAs identified within the study area relevant to this assessment are summarised in **Table 20-14** and shown in **Figure 20-7** to **Figure 20-14**.

Items with the potential to be directly affected by the project are shaded in **Table 20-14**. The significance of these heritage items and HCAs are discussed further in **Appendix U** (Technical working paper: Non-Aboriginal heritage).

Potential impacts on items above the current mainline tunnel alignment are assessed in **section 20.3.4**.

Table 20-14 Historic heritage items within the study area

Area	Item	Address	Significance	Register
Haberfield/Ashfield (Area 1)	Haberfield HCA	Haberfield	Local (potential for State)	• Ashfield LEP 2013(ID C42)
	Houses	146–148 Ramsay Street, Haberfield	Local	• Ashfield LEP 2013(ID 451)
	Houses	150–152 Ramsay Street, Haberfield	Local	• Ashfield LEP 2013(ID 452)
	Commercial building	476 Parramatta Road, Ashfield	Local	• Ashfield LEP 2013(ID 273)
Leichhardt (Area 2)	Leichhardt (Charles St) Underbridge (Charles Street)	Dulwich Hill to Rozelle Goods Line (Charles Street), Leichhardt	Local	• RailCorp S170 (#4805738)
Rozelle, Lilyfield and Annandale (Rozelle Rail Yards, The Crescent, Rozelle Bay and Victoria Road) (Area 3)	White Bay Power Station	Victoria Road and Robert Street, Rozelle	State	• State Heritage Register (#01015) • SREP 26 (#11) • Sydney Harbour Foreshore Authority S170 • Ausgrid S170 (#74)
	Brennan's Estate HCA	Rozelle	Local	• Leichhardt LEP 2013 (ID C16)
	Easton Park HCA	Rozelle	Local	• Leichhardt LEP 2013 (ID C18)
	Easton Park	Rozelle	Local	• Leichhardt LEP 2013 (ID I752)
	Sewage Pumping Station No. 6	168 Lilyfield Road, Rozelle	Local	• Sydney Water S170 (#4571704)
	Hornsey Street HCA	Rozelle	Local	• Leichhardt LEP 2013(ID C19)
	Whites Creek Stormwater Channel No. 95	Railway Parade to Parramatta Road, Rozelle	Local	• Sydney Water S170 (#4570343)
	Street trees – row of palms on Railway Parade	Railway Parade, Annandale	Local	• Leichhardt LEP 2013 (ID I78)
	Avenue of *Phoenix canariensis*	Railway Parade, Annandale	Local	• Leichhardt LEP 2013 (ID I79)

Area	Item	Address	Significance	Register
	Annandale (Railway Parade) Railway Bridge	Railway Parade, Annandale	Local	• SREP 26 (#7) • RailCorp S170 (4803231)
	Arched Bridge (at Whites Creek)	Whites Creek, Annandale	Local	• SREP 26 (#8)
	Annandale (Johnston Street) Underbridge	Johnston Street	Local	• SREP 26 (#9) • RailCorp S170 (4803229)
	Stormwater Canal	Lilyfield Road, Rozelle	Local	• SREP 26 (#6)
	'Cadden Le Messurier'	84 Lilyfield Road, Rozelle	Local	• SREP 26 (#3)
	Former Hotel	78 Lilyfield Road, Rozelle	Local	• SREP 26 (#2)
Iron Cove (Area 4)	Iron Cove Bridge (aka RTA Bridge No. 65)	Victoria Road, Drummoyne	State	• SREP SHC (#17) • RTA S170
	Iron Cove HCA	Drummoyne	Local	• Leichhardt LEP 2013 (ID C6)
Annandale (around Pyrmont Bridge Road and Parramatta Road) (Area 5)	Kerb and gutter	Chester Street, Camperdown	Local	• Leichhardt LEP 2013 (ID I613)
	Warehouse, including interiors	52–54 Pyrmont Bridge Road, Camperdown	Local	• Leichhardt LEP 2013 (ID I616)
	Former Grace Bros Repository including interiors	6–10 Mallett Street, Camperdown	Local	• Sydney LEP 2012 (ID I2242)
	Bridge Road School (former Camperdown Public School), including interiors	127 Parramatta Road, Camperdown	Local	• Marrickville LEP 2011 (ID I5)
St Peters (Area 6)	Terrace group including interiors	2–34 Campbell Road, Alexandria	Local	• Sydney LEP 2012 (ID I12)
	Remaining brick road and footpath paving and stone guttering	near 2 Bishop Street, St Peters	Local	• Marrickville LEP 2011 (ID I283)

20.2.5 Potential heritage

During the field surveys, buildings and structures of potential heritage value were investigated to identify items with heritage value that are not listed and may be directly or indirectly impacted by the project. Items of potential heritage significance were identified and were therefore subject to heritage values assessment and impact assessment. These items are outlined in **Table 20-15** (items subject to full or partial demolition are shaded).

Table 20-15 Potential heritage items identified within the study area

Area	Item	Address	Potential significance
Area 1 – Haberfield/ Ashfield	Single storey brick Federation cottage	135 Bland Street, Haberfield	Local
	Single storey brick Federation cottage	136 Bland Street, Haberfield	Local
	Single storey brick Federation cottage	138 Bland Street, Haberfield	Local
	Single storey brick Federation cottage	139 Alt Street, Ashfield	Local
	Single storey brick Federation cottage	144 Alt Street, Ashfield	Local
Area 3 – Rozelle and Lilyfield	Victoria Road bridge	Rozelle	Local
	Sandstone cutting within the Rozelle Rail Yards	Rozelle	Local
	Former White Bay Hotel site foundations (plinth and archaeology)	Rozelle	Local
	Southern Penstock (associated with the White Bay Power Station)	Rozelle	State
Area 4 – Iron Cove	Property at 260 Victoria Road	Rozelle	Local
	Property at 262 Victoria Road	Rozelle	
	Property at 264 Victoria Road	Rozelle	
	Property at 266 Victoria Road	Rozelle	
	Properties at 248 Victoria Road	Rozelle	Local
	Terraces at 250 Victoria Road	Rozelle	
	Single storey interwar brick house	8 Callan Street, Rozelle	Local
Area 5 – Annandale	Former Bank of NSW building	164 Parramatta Road, Annandale	Local

These potential heritage items are shown in **Figure 20-8** to **Figure 20-11** and discussed in **Appendix U** (Technical working paper: Non-Aboriginal heritage). No items of potential heritage significance were identified at St Peters (Area 6).

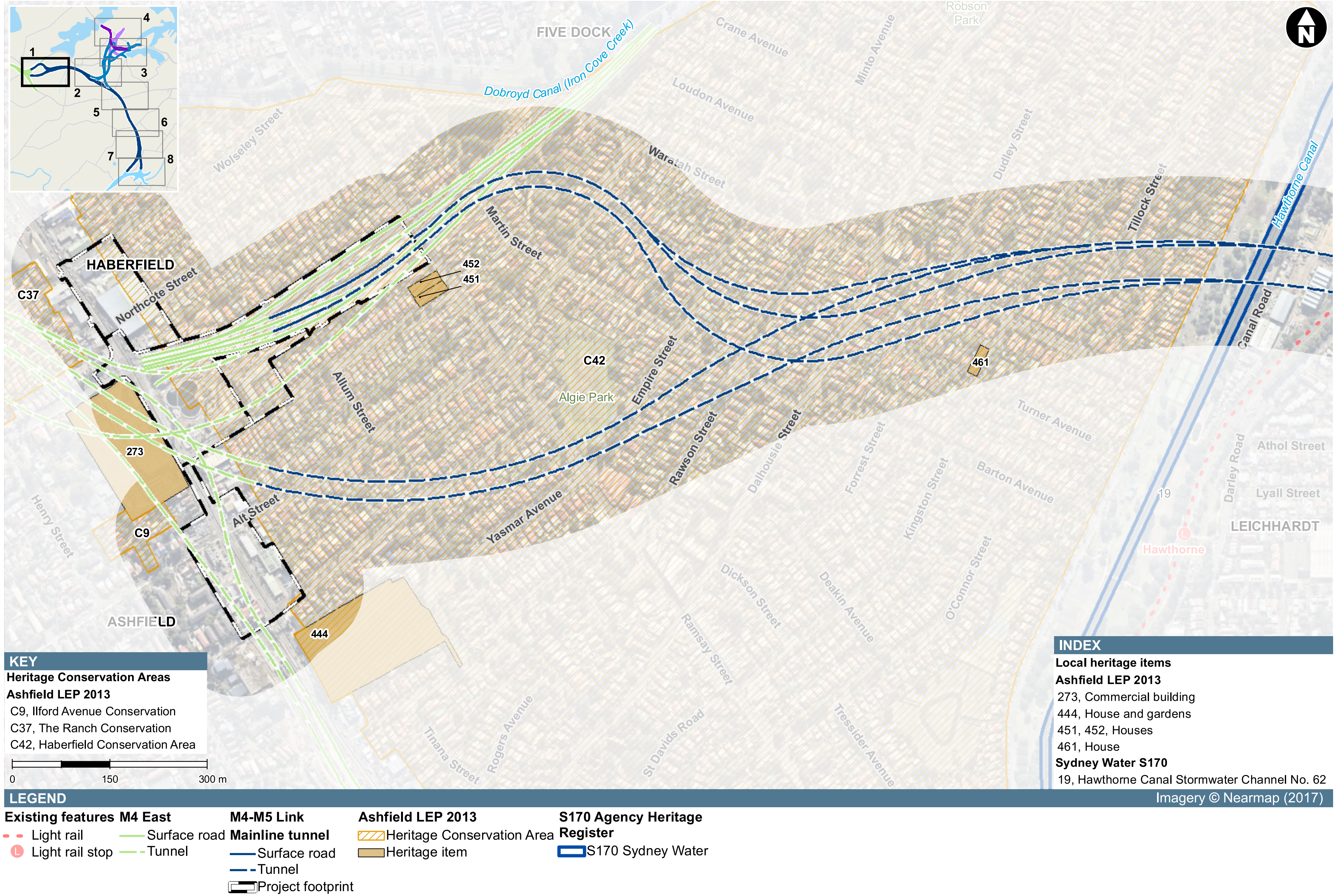
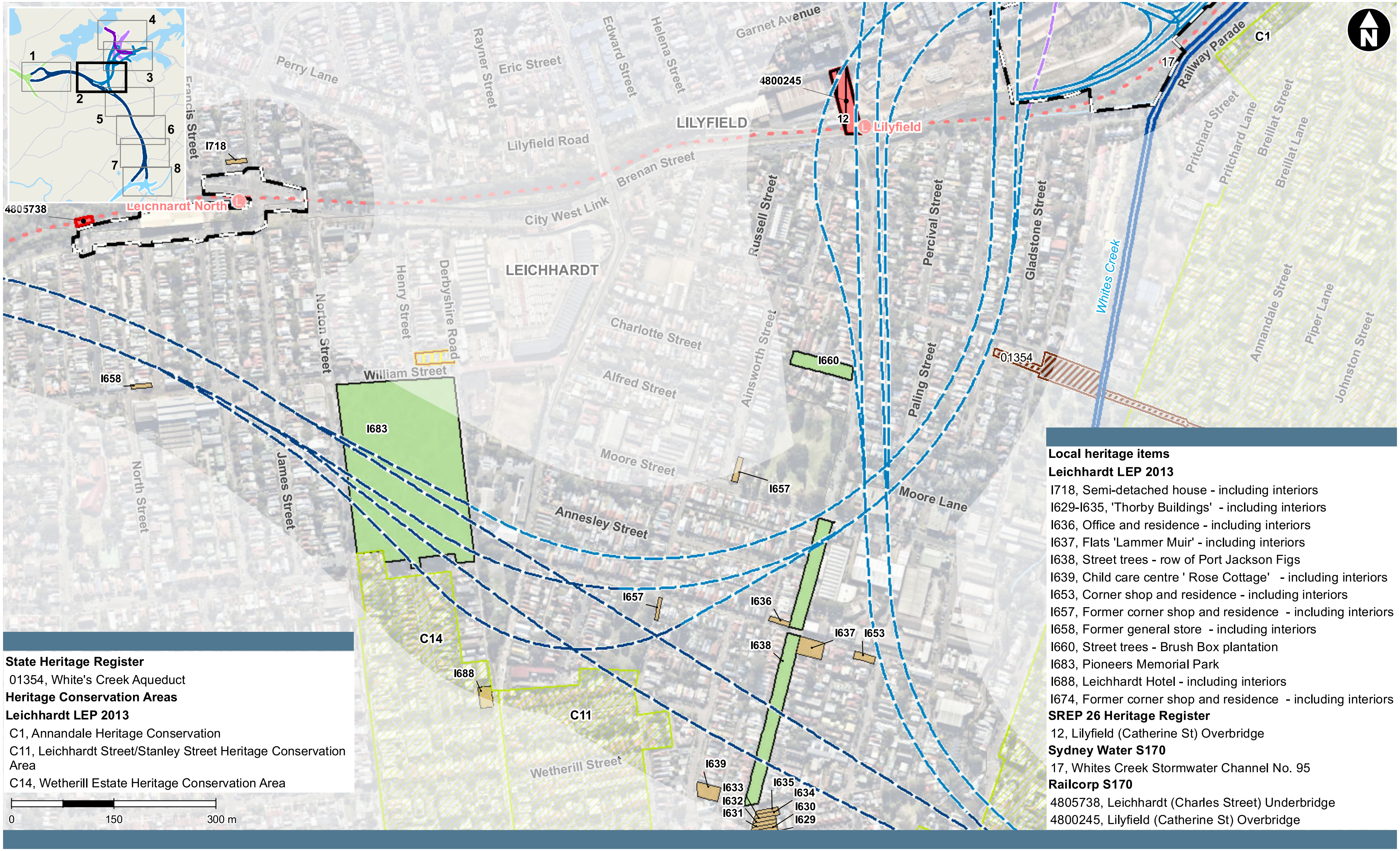


Figure 20-7 Heritage items within 100 metres of the project footprint – Map 1



Existing features
Light rail
Light rail stop

M4-M5 Link Mainline tunnel
Tunnel

M4-M5 Link Rozelle interchange
Surface road
Tunnel
Project footprint

Proposed future WHTBL connections (civil construction only)
Surface road
Tunnel

State Heritage Register
Item

SREP 26 Heritage Register
Item

Leichhardt LEP 2013
Heritage Conservation Area
Heritage item
Landscape heritage item

S170 Agency Heritage Register
S170 Sydney Water
S170 RailCorp item

Potential heritage item
Item

Figure 20-8 Heritage items within 100 metres of the project footprint – Map 2

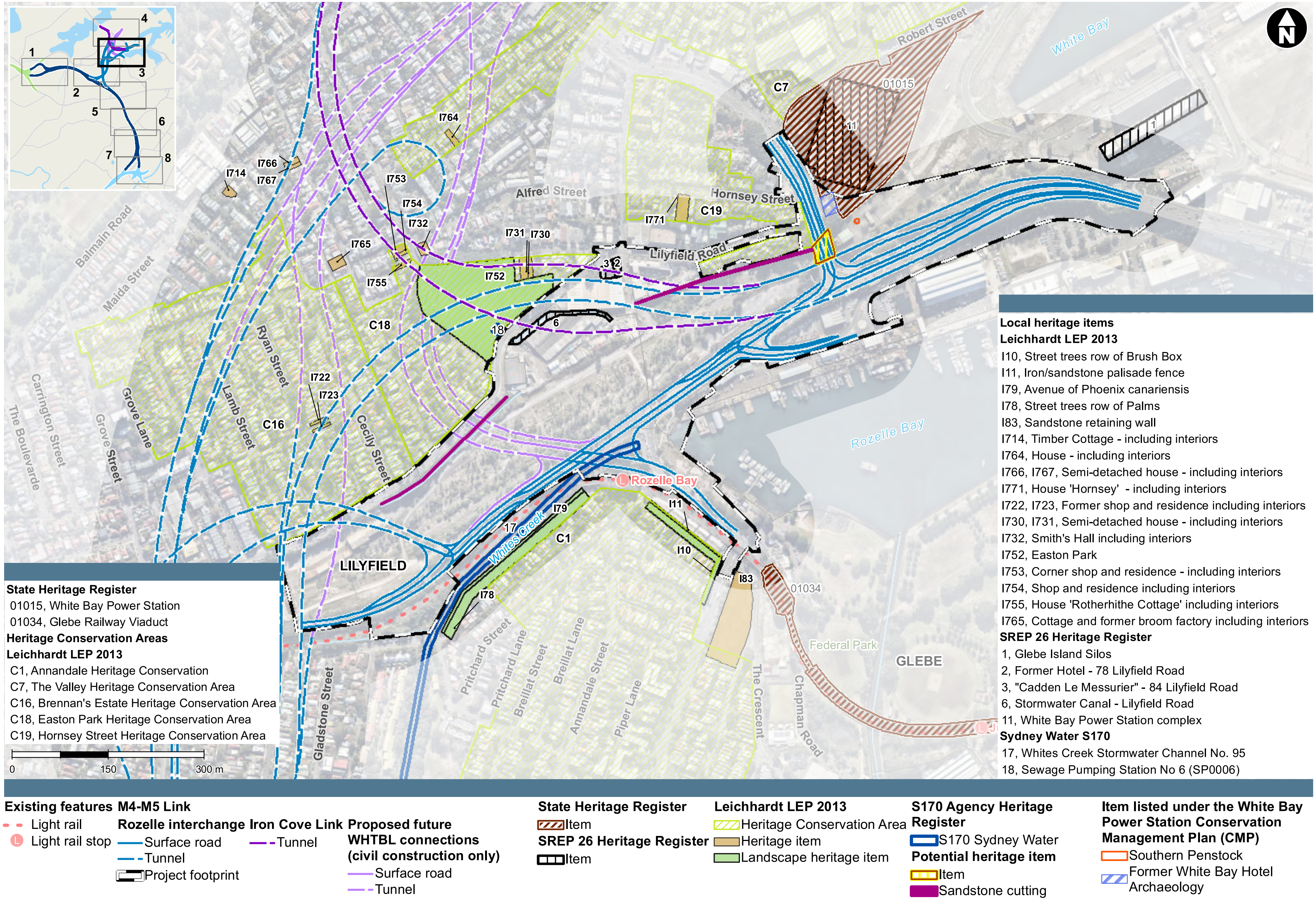
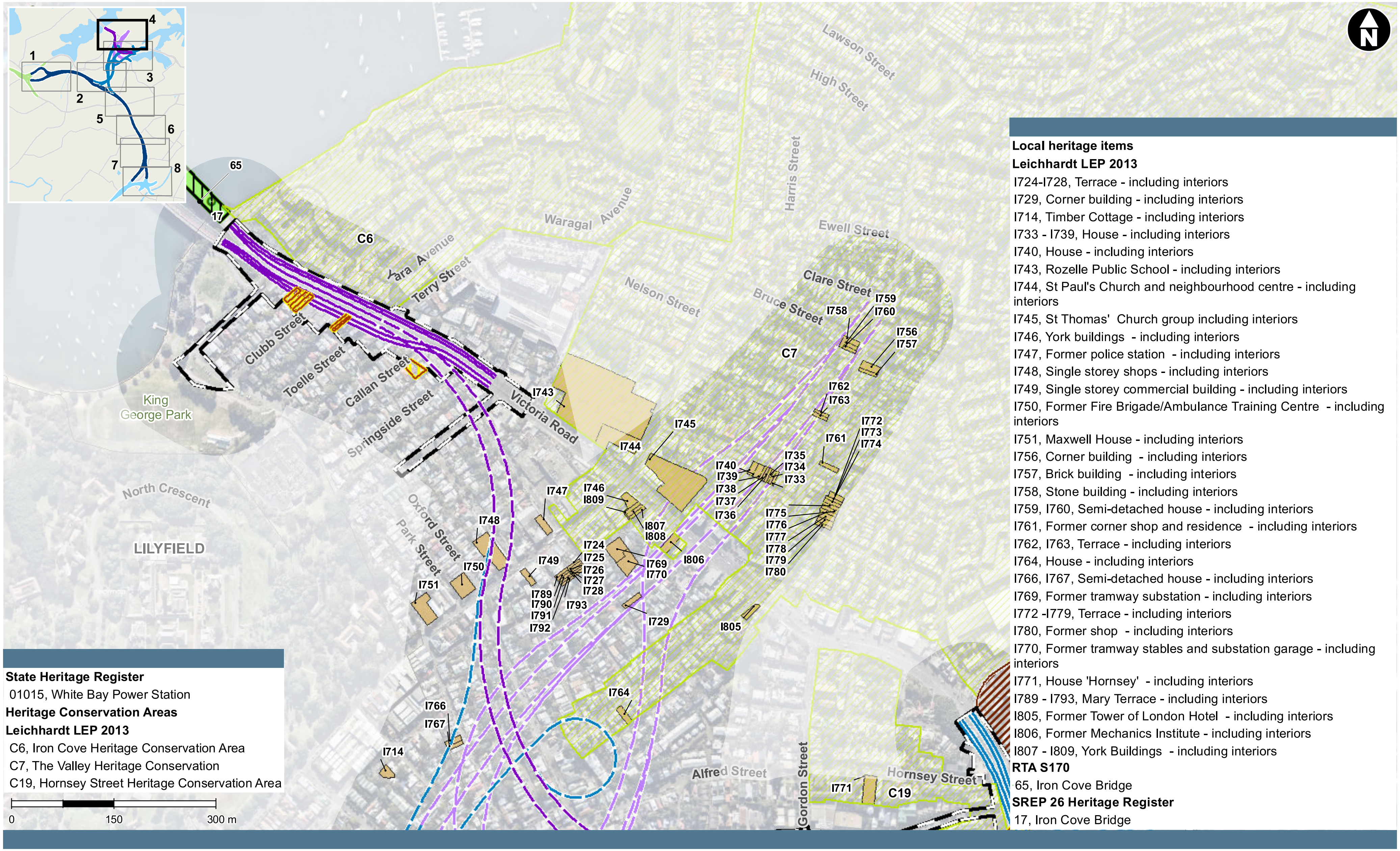


Figure 20-9 Heritage items within 100 metres of the project footprint – Map 3



M4-M5 Link

Rozelle interchange
- Surface road
- Tunnel
- Project footprint

Iron Cove Link
- Surface road
- Tunnel

Proposed future WHTBL connections (civil construction only)
- Tunnel

State Heritage Register
- Item

SREP 26 Heritage Register
- Item

Leichhardt LEP 2013
- Heritage Conservation Area
- Heritage item

S170 Agency Register
- S170 RTA item

Potential heritage item
- Item

Item listed under the White Bay Power Station Conservation Management Plan (CMP)
- Southern Penstock
- Former White Bay Hotel Archaeology

Figure 20-10 Heritage items within 100 metres of the project footprint – Map 4

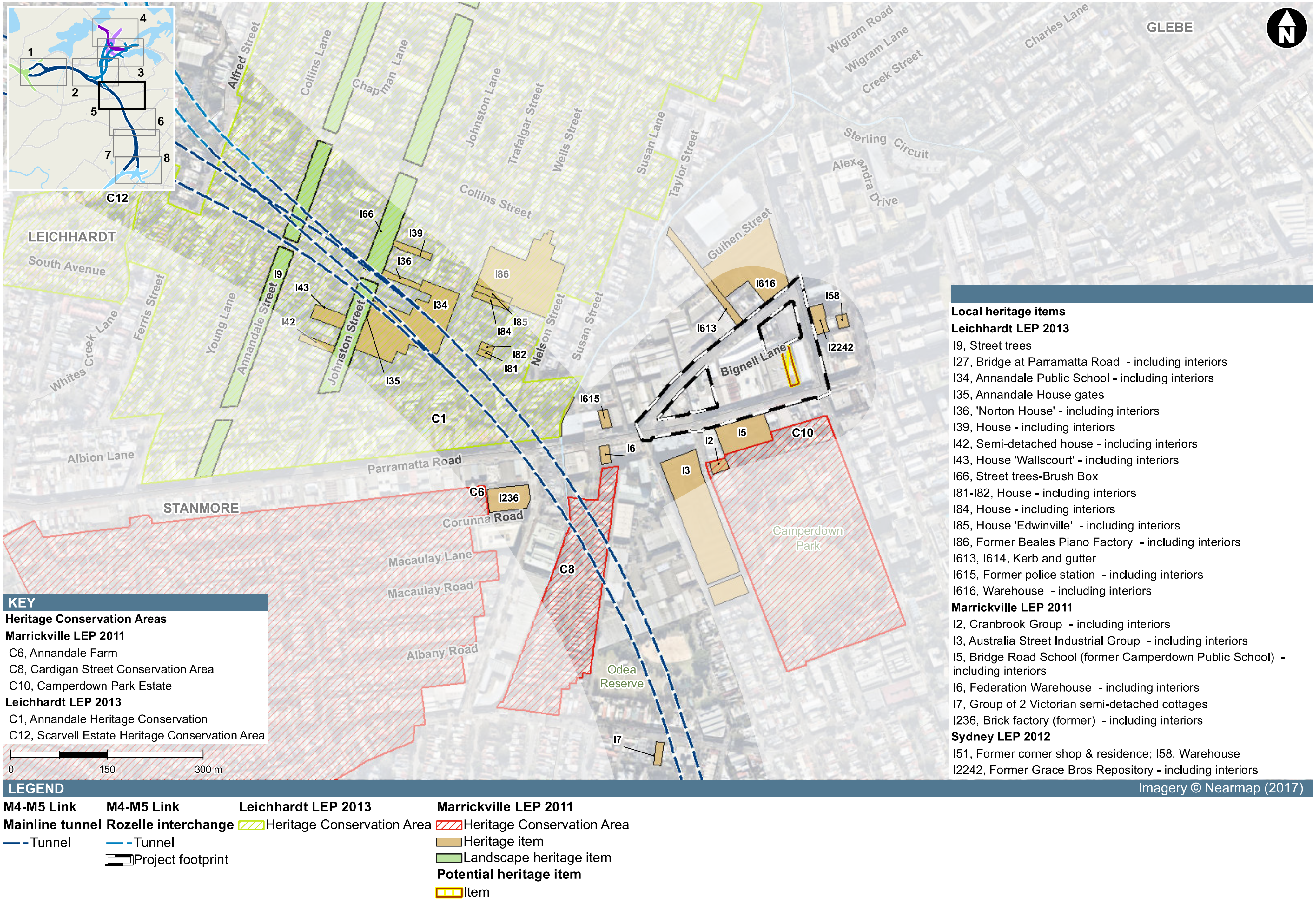


Figure 20-11 Heritage items within 100 metres of the project footprint – Map 5

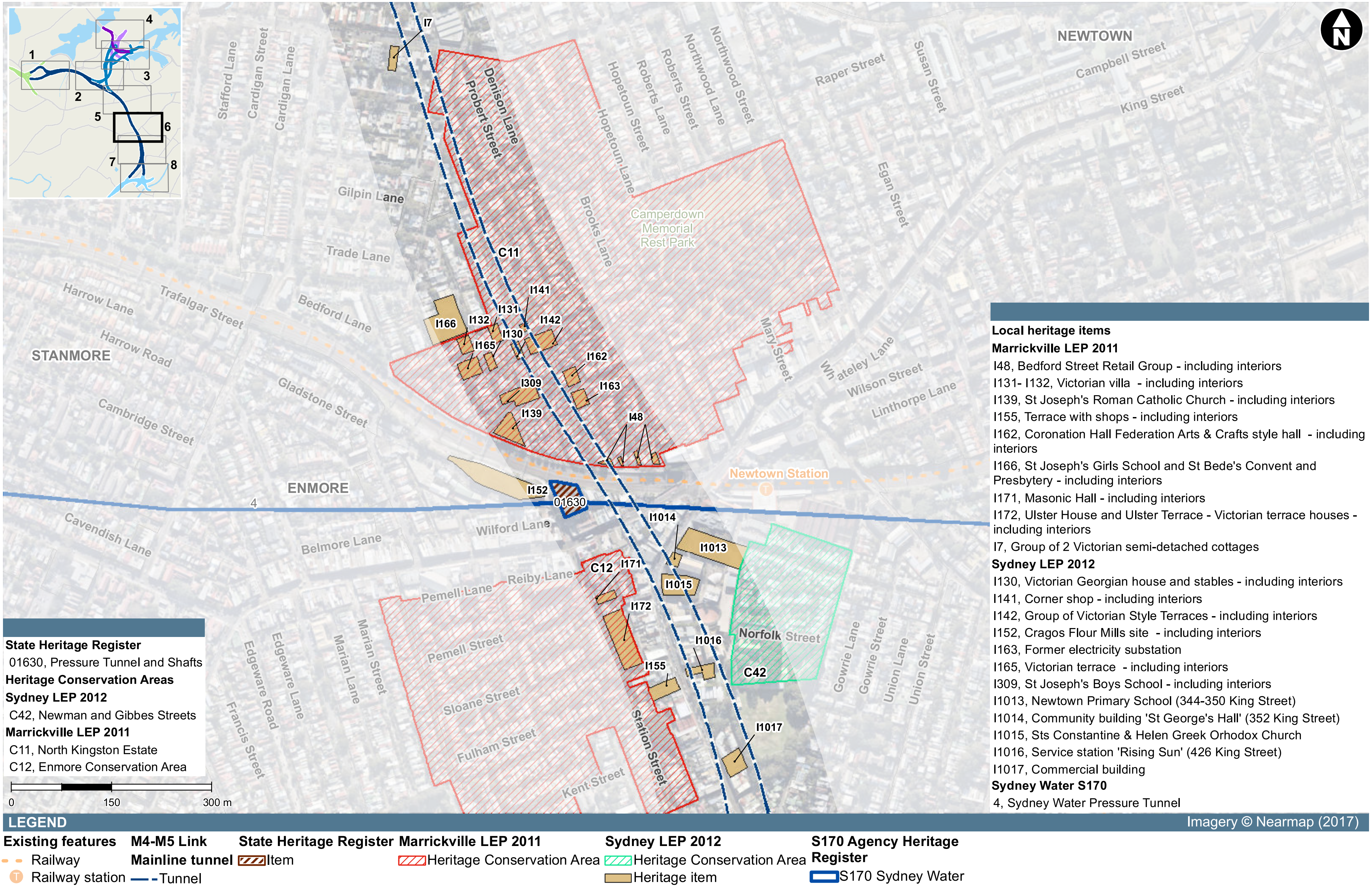


Figure 20-12 Heritage items within 100 metres of the project footprint – Map 6

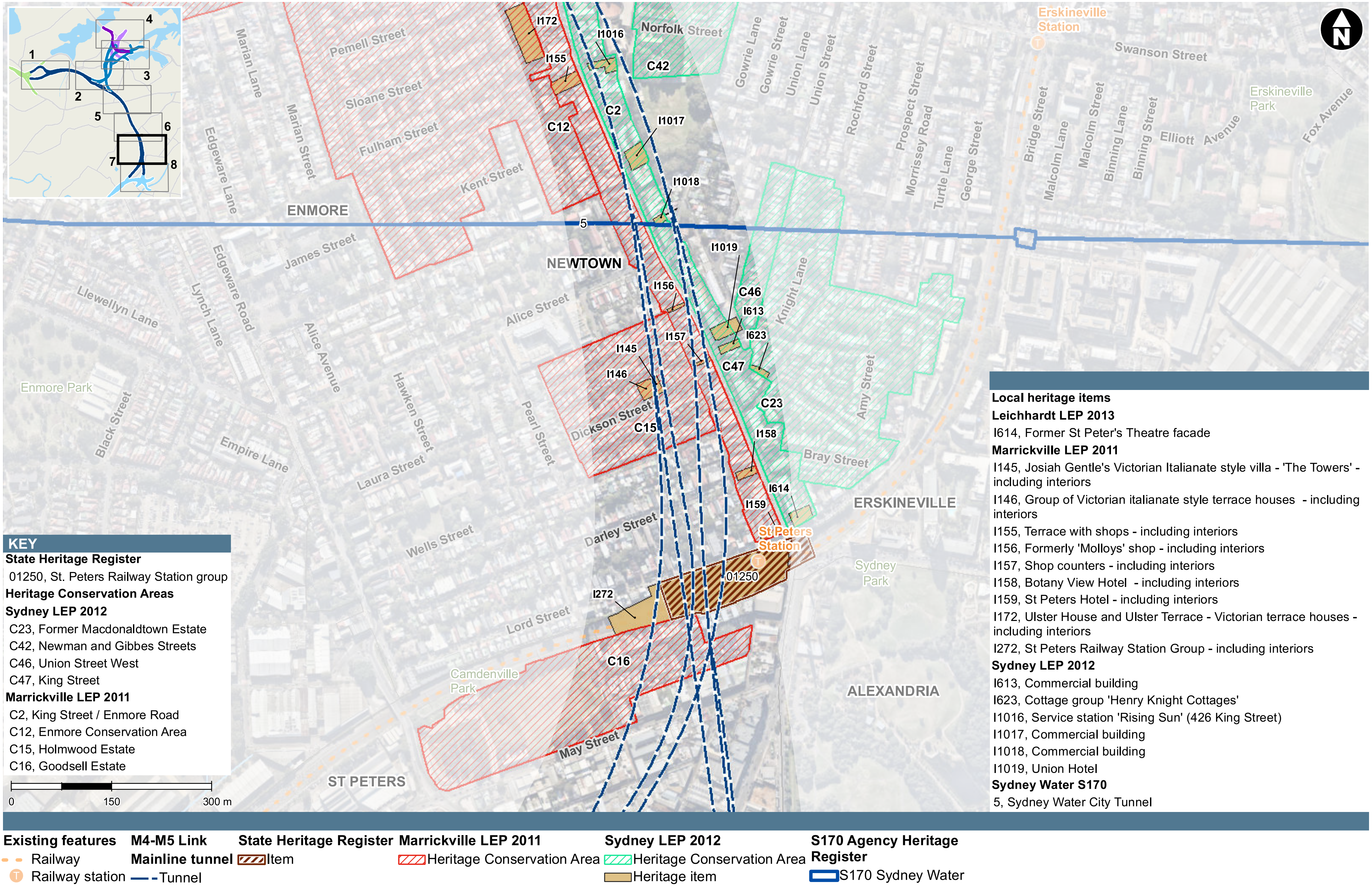
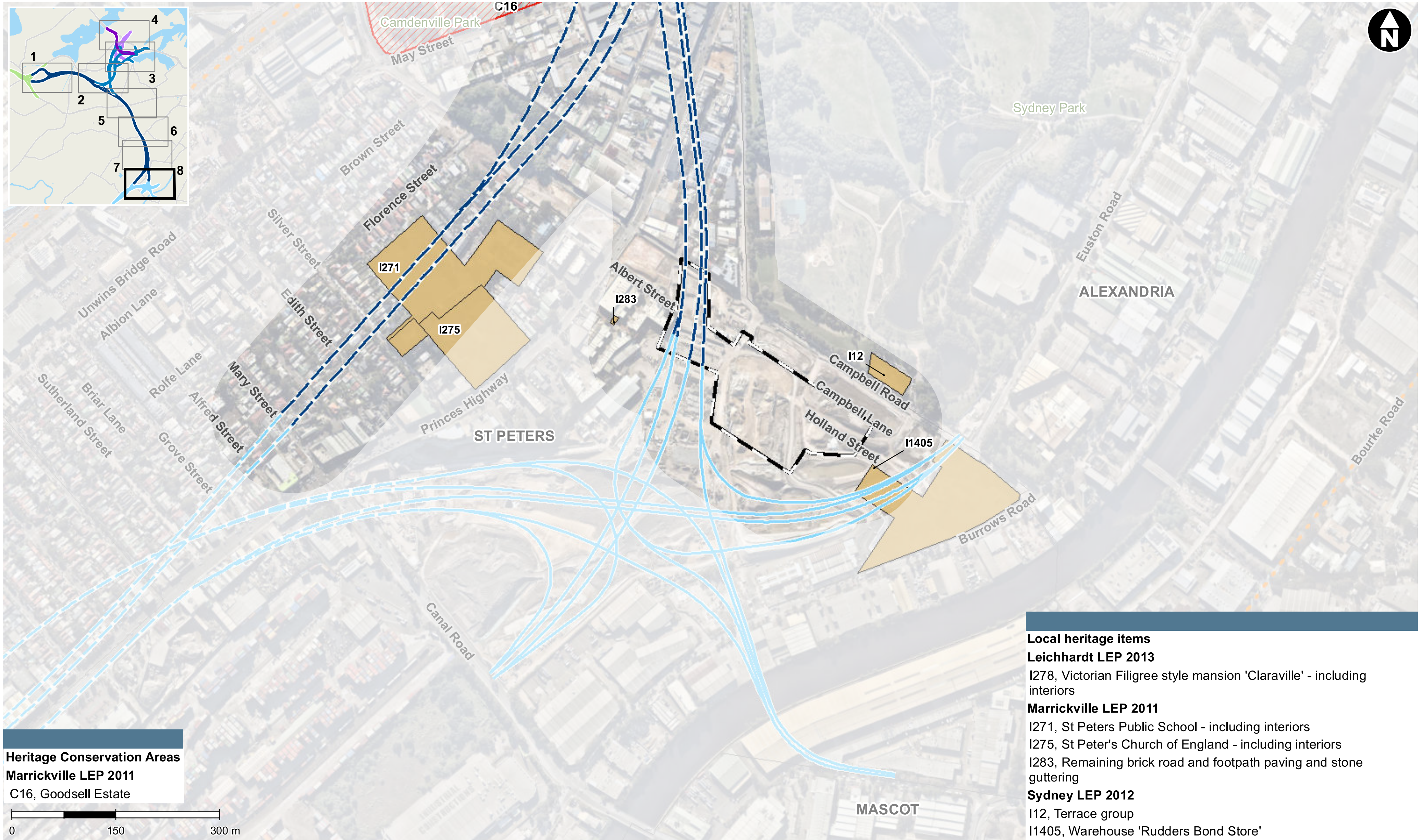


Figure 20-13 Heritage items within 100 metres of the project footprint – Map 7



LEGEND

Imagery © Nearmap (2017)

Existing features
Railway

New M5
Surface road
Tunnel

M4-M5 Link
Mainline tunnel
Tunnel
Project footprint

Marrickville LEP 2011
Heritage Conservation Area
Heritage item

Figure 20-14 Heritage items within 100 metres of the project footprint – Map 8

20.3 Assessment of potential impacts

20.3.1 Historical archaeology

Surface works associated with construction of the project have the potential to affect the archaeological resources identified in **section 20.2**. **Table 20-16** outlines the potential impacts on the identified HAMUs.

Where required, management measures to mitigate potential impacts on archaeological resources within the study area have been recommended. These are included in **section 20.4**.

Table 20-16 Potential impacts on HAMUs within the study area

HAMU	Activity	Potential impacts
HAMU 1 – Haberfield/ Ashfield	Works within HAMU 1 would include: • Enabling works • Tunnelling • Surface earthworks and structures • Finishing works.	Given that significant archaeological remains are considered unlikely in this HAMU, the project would have no impact on significant archaeological remains.
HAMU 2 – Darley Road	Works within HAMU 2 would include: • Enabling works • Drainage • Tunnelling • Construction of a permanent water treatment plant • Finishing works.	Given previous developments within this HAMU are likely to have completely removed any archaeological remains, project works would have no impact on significant archaeological remains.
HAMU 3 – Lilyfield Road and Gordon Street	Works within HAMU 3 would include: • Enabling works • Tunnelling • Surface works and structures • Drainage • Pavement • Operational ancillary facilities • Finishing works.	Deep excavation would result in a major adverse impact on archaeological remains, while surface works (such as drainage and finishing works) would have more localised impacts on archaeological remains that may be present within this HAMU. To mitigate these impacts, management measures outlined in **section 20.4** would be implemented, including preparation of a Historical Archaeological Research Design (HARD) which would include an assessment of any detailed design plans to develop a methodology and scope for a program of test excavation to determine the nature, condition and extent of potential archaeological remains.

HAMU	Activity	Potential impacts
HAMU 4 – Victoria Road/City West Link	Works within HAMU 4 would include: • Enabling works • Surface works and structures • Bridgeworks • Drainage • Pavement • Finishing works.	This HAMU is considered to have a low potential for archaeological remains, and any surviving remains are likely to have been highly disturbed and would not meet the threshold for local significance. Therefore, the works proposed in this HAMU are considered to have no impact on significant archaeological remains.
HAMU 5 – Rozelle Rail Yards (West)	Works within HAMU 5 would include: • Enabling works • Tunnelling • Surface earthworks and structures • Drainage • Pavement • Operational ancillary facilities • Finishing works.	This HAMU has low potential for archaeological remains, and any surviving remains are likely to have been highly disturbed and would not meet the threshold for local significance. Therefore, project works in this HAMU would have no impact on significant archaeological remains.
HAMU 6 – Rozelle Rail Yards (East)	Works within HAMU 6 would include: • Enabling works • Tunnelling • Earthworks and associated structures • Drainage • Pavement • Finishing works.	Deep excavation would result in a major adverse impact on archaeological remains, while surface works (such as drainage and finishing works) would have more localised impacts on archaeological remains that may be present within this HAMU. To mitigate these impacts, management measures outlined in **section 20.4** would be implemented, including preparation of a HARD which would include an assessment of any detailed design plans to develop a methodology and scope for a program of test excavation to determine the nature, condition and extent of potential archaeological remains.

HAMU	Activity	Potential impacts
HAMU 7 – White Bay Power Station	Works within HAMU 7 would include construction of the temporary City West Link to Anzac Bridge alignment, which would cross over the southern penstock of the power station complex.	The extent of excavation in this area is unknown at this stage and would be confirmed during detailed design. However, physical and indirect impacts on this heritage element should be avoided. The potential for impacts on these elements would be managed via the preparation of a HARD to guide archaeological investigation of the HAMU. Further details of management measures for the White Bay Power Station are outlined in **section 20.4** and include implementing protective measures for the water channels and southern penstock.
HAMU 8 – Iron Cove	Works within HAMU 8 would include: • Enabling works • Earthworks and associated structures • Tunnelling • Pavement • Operational ancillary facilities • Finishing works.	This HAMU has low potential for archaeological remains, and any surviving remains are likely to have been highly disturbed and would not meet the threshold for local significance. Therefore, project works in this HAMU would have no impact on significant archaeological remains.
HAMU 9 – Manning Street bioretention facility	Works within HAMU 9 would include construction of a new bioretention facility and upgrades to the existing car park within King George Park, adjacent to Manning Street at Rozelle, to treat stormwater runoff generated by the surface road works associated with the Iron Cove Link.	These works would require excavation in the area of identified archaeological potential, and are therefore likely to result in a major adverse impact on archaeological remains of local significance. To mitigate this impact, management measures outlined in **section 20.4** would be implemented, including preparation of a HARD which would include an assessment of any detailed design plans to develop a methodology and scope for a program of test excavation to determine the nature, condition and extent of potential archaeological remains.
HAMU 10 – Bignell Lane	Works within HAMU 10 would include: • Enabling works • Earthworks and associated structures • Pavement • Finishing works.	Deep excavation would result in a major adverse impact on archaeological remains, while surface works (such as drainage and finishing works) would have more localised impacts on archaeological remains that may be present within this HAMU. To mitigate this impact, management measures outlined in **section 20.4** would be implemented, including preparation of a HARD which would include an assessment of any detailed design plans to develop a methodology and scope for a program of test excavation to determine the nature, condition and extent of potential archaeological remains.

HAMU	Activity	Potential impacts
HAMU 11 – Parramatta Road/ Pyrmont Bridge Road	Works within HAMU 11 would include: • Enabling works • Earthworks and associated structures • Tunnelling • Pavement • Finishing works.	Deep excavation would result in a major adverse impact on archaeological remains, while surface works (such as drainage and finishing works) would have more localised impacts on archaeological remains that may be present within this HAMU. To mitigate this impact, management measures outlined in **section 20.4** would be implemented, including preparation of a HARD which would include an assessment of any detailed design plans to develop a methodology and scope for a program of test excavation to determine the nature, condition and extent of potential archaeological remains.

20.3.2 Heritage items and conservation areas

Construction of the project has the potential to impact on the heritage significance of the listed heritage items and HCAs in **Table 20-14**. Potential direct heritage impacts of the project include:

- Full or partial demolition of listed heritage items
- Full demolition of non-listed buildings assessed as having heritage values (potential heritage item)
- Full demolition of contributory buildings within an HCA
- Modifications to listed and potential heritage items/structures
- Removal of heritage vegetation
- Inadvertent damage to heritage trees/roots.

Potential indirect impacts of the project could include:

- Impacts on the curtilage or visual setting of heritage items or HCAs at Haberfield and St Peters
- Continued use of existing construction ancillary facilities in the vicinity of heritage items or HCAs
- Vibration impact from earthworks, piling and tunnelling activities
- Settlement from tunnelling activities.

Table 20-17 provides a summary of the listed heritage items that could potentially be impacted by the project.

In summary, the following impacts on non-Aboriginal heritage are expected from the project:

- Three listed heritage items would be fully demolished (major adverse impact):
  - Stormwater Canal at Rozelle (local)
  - 'Cadden Le Messurier' at Rozelle (local)
  - Former Hotel Rozelle (local)
- One item would be partially demolished (moderate adverse impact):
  - Whites Creek Stormwater Channel No. 95 at Rozelle (local)
- Several other items would be subject to potential indirect impacts through vibration, settlement and visual setting.

Items subject to full and/or partial demolition are shaded in **Table 20-17**. These items are shown in **Figure 20-15** to **Figure 20-17**.

Table 20-17 Summary of potential impacts on listed heritage items

Area	Item	Significance	Register	Impact type	Impact rating
Area 1 – Haberfield and Ashfield	Haberfield HCA	Local (potential for State)	• Ashfield LEP 2013 (ID C42)	Setting, vibration and settlement	Neutral
	Commercial Building (currently Bunnings Warehouse) at 476 Parramatta Road	Local	• Ashfield LEP 2013 (ID I273)	Setting, vibration and settlement	Neutral
Area 2 – Leichhardt	Leichhardt (Charles Street) Underbridge[1]	Local	• RailCorp S170 Register (#4805738)	Setting (from removal of existing trees along the northern boundary of the Darley Road civil and tunnel site (C4)), vibration	Minor adverse
Area 3 – Rozelle, and Lilyfield	White Bay Power Station[1]	State	• SHR (01015) • SREP 26 (11) • Pacific Power S170 Register (74)	Setting and minor curtilage encroachment	Minor adverse
	Brennan's Estate HCA	Local	• Leichhardt LEP 2013 (ID C16)	Setting, vibration and settlement	Minor adverse
	Easton Park HCA	Local	• Leichhardt LEP 2013 (ID C18)	Setting, vibration and settlement	Minor adverse
	Easton Park[1]	Local	• Leichhardt LEP 2013 (ID I752)	Setting (disturbance of tree roots), temporary visual impacts) vibration and settlement	Minor adverse
	Sewage Pumping Station No. 6[1]	Local	• Sydney Water S170 Register • (#4571704)	Setting, vibration and settlement	Minor adverse
	Hornsey Street HCA	Local	• Leichhardt LEP 2013 (ID C19)	Demolition of a non-contributory building (32 Victoria Road) within a listed HCA, potential impacts on the sandstone kerbing on the street frontage, setting, vibration and settlement	Neutral
	Whites Creek Stormwater Channel No. 95[1]	Local	• Sydney Water S170 Register • (#4570343)	Partial demolition, reshaping, setting, and vibration	Moderate adverse

Area	Item	Significance	Register	Impact type	Impact rating
	Street trees – row of palms on Railway Parade	Local	• Leichhardt LEP 2013 (ID I78)	Setting, vibration	Neutral
	Avenue of *Phoenix canariensis*	Local	• Leichhardt LEP 2013 (ID I79)	Setting, vibration	Neutral
	Annandale (Railway Parade) Railway Bridge[1]	Local	• SREP 26 (7) • RailCorp S170 Register (#4803231)	Setting, vibration	Minor adverse
	Arched Bridge (at Whites Creek)	Local	• SREP 26 (#8)	Nil	Neutral
	Annandale (Johnston Street) Underbridge[1]	Local	• SREP 26 (9) • RailCorp S170 Register (#4803229)	Setting, vibration	Neutral
	Stormwater Canal	Local	• SREP 26 (6)	Full demolition	Major adverse
	'Cadden Le Messurier'	Local	• SREP 26 (3)	Full demolition	Major adverse
	Former Hotel	Local	• SREP 26 (2)	Full demolition	Major adverse
Area 4 – Iron Cove	Iron Cove Bridge	State	• SREP SHC (17) • RTA S170 Register (65)	Setting, vibration	Minor adverse
	Iron Cove HCA	Local	• Leichhardt LEP 2013 (ID C6)	Setting, vibration	Neutral
Area 5 – Annandale	Kerb and gutter on Chester Street[1]	Local	• Leichhardt LEP 2013 (ID I613)	Setting, vibration	Neutral
	Warehouse including interiors at 52–54 Pyrmont Bridge Road[1]	Local	• Leichhardt LEP 2013 (ID I616)	Setting, vibration	Minor adverse
	Former Grace Bros Repository including interiors[1]	Local	• Sydney LEP 2012 (ID I2242)	Setting, vibration	Minor adverse

Area	Item	Significance	Register	Impact type	Impact rating
	Bridge Road School (former Camperdown Public School), including interiors[1]	Local	• Marrickville LEP 2011 (ID I5)	Setting, vibration and settlement	Minor adverse
Area 6 – St Peters	Terrace group at 2–34 Campbell Road	Local	• Sydney LEP 2012 (ID I12)	Setting, vibration	Neutral

Notes [1]Indicates items located within safe working distances of the project that may experience vibration impacts (see **section 20.3.4**)

20.3.3 Potential heritage

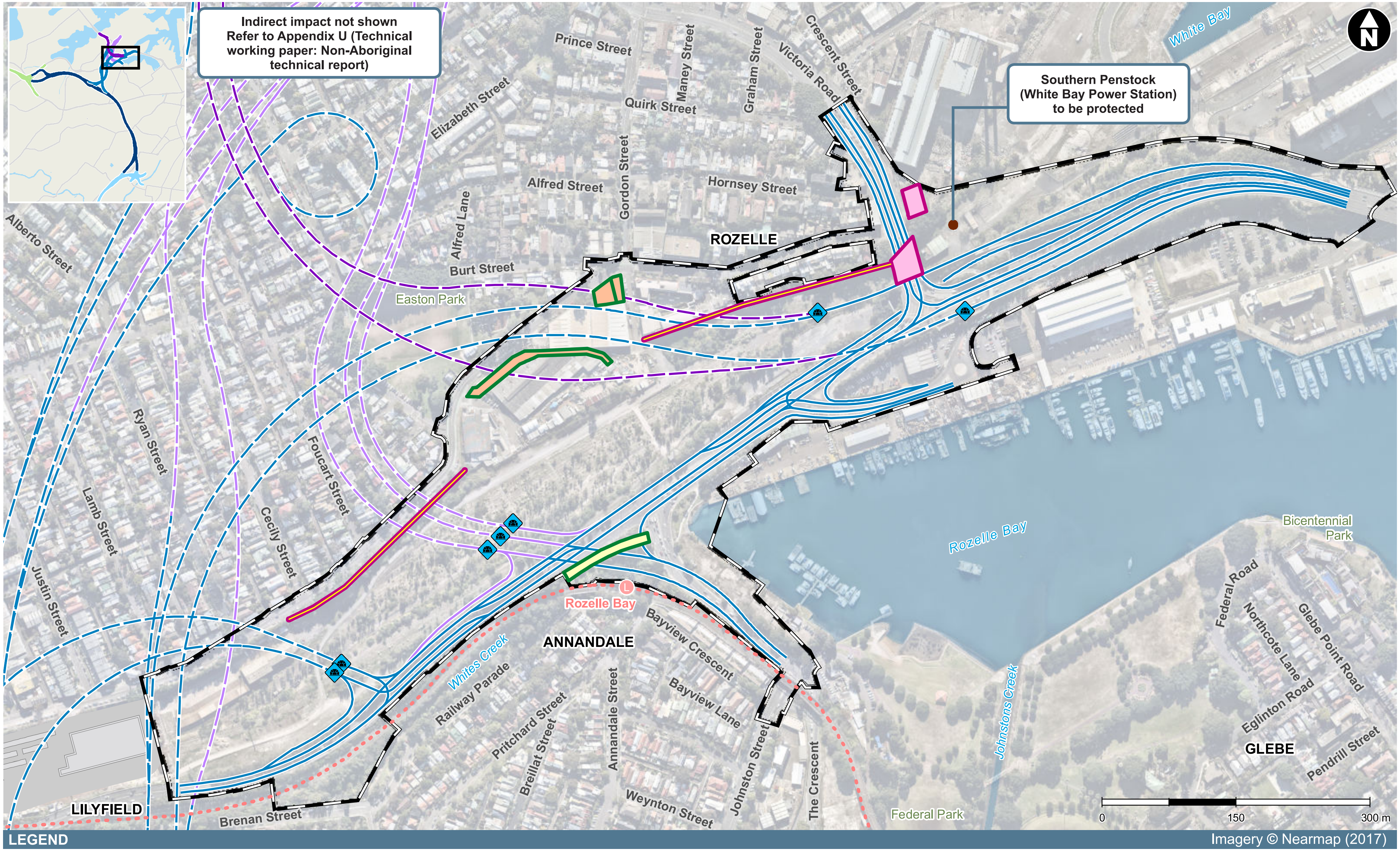
Table 20-18 provides a summary of the 17 identified items of potential heritage value that could be affected by the project. These items have been assessed as having potential local significance. In summary, the following impacts on potential heritage items are expected from the project:

- Nine potential local heritage items would be subject to direct impacts through full demolition
- One potential local heritage item would be subject to direct impacts through partial demolition
- One structure assessed as being of potential state significance would be indirectly impacted through vibration
- Six potential local heritage items and one potential state item would be subject to indirect impacts through setting, vibration and/or settlement.

Items subject to full or partial demolition are shaded in **Table 20-18**. These items are shown in **Figure 20-15** to **Figure 20-17**.

Table 20-18 Summary of potential impacts on potential heritage items

Area	Item	Assessed significance	Impact type	Impact rating
Area 1 – Haberfield/ Ashfield	135 Bland Street, Haberfield	Local	Setting	Neutral
	136 Bland Street, Haberfield	Local	Setting	Neutral
	138 Bland Street, Haberfield	Local	Setting	Neutral
	139 Alt Street, Ashfield	Local	Nil	Neutral
	144 Alt Street, Ashfield	Local	Nil	Neutral
Area 3 – Rozelle and Lilyfield	Victoria Road bridge, Rozelle	Local	Full demolition	Major adverse
	Sandstone cutting within the Rozelle Rail Yards, Rozelle	Local	Partial demolition	Moderate adverse
	White Bay Hotel site foundations (plinth and archaeology)	Local	Full Demolition	Major adverse
	White Bay Power Station Southern Penstock	State	Vibration	Neutral
Area 4 – Iron Cove	Property at 260 Victoria Road, Rozelle	Local	Full demolition	Major adverse
	Property at 262 Victoria Road, Rozelle	Local	Full demolition	Major adverse
	Property at 264 Victoria Road, Rozelle	Local	Full demolition	Major adverse
	Property at 266 Victoria Road, Rozelle	Local	Full demolition	Major adverse
	Properties at 248 Victoria Road, Rozelle	Local	Full demolition	Major adverse
	Terraces at 250 Victoria Road, Rozelle	Local	Full demolition	Major adverse
	Brick house at 8 Callan Street, Rozelle	Local	Vibration, setting	Neutral
Area 5 – Annandale	Former Bank of NSW at 164 Parramatta Road, Annandale	Local	Full demolition	Major adverse



LEGEND

Existing features
- Light rail
- Light rail stop

Project features
- Tunnel portal

M4-M5 Link

Rozelle interchange
- Surface road
- Tunnel

Iron Cove Link
- Tunnel

Proposed future WHTBL connections (civil construction only)
- Surface road
- Tunnel

Boundaries
- Project footprint

Listed heritage items
- Full demolition
- Partial demolition

Potential heritage items
- Full demolition
- Partial demolition

Figure 20-15 Listed and potential heritage items directly impacted at Rozelle, Lilyfield and Annandale

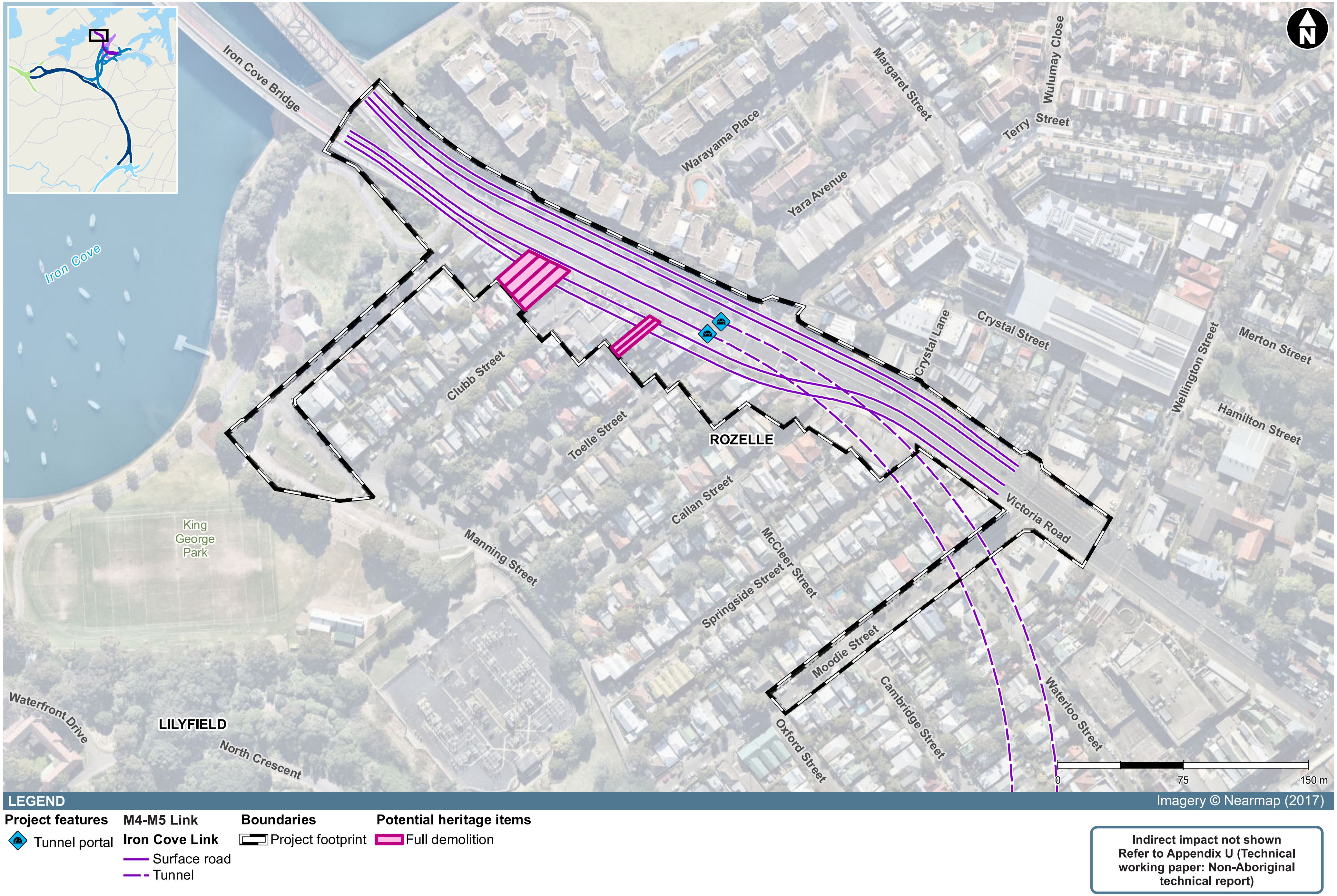


Figure 20-16 Listed and potential heritage items directly impacted at Victoria Road (east of the Iron Cove Bridge)

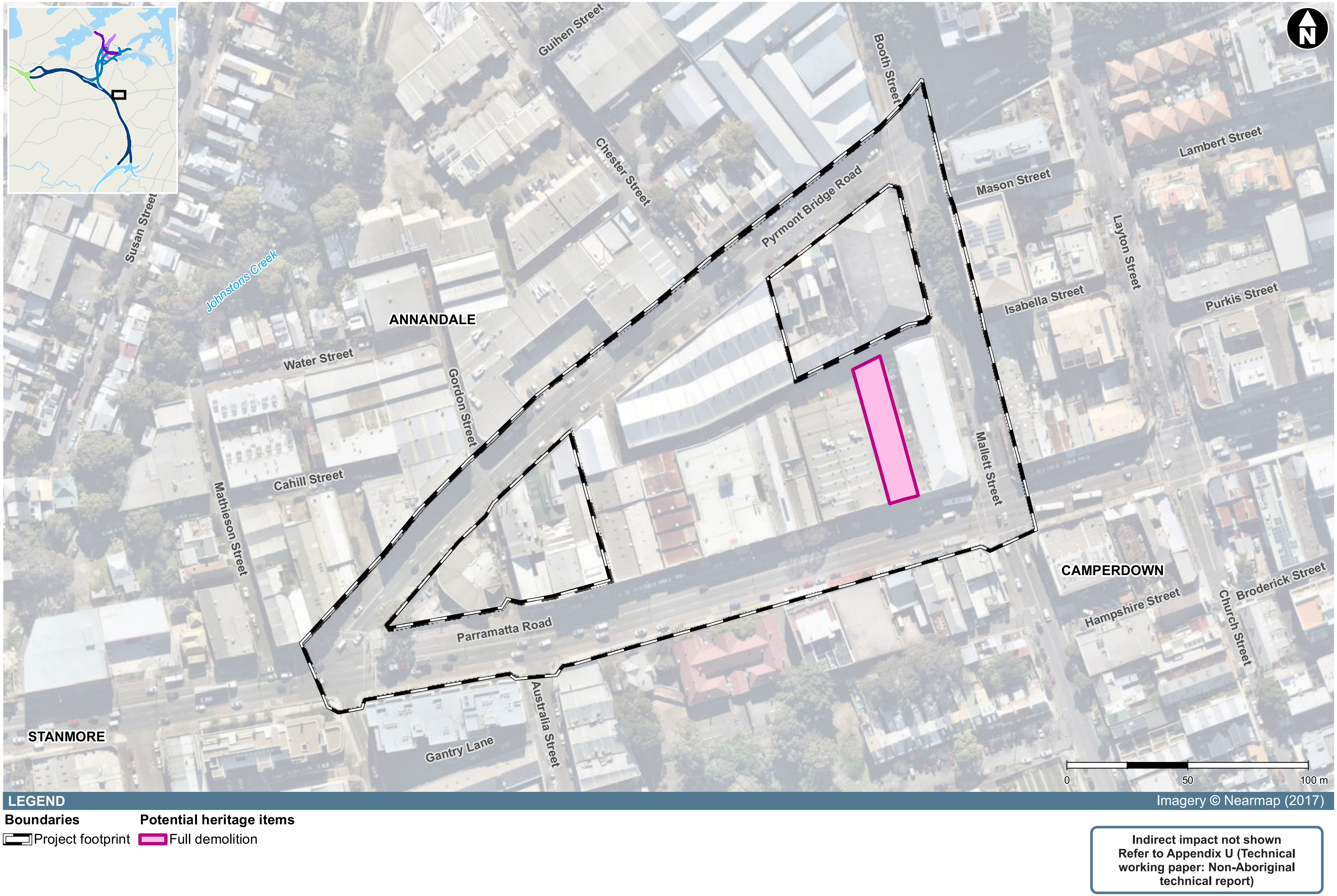


Figure 20-17 Listed and potential heritage items directly impacted at Annandale

20.3.4 Vibration and settlement

Heritage items, potential heritage items and HCAs along the tunnel alignment and in the vicinity of construction works may be subject to ground movement (predominantly settlement and vibration). Areas most likely to be affected by settlement are usually where tunnelling is closest to the ground surface (shallowest), around the tunnel portals and entry and exit ramps, and where soils are more likely to be compressible. This includes the estuarine and alluvial soils and fill material within the palaeovalley around the Rozelle Rail Yards.

The alignment of the tunnels and the locations of tunnel portals have given regard to maximising the use of the best possible geotechnical conditions. For much of its length, the tunnelling work for the project would be undertaken at depths of between 20 metres and greater than 65 metres below ground, which is unlikely to adversely affect structures above the tunnels.

Potential vibration impacts to heritage items have been assessed with 11 listed heritage items located within safe working distances of the project that may experience vibration impacts (see **Table 20-17**).

Other heritage items identified above the current project tunnelling alignment were considered with regard to vibration and settlement impacts. A detailed list of these items is provided in **Appendix U** (Technical working paper: Non-Aboriginal heritage). These items have been identified based on the current concept design, which may be subject to change following detailed design. Of these:

- The majority of items are assessed as having a neutral impact due to the separation distance from the tunnels. This includes:
  - The Pressure Tunnel and Shafts (Potts Hill Road to Waterloo Pumping Station Potts Hill to Waterloo, NSW) listed as a State item on the SHR (#01630) and Sydney Water S170 Register (#4570942)
  - The City Tunnel (Potts Hill Reservoir to Dowling Street Pumping Station Potts Hill to Waterloo, NSW) listed as a local item on the Sydney Water S170 Register (#4570942).
- Eight heritage items have the potential to be impacted by settlement and vibration from tunnelling activities (minor adverse impact) including:
  - Semi-detached house at 15 Burt Street, Rozelle
  - Semi-detached house at 17 Burt Street, Rozelle
  - Smith's Hall at 56 Burt Street, Rozelle
  - Corner shop and residence at 67 Denison Street, Rozelle
  - Shop and residence at 69 Denison Street, Rozelle
  - House 'Rotherhithe Cottage' at 73 Denison Street, Rozelle
  - Lilyfield (Catherine St) Overbridge at Catherine Street, Lilyfield
  - St Peters Railway Station Group King Street, St Peters.

These potential impacts are assessed in detail in **Appendix U** (Technical working paper: Non-Aboriginal heritage).

The noise and vibration assessment in **Appendix J** (Technical working paper: Noise and vibration) identifies vibration criteria and impact assessment for sensitive receivers. The report identifies that the minimum 'safe limit' of peak vibration velocity at low frequencies for structures (including heritage listed buildings), is three millimetres per second.

Vibration impacts would be managed in accordance with the recommendations of the noise and vibration assessment (**Appendix J** (Technical working paper: Noise and vibration)). Appropriate monitoring and protection of the physical fabric of heritage items to be retained would be provided during construction of the project.

Settlement is not anticipated to impact heritage items identified along the mainline tunnel alignment. A program to monitor settlement during operations would be outlined in the Operational Environmental Management Program for the project.

20.4 Environmental management measures

The detailed design and construction of the project would be managed to ensure that the identified potential heritage and archaeological impacts are minimised and/or avoided as far as practical, by implementing a range of environmental management measures.

The management measures provided in **Table 20-19** have been developed to avoid, reduce and manage identified potential impacts on non-Aboriginal heritage. These measures would be further developed on a case by case basis during detailed design. The final management measures would be documented in the Construction Environmental Management Plan (CEMP).

Table 20-19 Environmental management measures – non-Aboriginal heritage

Impact	No.	Environmental management measure	Timing
Impacts on heritage items	NAH01	A Construction Heritage Management Plan (CHMP) will be prepared and implemented as part of the CEMP. The CHMP will include: • Measures that will be implemented to manage potential impacts on items of heritage significance • Inclusion of heritage awareness and management training within the site induction process for relevant personnel involved in site works • Details regarding the conservation and curation of any historical artefacts recovered during works.	Construction
	NAH02	An Interpretation Strategy will be developed and implemented to identify and interpret the key heritage values and stories of the heritage areas affected by the project and inform the development of the Urban Design and Landscape Plan for the project, in accordance with NSW Heritage Office *Interpreting Heritage Places and Items Guideline August 2005*. The Interpretation Strategy will: • Build on themes, stories and initiatives proposed as part of other stages of WestConnex to ensure a consistent approach to heritage interpretation for the project • Include themes and stories including the Rozelle railways historic functions, trains and trams transport, industrialisation and The Rozelle-Darling Harbour Goods Line • Identify how the rail related infrastructure salvaged from the Rozelle Rail Yards will be reused.	Construction
	NAH03	Photographic recording will be undertaken of: • Infrastructure associated with the White Bay Power Station site that could be affected by the project • Whites Creek Stormwater Channel (in the area to be impacted) • Stormwater Canal off Lilyfield Road	Construction

Impact	No.	Environmental management measure	Timing
		• 'Cadden Le Messurier' at 84 Lilyfield Road • Former Hotel at 78 Lilyfield Road • Victoria Road bridge • Each house at 260–266 Victoria Road • Each house at 248–250 Victoria Road • Former Bank of NSW (164 Parramatta Road). It will be undertaken in accordance with the NSW Heritage Office guidelines *Photographic Recording of Heritage Items Using Film or Digital Capture* (2006). The photographic recording will occur prior to any works that have the potential to impact upon the items and the report development process will include the identification of appropriate stakeholders to receive copies of the documentation.	
	NAH04	As part of the CHMP, a HARD will be prepared before the start of proposed works within each of the following HAMUs: HAMU 3, HAMU 6, HAMU 7, HAMU 9, HAMU 10, and HAMU 11. The HARD will be prepared by a qualified archaeologist in consultation with the NSW Heritage Council and would include: • Descriptions of clear significance thresholds for possible archaeological items that may be uncovered during works • A methodology and scope for a program of archaeological excavation, investigation, and recording of any historical archaeological remains that will be impacted by the project • Requirement for post-excavation reporting, including artefact analysis and additional historical research, where necessary, and long term management of records • Details of what will happen with any artefacts uncovered and associated reports.	Construction
	NAH05	Before excavation of archaeological management sites, a suitably qualified Excavation Director who complies with the *Criteria for Assessment of Excavation Directors* (Heritage Council of NSW 2011) will be engaged to advise on matters associated with historic archaeology. Where archaeological excavation is required, the Excavation Director will oversee excavation and advise on archaeological matters.	Construction
Heritage impacts due to vibration	NAH06	Potential vibration impacts to features of heritage significance will be managed in accordance with the Construction Noise and Vibration Management Plan prepared for the project.	Construction
Heritage impacts due to settlement	NAH07	Potential heritage impacts due to settlement and ground movement caused by the project will be managed in accordance with the relevant measures identified in **Chapter 12** (Land use and property) and	Construction

Impact	No.	Environmental management measure	Timing
		monitored in accordance with the Settlement Monitoring Plan.	
Impacts to unexpected items of potential heritage conservation significance or human remains	NAH08	Any items of potential heritage conservation significance or human remains discovered during construction will be managed in accordance with an Unexpected Heritage Finds and Humans Remains Procedure developed for the project in accordance with relevant guidance provided by the Heritage Council of NSW, the NSW Heritage Division of the Office of Environment and Heritage and *Unexpected Archaeological Finds* (Roads and Maritime 2015a). The procedure will detail requirements regarding notification of relevant agencies and the NSW Police and will be implemented for the duration of construction.	Construction
Impact on potential salvageable items	NAH09	A Heritage Salvage Strategy will be prepared to identify the salvage potential of the fabric and features from heritage items and potential heritage items that will be demolished to facilitate the project. This could include timber joinery, fireplaces, stained glass, stairs, decorative tiles, bricks, steel truss structures, windows etc. The strategy will also identify options and a process for dissemination of salvaged items to owners, community groups and interested parties.	Construction
	NAH10	Sandstone kerbing in the vicinity of 32 and 34 Victoria Road, Rozelle that will be removed to facilitate the project will be salvaged and provided to Inner West Council.	Construction
Loss of heritage where items are required to be demolished	NAH11	The railway cutting on the eastern side of Victoria Road, associated with the White Bay Power Station, will be considered during the development of the detailed design for the realigned Victoria Road and associated bridge. The final design will seek to avoid impact to the railway cutting and maintain the visual relationship between the cutting and the White Bay Power Station site. Landscaping sympathetic to the relationship, developed in consultation with a heritage specialist, will be included in the Urban Design and Landscape Plan for the project.	Construction
	NAH12	A condition assessment of the southern penstock (and its associated water channels) will be carried out by a heritage specialist and a structural engineer prior to any works in the vicinity with the potential impact upon the item. If required any conservation works required to limit potential impacts on deteriorated fabric (loose bricks, corroded steel) will be identified and implemented prior to construction.	Construction
	NAH13	The southern penstock and its associated water channels (location and extent unknown) will be protected during works associated with the reconstruction of the Victoria Road Bridge.	Construction
Potential impact to Whites Creek	NAH14	The new bridge over the Whites Creek Stormwater Channel must not impact the extant significant heritage fabric of the channel and should be a solely	Construction

Impact	No.	Environmental management measure	Timing
Stormwater Channel No. 95		independent structure.	
Potential impacts on Leichhardt (Darley Road)	NAH15	Landscaping, following the construction of the substation, should consider screening the substation and water treatment plant, from the Leichhardt (Charles Street) Underbridge. The design and location of the landscaping will be informed by a heritage specialist and should seek to create a visual separation between the new structure and the heritage item.	Construction

21 Aboriginal heritage

This chapter outlines the potential Aboriginal heritage impacts associated with the M4-M5 Link project (the project). A detailed Aboriginal heritage assessment has been undertaken for the project and is included in **Appendix V** (Technical working paper: Aboriginal heritage).

The Secretary of the NSW Department of Planning and Environment (DP&E) has issued environmental assessment requirements for the project. These are referred to as the Secretary's Environmental Assessment Requirements (SEARs). **Table 21-1** sets outs these requirements and the associated desired performance outcomes that relate to Aboriginal heritage, and identifies where they have been addressed in this environmental impact statement (EIS).

Table 21-1 SEARs – Aboriginal heritage

Desired performance outcome	SEARs	Where addressed in the EIS
14. Heritage The design, construction and operation of the project facilitates, to the greatest extent possible, the long term protection, conservation and management of the heritage significance of Aboriginal objects and places. The design, construction and operation of the project avoids or minimises impacts, to the greatest extent possible, on the heritage significance of Aboriginal objects and places.	1. The Proponent must identify and assess any direct and or indirect impact (including cumulative impacts) to the heritage significance of listed heritage items inclusive of: (a) Aboriginal places and objects, as defined under the *National Parks and Wildlife Act 1974* and in accordance with the principles and methods of assessment identified in the current guidelines; (b) Aboriginal places of heritage significance, as defined in the Standard Instrument - Principal Local Environmental Plan.	Potential impacts of the project on Aboriginal places and objects have been assessed in **section 21.3**. Potential cumulative impacts of the project on Aboriginal places and objects are described in **Chapter 26** (Cumulative impacts). Relevant legislation considered for this assessment is outlined in **section 21.1.6**.
	3. Where archaeological investigations of Aboriginal objects are proposed these must be conducted by a suitable qualified archaeologist, in accordance with section 1.6 of the Code of Practice for Archaeological Investigation of Aboriginal Objects in NSW (Department of Environment Climate Change and Water (DECCW) 2010c).	The methodology adopted for archaeological investigations is outlined in **section 21.1**.
	4. Where impacts to Aboriginal objects and/or places are proposed, consultation must be undertaken with Aboriginal people in accordance with the current guidelines.	Consultation undertaken for this assessment is outlined in **section 21.1.2**. The project would not have any impacts on Aboriginal objects and/or places.

21.1 Assessment methodology

21.1.1 Overview

The Aboriginal heritage assessment was prepared to address the SEARs by identifying any potential Aboriginal cultural heritage values relevant to the project footprint and providing appropriate recommendations for any further assessment and/or identifying appropriate management and mitigation measures.

The methodology adopted for the Aboriginal heritage assessment was developed in accordance with the requirements of NSW Roads and Maritime Services (Roads and Maritime)'s *Procedure for Aboriginal Cultural Heritage Consultation and Investigation* ((PACHCI) (Roads and Maritime 2011a). The PACHCI guides consultation and investigation of Aboriginal cultural heritage and provides a consistent guide for effective consultation with Aboriginal communities regarding activities that may impact on Aboriginal cultural heritage. By adopting the PACHCI, the assessment is consistent with the NSW Office of Environment and Heritage (OEH)'s *Aboriginal Cultural Heritage Consultation Requirements for Proponents* (NSW Department of Environment Climate Change and Water (DECCW) 2010a).

The PACHCI involves three stages:

- Stage 1 involves an initial desktop assessment as outlined below to determine whether consultation with a heritage advisor and a site survey is required
- Stage 2 involves a site survey undertaken by a heritage archaeologist and representative from the relevant Local Aboriginal Land Council (LALC), Aboriginal archaeological assessment and preparation of an application for an Aboriginal Heritage Impact Permit (AHIP) under the *National Parks and Wildlife Act 1974* (NSW) (NPW Act) (if required)
- Stage 3 involves a full Aboriginal archaeological assessment in accordance with the *Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales* (DECCW 2010c), *Guide to Investigating, Assessing and Reporting on Aboriginal Cultural Heritage in NSW* (OEH 2011) and *Aboriginal community consultation in accordance with the Aboriginal Cultural Heritage Consultation Requirements for Proponents* (DECCW 2010a). The requirement for a Stage 3 assessment is determined by whether the Stage 2 assessment identifies Aboriginal sites or areas of archaeological sensitivity that would be impacted by the project.

The PACHCI, followed for the purpose of this project as outlined below, is further detailed in Annexure A of **Appendix V** (Technical working paper: Aboriginal heritage).

A PACHCI Stage 1 Aboriginal heritage assessment was undertaken by AECOM in May 2016. This forms part of the Aboriginal heritage assessment. The findings of that Stage 1 assessment concluded that the project had the potential to harm Aboriginal places or objects.

As a result, a PACHCI Stage 2 Aboriginal heritage assessment was undertaken. The Stage 2 assessment identified potential Aboriginal heritage values within the Aboriginal Heritage Information Management Systems (AHIMS) search area using an approach of desktop research, field survey and consultation with Aboriginal stakeholders.

The assessment methodology generally involved:

- A desktop assessment including:
  - Review of publicly available databases including the AHIMS database
  - Review of the landscape context of the AHIMS search area including disturbance history
  - Review of relevant archaeological and ethnohistorical information for the AHIMS search area
  - Identification of areas of Aboriginal archaeological sensitivity within the AHIMS search area
- Aboriginal community consultation
- Archaeological survey of the project footprint

- Consideration of relevant legislation and policy requirements, as outlined in **Table 21-2** and in **section 21.1.6**
- Preparation of an Aboriginal heritage assessment (refer to **Appendix V** (Technical working paper: Aboriginal heritage)) which includes an assessment of potential impacts (including cumulative impacts) and identifies measures to mitigate these impacts.

The PACHCI Stage 3 assessment concluded that it is unlikely that Aboriginal objects or places would be impacted by the project; therefore a PACHCI Stage 3 is not required. The relevant guidelines listed in **section 21.1.6** are still relevant for Stages 1 and 2 and were followed for the Aboriginal heritage assessment.

21.1.2 Study area

The study area for this Aboriginal heritage assessment is consistent with the project footprint and is referred to as such throughout this chapter. This area includes all temporary (construction) and permanent (operational) project land, infrastructure and associated construction ancillary facilities. The study area is shown in **Figure 21-1**.

21.1.3 AHIMS search area

A search of the AHIMS database for previously recorded Aboriginal sites was undertaken to inform this assessment on 21 September 2016. The search area centred on the project footprint and covered an area of 11 kilometres by nine kilometres (see **Figure 21-1**). The reason for the larger search area was to provide an adequate buffer around the project footprint, understand the spread and distribution of previously recorded Aboriginal sites and to provide context to the project footprint.

21.1.4 Consultation

Consultation with the Aboriginal community was undertaken in accordance with the PACHCI Stage 2 process, where the LALC relevant to the study area is identified and contacted to organise appropriate representation for fieldwork and consultation. The relevant LALC for this project is the Metropolitan Local Aboriginal Land Council (MLALC). The MLALC Aboriginal Sites Officer for the project was present during all fieldwork and reviewed the findings of the Aboriginal heritage assessment. No registered native title claimants were identified in relation to the project footprint.

21.1.5 Archaeological survey

An archaeological survey was undertaken to identify and record existing surface and potential subsurface evidence of past Aboriginal activity. The project footprint was surveyed, comprising land required for permanent operational infrastructure and for construction, including construction ancillary facilities.

The survey was undertaken in September 2016 by an archaeologist accompanied by a MLALC Aboriginal Sites Officer. All mature remnant trees and sandstone outcrops were inspected for signs of cultural modification and surface expressions of Aboriginal artefacts.

Figure 21-1 AHIMS sites within proximity of the project footprint

21.1.6 Legislation and policy framework

This Aboriginal heritage assessment has been prepared to assess the impacts of the project in accordance with relevant legislation as described in **Table 21-2**.

Table 21-2 Legislation relevant to the project – Aboriginal heritage

Legislation	Relevance to project
Aboriginal and Torres Strait Islander Heritage Protection Act 1984 (Commonwealth) (ATSIHP Act)	The ATSIHP Act provides for the preservation and protection of places, areas and objects of particular significance to Indigenous Australians. Under the ATSIHP Act, the Australian Government Minister for the Environment, in consultation with the relevant state/territory minister, may make a declaration to protect an Aboriginal area or object. The ATSIHP Act also protects Aboriginal burials in addition to any state legal protection.
Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth) (EPBC Act)	The EPBC Act proposes that actions that have or are likely to have a significant impact on a Matter of National Environmental Significance (MNES) must be referred to the Australian Government Minister for the Environment. Under the EPBC Act, 'environment' is defined as including both natural and cultural environments, and therefore includes Aboriginal heritage items. The heritage registers mandated by the EPBC Act were considered in relation to this project. No registered Aboriginal heritage items are located within the project footprint.
Native Title Act 1993 (Commonwealth) (NT Act)	The NT Act provides for the recognition and protection of Native Title for Aboriginal peoples and Torres Strait Islanders. It also makes provision for Indigenous Land Use Agreements (ILUA) to be formed, as well as a framework for notification of Native Title stakeholders for certain future acts on land where Native Title has not been extinguished. Initial searches of the National Native Title Registers were undertaken in May 2016 as part of the PACHCI Stage 1 assessment. An updated search was undertaken on 10 October 2016 for the Inner West Council local government area. No Native Title claims were identified within the project footprint.
Environmental Planning and Assessment Act 1979 (NSW) (EP&A Act)	The EP&A Act provides the framework for environmental planning and assessment in NSW and provides opportunity for public involvement in the environmental impact assessment process. Approval for the project is being sought under Part 5.1 of the EP&A Act, with the environmental impact assessment being documented in this EIS.
National Parks and Wildlife Act 1974 (NSW) (NPW Act)	The NPW Act is the primary legislation for the protection of Aboriginal cultural heritage in NSW and provides for the proper care, preservation and protection of 'Aboriginal objects' and 'Aboriginal places', defined under the NPW Act. Under Part 6 of the NPW Act it is an offence to harm or desecrate Aboriginal objects or places. It is a defence to prosecution for such an offence if the harm was authorised by an AHIP issued under section 90 of the NPW Act. The project would not impact any known Aboriginal objects or places and an AHIP would therefore not be required.

Legislation	Relevance to project
Standard Instrument – Principal Local Environmental Plan (LEP)	The SEARs state that the direct and indirect impact (including cumulative impacts) to Aboriginal places of heritage significance, as defined in the Standard Instrument – Principal Local Environmental Plan, must be considered in relation to the project. In general, section 115ZF(2) of the EP&A Act excludes the application of environmental planning instruments to State significant infrastructure (SSI) projects (except as those instruments apply to the declaration of SSI or critical SSI). The following LEPs have been considered: • Ashfield Local Environmental Plan 2013 (Ashfield LEP 2013) • Leichhardt Local Environmental Plan 2013 (Leichhardt LEP 2013) • Marrickville Local Environmental Plan 2011 (Marrickville LEP 2011) • Sydney Local Environmental Plan 2012 (Sydney LEP 2012).

The King George Park Draft Plan of Management referred to two ‘incomplete land claims’ lodged by MLALC. These were not deemed relevant to the assessment as the land claims were not complete, and land claims under the *Aboriginal Land Rights Act 1983* (NSW) do not necessarily denote Aboriginal cultural or scientific archaeological values. Land Councils are not required to establish cultural association with lands when making land claims under the *Aboriginal Land Rights Act 1983* (NSW). One of the two land claims referred to has, since preparation of the Draft Plan of Management, been determined by way of refusal.

The assessment has also been undertaken in accordance with the following current guidelines:

- *Aboriginal Cultural Heritage Consultation Requirements for Proponents* (DECCW 2010a)
- *Due Diligence Code of Practice for the Protection of Aboriginal Objects in NSW* (DECCW 2010b)
- *Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales* (DECCW 2010c)
- *Guide to Investigating, Assessing and Reporting on Aboriginal Cultural Heritage in NSW* (OEH 2011)
- PACHCI (Roads and Maritime 2011a).

21.2 Existing environment

21.2.1 Landscape context

The project footprint is partly located within the Cumberland Plain, a large topographic feature that lies at a relatively low elevation within the Sydney Basin. Historically, land use activities within the area have primarily included residential and industrial development. The majority of the ground surface of the project footprint comprises bitumen roads, buildings and concrete. A significant portion of the project footprint is also within disturbed terrain, being an area that has been impacted by past development or other human activity (Australian Soil Classification Soil Type map of NSW (OEH 2014)). Disturbed terrain is largely concentrated within the Rozelle Rail Yards and along watercourses in the project footprint.

Natural geological formations in the project footprint include the Ashfield Shale component of the Middle Triassic Wianamatta Group and the Hawkesbury Sandstone, also of Middle Triassic era. The majority of the project footprint is underlain by the Blacktown and Gymea soil landscapes, characterised by low hills and undulating to rolling rises. A small area of land adjacent to Iron Cove Bridge in Rozelle forms part of the Hawkesbury soil landscape. It is possible that outcrops of sandstone occurring within the AHIMS search area could have been utilised for the sharpening of edge-ground hatchets and spears (resulting in grinding grooves) as well as the production of engraved artwork. There are no known stone deposits with materials suitable for flaked stone artefact manufacture within or immediately surrounding the project footprint.

The project footprint also includes the highly disturbed Rozelle Rail Yards. This area has been subject to extensive disturbance from past activities including extensive quarrying of sandstone outcrops, excavation and levelling of soil and the installation of rail and supporting infrastructure. As a result of this past disturbance, the Rozelle Rail Yards have been classified as disturbed terrain.

Parts of the project footprint are located close to Rozelle Bay and Iron Cove, both of which would have provided a range of marine resources in the past. Other watercourses within proximity of the project footprint include Whites Creek, Johnstons Creek, Hawthorne Canal (formerly Long Cove Creek), Dobroyd Canal (Iron Cove Creek) and Alexandra Canal (formerly Sheas Creek). It is likely that the project footprint and local surroundings would have been well resourced in the past, in terms of both freshwater and marine resources. However, deposits associated with Aboriginal use of these aquatic features within the project footprint are unlikely to have survived due to historical land use activities such as the channelisation of natural waterways and bank stabilisation works.

Urban development for roads and residential areas has resulted in a high level of disturbance throughout the project footprint. This has included extensive vegetation clearance, landscape modification, road development and the installation of related infrastructure. The level of disturbance means that any Aboriginal deposits that were present are likely to have been destroyed.

21.2.2 Ethnographic and archaeological context

The project footprint falls within the boundaries of the Darug (also spelt Dhaŕ-rook, Dharrook, Dhaŕook, Dharruk and Dharug) linguistic group, which is known to have stretched from the Hawkesbury River in the north to Appin in the south, and west from the east coast across the Cumberland Plain into the Blue Mountains.

Available historic records indicate that the Darug-speaking peoples utilised a wide range of marine, freshwater, terrestrial and avian fauna for food. In coastal areas, marine resources (including fish and shellfish) were exploited, whereas further inland, land animals were hunted and eaten (including kangaroos, wallabies, possums, gliders and fruit bats).

The distribution of Aboriginal occupation across the Cumberland Plain has been linked to a variety of environmental factors, with proximity to water, stream order, landform and geology all key determinants. Most surface sites occur on land within 200 metres of a watercourse, with larger, more complex artefact assemblages associated with higher order streams.

Rockshelters appear to have been widely utilised by Darug-speaking peoples in coastal areas at the time of European contact. Generally, existing data suggests that dominant site types for this region include rockshelters, artefact scatters and isolated artefacts, with middens present in the coastal areas further north. Artefact distributions do not form specific ‘sites’, but rather ’landscapes’.

21.2.3 Database searches

Aboriginal Heritage Information Management System

A total of 49 AHIMS sites were identified within the search area. These sites are predominantly located in coastal fringe areas and were most commonly midden and rockshelter sites. The search results identified that there are no recorded sites within the project footprint. One AHIMS site was identified adjacent to the project footprint, around 50 metres north of the Rozelle Rail Yards. This site is Lilyfield Cave (site #45-6-2278) and is a rockshelter with midden.

A summary of the AHIMS sites identified within proximity of the project footprint is provided in **Table 21-3** and shown in **Table 21-3**.

Table 21-3 AHIMS sites within the search area

Site type	Number	Percent of total sites (%)
Midden	12	24.5
Rockshelter	12	24.5
Potential Archaeological Deposit (PAD)	8	16.3
Art site	8	16.3
Engraving	4	8.2
Artefact scatter	3	6.2
Not a site	1	2
Resource and gathering	1	2
Total	**49**	**100**

Note:

The designation 'Not a site' refers to areas that had been registered in AHIMS but later proved not to be legitimate Aboriginal sites and have therefore been renamed 'Not a site' in the AHIMS register.

Local environmental plans

A search of Schedule 5 of the relevant LEPs for environmental heritage items (see **Table 21-2**) identified the following:

- No Aboriginal sites were listed on the Ashfield LEP 2013 or the Sydney LEP 2012
- Four Aboriginal midden and rockshelter sites were identified on the Leichhardt LEP 2013 in the suburb of Birchgrove (one on Louisa Road and three on Numa Street), but are located more than 1.5 kilometres away from the project footprint, north of the Rozelle Rail Yards and would not be impacted by the project
- One listed item was identified on the Marrickville LEP 2011. Kendrick Park contains a shell midden, however this is located more than 2.5 kilometres away from the project footprint, southwest of the St Peters interchange.

It was concluded that there were no Aboriginal items listed in any relevant LEPs that would be subject to either direct or indirect impacts from the project. There is a shell midden (currently unregistered) at Timbrell Park, Five Dock, around 300 metres northeast of the Wattle Street interchange. No impacts are currently proposed in this area and no direct or indirect impacts on this midden site are expected.

21.2.4 Aboriginal site observations

Based on the landscape and archaeology context of the project footprint, the following observations regarding the potential for Aboriginal items and/or objects to be present within the project footprint have been made:

- If Aboriginal shell middens were present, they would be most likely to occur in tidal estuarine foreshore zones (within 10 metres of high water level) including areas adjacent to Rozelle Bay, Iron Cove, Whites Creek, Johnstons Creek, Hawthorne Canal (formerly Long Cove Creek) and Alexandra Canal (formerly Sheas Creek). However, it is unlikely that any shell midden sites remain in the project footprint given the high level of disturbance of those areas from activities including vegetation clearance, landscape modification, channelising of creek channels and road development
- Rockshelters are a common site type in the wider region and could occur in areas where in-situ natural overhangs have survived
- Aboriginal archaeological sites are highly unlikely to occur in areas previously subject to high levels of landscape modification and disturbance resulting from waterway channelisation, land reclamation and urban development.

21.2.5 Survey results

No surface expressions of Aboriginal objects or places were identified within the project footprint during the field surveys. In addition, the MLALC Aboriginal Sites Officer did not identify any specific areas of Aboriginal cultural attachment or intangible cultural heritage values within the project footprint.

As previously noted, most surface sites would occur on land within 200 metres of a watercourse. Within the project footprint, these areas would include Rozelle Bay, Iron Cove, Whites Creek, Johnstons Creek, Hawthorne Canal (formerly Long Cove Creek) and Alexandra Canal (formerly Sheas Creek). All inspected waterways within proximity to the project footprint were generally highly modified from their natural state, currently comprising concrete-lined, channelised open drains and subsurface piped drains.

At Whites Creek, outcropping sandstone bedrock was identified to the south of the shared path linking Railway Parade to The Crescent at Annandale, occurring on a short but relatively steep side slope below the Rozelle Bay light rail stop. This location is shown in **Figure 21-2**. No grinding grooves or pigment/engraved art were noted on exposed portions of the bedrock during the survey. The area surrounding Whites Creek has been largely modified through concrete channelisation and associated earthworks and landscaping, creek bank modification and the installation of park benches and telephone poles.

There are no Aboriginal objects/places/areas of cultural sensitivity at other areas of surface disturbance within the project footprint including Wattle Street at Haberfield; Darley Road at Leichhardt; the Rozelle Rail Yards, City West Link and The Crescent at Rozelle and Annandale; Victoria Road (near the eastern abutment of Iron Cove Bridge) at Rozelle; Pyrmont Bridge Road at Annandale; and Campbell Road at St Peters.

The potential for subsurface Aboriginal archaeology is also considered negligible given the areas of previous disturbance in the study area and the nature of the soils underlying the Rozelle Rail Yards (ie disturbed terrain).

Figure 21-2 Sandstone outcrop at Whites Creek to the south of the shared path linking Railway Parade to The Crescent at Annandale

21.3 Assessment of potential impacts

No surface expressions of Aboriginal objects or places were identified within the project footprint. Aboriginal deposits are shallow and usually occur within the top 20 centimetres of the ground surface in environments such as the project footprint. The terrain within the project footprint is highly disturbed and is unlikely to contain unidentified Aboriginal archaeological objects in either a surface or subsurface context. Waterways close to the project footprint (typically the most sensitive archaeological locations) were identified during the field survey as being highly modified from their natural state. These include Rozelle Bay, Iron Cove, Whites Creek, Johnstons Creek, Hawthorne Canal (formerly Long Cove Creek) and Alexandra Canal (formerly Sheas Creek).

Excavation associated with underground tunnelling would be required in the general area beneath registered AHIMS site #45-6-2278. Therefore, there is potential for the site to be indirectly impacted from vibration and settlement. The noise and vibration assessment carried out for the project identified vibration criteria to be applied to certain structures in accordance with the guideline DIN 4150: Part 3-1999 *Structural vibration – Effects of vibration on structures* (Deutsches Institute fur Normung 1999) (SLR 2017). The guideline identifies the minimum 'safe limit' of peak vibration levels for heritage structures is at three millimetres per second. AHIMS site #45-6-2278 is located outside the minimum safe working distance for vibration intensive plant associated with the mainline tunnel works, with vibration impacts associated with tunnelling works expected to be negligible (refer to **Appendix J** (Technical working paper: Noise and vibration)).

As the degree of movement experienced by a structure is dependent on its foundation type and how a structure responds to ground movements depends on its size, design and materials, ongoing observation and monitoring is recommended during construction. The site has not been accessed at part of this assessment due to its location within private property, and it is therefore recommended that its current condition is to be confirmed with a site survey during detailed design if possible (see **section 21.4**).

A series of exposed sandstone benches were identified adjacent to Whites Creek and to the north of Railway Parade at Annandale; however, no engravings, pigment art or any other signs of cultural use and/or modification were identified during the visual inspection (see **Figure 21-2**).

As no AHIMS registered Aboriginal sites occur within the areas of surface disturbance within the project footprint, none would be either directly or indirectly impacted by the project (see **Figure 21-2**). As no Aboriginal sites or areas of potential were identified for impacts, no recommendations for the project were provided by MLALC.

Based on the results of the Aboriginal heritage assessment, impacts on identified objects or places of Aboriginal heritage are considered unlikely. No known, potential or intangible cultural heritage values were identified within the project footprint. No known places of Aboriginal cultural heritage significance would be impacted by the project, and no known archaeological remains would be disturbed. Indirect impacts, such as those resulting from vibration during construction and settlement during operation, are also not anticipated or are considered to be negligible. Therefore, impacts on Aboriginal heritage would be avoided and no further assessment is required.

An assessment of potential cumulative impacts on Aboriginal heritage is provided in **Chapter 26** (Cumulative impacts).

21.4 Environmental management measures

The project is not anticipated to have any impact on identified Aboriginal objects or places of Aboriginal heritage significance. Mitigation and management measures would be implemented to avoid, minimise or mitigate impacts on unidentified Aboriginal heritage objects or places. These mitigation and management measures are outlined in **Table 21-4**.

Table 21-4 Environmental management measures – Aboriginal heritage

Impact	No.	Environmental management measure	Timing
Impacts on unexpected finds of Aboriginal objects	AH1	Any items of potential Aboriginal archaeological or cultural heritage conservation significance or human remains discovered during construction will be managed in accordance with the Unexpected Heritage Finds and Humans Remains Procedure developed for the project.	Construction
Vibration impacts on Aboriginal items	AH2	Subject to gaining access from the relevant landholder, a suitably qualified archaeologist would visit AHIMS site #45-6-2278 prior to the commencement of any vibration intensive construction activities in the vicinity of the site to verify the site to confirm and record its current condition.	Construction
	AH3	If the AHIMS site #45-6-2278 is verified, an assessment will be completed by a suitably qualified and experienced person prior to the commencement of any vibration intensive construction activities in the vicinity. The assessment will consider all vibration intensive activities that will occur in the vicinity, the likely vibration levels and relevant vibration criteria and identify the management measures, including monitoring, that will be implemented to prevent and reduce potential impacts. A final condition assessment will be carried out at the completion of construction detailing recommendations for remediation measures if required.	Construction

22 Greenhouse gas

This chapter outlines the legislative and policy framework for the control of greenhouse gas emissions. It provides an assessment of greenhouse gas emissions anticipated to be generated during the construction and operation stages of the M4-M5 Link project (the project) and provides recommended mitigation measures to reduce greenhouse gas emissions. There are no requirements of the Secretary of the NSW Department of Planning and Environment (DP&E) for this environmental assessment that are specific to greenhouse gas emissions. The assessment of greenhouse gas emissions for the project environmental impact statement (EIS) follows a similar approach adopted for the M4 East EIS and New M5 EIS.

Greenhouse gases (GHGs) are gases in the atmosphere that absorb and re-radiate heat from the sun, thereby trapping heat in the lower atmosphere and influencing global temperatures. Emissions of GHGs into the atmosphere are caused by both natural processes (eg bushfires) and human activities (eg burning of fossil fuels to generate electricity).

Since the industrial revolution there has been an increase in the amount of GHGs emitted from human activities, which has increased the global concentration of GHGs in the atmosphere. This has led to an increase in the Earth's average surface temperature (Intergovernmental Panel on Climate Change (IPCC) 2013). Further discussion on climate change, including the identification and assessment of climate change risks to the project, is provided in **Chapter 24** (Climate change and risk adaptation). Potential impacts of the project on air quality are assessed in **Chapter 9** (Air quality) and **Appendix I** (Technical working paper: Air quality).

22.1 Assessment methodology

The methodology for this GHG assessment has been based on relevant GHG reporting legislation and international reporting guidelines, including:

- *Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard* (World Council for Sustainable Business Development and World Resources Institute 2005)
- *National Greenhouse and Energy Reporting Act 2007* (Commonwealth)
- AS/ISO 14064.1:2006 *Greenhouse Gas Part 1: Specification with guidance at the organisational level for quantification and reporting of greenhouse gas emissions and removals*
- The current *Australian National Greenhouse Accounts: National Greenhouse Accounts Factors* (NGA Factors) (Department of the Environment 2016)
- *Greenhouse Gas Assessment Workbook for Road Projects* (the TAGG Workbook) (Transport Authorities Greenhouse Group (TAGG) 2013).

The TAGG was formed by Australian state road authorities, including NSW Roads and Maritime Services (Roads and Maritime), and the New Zealand Transport Agency as a collaborative effort to share information regarding the estimation, reporting and minimisation of GHG emissions. The TAGG Workbook provides a consistent methodology for estimating the GHG emissions from activities that may contribute significantly to the overall emissions associated with the construction, operation and maintenance of road projects. The TAGG Workbook has been adopted for the project.

To calculate the potential GHG emissions associated with the project, the following steps were followed:

1. Define the assessment boundary and identify potential sources of GHG emissions associated with the project
2. Determine the quantity of each emission source (fuel and electricity consumed, vegetation cleared, construction materials used and waste produced)
3. Quantify the potential GHG emissions associated with each GHG source, using equations and emission factors specified in the NGA Factors and the TAGG Workbook
4. Present the potential GHG emissions associated with the project.

Appendix W (Detailed greenhouse gas calculations) provides a detailed description of the GHG assessment methodology, including the emissions factors used for all emission sources, and detailed calculation methods used to estimate the GHG emissions from fuel combustion, electricity consumption, vegetation removed, materials use and waste.

GHG emissions are reported in this assessment as tonnes of carbon dioxide equivalent (t CO_2-e). While there are numerous GHGs, this standard metric takes account of the different global warming potentials of different GHGs, and expresses the cumulative effect in a common, universal unit of measurement. This allows for all GHGs associated with the project to be combined into one emissions calculation.

22.1.1 Greenhouse gas assessment boundary

The assessment boundary defines the scope of GHG emissions and the activities to be included in the assessment. The assessment boundary includes all emissions sources that can be influenced by decisions made by designers, constructors, managers or operators of the project and accounts for emissions anticipated to be generated during the construction and operation stages of the project. The guiding principles for GHG accounting and reporting, including an assessment of materiality, are provided in **Appendix W** (Detailed greenhouse gas calculations).

Emissions sources are categorised into the following three 'scopes':

- Scope 1 – direct emissions: GHG emissions generated by sources owned or controlled by the project, for example emissions generated by the use of diesel fuel in project-owned construction plant, equipment or vehicles
- Scope 2 – indirect emissions: GHG emissions from the consumption of purchased electricity in project-owned or controlled equipment or operations. These GHG emissions are generated outside the project's boundaries, for example the use of electricity purchased from the grid
- Scope 3 – indirect upstream/downstream emissions: GHG emissions generated in the wider economy due to third party supply chains and road users as a consequence of activity within the boundary of the project, for example GHG emissions associated with the mining, production and transport of materials used in construction (referred to as the embodied energy of a material).

Table 22-1 summarises the emission sources and activities considered within the project's GHG assessment boundary for construction and operation, according to scope.

Table 22-1 Emission sources and activities included in the assessment

Emission source category	Emission source	Emission scope	Emission scope	Emission scope
		Scope 1 (direct)	Scope 2 (indirect)	Scope 3 (indirect upstream/ downstream)
Construction				
Fuel use	Mobile construction equipment	✓		✓
	Site vehicles	✓		✓
	Delivery of plant, equipment and construction materials			✓
	Spoil and waste removal			✓
Electricity consumption	Electricity used to power construction plant (road headers, ventilation, lighting towers etc) and site offices		✓	✓
Vegetation removal	Clearance of vegetation as a result of the project	✓		
Materials	Embodied energy of construction			✓

Emission source category	Emission source	Emission scope	Emission scope	Emission scope
		Scope 1 (direct)	Scope 2 (indirect)	Scope 3 (indirect upstream/ downstream)
	materials			
Waste	Decomposition of waste generated during project construction			✓
Operation and maintenance				
Electricity consumption	Electricity used to power tunnel lighting and ventilation, project offices and other electrical systems		✓	✓
Fuel use	Operational road use by light and heavy vehicles			✓
	Mobile construction equipment used for maintenance activities	✓		✓
Materials	Materials used for maintenance activities			✓

Some emissions sources are categorised into two scopes; for example, the use of fuel by mobile construction equipment onsite would generate Scope 1 direct emissions from the combustion of fuel as well as Scope 3 indirect upstream emissions associated with the extraction, production and transport of the purchased fuel. Consumption of electricity purchased from the grid would generate Scope 2 indirect emissions from the use of electricity to power project equipment and facilities, as well as Scope 3 indirect upstream emissions associated with transmission and distribution losses within the electricity network.

22.2 Existing environment

22.2.1 International policy setting

The Kyoto Protocol to the United Nations Framework Convention on Climate Change (the Kyoto Protocol) (UNFCCC 1998) was signed in 1997 and Australia ratified the protocol in December 2007. The Kyoto Protocol serves to give effect to the UNFCCC's objective of reducing global GHG emissions by setting reduction targets and reporting requirements for certain ratifying countries. These targets are set using the relevant ratifying countries' 1990 baseline emissions. Australia committed to a target of 108 per cent of its 1990 GHG emission levels by the end of 2012. In December 2012, Australia signed the Doha Amendment to the Kyoto Protocol (UNFCCC 2012), agreeing to a second commitment period, from 1 January 2013 until 2020.

In 2015 the Australian Government announced its commitment to a target of reducing GHG emissions by 26 to 28 per cent below 2005 levels by 2030, building on its previous target of five per cent below 2000 emission levels by 2020, irrespective of what other countries do. The Australian Government submitted this new target as its intended nationally determined contribution to the UNFCCC for negotiation at the 21st Conference of the Parties (COP21) held in Paris in December 2015.

A global climate agreement was reached by all 197 countries in Paris on 12 December 2015. The Paris Agreement provides a framework for all countries to take action on climate change post 2020. Key outcomes of the Paris Agreement include (Department of Foreign Affairs and Trade (DFAT) 2016):

- A target to keep global temperature increase to well below two degrees Celsius (°C) and pursue efforts to keep warming below 1.5°C above pre-industrial levels
- All countries to set emissions reduction targets from 2020, with an agreement to review and strengthen targets every five years

- Transparency and accountability rules to provide confidence in countries' actions and track progress towards targets
- Promoting action to adapt and build resilience to climate impacts
- Financial, technological and capacity building support to help developing countries implement the Agreement.

The Australian Government ratified its commitment to the Paris Agreement on 9 November 2016.

22.2.2 National and State policy setting

The Australian Government's Direct Action Plan sets out how the 2030 emissions reduction target will be achieved. The Emissions Reduction Fund, as part of the Direct Action Plan, aims to reduce Australia's GHG emissions by creating positive incentives to adopt better technologies and practices to reduce emissions. The Australian Government will consider the 2030 target policy framework in detail in 2017-2018.

In 2016 the NSW Government released a new Climate Change Policy Framework, which includes a *Draft Climate Change Fund Strategic Plan 2017-2022* and *A Draft Plan to Save NSW Energy and Money*. The *Draft Plan to Save NSW Energy and Money* is proposed to meet the NSW Government's energy efficiency target of 16,000 gigawatt hours of annual energy savings by 2020 and contribute to the Climate Change Policy Framework's aspirational target of NSW achieving net-zero emissions by 2050. The draft plan summarises the preferred options for achieving the State's energy savings target, which include opportunities for implementing energy standards for State significant developments and major infrastructure projects such as road tunnels.

The NSW Government *Resource Efficiency Policy* (NSW Office of Environment and Heritage (OEH) 2014) aims to 'drive resource efficiency by NSW Government agencies in three main areas – energy, water and waste – and also reduce harmful air emissions from government operations'.

The *NSW Long Term Transport Master Plan* (Transport for NSW 2012) (Transport Master Plan) includes an objective to 'Improve sustainability – by maintaining and optimising the use of the transport network, easing congestion, growing the proportion of travel by sustainable modes such as public transport, walking and cycling, and becoming more energy efficient.' An action of the Transport Master Plan is also to 'continue to explore opportunities to reduce vehicle emissions, improve air quality and lower GHG emissions from the NSW transport sector.'

In addition, the *Transport Environment and Sustainability Policy Framework* (Transport for NSW 2013) includes an energy management objective 'to use Transport's energy sources more efficiently and reduce its greenhouse gas emissions'. The Roads and Maritime *Environmental Sustainability Strategy 2015-2019* (2016) aligns with the *Transport Environment and Sustainability Policy Framework* and includes energy and carbon management as one of the focus areas for integrating sustainability into Roads and Maritime operations and services. The *Environmental Sustainability Strategy* outlines the Roads and Maritime objective to minimise energy use and reduce GHG emissions without compromising the delivery of service to customers, and identifies the following management hierarchy to achieve this objective:

- Avoid – minimise the need for energy use
- Efficiency – implement energy efficiency measures such as light-emitting diode (LED) lighting and signalling
- Substitute – source electricity from renewable energy.

The WestConnex Sustainability Strategy (the Sustainability Strategy) (Sydney Motorway Corporation 2015) describes how sustainability will be integrated into the planning, construction and operation of WestConnex. The Sustainability Strategy includes objectives to optimise resource efficiency and outlines requirements for construction contractors to develop and implement an Energy Efficiency and Greenhouse Gas Emissions Strategy and Management Plan. Further detail regarding the Sustainability Strategy objectives and targets is provided in **Chapter 27** (Sustainability).

22.2.3 GHG emissions reporting

The Clean Energy Regulator and the Department of the Environment and Energy are responsible for administering the Australian Government's GHG emission policies, regulations and initiatives. The National Greenhouse and Energy Reporting (NGER) Scheme is a national framework for obligated corporations to report on GHG emissions, energy use and energy production. The NGER Scheme operates under the *National Greenhouse and Energy Reporting Act 2007* (Commonwealth) (NGER Act).

The most recently published Australian National Greenhouse Accounts estimate Australian GHG emissions for the year March 2016 to March 2017 to be 550.1 million tonnes of carbon dioxide equivalent (Mt CO_2-e) as reported under the Kyoto Protocol (Australian Government Department of the Environment and Energy 2017a). This figure is 0.8 per cent below 2000 levels, and demonstrates progress towards achieving Australia's targets for 2020 of five per cent below 2000 emissions levels. For 2015, annual NSW GHG emissions totalled around 133.4 Mt CO_2-e (Department of the Environment and Energy 2017b). Despite an increase of emissions in the transport sector for NSW, total emissions for the State decreased in 2015, with a 11.6 per cent reduction on 2000 levels.

The transport sector contributes about 18 per cent of Australia's total GHG emissions (Australian Government Department of the Environment 2016a). Around 90 per cent of these emissions are considered to be attributed to the combustion of fuel for road transport (Climate Change Authority 2014; Maddocks et al. 2010). Reducing the contribution of emissions from road transport would therefore have a significant impact on emissions reduction for the transport sector, and for Australia's overall emissions profile.

22.3 Assessment of potential construction impacts

The data used to estimate the GHG emissions associated with construction of the project is provided in **Appendix W** (Detailed greenhouse gas calculations). Assumptions have been made based on industry default factors and experience with similar road tunnel projects, where necessary, to provide a quantitative estimate of emissions.

Twelve construction ancillary facilities are described in this EIS. To assist in informing the development of a construction methodology that would manage constructability constraints and the need for construction to occur in a safe and efficient manner, while minimising impacts on local communities, the environment, and users of the surrounding road and other transport networks, two possible combinations of construction ancillary facilities at Haberfield and Ashfield have been assessed in this EIS. The construction ancillary facilities that comprise these options have been grouped together in this EIS and are denoted by the suffix a (for Option A) or b (for Option B).

The construction ancillary facilities required to support construction of the project include:

- Construction ancillary facilities at Haberfield (Option A), comprising:
  - Wattle Street civil and tunnel site (C1a)
  - Haberfield civil and tunnel site (C2a)
  - Northcote Street civil site (C3a)
- Construction ancillary facilities at Ashfield and Haberfield (Option B), comprising:
  - Parramatta Road West civil and tunnel site (C1b)
  - Haberfield civil site (C2b)
  - Parramatta Road East civil site (C3b)
- Darley Road civil and tunnel site (C4)
- Rozelle civil and tunnel site (C5)
- The Crescent civil site (C6)
- Victoria Road civil site (C7)
- Iron Cove Link civil site (C8)

- Pyrmont Bridge Road tunnel site (C9)
- Campbell Road civil and tunnel site (C10).

The following sections provide estimated GHG emissions for construction of the project for Option A and Option B, respectively. The remaining construction ancillary facilities (C4 to C10) are included in the assessment for each option.

22.3.1 Construction ancillary facilities: Option A

It is estimated that the project would generate about 528,000 t CO_2-e where Option A is selected as the preferred construction option at Haberfield. The breakdown of emissions by scope is shown in **Figure 22-1** and summarised (with numbers rounded to the nearest hundred tonnes) as:

- 132,500 t CO_2-e of Scope 1 (direct) GHG emissions
- 86,000 t CO_2-e of Scope 2 (indirect) GHG emissions
- 309,500 t CO_2-e of Scope 3 (indirect upstream/downstream) GHG emissions.

Key emissions sources during project construction are shown in **Table 22-2** and **Figure 22-1**. Detailed GHG emissions results are provided in Table 3-1 of **Appendix W** (Detailed greenhouse gas calculations).

Table 22-2 Construction GHG emissions results for Option A

Emissions source	GHG emissions (t CO_2-e) Scope 1	GHG emissions (t CO_2-e) Scope 2	GHG emissions (t CO_2-e) Scope 3	GHG emissions (t CO_2-e) Total	% of total
Fuel use (diesel) – mobile plant and equipment	32,336	-	2,455	**34,791**	6.59
Fuel use (diesel) – transport of materials, spoil and waste to/from site	90,392	-	6,863	**97,255**	18.42
Fuel use (petrol) –plant and equipment	69	-	5	**74**	0.01
Fuel use (petrol) – project light vehicles	8,483	-	671	**9,154**	1.73
Electricity consumption	-	86,017	13,003	**99,020**	18.75
Vegetation clearance	1,188	-	-	**1,188**	0.23
Construction materials - concrete	-	-	154,097	**154,097**	29.18
Construction materials - cement	-	-	100,040	**100,040**	18.95
Construction materials – steel	-	-	16,223	**16,223**	3.07
Construction materials – aggregate	-	-	140	**140**	0.03
Construction materials - asphalt	-	-	4,060	**4,060**	0.77
Construction materials - water	-	-	2,000	**2,000**	0.38
Construction and demolition waste	-	-	10,000	**10,000**	1.89
Total	**132,468**	**86,017**	**309,557**	**528,042**	**100%**
% of total	25%	16%	59%	**100%**	

Notes:

Results may not add up to totals due to rounding of emissions to the nearest whole number.

Assumptions for how these figures were calculated are presented in Appendix W (Detailed greenhouse gas calculations).

22.3.2 Construction ancillary facilities: Option B

It is estimated that the project would generate about 516,400 t CO_2-e where Option B is selected as the preferred construction option at Haberfield/Ashfield. The breakdown of emissions by scope is shown in **Figure 22-1** and summarised (with numbers rounded to the nearest hundred tonnes) as:

- 125,100 t CO_2-e of Scope 1 (direct) GHG emissions
- 82,800 t CO_2-e of Scope 2 (indirect) GHG emissions
- 308,500 t CO_2-e of Scope 3 (indirect upstream/downstream) GHG emissions.

Key emissions sources during project construction are shown in **Table 22-3** and **Figure 22-1.** Detailed GHG emissions results are provided in Table 3-2 of **Appendix W** (Detailed greenhouse gas calculations).

Table 22-3 Construction GHG emissions results for Option B

Emissions source	GHG emissions (t CO_2-e) Scope 1	GHG emissions (t CO_2-e) Scope 2	GHG emissions (t CO_2-e) Scope 3	GHG emissions (t CO_2-e) Total	% of total
Fuel use (diesel) – mobile plant and equipment	32,336	-	2,455	**34,791**	6.74
Fuel use (diesel) – transport of materials, spoil and waste to/from site	83,218	-	6,318	**89,536**	17.34
Fuel use (petrol) –plant and equipment	69	-	5	**74**	0.01
Fuel use (petrol) – project light vehicles	8,277	-	655	**8,932**	1.73
Electricity consumption	-	82,775	12,513	**95,288**	18.45
Vegetation clearance	1,188	-	-	**1,188**	0.23
Construction materials - concrete	-	-	154,097	**154,097**	29.84
Construction materials - cement	-	-	100,040	**100,040**	19.37
Construction materials – steel	-	-	16,223	**16,223**	3.14
Construction materials – aggregate	-	-	140	**140**	0.03
Construction materials - asphalt	-	-	4,060	**4,060**	0.79
Construction materials - water	-	-	2,000	**2,000**	0.39
Construction and demolition waste	-	-	10,000	**10,000**	1.94
Total	**125,088**	**82,775**	**308,506**	**516,369**	**100%**
% of total	24%	16%	60%	**100%**	

Note:

Results may not add up to totals due to rounding of emissions to the nearest whole number.

22.3.3 Construction GHG emissions results

The results demonstrate a marginal difference in emissions between construction ancillary facilities Option A and Option B, with Option A estimated to generate around two per cent (11,673 t CO_2-e) higher emissions compared with Option B. This difference is attributed to a larger fuel consumption and larger electricity consumption for Option A, associated with the two tunnelling sites at Haberfield compared to one site for Option B, and the additional requirements to support tunnelling activities at this additional site (eg vehicle movements, temporary ventilation and water treatment ancillary works).

The results demonstrate that the majority of GHG emissions associated with the construction of the project are attributed to indirect Scope 3 emissions (59 and 60 per cent for Option A and Option B respectively), followed by direct Scope 1 emissions (25 and 24 per cent for Option A and Option B respectively).

The embodied energy associated with the offsite mining, production and transport of materials that would be used for the construction of the project contributes the largest proportion of indirect Scope 3 emissions, accounting for around 89 per cent of these emissions for both Option A and Option B (see **Figure 22-1**). The use of concrete, cement and, to a lesser extent, steel would contribute significantly to Scope 3 emissions. The high proportions of emissions associated with these materials are attributed not only to the quantity required for the construction of the project, but also the emissions-intensive processes involved in the extraction and production of these materials.

Figure 22-1 illustrates the breakdown of construction emissions by emission source and scope. The consumption of diesel fuel associated with heavy vehicle movements for the haulage of spoil, construction materials and waste contributes the largest proportion of Scope 1 emissions (68 and 67 per cent for Option A and Option B respectively), followed by the consumption of fuel for the operation of mobile construction plant and equipment (24 and 26 per cent for Option A and Option B respectively). Indirect Scope 2 emissions from the use of electricity are estimated to account for around 16 per cent of total emissions during construction for both Option A and Option B.

Mitigation and management measures to reduce GHG emissions during construction of the project are provided in **section 22.7**.

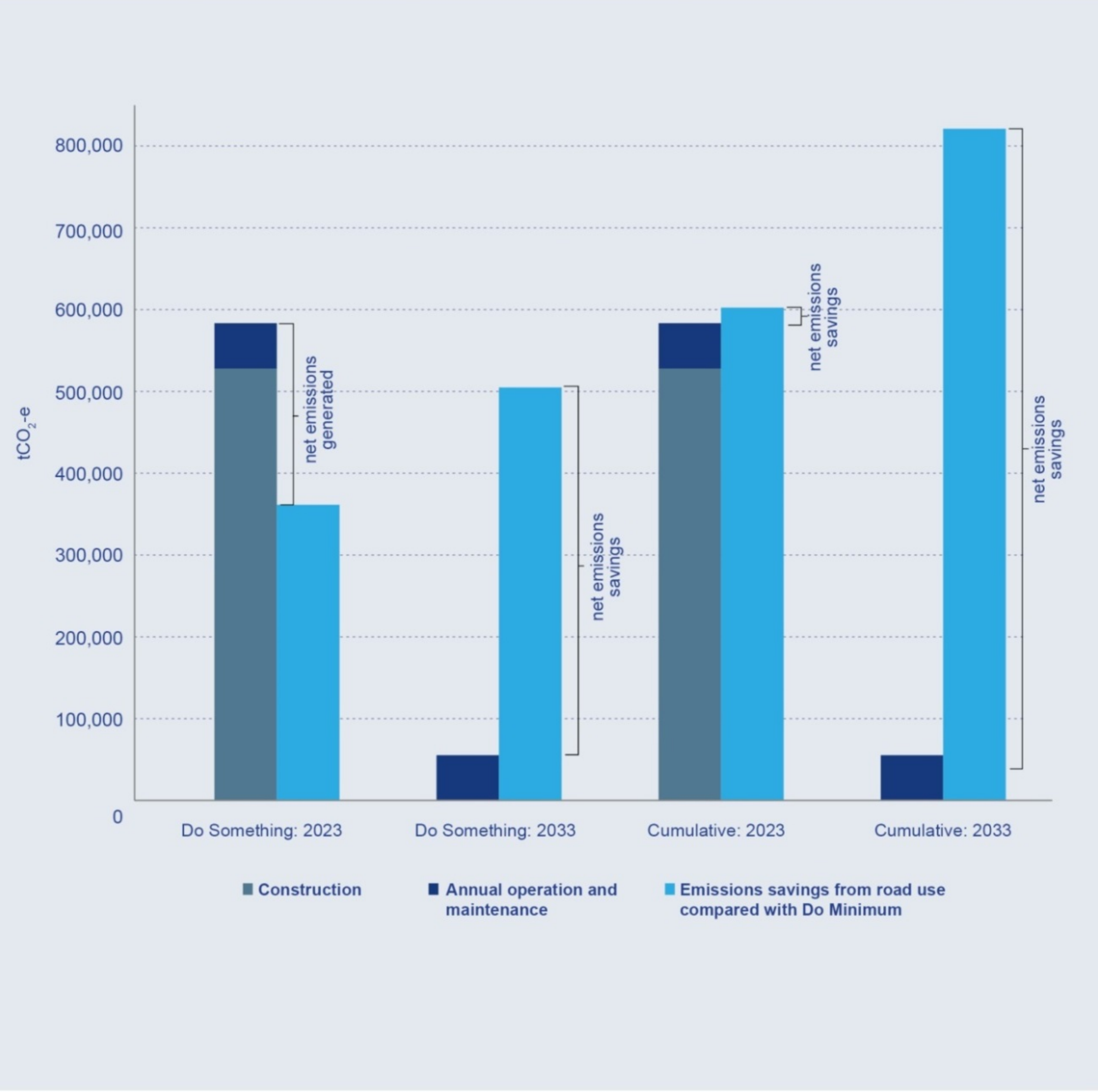


Figure 22-1 Construction GHG emissions by scope and emissions source

22.4 Assessment of potential operational impacts

Activities that would generate GHG emissions during operation and maintenance of the project include:

- Road infrastructure operation: the use of electricity for powering tunnel lighting and ventilation, operation of ventilation facilities, the operations and maintenance facility, water treatment, substation cooling, street lighting, electronic signage and other associated electrical systems
- Road infrastructure maintenance: diesel fuel use for the operation of maintenance equipment and the use of materials for maintaining road pavement
- Vehicles using the M4-M5 Link during operation: use of the M4-M5 Link during operation and the change in traffic volumes and traffic performance on alternative routes within the GHG assessment study area.

The GHG assessment results are presented in the following sections. The emission source data, and any assumptions used to estimate the GHG emissions associated with operation and maintenance of the project, are provided in **Appendix W** (Detailed greenhouse gas calculations).

22.4.1 Emissions from road infrastructure operation and maintenance

The estimated GHG emissions that would be generated by road infrastructure operation and maintenance activities are presented in **Table 22-4**. Annual operational emissions and emissions from major maintenance have been calculated according to the GHG assessment methodology summarised in **section 22.1** and the assumptions and inputs provided in **Appendix W** (Detailed greenhouse gas calculations).

Table 22-4 Road infrastructure operation and maintenance GHG emissions results

Emission source	GHG Emissions Scope 1	GHG Emissions Scope 2	GHG Emissions Scope 3	Total
Annual operation emissions (t CO_2-e per year)				
Electricity consumption	-	42,621	6,088	48,709
Total maintenance emissions (50 year major maintenance) (t CO_2-e)				
Fuel use (diesel) – mobile plant and equipment	3,271	-	248	3,519
Maintenance materials - cement	-	-	44	44
Maintenance materials - steel	-	-	406	406
Maintenance materials - aggregate	-	-	2,500	2,500
Maintenance materials - bitumen	-	-	264	264
Total maintenance emissions	3,271	-	3,462	6,733

Annual use of electricity for powering tunnel lighting and ventilation, building services, heating, ventilation and air conditioning (HVAC) systems, surface plants, wastewater treatment, pumps and drainage, communications systems, control systems, computer and safety systems, the emergency response system, operations and maintenance facility, electronic signage and other associated electrical systems would incur 42,621 t CO_2-e indirect Scope 2 emissions and 6,088 t CO_2-e indirect Scope 3 emissions per year.

Emission estimates for the use of fuel and materials for the maintenance of the road pavement are based on one major rehabilitation of asphalt pavement with the top 150 millimetres replaced and five per cent of pavement replaced for patching/repair every 50 years, and five per cent of concrete pavement replaced with only the top layer requiring replacement every 50 years (in accordance with 'typical' maintenance activities given in the TAGG Workbook).

The use of fuel and materials to undertake maintenance activities would result in around 3,271 t CO_2-e direct Scope 1 emissions and around 3,462 t CO_2-e indirect Scope 3 emissions. The total quantity of GHG emissions associated with the above road maintenance activities would be about 6,733 t CO_2-e. Averaged over the 50 year period from the commencement of operation, this would generate around 135 t CO_2-e of maintenance emissions per year.

22.4.2 Emissions from vehicles during operation

GHG emissions generated from the operation and maintenance of road infrastructure are relatively small in comparison with the indirect emissions associated with the fuel consumed by vehicles using the road network.

To assess the Scope 3 (indirect downstream) emissions associated with fuel consumed by vehicles using the project, and to evaluate any potential GHG emissions savings as a result of the project, the following operational scenarios, as presented in **Table 22-5**, were considered. Further description of these scenarios is presented in **Appendix W** (Detailed greenhouse gas calculations).

Table 22-5 Traffic modelling scenarios (describing components in the road network for each scenario)

Scenario	Year	Existing road network	WestConnex projects								
			M4 Widening	M4 East	New M5	M4-M5 Link	Sydney Gateway*	NorthConnex	Western Harbour Tunnel (to North Sydney)	Beaches Link (to Seaforth)	F6 Extension
'Do minimum' (without project)	2023	✓	✓	✓	✓			✓			
'With project'	2023	✓	✓	✓	✓	✓		✓			
'Cumulative'	2023	✓	✓	✓	✓	✓	✓	✓	✓		
'Do minimum' (without project)	2033	✓	✓	✓	✓			✓			
'With project'	2033	✓	✓	✓	✓	✓		✓			
'Cumulative'	2033	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Note:

* While the proposed future Sydney Gateway project is not part of the WestConnex program of works, it is considered for the 'cumulative' scenarios only as the project is in the early planning stages, with no detailed information available to inform the GHG assessment.

Traffic volumes were modelled for 2023 and 2033 in line with **Appendix H** (Technical working paper: Traffic and transport). These future years were chosen as they provide an indication of road network performance at project opening (2023), and 10 years after opening (2033).

The analysis is based on the vehicle kilometres travelled (VKT) and the average speed of vehicles travelling on key alternative routes within the GHG assessment study area, as generated by the WestConnex Road Traffic Model version 2.3 (WRTM v2.3) ie the strategic traffic model developed and operated by Roads and Maritime.

WRTM v2.3 provides a platform to understand changes in future weekday travel patterns under different land use, transport infrastructure and toll pricing scenarios. Further detail on WRTM v2.3 is provided in **Chapter 8** (Traffic and transport).

The GHG assessment for operational road use involved calculation of the following inputs, using WRTM v2.3 model outputs, industry default factors, current vehicle statistics and fuel intensity projections as detailed in **Appendix W** (Detailed greenhouse gas calculations):

- Average speed for each road link
- VKT for both light and heavy vehicles
- Rate of fuel consumption
- Total fuel quantity
- Fuel quantity by fuel type (eg petrol, diesel, liquid petroleum gas (LPG)).

These inputs were then used to estimate the GHG emissions associated with a change in traffic volumes on the road network within the study area as a result of the project, under different future timeframes and project scenarios as identified in **Table 22-5**. Further detail regarding the calculation of fuel use and GHG emissions is presented in **Appendix W** (Detailed greenhouse gas calculations).

As the project does not replace a single existing route within the road network, the GHG assessment study area boundary was selected to include key routes which currently serve as alternative routes to the project as well as roads within the vicinity that were considered to be influenced by the project.

Key alternative routes within the GHG assessment study area boundary include:

- Parramatta Road between Five Dock and Broadway
- City West Link and Anzac Bridge/Western Distributor
- Victoria Road between Lyons Road and Anzac Bridge
- The Sydney Harbour Bridge and Sydney Harbour Tunnel
- Cahill Expressway and Southern Cross Drive
- The eastern extent of the M4 East Motorway, between Five Dock and the Wattle Street interchange
- The existing M5 East Motorway and New M5 Motorway, between the Princes Highway and General Holmes Drive
- Princes Highway, King Street and City Road, between Rockdale and Ultimo
- Roads surrounding the Wattle Street interchange, the Rozelle interchange, and the St Peters interchange.

Appendix W (Detailed greenhouse gas calculations) provides further detail regarding the GHG assessment study area.

Results of the operational road use assessment are provided in **Table 22-6** and **Appendix W** (Detailed greenhouse gas calculations). **Table 22-6** shows the difference between the total GHG emissions generated in the 'do minimum' (without project) and 'with project' scenarios for both 2023 and 2033. The final column in **Table 22-6** shows the difference between the total GHG emissions generated in the 'do minimum' (without project) and the 'cumulative' scenarios for 2023 and 2033.

Table 22-6 Scope 3 operational road use GHG emissions results

Route	GHG emissions (t CO2-e)	GHG emissions (t CO2-e)	GHG emissions (t CO2-e)	GHG emissions (t CO2-e)	GHG emissions (t CO2-e)	GHG emissions (t CO2-e)	Difference between scenarios (t CO2-e)			
	'Do minimum' (without project)		'With project'		'Cumulative'		'With project' – 'Do minimum'		'Cumulative' – 'Do minimum'	
	2023	2033	2023	2033	2023	2033	2023	2033	2023	2033
Existing road network (within the study area)	9,891,755	11,687,799	9,491,704	11,140,131	9,242,368	10,811,985	-400,052	-547,668	-649,387	-875,814
M4-M5 Link	N/A	N/A	38,471	42,917	46,886	54,686	38,471	42,917	46,886	54,686
Totals	**9,891,755**	**11,687,799**	**9,530,175**	**11,183,048**	**9,289,254**	**10,866,671**	**-361,581**	**-504,751**	**-602,501**	**-821,128**

Note:

Negative values indicate a savings in GHG emissions for the 'with project' and 'cumulative' scenarios compared with the 'do minimum' (without project) scenario.

N/A = not applicable (the 'do minimum' scenario does not include the project).

The results demonstrate the benefits of road tunnel usage in urban areas, where travel along a more direct route at higher average speeds results in fewer GHG emissions being generated by road users, as reduced congestion and stop-start driving reduces the fuel used by vehicles. Despite increases to overall daily VKT on motorways and a reduction in performance of some non-motorway roads (as discussed in **Chapter 8** (Traffic and transport)), a reduction in GHG emissions is estimated as a result of the project compared with the 'do minimum' scenario.

The results for 2023 indicate that the project is forecast to reduce annual GHG emissions by around 361,600 t CO_2-e for the 'with project' scenario and around 602,500 t CO_2-e for the 'cumulative' scenario, within the study area assessed, when compared with the 'do minimum' scenario for 2023. Over time, it is anticipated that the road network performance would improve, as traffic becomes accustomed to changes brought about by the project.

The assessment results indicate that the project is forecast to reduce annual GHG emissions by around 504,750 t CO_2-e in 2033 for the 'with project' scenario and around 821,100 t CO_2-e in 2033 for the 'cumulative' scenario, within the study area assessed, when compared with the 'do minimum' scenario. The predicted reduction in GHG emissions as a result of the project would be due to an improvement in vehicle fuel efficiency for some links within the study area as well as the operational efficiency of the project tunnels.

The magnitude of GHG emissions savings for the 'cumulative' scenario is attributed to, not only an increase in average speeds, but an increase in the number of vehicles shifting off non-motorway roads within the study area as alternative routes become available through the completion of projects such as the proposed future Sydney Gateway, Western Harbour Tunnel, Beaches Link and the F6 Extension.

Vehicle fuel efficiency is anticipated to improve as part of the project based on:

- An overall increase in daily VKT and a reduction in daily vehicle hours travelled (VHT) on the road network, with more trips able to be made on the network in a shorter time, primarily associated with traffic using the new motorway
- A decrease in VKT and VHT on key alternative routes and non-motorway roads
- Increased average speeds as a result of the operational efficiency of the M4-M5 Link, which would reduce the number of intersections and the frequency of stopping
- Increased average speeds on key alternative routes (non-motorway roads) within the study area due to reduced congestion.

Mitigation and management measures, including efficiencies incorporated into the project design to reduce energy and resource requirements, and therefore GHG emissions, are provided in **section 22.7**.

22.5 Combined project GHG emissions

The GHG emissions saving for the project of around 361,600 t CO_2-e in 2023 would represent around 0.07 per cent of the Australian national inventory for the year March 2016 to March 2017, and 0.27 per cent of the NSW inventory for 2015, as discussed in **section 22.2.3**.

The GHG emissions saving for the project of around 504,750 t CO_2-e in 2033 would represent around 0.09 per cent of the Australian National inventory for the year March 2016 to March 2017, and 0.38 per cent of the NSW inventory for 2015.

Figure 22-2 shows the nett emissions profile for the project for the assessment years of 2023 and 2033, comparing the emissions estimated to be generated by the project's construction, operation and maintenance with the emissions savings for the 'with project' and cumulative scenarios compared with the 'do minimum' scenario.

Figure 22-2 demonstrates that emissions estimated to be generated during construction and the annual emissions from the operation and maintenance of road infrastructure would result in a nett increase of emissions generated for the project in 2023 for the 'with project' scenario. However, under the 'cumulative' scenario for 2023, emissions generated in construction and annual operation and maintenance would be offset against emissions savings as a result of improved road performance within the study area boundary. Similarly, annual operation and maintenance emissions estimated to be generated in 2033 would be offset against emissions savings for the 'with project' and 'cumulative' scenarios.

Emissions were not able to be extrapolated beyond the operational traffic impact footprint for the project, which was assessed up to 2033. However, it is expected that the savings in emissions from improved road performance would reduce over time as traffic volumes increase.

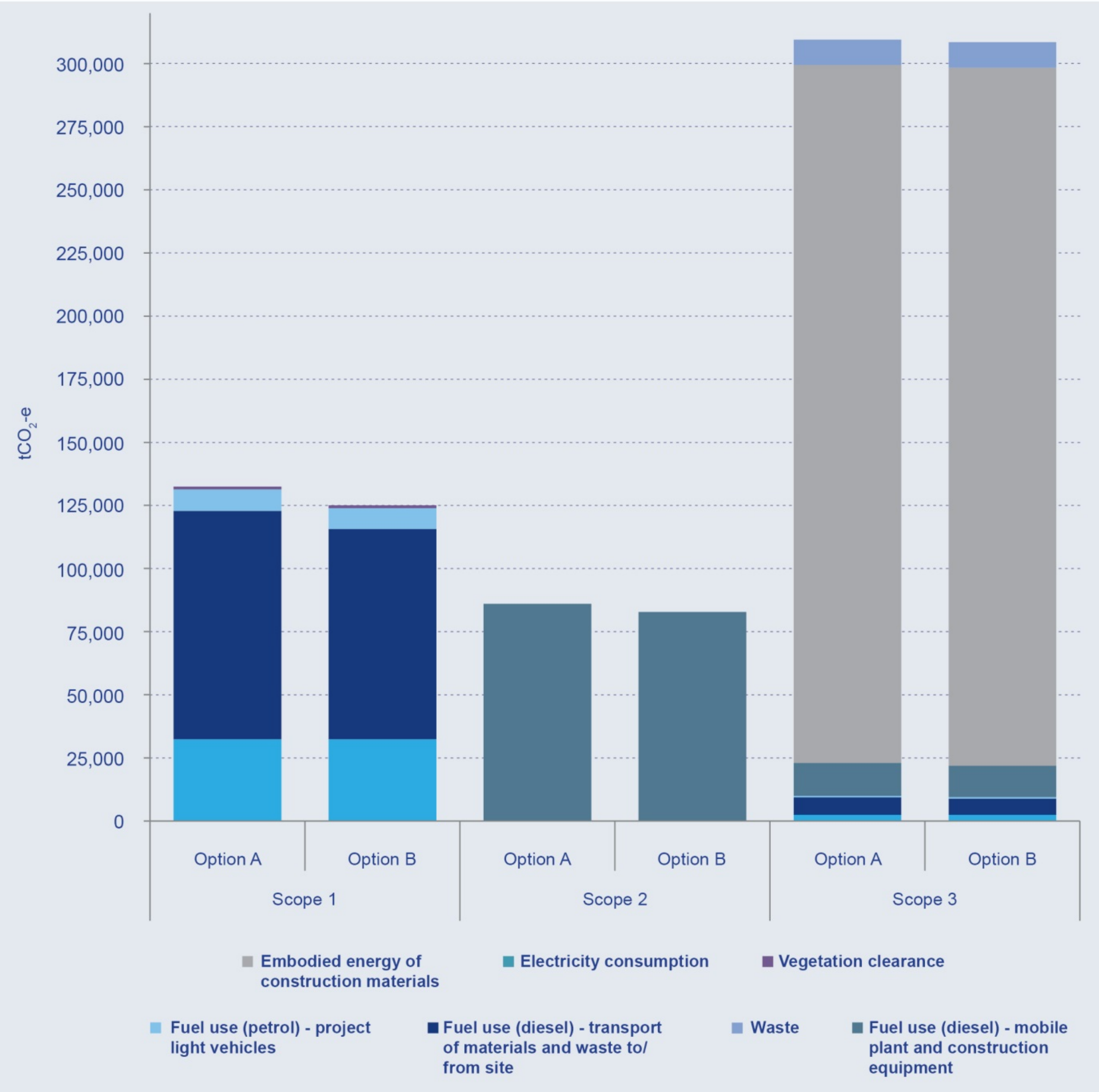


Figure 22-2 Combined GHG emissions profile: construction, operation and maintenance emissions offset against emissions savings

As discussed, the magnitude of GHG emissions savings for the 'cumulative' scenario is likely to be attributed to the reduction of traffic using the existing road network within the study area as alternative routes become available through the completion of projects such as the proposed future Sydney Gateway, Western Harbour Tunnel, Beaches Link and the F6 Extension.

22.6 Assessment of cumulative impacts

22.6.1 Cumulative construction emissions

Estimated construction emissions for each WestConnex component project are presented in **Table 22-7**, with a summary of the cumulative emissions for each scope.

Table 22-7 Estimated construction emissions for each WestConnex component project

WestConnex project	GHG emissions (t CO_2-e) Scope 1	GHG emissions (t CO_2-e) Scope 2	GHG emissions (t CO_2-e) Scope 3	Total
M4 Widening	10,195	-	477,340	487,540
M4 East	92,271	65,651	224,157	382,079
New M5	83,709	109,200	280,249	473,158
King Georges Road Interchange Upgrade	2,261	-	7,825	10,085
M4-M5 Link*	132,468	86,017	309,557	528,042
Total	**320,904**	**260,868**	**1,299,128**	**1,880,904**

Note:

* Construction estimate for M4-M5 Link using Option A of construction ancillary facilities at Haberfield (the larger estimate).

Mitigation and management measures would be implemented during each project to reduce GHG emissions during construction. Ongoing monitoring and reporting of project emissions would also be undertaken in accordance with the WestConnex Sustainability Strategy (Sydney Motorway Corporation 2015), as discussed in **Chapter 27** (Sustainability).

22.6.2 Cumulative operational emissions

The assessment of operational road use emissions for each component of the WestConnex program of works was undertaken for a discreet study area as relevant to each project component. The individual study areas were assessed for differing operational timeframes and assesses the changes in traffic performance brought about by each project component within their respective GHG study area boundaries. As a result, it was not appropriate to add these together to quantitatively assess the cumulative emissions of the WestConnex program of works as a whole.

However, results for each of the GHG assessments undertaken for EISs of the individual WestConnex component projects show greater emissions savings in the ‘cumulative’ scenario compared with the ‘project only’ scenario within their respective study area boundaries. This is associated with WestConnex’s contribution to improved traffic flow on the motorway network and additional network capacity and improvements proposed as part of future projects such as Sydney Gateway, Western Harbour Tunnel, Beaches Link and the F6 Extension.

These results align with the cumulative assessment presented in **Appendix H** (Technical working paper: Traffic and transport), which shows greater reductions in daily VKT and VHT for the ‘cumulative’ scenario compared with the ‘with project’ and ‘do minimum’ scenarios for key alternative routes and non-motorway roads, and a reduced daily VHT for the ‘cumulative’ scenario for motorways.

Despite increases to overall daily VKT on motorways, improvements to traffic flow and congestion are achieved through increased speeds and reduced frequency of stopping, as well as reduced daily VKT and VHT on alternative routes and non-motorway roads, which results in improved fuel efficiency and subsequently reduced GHG emissions associated with road use. Future improvements in vehicle fuel efficiency are also taken into account, as described in **Appendix W** (Detailed greenhouse gas calculations). It is expected that savings in emissions from improved road performance would reduce over time as traffic volumes increase.

22.7 Management of impacts

22.7.1 Management of emissions through design

The design of the project has been optimised such that measures to reduce energy and resource requirements, and therefore GHG emissions, are inherent in the design. Design development from the M4-M5 Link preliminary design, as discussed in **Chapter 4** (Project development and alternatives), has been optimised to include:

- Refinement and revision of the alignment of the mainline tunnels, reducing the length of the mainline tunnels between the Wattle Street interchange and the St Peters interchange, thereby reducing the volume of spoil generated, materials used, lighting and ventilation required, and emissions generated from operational road use by vehicles
- Reduced energy and resource consumption, and spoil generation, during tunnel excavation, through selection of roadheaders and drill and blast for excavation, as opposed to the use of a tunnel boring machine. The latter option consumes more electricity, potable water and concrete, and generates more spoil
- Reduced energy and resource consumption through an LED lighting design. The design significantly reduces the number of fittings required in comparison to similar existing NSW tunnels which use end-to-end fluorescent fittings or high-pressure sodium lights. When compared to interior zone tunnel high-pressure sodium lights, as used on the East Link and Airport Link, the number of fittings can be reduced with LED lights as they can be oriented to spread the light evenly whilst meeting lighting standards. LED light banks also have a longer operational life and lower operational power demand
- Reduced power consumption through the design of the ventilation system, which incorporates low pressure fans that consume about 50 per cent less energy compared with a high pressure fan solution. These low pressure fans are oriented vertically which also reduces the total ventilation structural footprint by 20 to 30 per cent, reducing the amount of embodied energy associated with construction materials used
- Optimal tunnel ventilation power consumption by locating the ventilation facilities close to the main alignment tunnel portals, thereby optimising the piston generated vehicle effect
- Mainline tunnels and the associated surface road network designed for long term performance and durability of materials, increasing asset design lives and reducing the frequency of maintenance activities
- The project would facilitate improvements to pedestrian and cyclist paths, linking existing active transport networks with new connections at Rozelle and St Peters, and reducing the need for reliance on road transport between these communities.

22.7.2 Next steps for emissions reduction

Table 22-8 provides a list of mitigation measures to be incorporated during the construction and operation of the project, in accordance with the WestConnex Sustainability Strategy, to further reduce the GHG emissions generated by the project.

Table 22-8 Environmental management measures - GHG

Impact	No.	Environmental management measures	Timing
Construction			
Emission of greenhouse gases during construction	GHG1	An Energy Efficiency and Greenhouse Gas Emissions Strategy and Management Plan will be prepared for the project as part of the project's Sustainability Management Plan and will be implemented to assist in achieving 'Design' and 'As Built' ratings of Excellent under the Infrastructure Sustainability Council of Australia infrastructure rating tool.	Construction

Impact	No.	Environmental management measures	Timing
	GHG2	Undertake an updated GHG assessment based on detailed design for ongoing monitoring and review of emissions during construction.	Construction
	GHG3	Opportunities to use low emission construction materials, such as recycled aggregates in road pavement and surfacing, and cement replacement materials will be investigated and incorporated where feasible and cost-effective.	Construction
	GHG4	Construction plant and equipment will be operated and maintained to maximise efficiency and reduce emissions, with construction planning used to minimise vehicle wait times and idling onsite and machinery turned off when not in use.	Construction
	GHG5	Locally produced goods and services will be procured where feasible and cost effective to reduce transport fuel emissions.	Construction
	GHG6	At least 20 per cent of construction energy required for the project will be sourced from an accredited GreenPower energy supplier, where possible. Six per cent of construction electricity requirements will be offset, with any offset undertaken in accordance with the Australian Government National Carbon Offset Standard	Construction
Operation			
Emission of greenhouse gases during operation	OGHG7	The tunnel will be designed with appropriate vertical alignments and grades to allow vehicles to maintain constant speeds and minimise fuel use to reduce potential greenhouse gas emissions.	Construction and operation
	OGHG8	Energy efficiency will be considered during the design of mechanical and electrical systems such as the tunnel ventilation system, tunnel lighting, water treatment systems and electronic toll and surveillance systems. Energy efficient systems will be installed where reasonable and practicable.	Operation
	OGHG9	At least six per cent of operational energy required for the project will be sourced from an accredited GreenPower energy supplier and/or through renewable energy generated onsite. Opportunities for operational energy offset, in accordance with the Australian Government National Carbon Offset Standard, will be considered during detailed design.	Operation

23 Resource use and waste minimisation

This chapter describes the resources and materials, including potential sources and expected quantities that would be used to construct the M4-M5 Link (the project).

In addition, both construction and operation of the project would generate waste streams that would require management and disposal in accordance with relevant NSW policies and guidelines. This chapter also provides a description of each waste stream, expected quantities of waste materials where known and applicable waste management strategies.

Resource consumption and waste generated by the project would also contribute to the emission of greenhouse gases during construction and operation. The consideration of this impact and emission reduction opportunities are discussed further in **Chapter 22** (Greenhouse gas).

The Secretary of the NSW Department of Planning and Environment (DP&E) has issued environmental assessment requirements for the project. These are referred to as Secretary's Environmental Assessment Requirements (SEARs). **Table 23-1** sets outs these requirements and the associated desired performance outcomes that relate to waste management, and identifies where they have been addressed in this environmental impact statement (EIS).

Table 23-1 SEARs - waste

Desired performance outcome	SEARs	Where addressed in the EIS
16. Waste All wastes generated during the construction and operation of the project are effectively stored, handled, treated, reused, recycled and/or disposed of lawfully and in a manner that protects environmental values.	1. The Proponent must assess predicted waste generated from the project during construction and operation, including:	Construction resource consumption and waste is discussed in **section 23.3**. Operational resource consumption and waste is discussed in **section 23.4**.
	a) classification of the waste in accordance with the current guidelines;	The classification of waste is described in **section 23.3.2**
	b) estimates/details of the quantity of each classification of waste to be generated during the construction of the project, including bulk earthworks and spoil balance;	The estimated quantities of waste to be generated are included in **section 23.3.2**.
	c) handling of waste including measures to facilitate segregation and prevent cross-contamination;	Construction waste management is discussed in **section 23.3.2**.
	d) management of waste including estimated location and volume of stockpiles;	Construction waste volumes and stockpile locations are provided in **section 23.3.2**.
	e) waste minimisation and reuse;	Efficient use of construction materials is discussed in **section 23.3.1**. Waste reuse is discussed in **section 23.3.2**.

Desired performance outcome	SEARs	Where addressed in the EIS
	f) lawful disposal or recycling locations for each type of waste; and	Potential disposal or recycling locations are discussed in **section 23.3.2**.
	g) contingencies for the above, including managing unexpected waste volumes.	Contingencies for managing unexpected waste volumes are discussed in **section 23.3.2** and are summarised in **section 23.5**.
	2. The Proponent must assess potential environmental impacts from the excavation, handling, storage on site and transport of the waste particularly with relation to sediment/leachate control, noise and dust.	Dust impacts and management are discussed in **Chapter 9** (Air quality). Noise impacts and management are discussed in **Chapter 10** (Noise and vibration). Sediment control and potential environmental impacts associated with the excavation of waste are described in **Chapter 15** (Soil and water quality) and **Chapter 16** (Contamination). Potential environmental impacts associated with the handling, storage and transport of waste are discussed throughout this chapter. Leachate control is discussed in **section 23.3.2**.

23.1 Assessment methodology

The *Protection of the Environment Operations Act 1997* (NSW) (POEO Act) establishes management and licensing requirements for waste. It also defines offences relating to waste and sets penalties. In accordance with the POEO Act and its regulations, the NSW Environment Protection Authority (NSW EPA) has established guidelines for the classification of waste. These have been considered in the assessment of waste generated by the project and subsequent development of mitigation and management measures.

Indicative quantities and types of waste that would be generated from the project have been estimated with consideration of earlier stages of WestConnex and form the basis for the preliminary classification in accordance with the *Waste Classification Guidelines: Part 1 Classifying Waste* (NSW EPA 2014).

Resource use for the project was assessed by reviewing the indicative scale and extent of the project as outlined in **Chapter 5** (Project description) and the construction methodology described in **Chapter 6** (Construction work) and estimating the resources required for construction, including their likely source. Waste types, anticipated quantities of waste and resource use estimates would be revised during the detailed design of the project and would be finalised as part of the detailed construction planning and during construction.

23.2 Legislative and policy framework

There are three main legislative instruments to manage waste in NSW:

- *Waste Avoidance and Resource Recovery Act 2001* (NSW) (WARR Act)
- POEO Act
- Protection of the Environment Operations (Waste) Regulation 2014 (NSW) (POEO Regulation).

The WARR Act is the primary legislation for managing waste. It aims (among other things) to reduce waste generation and improve the conversion of waste into recoverable resources. Resource and waste management for the project would be prioritised according to the principles of the resource management hierarchy defined in the WARR Act, namely (in order of preference):

- Avoidance of unnecessary resource consumption
- Resource recovery (including reuse, reprocessing, recycling and energy recovery)
- Disposal.

The POEO Act defines 'waste' for regulatory purposes and establishes management and licensing requirements for its transport, storage, disposal and reuse. Under the POEO Regulation, the NSW EPA may grant exemptions from some of the requirements under the POEO Act in the form of either a ’resource recovery order’ or a ’resource recovery exemption’ (refer to clauses 91, 92 and 93 of the POEO Regulation). There are a number of resource recovery orders and resource recovery exemptions currently in force, which are relevant to a range of materials that are commonly used in road construction activities.

Potentially relevant resource recovery orders under Part 9, Clause 93 of the POEO Regulation would include:

- The excavated natural material order 2014
- The excavated public road material order 2014
- The reclaimed asphalt pavement order 2014
- The recovered aggregate order 2014
- The stormwater order 2014.

Potentially relevant resource recovery exemptions under clauses 91 and 92 of Part 9 of the POEO Regulation would include:

- The excavated natural material exemption 2014
- The excavated public road material exemption 2014
- The reclaimed asphalt pavement exemption 2014
- The recovered aggregate exemption 2014
- The stormwater exemption 2014.

Additional guidelines considered for the assessment include:

- *NSW Sustainable Design Guidelines* Version 3.0 (Transport for NSW 2013)
- *Managing Urban Stormwater: Soils and Construction Volume 1* (Landcom 2004) and *Volume 2 (A. Installation of Services; B. Waste Landfills; C. Unsealed Roads; D. Main Roads; E. Mines and Quarries)* (NSW Department of Environment and Climate Change 2008).

23.3 Assessment of construction impacts

23.3.1 Construction resource consumption

Construction materials

Significant quantities of materials would be required for the construction of the project. Construction material would generally be sourced from off-site suppliers. Wherever practical, locally sourced construction materials would be used to minimise haulage distances and associated traffic impacts.

The project would adopt the following sustainability principles to optimise the efficient use of construction materials:

- Capitalise on opportunities to reduce material use and maximise the use of materials with low environmental impact
- Maximise the use of reused/recycled timber products and timber from sustainably managed forests that have obtained Forest Management Certification
- Optimise the amount of cement replacement material used in concrete
- Optimise the amount of recycled material used in road base and sub-base.

With the adoption of these principles, the project would minimise long-term impacts through the sustainable use of construction materials. Further detail of the overarching sustainability objectives for construction materials is provided in **Chapter 27** (Sustainability).

Indicative quantities and the major sources of materials required for construction are provided in **Table 23-2**.

Table 23-2 Indicative quantities of materials required for construction

Material	Estimated quantity required	Anticipated source/origin
Concrete	400,000 cubic metres	Sydney suppliers located close to the project
Precast concrete	32,250 cubic metres	Combination of NSW and overseas suppliers
Structural steel	450 tonnes	Manufactured in Australia and/or overseas
Reinforcing steel	15,000 tonnes	Manufactured in Australia
Asphalt	70,000 tonnes	Sydney suppliers located close to the project
Road base	20,000 tonnes	Quarries within the Sydney region
Water	2,000 megalitres	Recycled construction and mains water
Petrol	30,000 litres	Local Sydney supplier
Diesel	12 megalitres	Local Sydney supplier

Resource requirements may have an impact on resource availability within the local area over the construction period. However, with the adoption of the aforementioned sustainability principles, any impact would be reduced and limited to the construction period.

Sustainability would be considered when sourcing materials and equipment during construction of the project. A procedure for the procurement and management of subcontractors that factors in sustainability would be developed and implemented.

Water resources

Water would be required during construction for:

- Tunnelling activities, including for cooling water, dust suppression and concreting
- Surface works, including pavement construction, concrete works, washdown areas, dust suppression and landscaping activities
- Site offices and ablutions.

The total volume of water required for construction of the project would be around 6,000 kilolitres per day. Water would be sourced from sources where water quality and volume requirements are met, including:

- Stormwater harvesting (non-potable water)
- On-site construction water treatment and reuse (non-potable water)
- Mains supply (potable water).

Preference would be given to the use of non-potable water over potable water, in accordance with the *WestConnex Sustainability Strategy* (Sydney Motorway Corporation 2015). The extent to which non-potable water sources can be used would be governed by workplace health and safety considerations, economic feasibility, the functional specifications of the design, tunnelling equipment specifications, and non-potable water availability. Non-potable water could be used during construction for dust suppression and end-of-project landscaping. It is anticipated that the local water supply network would have sufficient capacity to accommodate project construction water requirements.

Estimated volumes and potential supplies of water for each construction ancillary facility are summarised in **Table 23-3**. A water balance has been prepared for the project and is outlined in **Chapter 17** (Flooding and drainage).

Table 23-3 Estimated daily construction water requirements at construction ancillary facilities

Construction ancillary facility	Daily construction water usage (kL / day)			
	Potable water supply from Sydney Water mains	Non-potable water supply	Non-potable water supply	Total
		Collected rainwater	Treated groundwater	
C1a Wattle Street civil and tunnel site	420	2	250	672
C2a Haberfield civil and tunnel site	420	1	0	421
C3a Northcote Street civil site	10	0	0	10
C1b Parramatta Road West civil and tunnel site	420	2	250	672
C2b Haberfield civil site	40	1	0	41
C3b Parramatta Road East civil site	10	1	0	11
C4 Darley Road civil and tunnel site	630	1	50	681
C5 Rozelle civil and tunnel site	1,000	3	370	1,373
C6 The Crescent civil site	40	1	0	41
C7 Victoria Road civil site	40	1	0	41
C8 Iron Cove Link civil site	30	1	20	51
C9 Pyrmont Bridge Road tunnel site	840	1	25	866
C10 Campbell Road civil and tunnel site	840	1	100	941

Power

The total energy requirements to construct the project would be around 100,000 megawatt hours. At least 20 per cent of the electricity requirements would be met from renewable energy sources and/or accredited Green Power energy supplier as required by the *WestConnex Sustainability Strategy* (Sydney Motorway Corporation 2015). A target minimum of six per cent of construction electricity requirements would be offset, with any offset undertaken in accordance with the Australian Government National Carbon Offset. Greenhouse gas impacts related to project energy requirements are discussed in **Chapter 22** (Greenhouse gas).

Most of the project would be located underground, which would reduce surface amenity and property acquisition impacts during construction and operation. To deliver an underground motorway, a large tunnelling effort would be needed, requiring large amounts of energy during construction, including for the operation of the tunnelling machinery (known as roadheaders). The mainline tunnel alignment has been optimised to minimise the length of the tunnel (refer to **Chapter 4** (Project development and alternatives)), helping to reduce construction power demands.

Construction ancillary facilities are required along the mainline tunnel alignment and for the Rozelle interchange and Iron Cove Link. Major construction power would be required at sites where tunnelling is to be carried out by roadheaders. Construction power supply requirements for major construction ancillary facilities are summarised in **Table 23-4**, including supply source and power requirements.

A Utilities Management Strategy (**Appendix F**) has been prepared for the project that identifies management options, including relocation or adjustment of utilities. This strategy includes a description of the process for confirming utility works within and outside the project footprint, an outline of the consultation that would be undertaken with utility providers and the local community regarding these works and an assessment of the range of potential environmental impacts associated with utility works. In addition, the strategy provides a process for how utility works not assessed as part of the EIS would be managed.

Table 23-4 Construction power supply for construction ancillary facilities

Construction ancillary facility	Maximum demand (MVA)[1]	Supply source connection point	Supply route length (metres)[2]
Wattle Street civil and tunnel site (C1a) and Haberfield civil and tunnel site (C2a)	10	Croydon Road at Croydon	850
Parramatta Road West civil and tunnel site (C1b)	10	Croydon Road at Croydon	850
Darley Road civil and tunnel site (C4)	8	Balmain Road at Leichhardt	850
Rozelle civil and tunnel site (C5)	13	Balmain Road at Leichhardt	1,500
Pyrmont Bridge Road tunnel site (C9)	10	Layton Street at Annandale	100
Campbell Road civil and tunnel site (C10)	10	Connection to be provided within site by New M5 contractor	N/A

Note:

1 Mega volt ampere

2 Supply route distance is measured as a straight line distance

Construction power demand for site offices, facilities, tools and small plant at the Northcote Street civil site (C3a), Haberfield civil site (C2b), Parramatta Road East civil site (C3b), Victoria Road civil site (C7) and the Iron Cove Link civil site (C8) would be within the capacity of the existing local distribution network.

Initial discussions with power supply authorities have confirmed that local substations have the required capacity to supply the construction ancillary facilities without affecting the local supply network. All power supply routes would be underground.

23.3.2 Construction waste management

Waste streams generated during construction of the project would include construction and demolition waste, vegetation waste, packaging materials and liquid wastes. All wastes would be managed using the hierarchy approach of waste avoidance and resource recovery before consideration of waste disposal.

Should the generation of wastes be unavoidable, or be unsuitable for reuse/recycling, disposal methods would 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 requirements for management, transportation and disposal of each waste category.

All wastes would be managed in accordance with the waste provisions contained within the POEO Act and, where reused off-site, would comply with relevant NSW EPA resource recovery exemptions and requirements.

Solid and liquid wastes

Solid and liquid waste streams generated during construction of the project would include:

- Excavated wastes (spoil), such as soil and rock, primarily from tunnelling and cutting including virgin excavated natural material (VENM)
- Demolition wastes including concrete, bricks, tiles, timber (untreated and treated), metals, plasterboard, carpets, electrical and plumbing fittings and furnishings (doors, windows)
- Asbestos and hazardous waste (including contaminated spoil (refer to **Chapter 16** (Contamination))
- Vegetation waste from the removal of trees, shrubs and ground cover that are unable to be mulched and reused within the project
- General construction waste such as timber formwork, scrap metal, steel, concrete, plasterboards and packaging material (crates, pallets, cartons, plastics and wrapping materials)
- Waste from operation and maintenance of construction vehicles and machinery including adhesives, lubricants, waste fuels and oils, engine coolant, batteries, hoses and tyres
- General wastes from site offices such as putrescibles, paper, cardboard, plastics, glass and printer cartridges.

Potential impacts arising from construction waste management may include:

- Large volumes of spoil being directed to landfill due to inadequate recycling and reuse
- Dust impacts due to incorrect storage, handling, transport and disposal of spoil
- Large volumes of waste being directed to landfill due to inadequate collection, classification and disposal of waste
- Contamination of soil, surface and/or groundwater from the inappropriate excavation, storage, transport and disposal of liquid and solid waste
- Risks to human health from the handling, storage, transport and disposal of contaminated (including asbestos containing) material from demolition waste generated by the project.

Existing metropolitan waste management facilities would have capacity to receive the anticipated waste streams generated by the project. General wastes from site offices such as putrescible wastes, paper, cardboard, plastics, glass and printer cartridges would be collected for off-site recycling wherever practicable. Demolition and excavation waste generated by the project have the potential to contain hazardous materials, including acid sulfate soils, asbestos containing material (ACM) and other contaminated materials. The management of this waste is discussed in the 'Special wastes' section below.

Construction waste management activities would not pose a significant risk to the environment or human health, with the implementation of standard measures (provided in **section 23.5**) to adequately address waste generation, handling storage, transport, disposal and reuse. A Construction Waste Management Plan, as part of the Construction Environmental Management Plan (CEMP), would be prepared and implemented for the project. These plans would take into account construction staging and specific conditions of approval that may be applied to the project. More information regarding spoil management is provided in the sections below.

Spoil management

Excavated soil and rock (spoil), mainly from tunnelling and bulk excavation works, would make up most of the solid waste generated by the project during construction. Up to about 4,000,000 cubic metres of spoil would be generated during construction of the project.

Spoil generation and management

Most spoil would be received and managed at tunnel construction sites. Smaller quantities of spoil would be generated during site preparation activities, excavation of dive structures, and cut-and-cover activities for the surface components of the project.

Anticipated spoil volumes generated from each construction ancillary facilities site for tunnelling and surface works are outlined in **Table 23-5**. Up to about 4,000,000 cubic metres of spoil would be generated during construction of the project. This large volume of spoil is a result of constructing tunnels to accommodate up to four lanes of traffic in each direction and large underground interchanges (the Inner West subsurface interchange and the Rozelle interchange).

Table 23-5 Anticipated spoil volumes

Site	Estimated spoil volume (cubic metres)	Estimated spoil volume (cubic metres)	Estimated spoil volume (cubic metres)
	Tunnel	Surface	Total
Wattle Street civil and tunnel site (C1a)	276,500	35,000	311,500
Haberfield civil and tunnel site (C2a)[1]	276,500	-	276,500
Parramatta Road West civil and tunnel site (C1b)	500,000	20,000	520,000
Darley Road civil and tunnel site (C4)	549,500	10,500	560,000
Rozelle civil and tunnel site (C5)	1,008,000	35,000	1,043,000
The Crescent civil site (C6)	-	43,800	43,800
Victoria Road civil site (C7)	-	25,000	25,000
Iron Cove Link civil site (C8)	-	44,100	44,100
Pyrmont Bridge Road tunnel site (C9)	849,500	5,000	854,500
Campbell Road civil and tunnel site (C10)	715,000	40,000	755,000
Total (with Option A ancillary facilities)	**3,675,000**	**238,400**	**3,913,400**
Total (with Option B ancillary facilities)	**3,622,000**	**223,400**	**3,845,400**

Note:

1 The Haberfield civil and tunnel site would be used as a support site for the construction of the M4-M5 Link/M4 East connection. This construction ancillary facility would be used to transport small plant, workers and materials. Tunnel spoil would not be transported to the surface from these tunnelling works. All spoil transport from these tunnelling works would occur via the M4 East tunnels and the M4 East Motorway.

The majority of excavated spoil material would be uncontaminated crushed sandstone and shale, classified as VENM. This would consist of mixed size crushed rock ranging from shale and sand to lumps of rock.

A contamination assessment has been carried out as part of this EIS (further details are provided in **Chapter 16** (Contamination)). The assessment identified that it is likely that contaminated materials, including asbestos, are present at sites where previous land uses included the use of asbestos materials (such as at the Rozelle Rail Yards) and where older buildings and structures would be demolished.

Spoil management hierarchy

The project design has taken into account the principles of the resource management hierarchy as defined in the WARR Act, including minimising excess spoil generation, as far as practical. Where possible and fit for purpose, spoil would be beneficially reused as part of the project before alternative spoil disposal options are pursued. Excess spoil which cannot be reused or recycled would be disposed of at a suitably licensed landfill or waste management facility.

The project would seek to reuse or recycle around 95 per cent of uncontaminated spoil, either within the project or at other locations. Spoil reuse would be prioritised in accordance with the spoil management hierarchy outlined below.

Where feasible and reasonable, spoil would be managed according to the following hierarchy:

- Minimisation of spoil generation through design and management
- Reuse of spoil within the project
- Beneficial reuse of spoil outside the project
- Where reuse is not possible, disposal of spoil would be the last resort.

The following spoil reuse opportunities have been identified within the project:

- The use of tunnel spoil for the backfill of cut-and-cover tunnels and the infill of temporary access shafts and declines
- The use of tunnel and civil surface works spoil for fill, landscaping and site rehabilitation purposes
- The use of tunnel spoil for local road upgrades, namely the replacement of existing unsuitable pavement subgrade material
- The use of tunnel spoil for remediation activities at the Rozelle Rail Yards.

Spoil reuse would include the opportunities above, and further opportunities would be investigated during the construction of the project.

The construction traffic and transport assessment has taken into account heavy vehicle movements associated with spoil management during the peak construction period. **Chapter 8** (Traffic and transport) provides a summary of heavy vehicle movements at each construction ancillary facility, including spoil related haulage.

Stockpile management

Stockpiles would be located at the following construction ancillary facilities:

- Wattle Street civil and tunnel site (C1a)
- Parramatta Road West civil and tunnel site (C1b)
- Darley Road civil and tunnel site (C4)
- Rozelle civil and tunnel site (C5)
- The Crescent civil site (C6)
- Victoria Road civil site (C7)
- Pyrmont Bridge Road tunnel site (C9)
- Campbell Road civil and tunnel site (C10).

The estimated stockpile volumes at these construction ancillary facilities are provided in **Table 23-6**. Stockpile material at the tunnelling sites listed above (C1a, C1b, C4, C5, C9 and C10) would consist primarily of spoil while stockpile material at the civil sites listed above (C6 and C7) would consist primarily of excavated infrastructure. At the Iron Cove Link civil site (C8), spoil from the construction of the dive and cut-and-cover structures would be loaded directly onto spoil trucks from excavation areas.

Table 23-6 Stockpile volumes

Stockpile location	Estimated stockpile volume (cubic metres)
Wattle Street tunnel and civil site (C1a)	20,000
Parramatta Road West civil and tunnel site (C1b)	1,600
Darley Road civil and tunnel site (C4)	20,000
Rozelle civil and tunnel site (C5)	40,000
The Crescent civil site (C6)	20
Victoria Road civil site (C7)	5,000
Pyrmont Bridge Road tunnel site (C9)	20,000
Campbell Road civil and tunnel site (C10)	20,000

Spoil stockpiles would be contained within acoustic sheds or separated by roller doors between cut-and-cover ramps and tunnel sections. Where excavations are carried out prior to the construction of cut-and-cover ramps, spoil would be stored on the surface within the Rozelle Rail Yards or loaded into spoil trucks directly from excavation areas.

The roller doors and acoustic sheds would minimise the potential for spoil sediments to be transported by wind or rain. They would also minimise the potential for impacts from runoff (including from contaminated materials) and sedimentation associated with stockpiling. Stockpiles would also be covered and bunded where appropriate to avoid potential impacts associated with runoff, sedimentation and leachate. Potential impacts from runoff and sedimentation would be further minimised through the implementation of the environmental management measures described in **Chapter 15** (Soil and water quality).

Potential impacts related to leachate (ie liquid that drains from a landfill or stockpile) are considered to be unlikely during construction as the project does not involve the excavation or disturbance of landfill areas, except at the Campbell Road civil and tunnel site (C10), where intrusive works would be undertaken within the former Alexandria Landfill Environment Protection Licence (EPL) boundary. Construction activities in this area would be required to comply with the existing Golder (2016) RAP, Landfill Closure Plan, EPL and New M5 conditions of approval. Stockpiles would be covered and bunded where appropriate to avoid potential impacts associated with runoff, sedimentation and leachate.

Contaminated material would be segregated from uncontaminated material on site to prevent cross-contamination during the storage and handling of spoil. The Construction Waste Management Plan would describe methodologies and strategies to prevent cross-contamination. Suitable areas would be identified to allow for contingency management of unexpected waste materials, including contaminated spoil. Suitable hardstand or lined areas would be required that are appropriately stabilised and bunded, with sufficient area for stockpile storage and segregation.

Potential impacts related to dust and noise and vibration associated with the management of stockpiles are discussed in **Chapter 9** (Air quality) and **Chapter 10** (Noise and vibration) respectively.

Spoil reuse sites and disposal sites

Excess spoil that cannot be reused within the project would require off-site reuse/disposal. Around 95 per cent of uncontaminated spoil would be beneficially reused in accordance with the project spoil management hierarchy.

Five potential sites have been identified for receiving excess spoil from the project, as summarised in **Table 23-7**. Negotiations for the final destination(s) for excess spoil would be carried out during detailed design, and may include one or more of the sites listed in **Table 23-7** or other alternative sites identified during detailed design.

Table 23-7 Potential spoil management sites

Spoil management site	Location	Distance from the project (kilometres)	Capacity for site to accept spoil (cubic metres)
Horsley Park (manufacturing facility)	Wall Grove Road at Horsley Park	About 40	Capacity for entirety of project spoil generation[1]
Blacktown Waste Services (landfill)	920 Richmond Road at Marsden Park	About 45	250,000
Sakkara Development (industrial estate)	Riverstone Parade at Riverstone	About 45	3,500,000
Kurnell Landfill	330 Captain Cook Drive at Kurnell	About 20	7,000,000
Moorebank Intermodal Terminal Precinct	Moorebank Avenue, Moorebank	About 30	2,500,000
Western Sydney Airport	Lot 1 DP 838361, Badgerys Creek	About 50	Capacity not known at this stage

Note:

1 The Horsley Park spoil management site is a manufacturing facility and currently does not have a definitive limit for the amount of spoil it can receive.

Spoil would be delivered to the spoil management sites in accordance with the conditions of approval and environment protection licences governing those sites. The spoil reuse and disposal sites identified above are based on the current existing availability of spoil receiving locations (including projects with a fill deficit) across the Sydney area. Construction of the project would occur over a five-year period, with spoil generation peaking in 2019–2021 when both the mainline tunnels and Rozelle interchange are under construction concurrently. It is therefore anticipated that alternative locations may emerge during construction that could represent an improved outcome.

The following criteria would be applied to determine the priority given to the identified spoil reuse and disposal sites, including how much spoil would be sent to each site, and to evaluate any additional spoil reuse or disposal options that emerge during construction:

- Environmental benefit – in terms of a preference for the material to be reused for such purposes as:
  - Environmental works (eg coastal protection works, flood mitigation or restoration)
  - Clean fill on other projects (eg landscaping, barrier mounds, land reclamation, capping)
  - Land restoration (eg filling of disused mines and quarries)
- Traffic impacts – with a preference for haulage routes that keep to major arterial roads and minimise total haulage requirements as far as possible
- Approvals – any receiving location would need to be approved to receive the applicable type and volume of spoil
- Economic – feasibility of transporting the spoil compared to the options already identified, including consideration of the distances to be travelled.

Spoil would be hauled using heavy vehicles to spoil reuse and disposal sites. The anticipated spoil haulage routes are outlined in **Chapter 6** (Construction work). Other disposal/reuse sites may be used depending on need at the time spoil is generated. In addition, there is the potential that spoil could be removed by barge, subject to further investigations. Further details regarding spoil generation and management are provided in **Chapter 6** (Construction work) and in **Chapter 8** (Traffic and transport).

<u>Cumulative spoil management</u>

Construction of the project would occur:

- At the same time as other tunnelling projects in Sydney, including:

- New M5 project
- M4 East project (for Option B construction ancillary facilities)
- Sydney Metro City and Southwest

- Within one year of the completion of other tunnelling projects in Sydney, including:
  - M4 East project (for Option A construction ancillary features)
  - NorthConnex.

The tunnelling projects listed above would also require the management and disposal of large volumes of spoil and there is the potential for cumulative impacts related to spoil disposal for the project. Cumulative impacts would arise if the spoil management sites identified for the project reach capacity as a result of receiving spoil from other tunnelling projects. Cumulative impacts may also arise where multiple tunnelling projects use the same spoil management sites and/or haulage routes (refer to **Chapter 26** (Cumulative impacts) for more detail regarding cumulative impacts).

Estimated spoil volumes and potential spoil management sites for the project and for other tunnelling projects (as identified in their respective environmental assessments) are outlined in **Table 23-8**.

Table 23-8 Estimated spoil volumes and spoil management site capacities for Sydney tunnelling projects

Project	Estimated spoil volume (cubic metres)	Spoil management sites	Capacity (cubic metres)[1]
M4-M5 Link (the project)	4,000,000	Horsley Park	Capacity for entirety of project spoil generation
		Blacktown Waste Services	250,000
		Sakkara Development, Riverstone	3,500,000
		Kurnell Landfill	7,000,000
		Moorebank Intermodal Terminal Precinct	2,500,000
		Western Sydney Airport	Capacity not known at this stage
M4 East	2,400,000	Sakkara Development, Riverstone	3,500,000
		Quakers Hill	600,000
		Marsden Park	360,000
		Horsley Park	Capacity for entirety of M4 East spoil generation
New M5	3,200,000	Boral-CSR Brick Pit, Schofields	550,000
		Quakers Hill	500,000
		Horsley Park	3,000,000
		Sakkara Development, Riverstone	3,500,000
		Kurnell Landfill	7,000,000
NorthConnex	2,600,000	Former Australian Defence Industries site, St Marys	2,500,000
		Gosford Quarry	2,500,000
		Hornsby Quarry	3,300,000
		CSR Quarry	1,160,000
		Quakers Hill	500,000
		Sandy Point Quarry	5,000,000

Project	Estimated spoil volume (cubic metres)	Spoil management sites	Capacity (cubic metres)[1]
Sydney Metro	2,400,000	CSR Quarry, Schofields	1,100,000
		Horsley Park (No. 2 and No. 3 Plants only)	600,000
		CSR Quarry, Schofields	1,100,000
		CSR Quarry, Horsley Park	2,000,000
		Hornsby Quarry	1,800,000
		Gosford Quarry	2,500,000

Note:
[1] Capacity data has been taken from relevant project environmental assessments and therefore represents the capacity of the spoil management sites at the time of the release of the assessments.

Considering the combined capacity of the Sakkara Development (3,500,000 cubic metres), Kurnell Landfill (7,000,000 cubic metres) and Horsley Park (capacity for entirety of project spoil generation), it is unlikely that any one spoil management site would reach capacity and it is highly unlikely that all the sites would reach capacity at the same time.

Spoil management site options, including the Western Sydney Airport, would continue to be investigated during detailed design. Internal coordination with the proponents of the tunnelling projects identified in **Table 23-8** would be undertaken to encourage cooperative approaches to spoil management.

Contaminated spoil

A contamination assessment has been carried out as part of this EIS. The assessment identified:

- Soil and groundwater contamination at some test locations within or adjacent to the project footprint including the Rozelle Rail Yards, Rozelle civil and tunnel site (C5), Victoria Road civil site (C7) and Campbell Road civil and tunnel site (C10)
- The potential for contamination at other locations within the project footprint based on existing or past land uses.

Further details are provided in **Chapter 16** (Contamination).

If previously unidentified contaminated material is discovered, all relevant work would cease in the vicinity of the discovery and the unidentified contaminated material would be managed in accordance with an unexpected contaminated lands discovery procedure, as outlined in the *Guideline for the Management of Contamination* (NSW Roads and Maritime Services (Roads and Maritime) 2013). Relevant works would not recommence until the scope of remedial action(s), if required, was identified in accordance with the requirements of the *Contaminated Land Management Act 1997* (NSW).

Spoil, including contaminated spoil, would be classified in accordance with the *Waste Classification Guidelines: Part 1 Classifying Waste* (NSW EPA 2014). Depending on the extent of contamination, spoil would be considered for reuse on the project site or, where reuse is not possible, disposed of lawfully at an appropriately licensed facility.

Suitable areas would be identified to allow for contingency management of unexpected waste materials, including contaminated materials. Suitable hardstand or lined areas would be required that are appropriately stabilised and bunded, with sufficient area for stockpile storage and segregation.

Material that is identified as contaminated would be segregated from uncontaminated material on site to prevent cross-contamination. A detailed sub-plan to the CEMP for the project would describe methodologies and strategies to prevent cross-contamination.

Special wastes

Acid sulfate soils

There is the potential for acid sulfate soils to be present within the project footprint (refer to **Chapter 16** (Contamination)). Procedures to manage acid sulfate soils would be included in a Construction Soil and Water Management Plan that would be prepared as part of the CEMP.

Identified acid sulfate soil material would be stored temporarily in a bunded area, transported, treated and disposed of off-site at a licensed facility. Management of acid sulfate soils would be in accordance with the *Guideline for the Management of Acid Sulfate Materials* (NSW Roads and Traffic Authority 2005c).

Asbestos

ACM are likely to be present within the project footprint. The excavation, handling, storage, movement and disposal of ACM would be undertaken in accordance with procedures detailed in an Asbestos Management Plan prepared as part of the Work Health and Safety Plan for the project, which would be prepared in accordance with:

- *Work Health and Safety Act 2011* (NSW)
- *Code of Practice for the Safe Removal of Asbestos 2nd Edition* (National Occupational Health and Safety Commission (NOHSC) 2005a)
- *Code of Practice for the Management and Control of Asbestos in Workplaces* (NOHSC 2005b)
- Protection of the Environment Operations (Waste) Regulation 2014 (NSW) – clause 42 special requirements relating to asbestos waste
- National Environment Protection (Assessment of Site Contamination) Measure 1999
- AS2601:2001 Demolition of Structures.

An asbestos survey would be undertaken of buildings to be demolished prior to demolition. Removal of ACM would be undertaken by suitably qualified experts in accordance with an Asbestos Management Plan which would include notification requirements. For further details on known and potentially contaminated sites within the project footprint, refer to **Chapter 16** (Contamination).

Heavy metals

There is the potential for heavy metals such as cadmium, arsenic, copper, lead, mercury, magnesium, aluminium and iron to exist at the Rozelle civil and tunnel site (C5), given the various historical land uses that have occurred at the Rozelle Rail Yards.

The excavation, handling, storage, movement and disposal of waste material that is identified as being contaminated with heavy metals would be undertaken in strict accordance with the procedures detailed in the CEMP and the Work Health and Safety Regulation 2011 (NSW). For further details on known and potentially contaminated sites within the project footprint, refer to **Chapter 16** (Contamination).

Wastewater

Tunnel construction would result in significant volumes of groundwater inflow that would require collection, treatment and disposal. Wastewater volumes generated during tunnel construction would vary depending on construction activity, tunnel groundwater infiltration rate and excavated tunnel length. In addition, wastewater would be generated from other construction activities including dust suppression, washdown areas and stormwater runoff from construction ancillary facilities (grey water). Indicative total wastewater volumes generated over the duration of the construction period are identified in **Table 23-9**.

Construction water would either be reused on site wherever feasible, or discharged into the local stormwater system in accordance with the requirements of the POEO Act, including an environment protection licence (if required).

Opportunities for the reuse of treated water would be considered in preference to discharge to the stormwater system or receiving waterbodies. This could include irrigation of landscaped areas within the project footprint, such as the new open space at the Rozelle Rail Yards. Preference would be given to reusing as much water as practicable before discharging.

Table 23-9 Indicative wastewater volumes

Construction ancillary facility	Estimated daily treatment (kilolitres)	Estimated daily discharge (kilolitres)	Available for reuse on site (kilolitres)	Discharge point
Haberfield civil and tunnel site (C2a)	2,000	1,200	800	Dobroyd Canal (Iron Cove Creek) via a stormwater piper under Parramatta Road.
Parramatta Road West civil and tunnel site (C1b)	2,000	1,200	800	Dobroyd Canal (Iron Cove Creek) via a stormwater piper under Parramatta Road.
Darley Road civil and tunnel site (C4)	1,500	700	800	Hawthorne Canal via the existing channel between Blackmore Park and Canal Road at Leichhardt.
Rozelle civil and tunnel site (C5)	4,000	2,400	1,600	Rozelle Bay near the intersection of City West Link and The Crescent.
The Crescent civil site (C6)	1	10	0.2	Whites Creek/Rozelle Bay via a sedimentation basin within the C6 site.
Victoria Road civil site (C7)	1	200	0.6	Existing drainage system at Victoria Road draining to White Bay.
Iron Cove Link civil site (C8)	10	300	2	Iron Cove via the existing outfall within King George Park.
Pyrmont Bridge Road tunnel site (C9)	2,000	1,200	800	Stormwater drainage system under Parramatta Road.
Campbell Road civil and tunnel site (C10)	2,000	1,200	800	Alexandra Canal.

Around six water treatment plants would be used during construction of the project. These would be located at the Haberfield civil and tunnel site (C2a) or the Parramatta Road West civil and tunnel site (C1b), the Darley Road civil and tunnel site (C4), the Rozelle civil and tunnel site (C5), the Iron Cove Link civil site (C8), the Pyrmont Bridge Road tunnel site (C9) and the Campbell Road civil and tunnel site (C10).

Details of water treatment methods and discharge water quality are provided in **Chapter 15** (Soil and water quality). For further information on water treatment plants proposed to collect and treat construction water, surface water runoff and groundwater inflows, as well as the expected groundwater discharge volumes during both construction and operation, refer to **Chapter 6** (Construction work) and **Chapter 15** (Soil and water quality).

An updated water balance would be prepared during detailed design. The outcomes of this study would be used to further improve water efficiency during construction and operation.

23.4 Assessment of operational impacts

23.4.1 Operational resource consumption

Water resources

During the operation of the project, water would be required for:

- Tunnel deluge system (testing and operation)
- Tunnel wall washing
- Motorway operations complex ablutions
- Landscape irrigation.

The anticipated volume, source, management and treatment of operational water are detailed in **Chapter 5** (Project description).

The local water supply network would have sufficient capacity to accommodate project operational water requirements. Opportunities for reuse of treated water would be considered in preference to discharge to the stormwater system or receiving waterbodies. This could include irrigation of landscaped areas within the project such as the new open space at the Rozelle interchange. In order to reduce demand on local water supplies, options would be investigated to provide water for the deluge system from wastewater produced through the tunnel drainage system, where it meets appropriate quality parameters.

Other than during regular maintenance testing, which would require relatively minor water volumes, the deluge system would only operate during emergencies. Water for the deluge system would be sourced from the mains supply.

Power

Operational electricity supply would be required for the mainline tunnels and associated mechanical and electrical equipment. As described in **Chapter 5** (Project description), the project would include the provision of five above ground substations, located at Darley Road motorway operations complex (MOC1), Rozelle West motorway operations complex (MOC2), Rozelle East motorway operations complex (MOC3), Iron Cove Link motorway operations complex (MOC4) and Campbell Road motorway operations complex (MOC5). The project would also include a series of underground substations at a spacing not exceeding 1,200 metres within the tunnel.

The anticipated energy consumption of each operational component of the tunnel is summarised in **Table 23-10**. A minimum of six per cent of operational electricity requirements for the project would be sourced from renewable sources and/or an accredited GreenPower energy supplier. Opportunities for operational energy offset, in accordance with the Australian Government National Carbon Offset Standard, would be considered during detailed design.

The project has been designed to minimise energy consumption and maximise energy efficiency. Measures to improve energy efficiency are detailed in **Chapter 22** (Greenhouse gas). Initial discussions with power supply authorities indicate that there is sufficient capacity to supply the project's power requirements without negative impacts on the local power supply.

Table 23-10 Anticipated operational power supply requirements

Location	Power requirement (MVA)
Mainline tunnels	35
Rozelle interchange and Iron Cove Link	30

Peak oil

Peak oil refers to the fact that oil production may peak, or may have already peaked, and that oil production would decline after this peak. The impact could increase the cost and reduce the availability of transport fuels. Peak oil issues in relation to transport generally include the use of fossil fuels, the energy efficiency of vehicles and construction products derived from fossil fuels. Although consideration of peak oil is not included in the SEARs, Roads and Maritime acknowledges that it is prudent to consider peak oil in terms of the project's resource needs.

Despite efforts to limit demand for road transport, it is expected that the need for road transport would continue to grow, as described in **Chapter 3** (Strategic context and project need). The WestConnex program of works is intended to increase travel speeds, reduce travel distances and improve travel efficiency across the city, including on parallel arterial roads. This may result in an overall reduction in the quantity of fuel consumed.

Further, by alleviating road congestion on key arterial and local roads and providing new and upgraded active transport links, the project would:

- Directly and indirectly improve opportunities for short and local journeys to be taken on foot or bicycle
- Indirectly facilitate the use and reliability of road based public transport (refer to **Chapter 3** (Strategic context and project need)).

The project would also be able to be utilised by vehicles not powered by fossil fuels (eg electric vehicles).

Government and industry initiatives relevant to peak oil but outside the scope of this project include the NSW Government's *Resource Efficiency Policy* (NSW Office of Environment and Heritage 2014a) and the participation of Roads and Maritime, Austroads and industry in research, with the goal of developing more sustainable road construction materials and practices, thereby reducing reliance on products derived from oil.

23.4.2 Operational waste management

Solid waste

Wastes would be generated during routine maintenance and repair activities required over time, as well as from the operation of the motorway operations complexes. The type and volume of wastes generated would depend on the nature of the activity, but would predominantly consist of minor volumes of general office waste (paper, plastics, food waste), green waste, oil and road materials, as well as contaminated waste resulting from potential fuel spills and leaks. Recycling bins would be provided at site offices to encourage local recycling.

The volumes and types of waste would be typical of motorway operations facilities and could be accommodated by existing metropolitan waste management facilities. Maintenance and repair activities would be subject to separate assessment processes, which would include the assessment of waste impacts associated with these activities.

With the implementation of standard work practices during routine maintenance and repair activities (which would be assessed separately from the project), the overall impact of operational waste streams would be minimal.

Wastewater

The mainline tunnels would include drainage infrastructure to capture groundwater and stormwater ingress, spills, maintenance wastewater, fire suppressant deluge and other potential water sources. The two tunnel drainage streams are expected to produce flows containing a variety of pollutants that require slightly different treatment before discharge to manage adverse impacts on the receiving environment. The pre-treatment water quality of each wastewater stream is expected to vary considerably, and consequently it is likely that the two wastewater streams would need to be collected and treated separately.

Tunnel wastewater from the mainline tunnels would be pumped to an operational water treatment facility at the Darley Road motorway operations complex (MOC1) at Leichhardt, with one option for treated flows being discharged into Hawthorne Canal. Hawthorne Canal discharge point has been considered as an indicative location. Other appropriate locations would be considered during detailed design.

Tunnel wastewater from the Rozelle interchange tunnels and Iron Cove Link would be pumped to an operational water treatment facility at the Rozelle East motorway operations complex (MOC3), with flows being treated at the constructed wetland at Rozelle civil and tunnel site (C5) and then discharged into Rozelle Bay. A small portion (around 1.6 kilometres) of tunnel, to and from the St Peters interchange, would also drain to the New M5 operational water treatment facility at Arncliffe, draining to the Cooks River.

The combined mainline tunnel and Rozelle interchange tunnel would generate around 1,418 megalitres per year of treated groundwater.

Collected groundwater would be pumped to water treatment facilities. Other sources of water captured by the tunnel drainage system (ie washdown or a spill) would be collected in one of the tunnel sumps, assessed to determine the source, tested, and either pumped to and discharged at the surface or removed directly from the sump by tanker for treatment, and disposal elsewhere.

Further information is provided in **Chapter 15** (Soil and water quality) including potential impacts associated with operational stormwater runoff.

23.5 Environmental management measures

Resource use and waste management can be managed and mitigated through the development of construction management plans and implementation of standard approaches.

Measures to avoid, minimise or manage resource consumption and waste streams generated as a result of the project are detailed in **Table 23-11** and would ensure that all wastes generated during the construction and operation of the project are effectively stored, handled, treated, reused, recycled and/or disposed of lawfully and in a manner that protects human health and environmental values. Specific contingency measures for waste management are outlined in the section below and are detailed in **Table 23-11**.

Contingency management of waste

Specific contingency measures to manage waste generated from the construction and operation of the project will be implemented to manage unexpected volumes of waste or otherwise exceptional circumstances. Suitable areas will be identified to allow for contingency management of unexpected waste materials, including contaminated materials. These areas will be hardstand or lined areas that are appropriately stabilised and bunded, with sufficient area for stockpile storage and segregation.

The spoil management sites identified in **section 23.3.2** will have adequate capacity to accept spoil from the project at the time of disposal and there is additional capacity at these sites in the event of additional unexpected spoil volumes.

In the event of discovery of previously unidentified contaminated material, all relevant work will cease in the vicinity of the discovery and the unidentified contaminated material would be managed in accordance with an unexpected contaminated lands discovery procedure, as outlined in the *Guideline for the Management of Contamination* (Roads and Maritime 2013).

The environmental management measures outlined in **Table 23-11** and throughout this assessment will be consistently implemented in the event of encountering unexpected volumes of waste or otherwise exceptional circumstances, along with adherence to all project resource use and waste principles and relevant legislation and regulations.

Table 23-11 Environmental management measures – waste

Impact	No.	Environmental management measure	Timing
Construction			
Resource consumption	RW1	Construction material will be sourced in accordance with the relevant aims of the *WestConnex Sustainability Strategy* (Sydney Motorway Corporation 2015) and a Sustainability Strategy (that will be developed during detailed design), including to optimise resource efficiency and waste management, and the selection of locally sourced materials and prefabricated assets where possible, to reduce greenhouse gas emissions. Unnecessary resource consumption will be avoided through the detailed design of the project and by making realistic predictions about the required quantities of resources, such as construction materials.	Construction
Waste generation and disposal	RW2	Wastes will be managed and disposed of in accordance with relevant NSW legislation and government policies.	Construction
	RW3	A Construction Waste Management Plan will be prepared as part of the CEMP and regularly updated during detailed design and construction, detailing appropriate procedures for waste management. The plan will include the waste management measures described in this EIS.	Construction
	RW4	Wastes will be managed using the waste hierarchy principles of: • Avoidance of unnecessary resource consumption to reduce the quantity of waste being generated • Recovery of resources for reuse on-site or off-site for the same or similar use, without reprocessing • Recovery of resources through recycling and reprocessing so that waste can be processed into a similar non-waste product and reused • Disposal of residual waste.	Construction
	RW5	Resource recovery will be applied to the management of construction waste and will include: • Recovery of resources for reuse – reusable materials generated by the project will be segregated for reuse on site, or off site where possible, including the reuse of the major waste streams (VENM) • Recovery of resources for recycling – recyclable resources (such as metals, plastics and other recyclable materials) generated during construction and demolition • Resources will be segregated for recycling and sent to an appropriate recycling facility for processing • Recovery of resources for reprocessing – cleared vegetation will be mulched or chipped on-site and used for landscaping, in the absence of a higher beneficial use being identified.	Construction

Impact	No.	Environmental management measure	Timing
	RW6	Options identified for the off-site reuse of waste will comply with relevant NSW EPA resource recovery exemptions and requirements.	Construction
	RW7	The Construction Waste Management Plan will document anticipated volumes of spoil that will be generated by the project, spoil storage locations within project sites and likely spoil disposal sites. The Construction Waste Management Plan and spoil reuse opportunities will be regularly reviewed and updated during detailed design and project construction.	Construction
	RW8	The project will reuse or recycle around 95 per cent of uncontaminated spoil generated for beneficial purposes, either within the project or at other locations in accordance with the project spoil management hierarchy.	Construction
	RW9	Suitable areas will be identified to allow for contingency management of unexpected waste materials, including contaminated materials. Suitable areas would be required to be hardstand or lined areas that are appropriately stabilised and bunded, with sufficient area for stockpile storage.	Construction
Exposure to unexpected contaminated land	RW10	The discovery of previously unidentified contaminated material will be managed in accordance with an unexpected contaminated lands discovery procedure, as outlined in the *Guideline for the Management of Contamination* (Roads and Maritime 2013) and detailed in the CEMP.	Construction
Dust generation, erosion and sedimentation of stockpiles	RW11	Spoil stockpiles will be provided with appropriate environmental controls and managed to reduce potential impacts associated with dust generation, erosion and sedimentation.	Construction
Generation of general waste	RW12	General wastes from site offices such as putrescibles, paper, cardboard, plastics, glass and printer cartridges will be separated and collected for recycling off-site wherever practicable.	Construction
Exposure to asbestos	RW13	An asbestos survey will be undertaken of buildings to be demolished as part of the project in accordance with an Asbestos Management Plan as part of the Work Health and Safety Plan. The survey will be conducted by a suitably qualified person.	Construction
	RW14	Asbestos handling and management will be undertaken in accordance with an Asbestos Management Plan as part of the Work Health and Safety Plan and relevant NSW legislation, government policies and Australian Standards. The plan will include prior notification to adjacent communities about potential hazards.	Construction

Impact	No.	Environmental management measure	Timing
Operation			
Waste generation and disposal	ORW1	The project will be operated in accordance with the relevant aims of the *WestConnex Sustainability Strategy* (Sydney Motorway Corporation 2015) and a Sustainability Strategy will be developed during detailed design to outline ways to optimise resource efficiency and waste management.	Operation
	ORW2	Waste will be managed and disposed of in accordance with relevant NSW legislation and government policies and the mitigation measures described in this EIS.	Operation
Wastewater use and discharge	ORW3	Opportunities to reuse treated groundwater during project operation will be considered in preference to discharge to the stormwater system or receiving waterbodies. This could include irrigation of landscaped areas within the project footprint such as new open spaces at the Rozelle interchange.	Operation
	ORW4	In order to reduce demand on local water supplies, options will be investigated to provide water for the deluge system from wastewater produced through the tunnel drainage system, where it meets appropriate quality parameters.	Operation

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24 Climate change risk and adaptation

The NSW Government has acknowledged that, despite efforts to reduce greenhouse gas emissions, some climate change is now inevitable. Adapting to these changes is necessary to minimise the impacts of climate change on natural and built environments, on communities and the economy, and aligns with the Australian Government's *National Climate Resilience and Adaptation Strategy* (2015) and the NSW Government's *Climate Change Policy Framework* (NSW Office of Environment and Heritage 2016).

For the M4-M5 Link project (the project), NSW Roads and Maritime Services (Roads and Maritime) has determined that an assessment of the potential impacts of climate change on the project is warranted, given the significant investment required for the project, the long design life of the project, and its exposure to potential flooding impacts. This chapter outlines the methodology adopted to assess the impacts of climate change on the project and adaptation measures that have been incorporated in the design of the project, as well as recommendations for further development of adaptation options during the project's detailed design. Impacts of the project on climate change relate to greenhouse gas emissions generated from the construction and operation of the project. Greenhouse gas emissions have been assessed in **Chapter 22** (Greenhouse gas).

The Secretary of the NSW Department of Planning and Environment (DP&E) has issued environmental assessment requirements for the project. These are referred to as the Secretary's Environmental Assessment Requirements (SEARs). **Table 24-1** sets out these requirements and the associated desired performance outcomes as they relate to climate change risk, and identifies where they have been addressed in this environmental impact statement (EIS).

Table 24-1 SEARs – climate change risk

Desired performance outcome	SEARs	Where addressed in the EIS
17. Climate Change Risk The project is designed, constructed and operated to be resilient to the future impacts of climate change.	1. The Proponent must assess the risk and vulnerability of the project to climate change in accordance with the current guidelines.	This chapter, and **Appendix X** (Climate change risk assessment framework), present a climate change risk assessment for the project in accordance with current guidelines as listed in **section 24.1**.
	2. The Proponent must quantify specific climate change risks with reference to the NSW Government's climate projections at 10 km resolution (or lesser resolution if 10 km projections are not available) and incorporate specific adaptation actions in the design.	Climate change risks to the project are identified in **section 24.3**, **section 24.4** and **Appendix X** (Climate change risk assessment framework), with reference to current climate change projections presented in **section 24.2.2**.
12. Flooding The project minimises adverse impacts on existing flooding characteristics. Construction and operation of the project avoids or minimises the risk of, and adverse impacts from, infrastructure flooding, flooding hazards, or dam failure.	1. The Proponent must assess (and model where required) the impacts on flood behaviour during construction and operation for a full range of flood events up to the probable maximum flood (PMF) (taking into account sea level rise and storm intensity due to climate change).	Flooding is addressed in **Chapter 17** (Flooding and drainage) and **Appendix Q** (Technical working paper: Surface water and flooding). Changes to rainfall frequency and/or intensity as a result of climate change are also discussed in **Appendix X** (Climate change risk assessment framework) and **section 24.2**.

During detailed design, a detailed climate change risk assessment would be undertaken (in accordance with the standard AS 5334-2013 Climate change adaptation for settlements and infrastructure – A risk based approach), informed by the initial climate change risk assessment set out in this chapter.

24.1 Assessment methodology

Roads and Maritime is currently in the process of finalising a *Technical Guide for Climate Change Adaptation for the State Road Network* (Roads and Maritime (unpublished) 2015) (Technical Guide). The Technical Guide would be aligned with existing Roads and Maritime processes, such as risk management and environmental planning, as well as broader NSW Government initiatives and programs responding to climate change impacts. Although the Technical Guide is not yet published, this assessment adopts the approach of the latest draft to ensure consistency with Roads and Maritime's planned approach to climate change adaptation.

The assessment set out in this chapter considers the impact of future climate change on the project, rather than the impacts of the project on the future of climate change, which relate to greenhouse gas emissions generated from the construction and operation of the project. Greenhouse gas emissions have been assessed in **Chapter 22** (Greenhouse gas).

In addition to the Technical Guide, the climate change risk assessment has been conducted in line with the following relevant standards and current guidelines:

- The risk assessment approach set out in AS/NZS ISO 31000:2009 Risk Management – Principles and Guidelines and ISO/IEC 31010 Risk Management – Risk assessment techniques
- AS 5334-2013 Climate change adaptation for settlements and infrastructure – A risk based approach, which follows ISO 31000:2009 Risk Management – Principles and guidelines
- *Australian Government, Climate Change Impacts & Risk Management – A Guide for Business and Government*, Australian Government (2006)
- *Guideline for Climate Change Adaptation*, Revision 2.1, Australian Green Infrastructure Council (2011)
- *Guidelines for Risk Management* (Roads and Maritime 2014).

The overall approach is focused on risk management and is closely aligned with AS/NZS 31000:2009 Risk Management and complements Roads and Maritime's *Guidelines for Risk Management*. The approach is detailed in the draft *Technical Guide: Climate Change Adaptation for the Road Network* (Roads and Maritime (unpublished) 2015), and comprises the following steps:

- Pre-screening
- Screening
- Detailed risk assessment
- Risk evaluation
- Adaptation (risk treatment).

Each of these steps is described in the following sections.

24.1.1 Pre-screening

A pre-screening exercise was undertaken by Sydney Motorway Corporation (SMC) and Roads and Maritime prior to this assessment to determine whether the project is likely to be impacted by climate change. As part of the exercise, key issues were considered to determine whether the project warrants consideration of climate change. These key issues included:

- Site location and project objectives
- Climate variables of relevance to the project
- Existing climate exposure of the local surroundings
- Likely capacity of project components to withstand changes in climate

- Significance of the project infrastructure and willingness to accept risk
- Desired level or service
- Design life.

It was determined that an assessment of the impact of climate change on the project is warranted due to the significant investment required, the long design life of the project, and its exposure to potential flooding impacts (in particular at Rozelle).

24.1.2 Screening

Screening aims to identify potential exposure to relevant climate change impacts. Each road infrastructure project has a range of engineering components and service provisions and is subject to different climate change impacts and risks. It is therefore not appropriate to consider a generic list of climate change risks.

For the project, specific risks were identified using a screening matrix, which plots relevant elements of the project on one axis and key climate change variables relevant to the region on the other axis. By identifying the intersection between the climate change variables and the elements of the project, relationships can be identified and used to form the basis of potential risk scenarios for further analysis. This step forms part of the ‘risk identification’ stage of a typical risk management process as described in Roads and Maritime’s *Guidelines for Risk Management*.

A multidisciplinary workshop was held on 8 September 2016 with key members of the project design team to identify and validate the project’s exposure to climate change and inform the development of risk scenarios specific to the project, as discussed in **section 24.1.3**. The climate change risk screening for the project is provided in **Appendix X** (Climate change risk assessment framework).

24.1.3 Detailed risk assessment

The first step of the detailed risk assessment was the formulation of risk scenarios for each of the relationships identified in the screening stage. Each risk scenario was then analysed in detail by assigning a likelihood and consequence rating. The criteria used for likelihood and consequence (following the Roads and Maritime *Guidelines for Risk Management*) are shown in Table 1-1 and Table 1-2 of **Appendix X** (Climate change risk assessment framework). The consequence rating considers the potential consequences for the physical asset (damages), service provision (loss), safety, the environment and the community.

By combining the likelihood and consequence rating for each risk scenario, using the risk ranking matrix in **Table 24-2**, a level of risk can be determined. These levels represent that risk that exists before any mitigation or adaptation treatments are applied. For example, a risk with medium likelihood and low consequence results in a risk level of low.

The detailed risk assessment for the project is provided in **Appendix X** (Climate change risk assessment framework).

Table 24-2 Risk level matrix

Likelihood	Consequence					
		Negligible	**Low**	**Medium**	**High**	**Extreme**
	Extreme	Medium	High	Extreme	Extreme	Extreme
	High	Low	Medium	High	Extreme	Extreme
	Medium	Negligible	Low	Medium	High	Extreme
	Low	Negligible	Negligible	Low	Medium	High
	Negligible	Negligible	Negligible	Negligible	Low	Medium

24.1.4 Risk evaluation

The purpose of risk evaluation was to identify which risks require treatment, through either mitigation or adaptation. Treatments should be applied to those risks evaluated as extreme or high. Risks evaluated as negligible or low do not require any further consideration.

As this is a preliminary climate change risk assessment, and a subsequent detailed risk assessment would be undertaken during detailed design, any risks rated medium or higher have been retained for further consideration. The risk evaluation for the project is provided in **section 24.3.1** and **section 24.4.1**.

24.1.5 Adaptation (risk treatment)

This step involves the development of risk treatments that can reduce the original unmitigated risk rating. Adaptation measures incorporated in the project design at this stage are associated with broader design refinements and opportunities for optimisation, as discussed in **section 24.5.1**. Additional options for further consideration during the detailed design of the project are provided in **section 24.5.2**.

24.2 Existing environment

An increase in global concentrations of greenhouse gases has led to an increase in the Earth's average temperature (surface temperature) (Intergovernmental Panel on Climate Change (IPCC) 2013)). The Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC) (IPCC 2013) states that 'human influence on the climate system is clear. This is evident from the increasing greenhouse gas concentrations in the atmosphere, positive radiative forcing, observed warming, and understanding of the climate system'.

In 2015, the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the Australian Bureau of Meteorology (BoM) released an assessment of observed climate change and projected future changes in Australia over the 21st century (CSIRO and BoM 2015a). This recent assessment confirms the long-term warming trend, showing that in Australia, the average surface air temperature has increased by 0.9°C since records began in 1910, with most of the warming occurring since 1950. Australia's warmest year since 1910 was 2013 (CSIRO and BoM 2015a).

The AR5 states with high confidence that Australia is already experiencing impacts from climate change. Observed trends include changes in the frequency of air temperature extremes, changes in mean and extreme rainfall, changes in the frequency and intensity of storm events, ocean warming, ocean acidification and sea level rise.

Due to the long lag times associated with climate processes, even if greenhouse gas emissions are mitigated and significantly reduced, the warming trend and associated impacts of climate change are expected to continue for centuries (IPCC 2013). Key projected trends include:

- Increase in atmospheric carbon dioxide concentrations
- Increase in mean temperature
- Increase in frequency, intensity and duration of heat extremes
- Decrease in frequency, intensity and duration of cold extremes
- Changes in mean rainfall
- Changes in the intensity and frequency of extreme rainfall and storm events
- Rise in sea level
- Increase in extreme sea levels (eg storm surge)
- Increase in ocean acidity
- Increase in bushfire weather.

The magnitude of these projected changes would vary both spatially and temporally (IPCC 2013).

Appendix X (Climate change risk assessment framework) provides information on the existing climate and historical climate trends of the project footprint.

24.2.1 Policy setting

In 2015, the Australian Government released the *National Climate Resilience and Adaptation Strategy*, which recognises Australia's vulnerability to climate change and provides a set of principles to guide effective adaptation and build the resilience of Australia's communities, economy and environment. The guiding principles include priorities for:

- Shared responsibility and collaboration among stakeholders
- Climate risk factored into decision making
- A risk management approach based on the best available scientific data
- Assisting the vulnerable
- The importance of monitoring decisions and outcomes over time.

The Strategy identifies the need to consider future climate and extreme weather events in the design and construction of infrastructure, and references the Australian Government's *Critical Infrastructure Resilience Strategy: Policy Statement* (2015), which aims for the continued operation of critical infrastructure and essential services in the face of all hazards.

In 2016, the NSW Government released a new *Climate Change Policy Framework*, which aims to maximise the economic, social and environmental wellbeing of NSW in the context of a changing climate. The Framework includes the development and implementation of a *Draft Climate Change Fund Strategic Plan 2017–2022* and *A Draft Plan to Save NSW Energy and Money*.

The *Draft Climate Change Fund Strategic Plan 2017–2022* sets out priority investment areas for funding over the next five years, including up to $100 million in new funding for actions to prepare NSW for a changing climate. As part of this priority investment area, the *Draft Climate Change Fund Strategic Plan 2017–2022* identifies actions for reducing the costs to public and private assets arising from climate change, reducing the impacts of climate change on health and wellbeing, particularly for vulnerable communities, and managing the impacts of climate change on natural resources, natural ecosystems and communities.

Further discussion of the policy setting for climate change mitigation and emissions reduction is provided in **Chapter 22** (Greenhouse gas) and summarised in **Chapter 27** (Sustainability).

24.2.2 Future climate

This section discusses the selection of climate projections relevant to the project and provides a summary of projections for key climate change variables.

Selection of climate change projections

Climate change projections selected to inform this risk assessment are based on information published by CSIRO and BoM in 2015. The design life of the project is 100 years. As such, projections modelled for 2030 (an average of the period 2020–2039) and 2090 (an average of the period 2080–2100) have been selected for the assessment. These are the available projections for the time horizon closest to project opening and the end of the project design life, respectively.

Projections for southeast Australia have also been published by the NSW and the Australian Capital Territory (ACT) Regional Climate Modelling (NARCliM) project (2014) in collaboration with OEH. These projections are based on the earlier climate models used for the IPCC's Fourth Assessment Report (AR4) and provide downscaled climate change data for a 10 kilometre resolution specific to NSW and the ACT.

While both sets of projections provide robust information on possible changes to the NSW climate, NARCliM projections are not yet available for a number of key climate variables (extreme rainfall, sea level rise, storm surge, wind speed) and the 'far future' projections are limited to projections from 2060 to 2079. This presents limitations when considering climate change impacts on road planning.

For the purposes of this climate change risk assessment, it is considered prudent to consider the potential impact of sea level rise on the project, given the project's proximity to the coastline, particularly at Rozelle Bay, and the sensitivity of road infrastructure to inundation impacts. Therefore, projections provided by CSIRO and BoM are considered most appropriate for this project and are recommended in the draft *Technical Guide: Climate Change Adaptation for the Road Network* (Roads and Maritime (unpublished) 2015).

It is important that a single source of projections is used as this ensures an 'internally consistent climate future' is presented, with a consistent set of assumptions, scenarios and modelling methods applied to each projection to represent the complex interactions that occur between climate variables within the climate system. As such, only the CSIRO and BoM projections have been used. Regardless, the purpose of this chapter is to inform a climate change risk assessment and the difference between the sources of projections is not considered to impact on the development of risk scenarios for the project, except where data is unavailable for particular climate variables, such as sea level rise.

Summary of climate change projections

Projections are presented for two emission scenarios or possible pathways, referred to as 'representative concentration pathways' (RCPs), each reflecting a different concentration of global greenhouse gas emissions. The two RCPs reported here are Intermediate emissions (RCP4.5) and High emissions (RCP8.5). Intermediate emissions projections are only provided in this report for context. The assessment is based on 'High' emissions projections, to account for a worst case scenario based on the precautionary principle.

The projections published by CSIRO and BoM (2015b) are spatially divided into eight natural resource management 'clusters', which largely correspond to broad-scale climate and biophysical regions of Australia. The project falls within the East Coast cluster. Due to the large north–south extent of the East Coast cluster and the diversity of the region, climate change projections are presented for the East Coast South sub-cluster where available. The sub-cluster extends from the south of Sydney to the Queensland border. Projections at this scale are considered appropriate for the consideration of future climate for road projects, in line with guidance provided in the draft *Technical Guide: Climate Change Adaptation for the Road Network* (Roads and Maritime, unpublished 2015).

A summary of projections for the East Coast cluster for 2030 and 2090, for both the Intermediate and High emissions scenarios, is provided in **Table 24-3**. Projections are provided for the East Coast South sub-cluster or Sydney where data at that resolution is available. This table is followed by a description of each climate variable.

Table 24-3 Projections for the East Coast Cluster for 2030 and 2090

Climate variable	2030		2090	
	Intermediate emissions	High emissions	Intermediate emissions	High emissions
Mean surface temperature (East Coast South projections)	Increase of 0.6°C to 1.0°C	Increase of 0.7°C to 1.3°C	Increase of 1.3°C to 2.5°C	Increase of 2.9°C to 4.6°C
Extreme temperature (days per year) (Projections for Sydney)	4.3 days over 35°C 0.5 days over 40°C	Data not available (projections expected to be similar to intermediate emissions for 2030)	6.0 days over 35°C 0.9 days over 40°C	11 days over 35°C 2.0 days over 40°C
Mean annual rainfall (%) (East Coast South projections)	Between a decrease of 10% and increase of 6%	Between a decrease of 11% and increase of 6%	Between a decrease of 16% and increase of 9%	Between a decrease of 20% and increase of 16%
Extreme Rainfall (one in 20 year, %) (East Coast South projections)	Data not available	Data not available	Increase by 0% to 30%	Increase by 5% to 40%
Mean annual wind speed (%) (East Coast South projections)	Between a decrease of 2.9% and increase of 0.5%	Between a decrease of 2.3% and increase of 1.9%	Between a decrease of 4.2% and increase of 0.2%	Between a decrease of 6.9% and increase of 4.2%
Bushfire weather (annual cumulative Forest Fire Danger Index (FFDI)/number of days with a fire danger rating of severe and above) (East Coast projections)	Increase of annual cumulative FFDI by 5% Increase of number of days with a fire danger rating of severe and above by 20%	Increase of annual cumulative FFDI by 12% Increase of number of days with a fire danger rating of severe and above by 45%	Increase of annual cumulative FFDI by 13% Increase of number of days with a fire danger rating of severe and above by 45%	Increase of annual cumulative FFDI by 30% Increase of number of days with a fire danger rating of severe and above by 130%
Sea level (m) (compared to 1986–2005) (Projections for Sydney)	Increase of 0.09 m to 0.18 m	Increase of 0.10 m to 0.19 m	Increase of 0.30 m to 0.65 m	Increase of 0.45 m to 0.88 m

Source: CSIRO and BoM 2015b

Mean surface temperature

Mean surface temperature is projected to continue warming during the 21st century, at a rate that strongly reflects the increase in global greenhouse gas emissions (CSIRO and BoM 2015b). Mean surface temperatures are projected to increase by 0.6°C to 1.1°C by 2030, and 1.3°C to 2.5°C by 2090, under an ‘Intermediate’ emissions scenario.

Under a ‘High’ emissions scenario, mean surface temperatures are projected to increase by 0.7°C to 1.3°C by 2030 and by 2.9°C to 4.6°C by 2090. There is very high confidence in these projections (CSIRO and BoM 2015b).

Extreme temperature

The trend of increasing extreme temperatures is projected to continue, with increases in the annual number of days over 35°C and 40°C projected for Sydney. The current annual number of days over 35°C in Sydney is 3.1, and the current annual number of days over 40°C in Sydney is 0.3.

Under an ‘Intermediate’ emissions scenario, the annual number of days over 35°C is projected to increase for Sydney by 1.2 days by 2030 (to 4.3 days in total) and 2.9 days by 2090 (to 6.0 days in total). The annual number of days over 40°C is projected to increase by 0.2 days by 2030 (to 0.5 days in total) and 0.6 days by 2090 (to 0.9 days in total) (CSIRO and BoM 2015b).

Under a ‘High’ emissions scenario, the annual number of days over 35°C and 40°C is projected to increase by 7.9 (to 11 in total) and 1.7 (to two in total) days respectively by 2090 (CSIRO and BoM 2015b). There is very high confidence in these projections (CSIRO and BoM 2015b).

Mean annual rainfall

Projections for mean annual rainfall are influenced by changes in seasonal variability. Projections for seasonal rainfall indicate a reduction in winter rainfall, based on medium confidence and good understanding of the natural climate drivers, including a projected southward shift of winter storm systems (CSIRO and BoM 2015b). Climate models project a range of changes in rainfall for other seasons, with less certainty around the driving climate processes for these periods.

As a result of the variability in model results, CSIRO and BoM recommend considering future climate scenarios that are both drier and wetter (2015b). However, it is projected that extreme rainfall events would become more frequent and intense (refer to discussion of extreme rainfall below).

There is low confidence in mean rainfall projections (CSIRO and BoM 2015b). There is generally a high degree of uncertainty in rainfall projections because mean rainfall in Australia is influenced by a number of climate drivers, and there is no consensus on how these drivers would be affected by and respond to climate change.

Extreme rainfall

Projections of extreme rainfall events (wettest day of the year and wettest day in 20 years) are projected to increase in intensity across Australia. By 2090, one in 20 year events are expected to increase by between zero and 30 per cent under an ‘Intermediate’ emissions scenario and between five and 40 per cent under a ‘High’ emissions scenario (CSIRO and BoM 2015b).

There is high confidence that the intensity of extreme rainfall would increase in the East Coast cluster; however, the magnitude of the change cannot be reliably projected (CSIRO and BoM 2015b).

The flood modelling undertaken for the project, summarised in **Chapter 17** (Flooding and drainage) and **Appendix Q** (Technical working paper: Surface water and flooding), considers the impact of climate change on rainfall using the approach recommended in the *Practical Considerations of Climate Change – Floodplain Risk Management Guideline* (NSW Department of Environment and Climate Change 2007). Use of the *Practical Considerations of Climate Change – Floodplain Risk Management Guideline* is in accordance with the draft *Technical Guide: Climate Change Adaptation for the Road Network* (Roads and Maritime (unpublished) 2015).

The *Practical Considerations of Climate Change – Floodplain Risk Management Guideline* recommends that sensitivity analyses should be undertaken based on increased rainfall intensities of between 10 and 30 per cent. Under present day climatic conditions, increasing the 100 year ARI design rainfall intensities by 10 per cent would produce about a 200 year ARI flood. Increasing the 100 year ARI design rainfall intensities by 30 per cent would produce about a 500 year ARI flood.

Geoscience Australia recently released the updated *Australian Rainfall and Runoff: A guide to flood estimation* (2016) (ARR), which includes updated guidance for consideration of climate change in design rainfall intensity frequency duration and design flood events. The updated ARR approach is based on the latest climate change science, in accordance with the IPCC Fifth Assessment Report, and uses projections from CSIRO and BoM (as per **Table 24-3**). Flood modelling for the project was already underway when the updated guidance was released. Use of the updated ARR approach would be considered as part of the project's detailed design. **Chapter 17** (Flooding and drainage) and **Appendix Q** (Technical working paper: Surface water and flooding) provide further information regarding the updated ARR approach.

Mean annual wind speed

Under both an 'Intermediate' emissions scenario and a 'High' emissions scenario, there is little change projected in mean wind speed by 2030 and 2090 (CSIRO and BoM 2015b). There is low to medium confidence in these projections (CSIRO and BoM 2015b).

Bushfire weather

Projections of weather conducive to bushfires show that projected warming and drying would lead to fuels that are drier, with increases in the average FFDI and a greater number of days with a severe fire danger rating and above (CSIRO and BOM 2015b).

Under an 'Intermediate' emissions scenario, cumulative FFDI is projected to increase by five per cent by 2030 and 13 per cent by 2090, and the number of days with severe fire danger is projected to increase by 20 per cent by 2030 and 45 per cent by 2090. Under a 'High' emissions scenario, cumulative FFDI is projected to increase by 12 per cent by 2030 and 30 per cent by 2090 and the number of days with a fire danger rating of severe and above is projected to increase by 45 per cent by 2030 and 130 per cent by 2090.

There is high confidence that climate change would result in a harsher fire weather climate in the future; however, there is low confidence in the magnitude of the change, largely due to the uncertainty associated with rainfall projections (CSIRO and BoM 2015b).

Sea level rise

CSIRO and BOM (2015b) state that there is very high confidence that sea levels would continue to rise during the 21st century.

By 2030, projections are similar for 'Intermediate' and 'High' emissions scenarios, with sea levels for Sydney projected to rise by 0.09 metres to 0.18 metres under an 'Intermediate' emissions scenario, and by 0.10 metres to 0.19 metres under a 'High' emissions scenario. By 2090, projections differ significantly between emissions scenarios. Sea levels along the Sydney shoreline are projected to rise by 0.30 metres to 0.65 metres under an 'Intermediate' emissions scenario, and by 0.45 metres to 0.88 metres under a 'High' emissions scenario.

Flood modelling for the project (**Chapter 17** (Flooding and drainage) and **Appendix Q** (Technical working paper: Surface water and flooding)) has considered the impact of future sea level rise using the 2009 NSW Government *Sea Level Rise Policy Statement* planning benchmarks of 0.4 metres by 2050 and 0.9 metres by 2100 (relative to 1990 mean sea level) (NSW Government 2009).

In its Flood Risk Management Guide: Incorporating Sea Level Rise Benchmarks in Flood Risk Assessments (NSW Department of Environment, Climate Change and Water 2010), the NSW Government recommended that these benchmark rises should be used to assess the sensitivity of flood behaviour to future sea level rise. It is acknowledged that the NSW Government Sea Level Rise Policy Statement has since been repealed. However, in the absence of other formal state or Australian Government policy on sea level rise benchmarks, the previously recommended benchmarks have been adopted to assess the impacts of future climate change on flooding conditions in the vicinity of the project.

Use of these benchmarks, which represent an average sea level rise for NSW, is considered to be a conservative approach, as sensitivity testing undertaken for the project for up to 0.9 metres of sea level rise, is more conservative compared with the current CSIRO and BoM (2015) projections for Sydney, which project up to 0.88 metres of sea level rise by 2090 under a 'High' emissions scenario.

Extreme sea level

CSIRO and BOM (2015b) have calculated a 'vertical allowance' for extreme sea level, which is the minimum distance required to raise an asset to maintain the current frequency of breaches under projected sea level rise. The allowance takes into account the nature of extreme levels along the coastline, influenced by factors such as astronomical tides, storm surges and wind waves. This is the parameter that should be used in planning along the coastline.

For 2030, the vertical allowance for the Sydney shoreline ranges from 0.14 metres under an 'Intermediate' emissions scenario to 0.15 metres under a 'High' emissions scenario. For 2090, the vertical allowance for the Sydney shoreline ranges from 0.59 metres under an 'Intermediate' emissions scenario to 0.84 metres under a 'High' emissions scenario.

As discussed in the previous section, sea level rise benchmarks incorporated in the flood risk assessment for the project are conservative in comparison to current sea level rise and extreme sea level rise projections, with a benchmark of up to 0.9 metres of sea level rise by 2100 used in the sensitivity testing undertaken for the project.

Increase in atmospheric carbon dioxide

The current concentration of atmospheric carbon dioxide (CO_2) is around 400 parts per million (United States' National Oceanic and Atmospheric Administration 2015). The 'High' emissions scenario (RCP8.5) represents a future with little curbing of emissions, with CO_2 concentration continuing to rise rapidly, reaching around 940 parts per million by 2100. Under an 'Intermediate' emissions scenario (RCP4.5), CO_2 concentrations peak at around 2040 and stabilise at around 540 parts per million by 2100.

24.3 Assessment of potential construction impacts

24.3.1 Risk evaluation

Climate change projections for the near future (2030) represent an average of projections for the period 2020–2039. Projections for the near future are considered relevant to the project's proposed construction timeframes, planned for the period between 2018 and 2023. Scientific evidence also demonstrates that Australia is already experiencing impacts from climate change, as discussed in **section 24.2**.

Project construction may be susceptible to climate change impacts, including changes in the frequency of air temperature extremes, changes in mean and extreme rainfall, and changes in the frequency and intensity of storm events. **Table 24-4** identifies potential climate change risks to project construction, with a risk rating of medium or higher.

Table 24-4 Climate change risks to project construction (2030)

Risk scenario	Risk rating
Increase in the intensity and frequency of extreme rainfall leads to localised flooding of project construction sites and ancillary facilities, resulting in delays to project program.	Medium
Increase in the intensity and frequency of storm events leads to unsuitable conditions for undertaking construction works, requiring stop work procedures to be implemented for the safety of construction personnel, resulting in delays to project program.	Medium
Increase in frequency and intensity of extreme heat events increases the risk of heat stress conditions for construction personnel, resulting in increased work health and safety risks and potential delays to project program.	Medium

24.4 Assessment of potential operational impacts

Road networks and infrastructure assets are exposed and vulnerable to climate change because of their long design life, during which many impacts of climate change are likely to become more significant.

The main impacts relevant to these assets are associated with an increase in the intensity of extreme rainfall (which can increase the risk of flooding or landslides and exacerbate damage to pavements), and sea level rise (which is likely to exacerbate coastal erosion, cause an increase in storm surges and coastal flooding and may eventually lead to long-term inundation and loss of land). The largest impacts are likely to be borne by surface roads in low-lying areas or those with steep gradients, and by coastal infrastructure in areas exposed to coastal erosion and storm surges.

24.4.1 Risk evaluation

As discussed in **section 24.1.3**, high and extreme risks identified in the detailed risk assessment should be addressed. Subsequently, a detailed risk assessment would be undertaken during detailed design, any risks rated medium or higher have been retained for further consideration.

The detailed risk assessment (**Appendix X** (Climate change risk assessment framework)) identified a total of 33 direct and indirect risks to the project. Of these risks, the detailed risk assessment identified one extreme, four high and 12 medium risks. These risks are listed in **Table 24-5**. Risks rated as low and negligible are provided in the full risk assessment in **Appendix X** (Climate change risk assessment framework).

Table 24-5 Climate change risks to project operation (2030 to 2090) ranked extreme, high and medium

Risk scenario	Risk rating
Extreme rainfall and sea level rise	
Increase in the intensity and frequency of extreme rainfall, combined with sea level rise (and increased extreme sea levels during storm surges) leads to exacerbated localised flood risks at the Rozelle interchange surface road connections and the new intersection at The Crescent and Victoria Road/Anzac Bridge.	Extreme
Increase in the intensity and frequency of extreme rainfall, combined with sea level rise (and increased extreme sea levels during storm surges) adversely affects performance of surface drainage system at the Rozelle interchange surface road connections and the new intersection at The Crescent and Victoria Road/Anzac Bridge due to increased runoff, leading to localised flooding of surface roads, and potential flooding of ancillary infrastructure, landscaped areas and within the project tunnels.	High
Increase in the intensity and frequency of extreme rainfall, combined with sea level rise (and increased extreme sea levels during storm surges) leads to an intrusion of saltwater into bioretention basins, such as the wetland proposed as part of the project at the Rozelle Rail Yards and the bioretention facility within the informal car park at King George Park, adjacent to Manning Street at Rozelle, proposed for the Iron Cove Link as part of the project.	Medium
Increase in the intensity and frequency of extreme rainfall, combined with sea level rise (and increased extreme sea levels during storm surges) leads to exacerbated localised flood risks at the Hawthorne Canal, Whites Creek, Dobroyd Canal (Iron Cove Creek) and Cooks River.	Medium
Increase in the intensity and frequency of extreme rainfall adversely affects performance of surface drainage system in the vicinity of the Iron Cove Link at Victoria Road and local road upgrades due to inundation, leading to localised flooding of surface roads and through the tunnel outlet.	Medium
Increase in the intensity and frequency of extreme rainfall, combined with sea level rise (and increased extreme sea levels during storm surges) adversely affects performance of surface drainage system in the vicinity of intersections, ancillary infrastructure, substations, landscaped areas, and tunnel outlets.	Medium

Risk scenario	Risk rating
Increase in the intensity and frequency of extreme rainfall adversely affects performance of tunnel drainage system due to increased groundwater infiltration, leading to reduced capacity of drainage sump and pumping system and subsequent localised tunnel flooding.	Medium
Sea level rise causes reduced performance or failure of the water treatment system (culverts, pumping stations) due to increased water levels at the location of the submerged discharge infrastructure at Alexandra Canal and Hawthorne Canal and deterioration from saline intrusion.	Medium
Sea level rise causes reduced performance or failure of water treatment system due to increased water levels at the location of the submerged discharge infrastructure at Rozelle Bay and deterioration from saline intrusion.	Medium
Increase in the intensity and frequency of extreme rainfall, combined with sea level rise, leads to exacerbated risk of flooding to bicycle and pedestrian facilities such as the Bay Run, connections at City West Link/The Crescent/Victoria Road/Anzac Bridge at Rozelle and at other surface portal locations.	Medium
Increase in the intensity and frequency of extreme rainfall, combined with sea level rise (and increased extreme sea levels during storm surges) leads to exacerbated risk of power outages (including subsequent pumping station failure) due to increased flooding.	Medium
Increase in the intensity and frequency of extreme rainfall leads to exacerbated risk of road incidents and increases the safety risk for operational personnel and road users.	Medium
Extreme heat	
Increase in frequency and intensity of extreme heat events causes power outages due to spikes in energy demand across the grid for cooling systems.	High
Increase in frequency and intensity of extreme heat events increases the risk of heat stress conditions for operational personnel.	Medium
Increase in frequency and intensity of extreme heat events leads to reduced efficiency of power generation and transmission, resulting in increased electricity consumption.	Medium
Bushfire	
Increased frequency and intensity of bushfire events leads to failure of communications network due to fire damage to network infrastructure and indirect impacts on the project through communications outages.	High
Increased frequency and intensity of bushfire events leads to failure of power supply infrastructure due to fire damage to the energy transmission network and indirect impacts on the project through power outages.	High

An assessment of potential cumulative impacts on climate change risk during project operation is provided in **Chapter 26** (Cumulative impacts).

Post-adaptation residual risk levels for extreme and high risks are discussed in **Chapter 28** (Environmental risk analysis). Adaptation measures for medium risks would be considered further during detailed design and implemented where reasonable and feasible.

24.5 Management of impacts

24.5.1 Adaptation for climate change

Adaptation measures to address climate change risks that are incorporated in the project design at this stage include broader design refinements and opportunities for optimisation. These refinements have been made based on best practice design, with assessment against multidisciplinary criteria. Consideration has been given to avoiding, minimising or managing risks from future climate change, where possible.

As discussed in **section 24.4**, key climate change risks for the project are associated with an increase in the intensity of extreme rainfall and sea level rise, which are likely to exacerbate the existing flood risk experienced in some project locations, particularly the intersection of The Crescent and City West Link at Rozelle. In order to assess the impact of climate change on flood behaviour, sensitivity analyses were undertaken for increases in extreme rainfall and sea level rise (see **section 24.2.2**), with design refinements made to manage potential flood risks and flood risks likely to be exacerbated by climate change. These refinements, and design refinements which address additional climate change risks, are outlined in the following points.

Construction

- The indicative layouts of the temporary construction ancillary facilities have taken into consideration the flood risk posed to the land, including increased flood risk due to climate change. This includes identifying opportunities to provide setback from areas at risk of flooding, locating uses considered more disruptive or vulnerable to flooding – such as stockpile areas, chemical storage areas, tunnel dives and deep excavations – away from areas of highest risk, and allowing controlled flooding of suitable areas such as car parks, where feasible. Refer to **Chapter 17** (Flooding and drainage) and **Appendix Q** (Technical working paper: Surface water and flooding) for further detail.

Operation

- Refinement and revision of the alignment of the proposed future Western Harbour Tunnel and Beaches Link ramps reduces exposure of portals and surface connections to potential impacts from sea level rise and flooding from extreme rainfall at the existing intersection of The Crescent and City West Link
- Due to the high risk of flooding posed to the Rozelle interchange, the road design has been heavily influenced by flood risk and drainage considerations through its evolution. As part of the design development and refinement, design options for the Rozelle interchange were revised to include tunnel connections which extend underground beyond the boundaries of the Rozelle Rail Yards site. Refer to **Chapter 17** (Flooding and drainage) and **Appendix Q** (Technical working paper: Surface water and flooding) for further detail regarding the flood assessment for the Rozelle interchange. Figures in section 6.2.2 of **Appendix Q** (Technical working paper: Surface water and flooding) show the potential climate change impact on peak flood depths for the Probable Maximum Flood (PMF) and 100 year ARI events for the Rozelle interchange
- The design of the operational sites has taken into consideration the flood risk posed to the sites and how to manage these risks, as appropriate. The process for establishing flood risk for the project is outlined in **Chapter 17** (Flooding and drainage). This has meant that mitigation measures are already included as a consequence of the evolution of the project design, as discussed in **Chapter 17** (Flooding and drainage) and **Appendix Q** (Technical working paper: Surface water and flooding)
- Tunnel portals have been designed to ensure immunity from the greater of the PMF or 100 year Average Recurrence Interval (ARI) event plus 0.5 metre freeboard. Where the portals lie within the PMF extent, this would be achieved by appropriate flood protection measures. Refer to management measures in **Chapter 17** (Flooding and drainage) and **Appendix Q** (Technical working paper: Surface water and flooding) for further detail
- To accommodate increased flows as a result of the project, the design includes upgrade of the intersection of City West Link and The Crescent, including realigning The Crescent bridge structure over Whites Creek and naturalisation of the section of Whites Creek between the bridge and Rozelle Bay. The new bridge structure has been designed to include a second span over a

landscaped overflow area to increase the capacity of Whites Creek during large flood events. Figures in section 6 of **Appendix Q** (Technical working paper: Surface water and flooding) showing the design flood behaviour for key project components

- Upgrade of drainage infrastructure discharging from Rozelle Rail Yards under City West Link to Rozelle Bay has been incorporated in the design, including provision of three flood channels and a culvert arrangement with increased capacity to accommodate flows from the Rozelle Rail Yard drainage upgrades. The outfall includes a tide gate to minimise tidal intrusion and improve durability of the Rozelle Rail Yards drainage system (refer to **Appendix Q** (Technical working paper: Surface water and flooding))
- Design of landscape topography at Rozelle Rail Yards to consider increased flood risk from extreme rainfall events. These areas have been designed to act as additional waterway areas and flood storage, to minimise impacts in extreme rainfall events (refer to **Appendix Q** (Technical working paper: Surface water and flooding))
- Provision of a constructed wetland and additional bioretention treatment facilities (where space and grade allow) within the Rozelle Rail Yards site, designed to receive and treat stormwater runoff from the Rozelle Rail Yards as well as groundwater effluent from the water treatment plant (refer to **Appendix Q** (Technical working paper: Surface water and flooding))
- Development of design options for stormwater treatment for the Iron Cove Link, with a bioretention facility within the informal car park at King George Park adjacent to Manning Street at Rozelle. Detailed design of the bioretention facility would consider the impact of future climate change on rainfall intensities. Further detail regarding the drainage design for the Iron Cove Link is provided in **Appendix Q** (Technical working paper: Surface water and flooding)
- Consideration of increased extreme heat events has been incorporated into the urban design of project surface infrastructure and areas of open space created by the project, including landscaped areas to increase shading and areas of respite and reduce the absorption of heat by infrastructure, where possible
- The design reduces power consumption associated with tunnel ventilation by locating the ventilation facilities close to the mainline tunnel portals, thereby optimising the piston effect generated by vehicles
- Backup power and other redundancy measures have been built in to ensure temporary continuity of powered infrastructure in the event of a power outage
- Project infrastructure has been designed for long term performance and durability of structures, increasing asset design lives and reducing the frequency of maintenance activities.

24.5.2 Next steps for adaptation

This initial climate change risk assessment would inform a detailed climate change risk assessment, which will be undertaken during detailed design, in accordance with AS 5334-2013 Climate change adaptation for settlements and infrastructure – A risk based approach. The assessment will identify and implement adaptation measures to address high and extreme risks. The decision to implement adaptation measures for medium risks will also be considered during detailed design.

Table 24-6 lists recommended next steps for the development of adaptation options to be further considered during detailed design and the further detailed climate change risk assessment.

Table 24-6 Environmental management measures – climate change risk and adaptation

Impact	No.	Environmental management measures	Timing
Impacts of climate change	CC1	In the refinement of construction Work Health and Safety Management Plans, consider the increased potential for heat stress among construction personnel and implement measures for greater awareness and education of personnel around health and wellbeing during periods of extreme heat.	Construction
	CC2	This initial climate change risk assessment would inform a detailed climate change risk assessment, which will be undertaken during detailed design, in accordance with AS 5334-2013 Climate change adaptation for settlements and infrastructure – A risk based approach. The assessment will identify and implement adaptation measures to address high and extreme risks. The decision to implement adaptation measures for medium risks will also be considered during detailed design.	Construction
	CC3	Adaptation measures will be identified and implemented to address high and extreme climate change risks. Adaptation measures for medium risks will also be considered further during detailed design and implemented where reasonable and feasible.	Construction
	CC4	The impact of climate change on potential flood risks will be considered during development of the detailed design in accordance with relevant guidelines as described in **Chapter 17** (Flooding and drainage) and **Appendix Q** (Technical working paper: Surface water and flooding).	Construction
	CC5	Increased flood risks due to climate change will be considered in the detailed design of drainage systems. Drainage network features will be developed and installed to mitigate potential increased flood risks as described in **Chapter 17** (Flooding and drainage) and **Appendix Q** (Technical working paper: Surface water and flooding).	Construction
	CC6	Potential changes to sea levels due to climate change will be considered during the design of operational water treatment plants that will discharge to waterways. Discharge outlets and relevant plant features will be designed and constructed accordingly.	Construction
	CC7	Consider the projected increase in the intensity and frequency of extreme rainfall during detailed design, which may lead to exacerbated risk of road incidents. Consider implementation of operational procedures for surface connections to increase safety during extreme rainfall events, such as use of variable speed signs and reduced speed limits.	Construction and operation

Note:

During the consideration of any the above adaptation options, analyses of costs and benefits should be undertaken.

25 Hazard and risk

The construction and operation of the M4-M5 Link (the project) has the potential to create a number of environmental hazards. This chapter identifies potential hazards that could pose a risk to the surrounding community or the environment and outlines measures to avoid, mitigate or manage those risks.

The Secretary of the NSW Department of Planning and Environment (DP&E) has issued environmental assessment requirements for the project. These are referred to as the Secretary's Environmental Assessment Requirements (SEARs). **Table 25-1** sets outs these requirements and the associated desired performance outcomes that relate to hazards, and identifies where they have been addressed in this environmental impact statement (EIS).

Table 25-1 SEARs – hazards

Desired Performance Outcome	SEARs	Where addressed in the EIS
3. Health and safety The project avoids, to the greatest extent possible, risk to public safety.	2. The assessment must: e) assess the likely risks of the project to public safety, paying particular attention to:	Refer below.
	• pedestrian safety	Pedestrian safety during construction and operation is addressed in **Chapter 8** (Traffic and transport).
	• subsidence risks	Subsidence risks are addressed in **Chapter 12** (Land use and property) and **Chapter 19** (Groundwater).
	• bushfire risks	Bushfire risks are addressed in **section 25.1.4** and **section 25.2.7**.
	• the handling and use of dangerous goods.	Handling and use of dangerous goods are addressed in **section 25.1.1**, **section 25.1.2**, **section 25.2.1** and **section 25.2.2**.
9. Socio-economic, land use and property The project minimises impacts on property and business and achieves appropriate integration with adjoining land uses, including maintenance of appropriate access to properties and community facilities, and minimisation of displacement of existing land use activities, dwellings and infrastructure.	6. The Proponent must assess potential impacts on utilities (including communications, electricity, gas, and water and sewerage) and the relocation of these utilities. 7. Where the project is predicted to impact on utilities the Proponent must undertake a utilities management strategy. The strategy must identify proposed management strategies, including relocation or adjustment of the utilities, and their estimated timing and duration. This strategy must be developed in consultation with the relevant utility owners or providers.	**Section 25.1.4** addresses potential impacts on utilities. Potential impacts on utilities are also addressed in **Chapter 12** (Land use and property). A Utilities Management Strategy has been prepared for the project and is included in **Appendix F**. The strategy considers issues associated with the need to relocate utilities, and identifies management strategies.

Desired Performance Outcome	SEARs	Where addressed in the EIS
12. Flooding The project minimises adverse impacts on existing flooding characteristics. Construction and operation of the project avoids or minimises the risk of, and adverse impacts from, infrastructure flooding, flooding hazards, or dam failure.	1. The Proponent must assess and (model where required) the impacts on flood behaviour during construction and operation for a full range of flood events up to the probable maximum flood (taking into account sea level rise and storm intensity due to climate change) including:	Refer below.
	a) how the tunnel entries and cut-and-cover sections of the tunnels would be protected from flooding during construction works;	Hazards associated with flooding, including the risk of flooding in tunnels and cut-and-cover sections, are outlined in **section 25.1.3** and discussed further in **Chapter 17** (Flooding and drainage). An assessment of the compatibility of the project with the flood hazard of the land is provided in **Chapter 17** (Flooding and drainage).
13. Soils Risks arising from the disturbance and excavation of land and disposal are minimised, including disturbance to acid sulfate soils and site contamination.	1. The Proponent must verify the risk of acid sulfate soils (Class 1, 2, 3 or 4 on the Acid Sulfate Soil Risk Map) within the area likely to be impacted by, the project. 2. The Proponent must assess the impact of the project on acid sulfate soils (including impacts of acidic runoff offsite) in accordance with the current guidelines and detail the mitigation measures proposed to minimise the potential impacts 3. The Proponent must assess whether the land is likely to be contaminated and identify if remediation of the land is required, having regard to the ecological and human health risks posed by the contamination in the context of past, existing and likely (or potential) future land uses. Where assessment and/or remediation is required, the Proponent must document how the assessment and/or remediation would be undertaken in accordance with current guidelines.	The risk of acid sulfate soils being present in the project footprint, and the potential impacts from disturbing these materials, are described in **Chapter 15** (Soil and water quality) and **Chapter 16** (Contamination). **Chapter 16** (Contamination) also assesses whether land within the project footprint is contaminated, and whether remedial action is required.

Desired Performance Outcome	SEARs	Where addressed in the EIS
17. Climate change risk The project is designed, constructed and operated to be resilient to the future impacts of climate change.	1. The Proponent must assess the risk and vulnerability of the project to climate change in accordance with the current guidelines. 2. The Proponent must quantify specific climate change risks with reference to the NSW Government's climate projections at 10 km resolution (or lesser resolution if 10 km projections are not available) and incorporate specific adaptation actions in the design.	The risk and vulnerability of the project to climate change and adaptation measures are described in **Chapter 24** (Climate change risk and adaptation) and **Appendix X** (Climate change risk assessment framework).
18. Hazards	1. The Proponent must describe the process for assessing the risk of emissions from ventilation facilities on aircraft operations taking into consideration the requirements of the *Airports Act 1996* (Commonwealth) (Airports Act) and the Airports Regulation 1997.	The process for the assessment of risk of emissions from ventilation facilities on aircraft operation is described in **section 25.1.4** and **section 25.2.7**.

25.1 Assessment of construction impacts

During construction, the following hazards may be associated with the project:

- Potential hazards resulting from accidental releases or improper handling and storage of dangerous goods and hazardous substances within construction ancillary facilities
- Potential hazards resulting from release of hazardous substances from vehicles transporting them to and from the construction ancillary facilities in the event of an accident
- Potential safety hazards, such as dangers to construction workers, road users and the community, associated with the potential risk of tunnel collapse, tunnel fires or explosions, rock falls at cuttings and mobile plant (including plant overturning and plant collisions with workers or other plant)
- Potential hazards associated with encountering acid sulfate soils, asbestos and contaminated soils during construction activities
- Potential accidental spills or leaking of fuels, chemicals or other hazardous substances during construction activities, including during refuelling of construction vehicles and machinery
- Potential hazards associated with mobile construction plant
- Potential hazards relating to flooding
- Potential rupture of, or interference with, utilities
- Potential hazards relating to bushfires.

The following risks have been assessed for the construction of the project:

- Pedestrian safety risks (discussed in **Chapter 8** (Traffic and transport))
- Subsidence (ground settlement) risks (discussed in **Chapter 12** (Land use and property) and **Chapter 19** (Groundwater))
- Bushfire risks
- Risks associated with the storage and handling of dangerous goods

- Potential risk of encountering acid sulfate soils, asbestos and contaminated soils during construction activities (discussed in **Chapter 15** (Soil and water quality) and **Chapter 16** (Contamination))
- Potential risks associated with the impact of project construction and operational activities on aircraft operations
- Potential risks associated with climate change impacts, including changes in the frequency of air temperature extremes, changes in mean and extreme rainfall, and changes in the frequency and intensity of storm events (discussed in **Chapter 24** (Climate change risk and adaption)).

25.1.1 Storage and handling of dangerous goods and hazardous substances

The transport, storage, handling and use of dangerous goods and hazardous substances would be undertaken in accordance with the *Work Health and Safety Act 2011* (NSW) (WHS Act), the Storage and Handling of Dangerous Goods Code of Practice (WorkCover NSW 2005), Environment Protection Manual for Authorised Officers: Bunding and Spill Management, technical bulletin (NSW Environment Protection Authority (NSW EPA) 1997), *Dangerous Goods (Road and Rail Transport) Act 2008* (NSW), Dangerous Goods (Road and Rail Transport) Regulation 2014 (NSW) and relevant Australian Standards.

The types and estimated quantities of dangerous goods and hazardous substances that would be stored and used within the construction ancillary facilities, and used for construction activities elsewhere in the project footprint, are outlined in **Table 25-2**. The location and purpose of each construction ancillary facility are detailed in **Chapter 6** (Construction work). Minor quantities of other hazardous materials other than those outlined in **Table 25-2** may also be used at the construction ancillary facilities from time to time.

State Environmental Planning Policy No. 33 – Hazardous and Offensive Development (SEPP 33) applies to development that requires consent and is not strictly applicable to infrastructure (refer to **Chapter 2** (Assessment process)). However, the principles which are applied in relation to SEPP 33 have been followed (through the undertaking of a preliminary hazard analysis, as outlined below), to consider potential hazards associated with the use and transport of dangerous goods for the project.

The thresholds specified in *Hazardous and Offensive Development Application Guidelines: Applying SEPP 33* (NSW Department of Planning 2011) (SEPP 33 Guidelines) have been applied to the inventories of dangerous goods to be transported to and stored at each construction ancillary facility. These screening thresholds represent the level at which dangerous goods may present a credible off-site hazard that requires a further, more detailed assessment of risks. Application of the screening thresholds specified in the SEPP 33 Guidelines is included in **Table 25-2**.

Table 25-2 Indicative dangerous goods and hazardous substances used on site during the construction period (quantities are indicative only)

Material and Australian Dangerous Goods (DG) Code class	Wattle Street civil and tunnel site (C1a)	Haberfield civil and tunnel site (C2a)	Northcote Street civil site (C3a)	Parramatta Road West civil and tunnel site (C1b)	Haberfield civil site (C2b)	Parramatta Road East civil site (C3b)	Darley Road civil and tunnel site (C4)	Rozelle civil and tunnel site (C5)	The Crescent civil site (C6)	Victoria Road civil site (C7)	Iron Cove Link civil site (C8)	Pyrmont Bridge Road tunnel site (C9)	Campbell Road civil and tunnel site (C10)	Assessment against inventory thresholds in the SEPP 33 Guidelines
Acetylene (litres) DG class 2.1	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Individual cylinders containing acetylene would not trigger the threshold in the SEPP 33 Guidelines (100 kilograms). Maximum stored inventories (1,040 litres) would also be located more than 50 metres away from the nearest construction ancillary facility boundary and would also not trigger the threshold in the SEPP 33 Guidelines if considered in aggregate.
Ammonium nitrate emulsion DG class 5.1	Y	Y	N	Y	N	N	Y	Y	N	N	N	Y	Y	Ammonium nitrate would not trigger the threshold in the SEPP 33 Guidelines (five tonnes) if considered as individual containers or in aggregate.
Concrete bonding agent base (litres) DG class N/A	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Concrete bonding agent bases are not dangerous goods and therefore do not trigger the thresholds in the SEPP 33 Guidelines.

Material and Australian Dangerous Goods (DG) Code class	Wattle Street civil and tunnel site (C1a)	Haberfield civil and tunnel site (C2a)	Northcote Street civil site (C3a)	Parramatta Road West civil and tunnel site (C1b)	Haberfield civil site (C2b)	Parramatta Road East civil site (C3b)	Darley Road civil and tunnel site (C4)	Rozelle civil and tunnel site (C5)	The Crescent civil site (C6)	Victoria Road civil site (C7)	Iron Cove Link civil site (C8)	Pyrmont Bridge Road tunnel site (C9)	Campbell Road civil and tunnel site (C10)	Assessment against inventory thresholds in the SEPP 33 Guidelines
Concrete bonding agent hardener (litres) DG class 8	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Concrete bonding agent hardener would not trigger the threshold in the SEPP 33 Guidelines (25 tonnes) if considered as individual containers or in aggregate.
Concrete surface retarder (litres) DG class 3 PGIII	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Concrete surface retarder would not trigger the threshold in the SEPP 33 Guidelines (five tonnes) if considered as individual containers or in aggregate.
Construction grout (kilograms) DG class N/A	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Construction grout is not a dangerous good and therefore does not trigger the threshold in the SEPP 33 Guidelines.
Curing compound (litres) DG class N/A	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Curing compounds are not dangerous goods and therefore do not trigger the thresholds in the SEPP 33 Guidelines.
Diesel DG class C1 PGIII	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Diesel would not be stored with Class 3 materials and would therefore not be subject to the thresholds in the SEPP 33 Guidelines.

Material and Australian Dangerous Goods (DG) Code class	Wattle Street civil and tunnel site (C1a)	Haberfield civil and tunnel site (C2a)	Northcote Street civil site (C3a)	Parramatta Road West civil and tunnel site (C1b)	Haberfield civil site (C2b)	Parramatta Road East civil site (C3b)	Darley Road civil and tunnel site (C4)	Rozelle civil and tunnel site (C5)	The Crescent civil site (C6)	Victoria Road civil site (C7)	Iron Cove Link civil site (C8)	Pyrmont Bridge Road tunnel site (C9)	Campbell Road civil and tunnel site (C10)	Assessment against inventory thresholds in the SEPP 33 Guidelines
Epoxy paste part A (litres) DG class 3 PGIII	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Epoxies would not trigger the threshold in the SEPP 33 Guidelines (five tonnes) if considered as individual containers or in aggregate.
Epoxy paste part B (litres) DG class 3 PGIII	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Epoxies would not trigger the threshold in the SEPP 33 Guidelines (five tonnes) if considered as individual containers or in aggregate.
Form oil (litres) DG class C2	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Form oil would not be stored with Class 3 materials and would therefore not be subject to the thresholds in the SEPP 33 Guidelines.
Grease (kilograms) DG class C2	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Grease would not be stored with Class 3 materials and would therefore not be subject to the thresholds in the SEPP 33 Guidelines.
Hydraulic oil (litres) DG class C2	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Hydraulic oil would not be stored with Class 3 materials and would therefore not be subject to the thresholds in the SEPP 33 Guidelines.

Material and Australian Dangerous Goods (DG) Code class	Wattle Street civil and tunnel site (C1a)	Haberfield civil and tunnel site (C2a)	Northcote Street civil site (C3a)	Parramatta Road West civil and tunnel site (C1b)	Haberfield civil site (C2b)	Parramatta Road East civil site (C3b)	Darley Road civil and tunnel site (C4)	Rozelle civil and tunnel site (C5)	The Crescent civil site (C6)	Victoria Road civil site (C7)	Iron Cove Link civil site (C8)	Pyrmont Bridge Road tunnel site (C9)	Campbell Road civil and tunnel site (C10)	Assessment against inventory thresholds in the SEPP 33 Guidelines
Injectable mortar (kilograms) DG class N/A	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Injectable mortar is not a dangerous good and therefore does not trigger the thresholds in the SEPP 33 Guidelines.
Joint sealant (kilograms) DG class N/A	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Joint sealant is not a dangerous good and therefore does not trigger the thresholds in the SEPP 33 Guidelines.
Line marking aerosol (kilograms) DG class 2.1	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Individual cylinders containing line marking aerosol would not trigger the threshold in the SEPP 33 Guidelines (100 kilograms).
Liquid nails (kilograms) DG class 3 PGII	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Liquid nails would not trigger the threshold in the SEPP 33 Guidelines (five tonnes) if considered as individual containers or in aggregate.
Oxygen (litres) DG class 2.2	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Industrial grade oxygen is a Class 2.2 dangerous good and is therefore not subject to the thresholds in the SEPP 33 Guidelines. Oxygen has a subsidiary risk of Class 5.1. Oxygen would not trigger the threshold in the SEPP 33

Material and Australian Dangerous Goods (DG) Code class	Wattle Street civil and tunnel site (C1a)	Haberfield civil and tunnel site (C2a)	Northcote Street civil site (C3a)	Parramatta Road West civil and tunnel site (C1b)	Haberfield civil site (C2b)	Parramatta Road East civil site (C3b)	Darley Road civil and tunnel site (C4)	Rozelle civil and tunnel site (C5)	The Crescent civil site (C6)	Victoria Road civil site (C7)	Iron Cove Link civil site (C8)	Pyrmont Bridge Road tunnel site (C9)	Campbell Road civil and tunnel site (C10)	Assessment against inventory thresholds in the SEPP 33 Guidelines
														Guidelines (five tonnes) if considered as individual containers or in aggregate.
Polyurethane foam (kilograms) DG class 2.1	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Individual cylinders containing polyurethane foam would not trigger the threshold in the SEPP 33 Guidelines (100 kilograms) if considered as individual containers or in aggregate.
Sodium hydroxide (litres) DG class 8 PGII	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Sodium hydroxide would not trigger the threshold in the SEPP 33 Guidelines (25 tonnes) if considered as individual containers or in aggregate.
Sulfuric acid (litres) DG class 8 PGII	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Sulfuric acid would not trigger the threshold in the SEPP 33 Guidelines (25 tonnes) if considered as individual containers or in aggregate.
Unleaded Petrol (litres) DG class 3 PGII	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Epoxies would not trigger the threshold in the SEPP 33 Guidelines (five tonnes) if considered as individual containers or in aggregate.

Table 25-2 demonstrates that the dangerous goods and hazardous substances proposed to be stored and used at each construction ancillary facility and used for construction activities elsewhere in the project footprint would not exceed the inventory thresholds in the SEPP 33 Guidelines. This indicates that the proposed storage of dangerous goods and hazardous substances at construction ancillary facilities would not pose a material off-site hazard, in the unlikely event of an incident at the proposed construction ancillary facility locations.

At each construction ancillary facility:

- Liquid dangerous goods and hazardous chemicals would be stored within a bunded storage container or spill tray
- Gases would be secured and stored in a storage cage in a well ventilated area
- Storage areas would be located away from natural or built drainage lines, to minimise the likelihood of pollutants entering adjacent watercourses in the event of a spill or leak escaping the bunded area
- Self-bunded fuel storage areas would be located within or adjacent to acoustic sheds.

A register and inventory of the dangerous goods and hazardous substances to be stored at each construction ancillary facility would be kept as part of the Incident Response Plan for the project. Material Safety Data Sheets would also be kept on site for each relevant material.

Implementation of environmental management measures for the storage and handling of dangerous goods and hazardous substances, as detailed in **Table 25-7**, would reduce the risk to the environment, construction personnel and the public. Safety hazards associated with the use of hazardous materials during construction, including within enclosed tunnel environments, are discussed in **section 25.1.3**.

25.1.2 Transport of dangerous goods and hazardous substances

Transportation of dangerous goods would not exceed the thresholds in the SEPP 33 Guidelines and would be undertaken in accordance with suppliers' instructions as well as the WHS Act, the Storage and Handling of Dangerous Goods Code of Practice (WorkCover NSW 2005), *Dangerous Goods (Road and Rail Transport) Act 2008* (NSW), Dangerous Goods (Road and Rail Transport) Regulation 2014 (NSW) and relevant Australian Standards.

Table 25-3 outlines the dangerous goods and hazardous substances that would be transported to construction ancillary facilities. Potential hazards and risks associated with the transportation of dangerous goods and hazardous substances have been considered by comparing the type, quantity and frequency of dangerous goods and hazardous substances with the thresholds presented in the SEPP 33 Guidelines.

Table 25-3 Dangerous goods and hazardous substances transported to construction sites

Material and Australian Dangerous Goods Code class	Transport quantity and frequency to each facility (indicative only)	Construction ancillary facility destination	Transportation thresholds in the SEPP 33 Guidelines	Assessment against transportation thresholds in the SEPP 33 Guidelines
Acetylene DG class 2.1	35 litres per month	All construction ancillary facilities	Minimum transport load or transport frequency of two tonnes more than 30 times per week	Industrial grade acetylene would not trigger the transportation thresholds in the SEPP 33 Guidelines.
Ammonium nitrate emulsion DG class 5.1	3,600 litres once during the project	Wattle Street civil and tunnel site (C1a), Haberfield civil and tunnel site (C2a), Parramatta Road West civil and tunnel site (C1b), Darley Road civil and tunnel site (C4), Rozelle civil and tunnel site (C5), Pyrmont Bridge Road tunnel site (C9), Campbell Road civil and tunnel site (C10).	Minimum transport load or transport frequency of two tonnes more than 30 times per week	Ammonium nitrate emulsion would trigger the minimum transport load threshold of two tonnes. However, it would not trigger the threshold for transport frequency and thus is unlikely to be significant.
Concrete bonding agent base DG class N/A	18 litres per month	Wattle Street civil and tunnel site (C1a), Haberfield civil and tunnel site (C2a), Parramatta Road West civil and tunnel site (C1b), Darley Road civil and tunnel site (C4), Rozelle civil and tunnel site (C5), Pyrmont Bridge Road tunnel site (C9), Campbell Road civil and tunnel site (C10).	N/A	Concrete bonding agent base is not subject to the transportation thresholds in the SEPP 33 Guidelines.
Concrete bonding agent hardener DG class 8	18 litres per month	Wattle Street civil and tunnel site (C1a), Haberfield civil and tunnel site (C2a), Parramatta Road West civil and tunnel site (C1b), Darley Road civil and tunnel site (C4), Rozelle civil and tunnel site (C5), The Crescent civil site (C6), Victoria Road civil site (C7), Iron Cove Link civil site (C8), Pyrmont Bridge Road tunnel site (C9), Campbell Road civil and tunnel site (C10).	Minimum transport load or transport frequency of two tonnes more than 30 times per week	Concrete bonding agent hardener would not trigger the transportation thresholds in the SEPP 33 Guidelines.

Material and Australian Dangerous Goods Code class	Transport quantity and frequency to each facility (indicative only)	Construction ancillary facility destination	Transportation thresholds in the SEPP 33 Guidelines	Assessment against transportation thresholds in the SEPP 33 Guidelines
Concrete surface retarder DG class 3 PGIII	180 litres per month	Wattle Street civil and tunnel site (C1a), Haberfield civil and tunnel site (C2a), Parramatta Road West civil and tunnel site (C1b), Darley Road civil and tunnel site (C4), Rozelle civil and tunnel site (C5), The Crescent civil site (C6), Victoria Road civil site (C7), Iron Cove Link civil site (C8), Pyrmont Bridge Road tunnel site (C9), Campbell Road civil and tunnel site (C10).	Minimum transport load or transport frequency of 10 tonnes more than 60 times per week	Concrete surface retarder would not trigger the transportation thresholds in the SEPP 33 Guidelines.
Construction grout DG class N/A	50 kilograms per month	Wattle Street civil and tunnel site (C1a), Haberfield civil and tunnel site (C2a), Parramatta Road West civil and tunnel site (C1b), Darley Road civil and tunnel site (C4), Rozelle civil and tunnel site (C5), The Crescent civil site (C6), Victoria Road civil site (C7), Iron Cove Link civil site (C8), Pyrmont Bridge Road tunnel site (C9), Campbell Road civil and tunnel site (C10).	N/A	Construction grout is not subject to the transportation thresholds in the SEPP 33 Guidelines.
Curing compound DG class N/A	170 litres per month	Wattle Street civil and tunnel site (C1a), Haberfield civil and tunnel site (C2a), Parramatta Road West civil and tunnel site (C1b), Darley Road civil and tunnel site (C4), Rozelle civil and tunnel site (C5), The Crescent civil site (C6), Victoria Road civil site (C7), Iron Cove Link civil site (C8), Pyrmont Bridge Road tunnel site (C9), Campbell Road civil and tunnel site (C10).	N/A	Curing compounds are not subject to the transportation thresholds in the SEPP 33 Guidelines.
Diesel DG class C1 PGIII	1,800 litres[1] per day	Wattle Street civil and tunnel site (C1a), Haberfield civil and tunnel site (C2a), Parramatta Road West civil and tunnel site (C1b), Darley Road civil and tunnel site (C4), Rozelle civil and tunnel site (C5), The Crescent civil site (C6), Victoria Road civil site (C7), Iron Cove Link civil site (C8), Pyrmont Bridge Road tunnel site (C9), Campbell Road civil and tunnel site (C10).	N/A	Diesel would not be transported with Class 3 dangerous goods. Therefore, it would not be subject to the transportation thresholds in the SEPP 33 Guidelines.

Material and Australian Dangerous Goods Code class	Transport quantity and frequency to each facility (indicative only)	Construction ancillary facility destination	Transportation thresholds in the SEPP 33 Guidelines	Assessment against transportation thresholds in the SEPP 33 Guidelines
Epoxy paste part A DG class 3 PGIII	18 litres per month	Wattle Street civil and tunnel site (C1a), Haberfield civil and tunnel site (C2a), Parramatta Road West civil and tunnel site (C1b), Darley Road civil and tunnel site (C4), Rozelle civil and tunnel site (C5), Pyrmont Bridge Road tunnel site, The Crescent civil site (C6), Victoria Road civil site (C7), Iron Cove Link civil site (C8), Pyrmont Bridge Road tunnel site (C9), Campbell Road civil and tunnel site (C10).	Minimum transport load or transport frequency of 10 tonnes more than 60 times per week	Epoxies would not trigger the transportation thresholds in the SEPP 33 Guidelines.
Epoxy paste part B DG class 3 PGIII	18 litres per month	Wattle Street civil and tunnel (C1a), Haberfield civil and tunnel site (C2a), Parramatta Road West civil and tunnel site (C1b), Darley Road civil and tunnel site (C4), Rozelle civil and tunnel site (C5), The Crescent civil site (C6), Victoria Road civil site (C7), Iron Cove Link civil site (C8), Pyrmont Bridge Road tunnel site (C9), Campbell Road civil and tunnel site (C10).	Minimum transport load or transport frequency of 10 tonnes more than 60 times per week	Epoxies would not trigger the transportation thresholds in the SEPP 33 Guidelines.
Form oil (litres) DG class C2	180 litres per month	Wattle Street civil and tunnel site (C1a), Haberfield civil and tunnel site (C2a), Parramatta Road West civil and tunnel site (C1b), Darley Road civil and tunnel site (C4), Rozelle civil and tunnel site (C5), The Crescent civil site (C6), Victoria Road civil site (C7), Iron Cove Link civil site (C8), Pyrmont Bridge Road tunnel site (C9), Campbell Road civil and tunnel site (C10).	N/A	Form oil is not a dangerous good and would not be transported with Class 3 dangerous goods. Therefore, it would not be subject to the transportation thresholds in the SEPP 33 Guidelines.
Grease DG class C2	4 kilograms per month	Wattle Street civil and tunnel site (C1a), Haberfield civil and tunnel site (C2a), Parramatta Road West civil and tunnel site (C1b), Darley Road civil and tunnel site (C4), Rozelle civil and tunnel site (C5), The Crescent civil site (C6), Victoria Road civil site (C7), Iron Cove Link civil site (C8), Pyrmont Bridge Road tunnel site (C9), Campbell Road civil and tunnel site (C10).	N/A	Grease is not a dangerous good and would not be transported with Class 3 dangerous goods. Therefore, it would not be subject to the transportation thresholds in the SEPP 33 Guidelines.

Material and Australian Dangerous Goods Code class	Transport quantity and frequency to each facility (indicative only)	Construction ancillary facility destination	Transportation thresholds in the SEPP 33 Guidelines	Assessment against transportation thresholds in the SEPP 33 Guidelines
Hydraulic oil DG class C2	190 litres per month	Wattle Street civil and tunnel site (C1a), Haberfield civil and tunnel site (C2a), Parramatta Road West civil and tunnel site (C1b), Darley Road civil and tunnel site (C4), Rozelle civil and tunnel site (C5), The Crescent civil site (C6), Victoria Road civil site (C7), Iron Cove Link civil site (C8), Pyrmont Bridge Road tunnel site (C9), Campbell Road civil and tunnel site (C10).	N/A	Hydraulic oil is not a dangerous good and would not be transported with Class 3 dangerous goods. Therefore, it would not be subject to the transportation thresholds in the SEPP 33 Guidelines.
Injectable mortar DG class N/A	8 kilograms per month	Wattle Street civil and tunnel site (C1a), Haberfield civil and tunnel site (C2a), Parramatta Road West civil and tunnel site (C1b), Darley Road civil and tunnel site (C4), Rozelle civil and tunnel site (C5), The Crescent civil site (C6), Victoria Road civil site (C7), Iron Cove Link civil site (C8), Pyrmont Bridge Road tunnel site (C9), Campbell Road civil and tunnel site (C10).	N/A	Injectable mortar is not subject to the transportation thresholds in the SEPP 33 Guidelines.
Joint sealant DG class N/A	5 kilograms per month	Wattle Street civil and tunnel site (C1a), Haberfield civil and tunnel site (C2a), Parramatta Road West civil and tunnel site (C1b), Darley Road civil and tunnel site (C4), Rozelle civil and tunnel site (C5), The Crescent civil site (C6), Victoria Road civil site (C7), Iron Cove Link civil site (C8), Pyrmont Bridge Road tunnel site (C9), Campbell Road civil and tunnel site (C10).	N/A	Joint sealant is not subject to the transportation thresholds in the SEPP 33 Guidelines.
Line marking aerosol DG class 2.1	16 kilograms per month	Wattle Street civil and tunnel site (C1a), Haberfield civil and tunnel site (C2a), Parramatta Road West civil and tunnel site (C1b), Darley Road civil and tunnel site (C4), Rozelle civil and tunnel site (C5), Pyrmont Bridge Road tunnel site (C9), Campbell Road civil and tunnel site (C10).	Minimum transport load or transport frequency of two tonnes more than 30 times per week	Line marking aerosol would not trigger the transportation thresholds in the SEPP 33 Guidelines.

Material and Australian Dangerous Goods Code class	Transport quantity and frequency to each facility (indicative only)	Construction ancillary facility destination	Transportation thresholds in the SEPP 33 Guidelines	Assessment against transportation thresholds in the SEPP 33 Guidelines
Liquid nails DG class 3 PGII	6 kilograms per month	Wattle Street civil and tunnel site (C1a), Haberfield civil and tunnel site (C2a), Parramatta Road West civil and tunnel site (C1b), Darley Road civil and tunnel site (C4), Rozelle civil and tunnel site (C5), Pyrmont Bridge Road tunnel site (C9), Campbell Road civil and tunnel site (C10).	Minimum transport load or transport frequency of three tonnes more than 45 times per week	Liquid nails would not trigger the transportation thresholds in the SEPP 33 Guidelines.
Oxygen DG class 2.2	180 litres per month	All construction ancillary facilities.	N/A	Industrial grade oxygen is not subject to the transportation thresholds in the SEPP 33 Guidelines.
Oxygen subsidiary risk DG class 5.1	180 litres per month	All construction ancillary facilities.	Minimum transport load or transport frequency of two tonnes more than 30 times per week	Oxygen has a subsidiary risk class of 5.1. Oxygen would not trigger the transportation thresholds in the SEPP 33 Guidelines.
Polyurethane foam DG class 2.1	7 kilograms per month	Wattle Street civil and tunnel site (C1a), Haberfield civil and tunnel site (C2a), Parramatta Road West civil and tunnel site (C1b), Darley Road civil and tunnel site (C4), Rozelle civil and tunnel site (C5), The Crescent civil site (C6), Victoria Road civil site (C7), Iron Cove Link civil site (C8), Pyrmont Bridge Road tunnel site (C9), Campbell Road civil and tunnel site (C10).	Minimum transport load or transport frequency of two tonnes more than 30 times per week	Polyurethane foam would not trigger the transportation thresholds in the SEPP 33 Guidelines.
Sodium hydroxide DG class 8 PGII	2,600 litres per month	Wattle Street civil and tunnel site (C1a), Haberfield civil and tunnel site (C2a), Parramatta Road West civil and tunnel site (C1b), Darley Road civil and tunnel site (C4), Rozelle civil and tunnel site (C5), Pyrmont Bridge Road tunnel site (C9), Campbell Road civil and tunnel site (C10).	25 tonnes as individual containers or in aggregate	Sodium hydroxide would not trigger the transportation threshold in the SEPP 33 Guidelines.

Material and Australian Dangerous Goods Code class	Transport quantity and frequency to each facility (indicative only)	Construction ancillary facility destination	Transportation thresholds in the SEPP 33 Guidelines	Assessment against transportation thresholds in the SEPP 33 Guidelines
Sulfuric acid DG class 8 PGII	2,600 litres per month	Wattle Street civil and tunnel site (C1a), Haberfield civil and tunnel site (C2a), Parramatta Road West civil and tunnel site (C1b), Darley Road civil and tunnel site (C4), Rozelle civil and tunnel site (C5), Pyrmont Bridge Road tunnel site (C9), Campbell Road civil and tunnel site (C10).	25 tonnes as individual containers or in aggregate	Sulfuric acid would not trigger the transportation threshold in the SEPP 33 Guidelines.
Unleaded Petrol DG class 3 PGII	180 litres[1] per month	All construction ancillary facilities.	Minimum transport load or transport frequency of three tonnes more than 45 times per week	Unleaded petrol would not trigger the transportation thresholds in the SEPP 33 Guidelines.

Note:

1 For some construction ancillary facilities, the quantity of diesel and unleaded petrol delivered to site would be greater than the quantity stored within the facility at any time, because the delivery volume takes into the account fuel which is brought to the facility by mini-tanker and used to directly refuel plant. As this fuel is 'in use' in the plant it is not classified as 'stored'.

25.1.3 Safety hazards

Factors contributing to safety hazards in tunnelling projects include uncertainty in the nature and variability of ground conditions, the restricted tunnel environment, difficulty in communications and the use of compressed air.

Hazards/risks include:

- Partial or complete tunnel collapse with potential associated surface impacts
- Tunnel fires or explosions
- Rock falls at cut-and-cover tunnels and cuttings
- Exposure to airborne pollutants such as asbestos fibres during demolition work, dust during tunnelling and diesel particulate matter from the operation of diesel fuelled construction equipment within the tunnels
- Exposure of acid sulfate soils to the atmosphere and subsequent acid generation
- Disturbance of contaminated soils
- Incidents involving mobile plant.

Tunnel collapse

The project tunnels would generally be excavated in good quality Hawkesbury sandstone. A number of major design and construction method reviews have been undertaken to better understand historical tunnel collapses, including the collapse of the Lane Cove Tunnel in 2005 during construction and other incidents overseas. Consequently, the risks of a similar incident occurring during a Sydney tunnelling project are extremely low. The reasons for this include:

- Vastly improved geotechnical assessment and modelling
- Improved predictive two dimensional and three dimensional modelling of geology, excavation spans, temporary and permanent loads
- Fit for purpose design to develop the appropriate type of ‘support’ to match the ground conditions as the excavation progresses on a day to day basis
- Continuous independent review of the temporary and permanent works design and construction methods by experts
- Continual construction verification that tunnel support is installed and performing as per design
- Robust change management processes for conditions that are out of the ordinary or unexpected, including probe drilling and ground treatment through suspected poor ground zones
- Continuous assessment of likely excavation and groundwater conditions
- Detailed survey monitoring of surface roads, buildings and structures in the tunnel vicinity.

Construction of the tunnels would be undertaken in sections. A ‘permit to tunnel’ system would be implemented, which would require authorisation from the tunnel construction manager (or authorised delegate) and geotechnical engineer before tunnelling is allowed to continue to the next section. The 'permit to tunnel' authorisation considers the anticipated and observed ground support performance, and geotechnical and groundwater conditions. This would minimise the risk of tunnel collapse.

Tunnel fires or explosions

Combustible materials within a tunnel have the potential to cause tunnel fires and explosions. The rapid consumption of oxygen and production of noxious fumes and gases can make tunnel fires severe. Diesel equipment fire precautions, hot work procedures and electrical equipment procedures would be followed and adequate training would be provided to minimise risks associated with fire and explosion. Construction ancillary facilities would be maintained in a tidy and orderly condition, with the aim of minimising potential fuel loads and isolating fuel sources from ignition sources.

Rock falls at cuttings

Rock falls can occur during excavation of the portals, if the portal breakthrough area is not secured before excavation. Rock falls have the potential to injure construction workers and cause damage to construction equipment. The interchange dive structures have the potential to create rock fall hazards as steep slope sites have the potential to pose slip, fall and unsecured equipment hazards.

Standard construction and mitigation measures would be applied to manage rock fall risk, including the use of appropriate personal protective equipment, frequent tunnel inspections, scaling, progressive installation of properly secured ground support, safety fencing and overhead protection.

Exposure to airborne pollutants

During construction and demolition activities, airborne pollutants have the potential to be generated, including dust and toxic gas. If this were to occur, it may result in oxygen deficient or toxic environments and other potential health risks for construction workers and local community members. The operation of diesel and petrol-fuelled equipment and the use of hazardous materials also have the potential to produce a range of air contaminants, including diesel particulate matter from diesel combustion. Dust generation in the tunnels would be minimised by wetting down the cutting face and the use of temporary fans and dry dust scrubbers. Standard ventilation, dust extraction and monitoring procedures would be carried out when appropriate.

Acid sulfate soils

Acid sulfate soils are naturally occurring soils that contain iron sulphides. When acid sulfate soils are exposed to the air, they oxidise and create sulfuric acid. This increase in acidity can result in the mobilisation of aluminium, iron and manganese from the soils. Other impacts include the de-oxygenation of water. Potential acid sulfate soils are waterlogged soils rich in pyrite that have not been oxidised. Disturbance of potential acid sulfate soils during construction causing exposure to oxygen would lead to the development of actual acid sulfate soil layers.

For construction workers, physical contact with ground and water containing toxic concentrations of acid and metal contaminants is associated with health risks. Standard construction and mitigation measures would be applied to mitigate the potential risks associated with the disturbance of acid sulfate soils, including the use of appropriate personal protective equipment.

Further information regarding acid sulfate soils is provided in **Chapter 15** (Soil and water quality).

Contamination

Asbestos and other contamination is likely to be located within the project footprint. Exposure to asbestos and other contaminants during construction may result in health risks for construction workers and people in neighbouring communities.

Environmental management measures to manage potential risks related to contaminated soil and water are provided in **Chapter 16** (Contamination). Standard construction and mitigation measures would be applied to manage potential risks to the construction workers from exposure to asbestos and other contamination including the use of appropriate personal protective equipment.

Management and disposal of asbestos containing material would be undertaken in accordance with procedures detailed in the Work Health and Safety Plan for the project, which would be developed in accordance with:

- *Work Health and Safety Act 2011* (NSW)
- Code of Practice for the Safe Removal of Asbestos 2nd Edition (National Occupational Health and Safety Commission (NOHSC) 2005a)
- Code of Practice for the Management and Control of Asbestos in Workplaces (NOHSC 2005b)
- Protection of the Environment Operations (Waste) Regulation 2014 (NSW) – Part 7 special requirements relating to the transportation and management of asbestos waste
- National Environment Protection (Assessment of Site Contamination) Measure 1999
- AS2601:2001 Demolition of Structures.

Removal of asbestos containing material would involve suitably qualified experts in accordance with the Work Health and Safety Plan and would include notification requirements to communities and relevant stakeholders.

Refer to **Chapter 16** (Contamination) and **Chapter 23** (Resource use and waste minimisation) for further information on asbestos management.

Spills and leaks from construction vehicles and machinery

There is potential for fuel spills to occur during refuelling of construction vehicles and machinery, and for oil spills or the emission of other hazardous substances to occur as a result of mechanical or other failures of construction plant. For construction workers, physical contact with fuels, oils and other hazardous materials is associated with health risks.

These hazards would be managed by the implementation of standard construction environmental measures, including measures for fuel and chemical handling, spill containment and the use of appropriate personal protective equipment. These measures would form part of the Construction Environmental Management Plan (CEMP) for the project.

Mobile plant

The operation of powered mobile plant during construction would be associated with a number of safety hazards including:

- The plant overturning
- Objects falling on the operator of the plant
- The operator being ejected from the plant
- The plant colliding or coming into contact with any person or object (eg workers, other vehicles or plant, energised powerlines).

In order to manage these hazards, mobile plant on construction sites would be operated in accordance with *Moving Plant on Construction Sites: Code of Practice* (SafeWork NSW 2004).

Flooding

Flooding during construction of the project could potentially impact areas within and near the construction sites. Flood related impacts during construction could include:

- Inundation of excavated tunnels
- Damage to facilities, infrastructure, equipment, stockpiles and downstream sensitive areas caused by inundation from floodwaters
- Increased risk of flooding of adjacent areas due to temporary loss of floodplain storage (due to displacement of water) or impacts on the conveyance of floodwaters.

The project proposes permanent portals at the Rozelle interchange and Iron Cove Link. These would be created using cut-and-cover techniques. Tunnelling would also occur through temporary shafts at the Parramatta Road West civil and tunnel site (C1b), Darley Road civil and tunnel site (C4) and the Pyrmont Bridge Road tunnel site (C9).

Ingress of floodwater into the shafts or portals during construction would pose significant risk to personal safety for those working in the tunnel. Where these facilities occur within the floodplain or other areas that are flood prone, such as at Darley Road and the Rozelle Rail Yards, protection measures such as bunding or floodwater barriers would be provided to ensure floodwaters do not enter shafts or portals. Other flooding impacts during construction, such as flooding of stockpiles and erosion of cleared areas, are expected to be minor.

These impacts would be mitigated by adjusting the ancillary facility designs and planning sites to recognise the identified flood conditions and minimise the potential for off-site flood impacts. The indicative layouts of the construction ancillary facilities have been developed to provide setback from high risk flooding areas to minimise impacts on existing flowpaths, where feasible. Mitigation measures that would be employed are outlined in **Chapter 17** (Flooding and drainage).

25.1.4 Road user and general public hazards

Utilities

The potential rupture or severing of underground utilities due construction activities could pose a hazard in the form of loss of service to local communities, electrocution, release of sewage from a sewer main or fire if a gas main is impacted. The risks associated with these hazards would be minimised by undertaking the following activities during the works:

- Utility checks (such as 'dial before you dig')
- Consulting with the relevant utility service providers
- Service and utility identification works (where possible by non-destructive means, eg vacuum truck)
- Relocating and/or protecting utilities in and around the project before construction begins, if required.

A Utilities Management Strategy (**Appendix F**) has been prepared for the project that identifies management options, including relocation or adjustment of the utilities. This strategy includes a description of the process for confirming utility works within and outside the project footprint, an outline of the consultation that would be undertaken with utility service providers and the local community regarding these works, and a description of how further environmental assessment of the impacts of these utility works would be carried out.

Consultation with utility service providers has commenced and would be ongoing during the detailed design and throughout construction to mitigate the risk of unplanned or unexpected disturbance of utilities. Confirmation of the presence, location and status of subsurface utilities at the Rozelle Rail Yards is being undertaken as part of a separate Roads and Maritime project involving site management works. This would further inform the utilities management for the project.

Bushfire risks

The project would not be located in or near bushfire-prone land. The project footprint is highly urbanised and does not contain large areas of vegetation that are associated with bushfire risk. As such, bushfire risks associated with the project are considered to be minor.

Temporary construction ancillary facilities and construction infrastructure would be generally less sensitive to bushfire risks than operational facilities, given the temporary nature of the construction ancillary facilities and the absence of critical infrastructure within the facilities. Notwithstanding the low likelihood of bushfire events within the project footprint, measures to mitigate and manage bushfire risks would be developed and included as part of site specific hazard and risk management measures within the CEMP.

Temporary construction ancillary facilities would be maintained in a tidy and orderly condition to minimise potential fuel loads in the event that the facilities are affected by fire. Storage and management of dangerous goods and hazardous materials would occur in a safe, secure location consistent with the requirements of applicable Australian Standards.

Construction activities involving flammable materials and ignition sources (for example, welding) would be proactively managed to ensure that fire risks are effectively minimised. High risk construction activities, such as welding and metal work, would be subject to a risk assessment on total fire ban days, and restricted or ceased as appropriate.

Aviation risks

Australia's Civil Aviation Safety Authority (CASA) has determined that exhaust plumes with vertical velocities exceeding 4.3 metres per second may cause damage to aircraft airframes, or upset an aircraft flying at low levels. Light aircraft, including helicopters, are more likely to be affected by a plume than heavier aircraft cruising at the same altitude.

The *Airports Act 1996* (Commonwealth) (Airports Act) and the Airports (Protection of Airspace) Regulations 1996 (Commonwealth) (Airspace Regulations) were established for the protection of airspace at and around regulated airports in Australia including Sydney Airport. The Airspace

Regulations define the ‘prescribed airspace’ for Sydney Airport as the airspace above any part of either an obstacle limitation surface (OLS) or procedures for air navigation systems operations (PANS-OPS) surface for the airport. Part 139.70 of the Civil Aviation Safety Regulations 1998 (Commonwealth) provides for determination that a plume is a hazardous object if the vertical velocity exceeds 4.3 metres per second.

The OLS is an invisible level that defines the limits to which objects may project into the airspace around an aerodrome so that aircraft operations may be conducted safely. PANS-OPS protection surfaces are imaginary surfaces in space that establish the airspace that is to remain free of any potential disturbance (including physical objects and other disturbances such as emissions from ventilation outlets) so that aircraft operations may be conducted safely. Where structures may (under certain circumstances) be permitted to penetrate the OLS, they would not ordinarily be permitted to penetrate any PANS-OPS surface.

Under the Airports Act, a ‘controlled activity’ (as defined in section 182(1) of the Act) in relation to a prescribed airspace must not be carried out or caused to be carried out without the approval of the Secretary of the Australian Government Department of Infrastructure and Regional Development (DIRD) or unless it is otherwise exempt under the Airspace Regulations. Controlled activities include:

- The construction of buildings and structures that intrude into prescribed airspace
- Artificial light sources that exceed specified intensity levels
- Activities that result in air turbulence that exceed specified levels
- Activities that involve the emission of smoke, dust, other particulate matter, steam or other gas that exceed specified levels.

The OLS defines the airspace to be protected for aircraft operating during the initial and final stages of flight, or manoeuvring in the vicinity of Sydney Airport. This has been established in accordance with International Civil Aviation Organisation specifications, as adopted by CASA. Construction activities would be carried out to ensure that equipment such as cranes and materials do not intrude into the OLS or PANS-OPS.

CASA and DIRD have been consulted during the development of the project design and would be consulted further prior to commencement of construction to ensure that the construction activities proposed at Rozelle and St Peters, as well as surface road upgrades, are undertaken in line with the Airspace Regulations and the Airports Act, in a manner that satisfies the requirements of CASA.

CASA, under the Civil Aviation Regulations 1998 (Commonwealth), also regulates ground lighting where it has the potential to impact airport operations (such as causing confusion or distraction from glare to pilots in the air). The Sydney Airport Master Plan 2033 outlines the requirements for external lighting. Lighting during construction would adhere to established guidelines including *Lighting in the vicinity of aerodromes: Advice to lighting designer* (CASA 1999) and *National Airports Safeguarding Framework Guideline E: Managing the Risk of Distractions to Pilots from Lighting in the Vicinity of Airports* (DIRD 2012) in relation to the location and permitted intensities of ground lights within a six kilometre radius of Sydney Airport.

25.2 Assessment of operational impacts

During operation, the following potential hazards and risks may be associated with the project:

- Accidental releases or improper handling and storage of dangerous goods and hazardous substances in water treatment facilities
- Releases of hazardous substances from vehicles transporting dangerous goods and hazardous substances to and from the water treatment facilities in the event of an accident
- Releases of hazardous substances from non-project vehicles transporting dangerous goods and hazardous substances in the tunnels
- Crashes and incidents in the mainline tunnels or entry and exit ramps
- Crashes and incidents on surface roads
- Electric and magnetic fields from the project substations
- Potential hazards to road users and the general public relating to:
  - Electric and magnetic fields
  - Bushfires
  - Aviation hazards.

25.2.1 Storage and handling of dangerous goods and hazardous substances

Dangerous goods and hazardous substances stored and used during operation of the project would be limited and may include coagulants, polymers, acid and bases (outlined in **Table 25-4**). Additional small quantities of other hazardous materials may occasionally be required on site to support maintenance activities.

A comparison of the likely types and quantities of dangerous goods and hazardous substances to be stored on site with applicable thresholds in the SEPP 33 Guidelines indicates that operational inventories would not be potentially hazardous.

25.2.2 Transport of dangerous goods and hazardous substances for the project

Dangerous goods and hazardous substances that would be transported for the project during operation are outlined in **Table 25-5**. Additional small quantities of other materials may occasionally be required on site to support maintenance activities.

A comparison of the likely types and quantities of dangerous goods and hazardous materials to be transported within the thresholds in the SEPP 33 Guidelines indicates that the transport of operational inventories would not be potentially hazardous. In the event that thresholds are exceeded, transport frequency is likely to be well below the frequency threshold and as such, risks are unlikely to be significant.

Table 25-4 Indicative dangerous goods and hazardous substances stored on site during operation

Material and Australian Dangerous Goods (DG) Code Class	Storage method (amount stored at any one time)	Inventory thresholds in the SEPP 33 Guidelines	Assessment against SEPP 33 inventory thresholds
Sodium Hydroxide DG class 8 PGII	10,000 litres feed tank in an undercover bunded area on site	25 tonnes	Sodium hydroxide would not trigger the thresholds in the SEPP 33 Guidelines if considered as individual containers or in aggregate.
Coagulant DG class N/A	12,000 litres feed tank in an undercover bunded area on site	N/A	Coagulant is not a dangerous good and does not trigger the thresholds in the SEPP 33 Guidelines.
Polymers DG class N/A	20 kilogram bags stored in a undercover container on site	N/A	Polymers are not a dangerous good and do not trigger the thresholds in the SEPP 33 Guidelines.
Diesel DG class C1 PGIII	Bunded tanks on site	N/A	Diesel would not be stored with Class 3 materials and would therefore not be subject to the thresholds in the SEPP 33 Guidelines.
Acetylene DG class 2.1	Size G cylinders on site	100 kilograms	Individual cylinders containing acetylene would not trigger the thresholds in the SEPP 33 Guidelines. Maximum stored inventories would not trigger the thresholds in the SEPP 33 Guidelines if considered in aggregate.
Oxygen DG class 2.2	Size G cylinders on site	N/A	Industrial grade oxygen is a Class 2.2 dangerous good and is not subject to the thresholds in the SEPP 33 Guidelines.
Oxygen (subsidiary risk) DG class 5.1	Size G cylinders on site	Five tonnes	Oxygen has a subsidiary risk class of 5.1. Oxygen would not trigger the thresholds in the SEPP 33 Guidelines if considered as individual containers or in aggregate.
Grease DG class C2	400 grams cartridge, 20 litre container stored undercover on site	N/A	Grease would not be stored with Class 3 materials and would not be subject to the thresholds in the SEPP 33 Guidelines.
Adhesives DG class 3 PGIII	375 grams cartridge, 20 litre container on site	Five tonnes	Adhesives would not trigger the thresholds in the SEPP 33 Guidelines if considered as individual containers or in aggregate.
Bitumen DG class 9	12,000 litre tanker (brought onto site as required for the days operation)	N/A	Bitumen is a Class 9 dangerous good and not subject to the thresholds in the SEPP 33 Guidelines.

Material and Australian Dangerous Goods (DG) Code Class	Storage method (amount stored at any one time)	Inventory thresholds in the SEPP 33 Guidelines	Assessment against SEPP 33 inventory thresholds
Kerosene DG class 3 PGIII	20 litre container stored undercover in bunded area on site	Five tonnes	Kerosene would not trigger the thresholds in the SEPP 33 Guidelines if considered as individual containers or in aggregate.
Non shrink grout DG class N/A	20 kilogram bags stored under cover on site	N/A	Non shrink grout is not a dangerous good.
Release agent (Lanolin based) DG class N/A	20 litre drums stored undercover on site	N/A	Release agent (Lanolin based) is not a dangerous good and does not trigger the thresholds in the SEPP 33 Guidelines.
Line marking aerosol DG class 2.1	375 millilitre aerosol container stored undercover on site	100 kilograms	Line marking aerosol would not trigger the thresholds in the SEPP 33 Guidelines.

Table 25-5 Dangerous good and hazardous substances transported during operation

Material and Australian Dangerous Goods Code Class	Transport frequency	Transport quantity (indicative only)	Transport thresholds in the SEPP 33 Guidelines	Assessment against Applying SEPP 33 inventory thresholds
Sodium Hydroxide DG class 8 PGII	Six monthly	10,000 litres	Minimum transport load of 25 tonnes	Sodium hydroxide would not trigger the thresholds in the SEPP 33 Guidelines if considered as individual containers or in aggregate.
Coagulant DG class N/A	Quarterly	10,000 litres	N/A	Coagulant is not a dangerous good and does not trigger the thresholds in the SEPP 33 Guidelines.
Polymers DG class N/A	Quarterly	1,000 kilograms	N/A	Polymers are not a dangerous good and do not trigger the thresholds in the SEPP 33 Guidelines.
Diesel DG class C1 PGIII	As required	As required	N/A	Diesel would not be transported with Class 3 dangerous goods. It is not subject to the thresholds in the SEPP 33 Guidelines.
Acetylene DG class 2.1	Weekly	50 cylinders	Minimum transport load or transport frequency of two tonnes,	Industrial grade acetylene would not trigger the thresholds in the SEPP 33 Guidelines for minimum transport load or transport frequency of two tonnes, more than 30 times per

Material and Australian Dangerous Goods Code Class	Transport frequency	Transport quantity (indicative only)	Transport thresholds in the SEPP 33 Guidelines	Assessment against Applying SEPP 33 inventory thresholds
			more than 30 times per week	week.
Oxygen DG class 2.2	Weekly	50 cylinders	N/A	Industrial grade oxygen is a Class 2.2 dangerous good and is not subject to the thresholds in the SEPP 33 Guidelines.
Oxygen (subsidiary risk) DG class 5.1	Weekly	50 cylinders	Minimum transport load or transport frequency of two tonnes more than 30 times per week	Oxygen has a subsidiary risk class of 5.1. Oxygen would not trigger the transportation thresholds in the SEPP 33 Guidelines.
Grease DG class C2	Weekly	50 cartridges (20 kilograms)	N/A	Grease is not a dangerous good and would not be transported with Class 3 dangerous goods. Therefore, it is not subject to the thresholds in the SEPP 33 Guidelines.
Adhesives DG class 3 PGIII	Weekly	50 cartridges (19 kilograms)	Minimum transport load or transport frequency of 10 tonnes, more than 60 times per week	Adhesives would not trigger the thresholds in the SEPP 33 Guidelines.
Bitumen DG class 9	Quarterly	12,000 litres	Minimum transport frequency of more than 60 times per week	Bitumen would not trigger the thresholds in the SEPP 33 Guidelines.
Kerosene DG class 3 PGIII	Monthly	80 litres	Minimum transport load or transport frequency of 10 tonnes, more than 60 times per week	Kerosene would not trigger the thresholds in the SEPP 33 Guidelines.
Non shrink grout DG class N/A	Monthly	1,900 kilograms	N/A	Non shrink grout is not a dangerous good and therefore does not trigger the thresholds in the SEPP 33 Guidelines.
Release agent (Lanolin based) DG class N/A	Two monthly	180 litres	N/A	Release agent (Lanolin based) is not a dangerous good and therefore does not trigger the thresholds in the SEPP 33 Guidelines.
Line marking aerosol DG class 2.1	Quarterly	50 cans	Minimum transport load or transport frequency of two tonnes, more than 30 times per week	Line marking aerosol would not trigger the thresholds in the SEPP 33 Guidelines.

25.2.3 Transport of dangerous goods and hazardous substances in project tunnels

Dangerous goods and hazardous substances are not allowed to be transported within prohibited areas, in accordance with Road Rules 2014 – Regulation 300-2: NSW rule: carriage of dangerous goods in prohibited areas (Regulation 300-2). Prohibited areas are listed under Regulation 300-2 and include Sydney’s major tunnels.

The project tunnels would be listed as a prohibited area under Regulation 300-2 prior to the commencement of the operation of the project. Signage would be provided near tunnel entry portals advising of applicable restrictions to ensure compliance with Regulation 300-2.

25.2.4 Incidents in the tunnels

Any road project carries an inherent risk of vehicle collision associated with its operation. The potential for incidents and crashes to occur is a function of:

- The design of the project
- The type and volumes of traffic using the project
- Driving conditions, including light conditions and meteorology
- Human factors, including compliance with road rules, attention to driving conditions, driver behaviour and fatigue
- Vehicle failure and breakdown.

The project has been designed to provide for efficient, free-flowing traffic with physical capacity to accommodate predicted traffic volume. The design has incorporated all feasible and reasonable design measures in relation to geometry, pavement, breakdown bays, lighting and signage. The design is consistent with current Australian Standards, road design guidelines and industry best practice, inherently minimising the likelihood of incidents and crashes.

Tunnel features designed to minimise the disruption caused by incidents and crashes include:

- Height detection system prior to the tunnel entry portals
- Tunnel barrier gates to prevent access in the event of tunnel closure
- Closed-circuit television (CCTV) throughout the tunnel and approaches
- Adjustable speed signs
- Appropriately spaced breakdown bays and emergency telephones.

The project has also been designed to meet appropriate fire and life safety requirements in the event of an incident or accident in the tunnel, as described in **Chapter 5** (Project description). Consultation has been undertaken and would be ongoing with Fire and Rescue NSW and other emergency services to ensure the fire and life safety requirements are achieved.

Each project tunnel would be one-directional, reducing the risk of crashes through head-on collisions and simplifying smoke management and egress requirements. The transport of dangerous goods and hazardous substances would be prohibited through the mainline tunnels and entry and exit ramps, reducing the risk of very large fires or the release of toxic materials in the tunnel.

Other fire and life safety aspects that would be incorporated into the project include:

- State of the art CCTV and audible systems to detect incidents and manage evacuation processes
- Multiple pedestrian cross-passages between the mainline tunnels and longitudinal egress passages along the entry and exit ramps, to allow pedestrians to exit the tunnel and ramps in the event of a major incident (refer to **Chapter 5** (Project description)). Cross-passages would cater for egress for people with disabilities; therefore, stairs or ramps with steep grades would be limited, or alternative safe holding zones would be provided where necessary
- Automatic fire and smoke detection within the tunnels

- Longitudinal ventilation to ‘push’ smoke in the direction of traffic flow away from the fire source towards a ventilation facility or tunnel portal
- A water deluge system that could be activated manually or automatically at the fire source
- Structures, linings and services that would be fire hardened to protect them from fire damage before the activation of the deluge system, or if the deluge system fails.

The likelihood of a fire during operation of the project cannot be entirely removed. Uncontrollable human factors inherently lead to a residual risk of incidents and crashes, although the likelihood of such events would be low.

In the event of an incident, approaching traffic would be prevented from entering the mainline tunnels. Vehicle occupants at the location of the fire and upstream of the fire source would be instructed to stop their vehicles, and exit in the opposite direction through the section of carriageway that would be protected by the smoke management system, or through an exit door to a cross-passage leading to the other (‘non-incident’) mainline tunnel.

Occupants downstream of the fire source would be encouraged to continue driving out of the tunnel. If this is not possible and they are forced to evacuate on foot, egress would be provided via an exit door to a cross-passage leading to the non-incident mainline tunnel. Emergency services would be able to reach the fire source via the non-incident tunnel (by vehicle or foot), or from the upstream direction in the affected tunnel (by foot).

25.2.5 Probability of tunnel fires

A summary of available tunnel fire incident data for Australia is provided in **Table 25-6**. A historical tunnel fire frequency based on a vehicle-kilometre basis for two of the tunnels listed in **Table 25-6** has been calculated:

- For the Lane Cove Tunnel, historical fire frequency has been around 0.5 fires per 100 million vehicle kilometres (all vehicles)
- For the CityLink Tunnels (in Victoria), historical fire frequency has been around 0.8 fires per 100 million vehicle kilometres (all vehicles).

Based on traffic forecasts, the mainline tunnels are anticipated to experience around 20 million vehicle kilometres in 2023 and around 40 million vehicle kilometres in 2033. Applying similar tunnel fire frequencies to forecast traffic volumes for the project indicates:

- An expected annual tunnel fire frequency of 0.10 to 0.15 is expected in 2021 (equivalent to about one fire incident every 6.6 to 10 years)
- An expected annual tunnel fire frequency of 0.20 to 0.30 is expected in 2031 (equivalent to one fire incident every 3.3 to five years).

These values are comparable to observed annual tunnel fire incident rates for other Australian tunnels presented in **Table 25-6**, which range from around 0.16 to 0.76 per year, or around 0.5 to 0.8 100 million vehicle kilometres. Details regarding traffic volumes with and without the project are provided in **Chapter 8** (Traffic and transport).

Table 25-6 Tunnel fire frequency based on available data for Australian tunnels (up to 2016)

Tunnel	Length	Opened to traffic	Comments on fire incidents	Traffic volumes	Incident frequency
Sydney Harbour Tunnel (NSW)	Two tunnels, each 2.7 kilometres	August 1992	Around 10 fires since opening (around 0.4 per year).	Around 80,000 vehicles per day Around 86 million vehicle kilometres per annum	0.5 per 100 million vehicle kilometre
M5 East Motorway Tunnel (NSW)	Two tunnels, each four kilometres	December 2001	Around 72 fire and smoke/fume incidents between 2002 and 2009, although this includes non-fire incidents (ie vehicle exhaust/fume events are included in the figure). A heavy vehicle fire in August 2012 led to closure of the tunnel (reopened within two hours), operation of the deluge system and fire brigade response.	Around 90,000 vehicles per day Around 130 million vehicle kilometres per annum	Insufficient data
M2 Motorway Tunnel (Norfolk Tunnel) (NSW)	Two tunnels, each 0.5 kilometres	May 1997	One heavy vehicle fire since opening (around 0.05 per year). A fire in September 2013 led to closure of the tunnel (reopened in three hours), operation of the deluge system and fire brigade response. The fire started in a vehicle’s engine compartment.	Around 50,000 vehicles per day Around nine million vehicle kilometres per annum	0.7 per 100 million vehicle kilometres
Cross City Tunnel (NSW)	Two tunnels, each 2.1 kilometres	August 2005	Two fires recorded since the tunnel was opened in 2005 (around 0.16 per year). Of these fire incidents, one required the operation of the deluge system. The second fire was extinguished without the need for deluge.	Around 30,000 vehicles per day Around 23 million vehicle kilometres per annum	0.7 per 100 million vehicle kilometres

Tunnel	Length	Opened to traffic	Comments on fire incidents	Traffic volumes	Incident frequency
CityLink Tunnels (Burnley Tunnel and Domain Tunnel) (VIC)	Burnley Tunnel – two tunnels each 3.4 kilometres Domain Tunnel – two tunnels each 1.6 kilometres	December 2000	A total of 13 fires recorded since the tunnels were opened in late 2000 (around 0.76 per year). Of these fires, seven related to vehicle fires where the vehicle exited the tunnels without incident. Three of the fires required use of the deluge system and the remaining three fires required use of extinguishers. The most significant fire to occur was a result of a major car/truck collision in the Burnley Tunnel in 2007. This incident resulted in three fatalities and required closure of the tunnel for four days.	Around 55,000 (Burnley) and 45,000 (Domain) vehicles per day Around 94 million vehicle kilometres per annum (combined)	0.8 per 100 million vehicle kilometres (fires within the tunnel only)
Lane Cove Tunnel (NSW)	Two, tunnels, each 3.6 kilometres	March 2007	A total of five fires were recorded since the tunnels were opened in 2007 (around 0.5 per year). All of these fires required use of the deluge system.	Around 66,000 vehicles per day Around 87 million vehicle kilometres per annum	0.5 per 100 million vehicle kilometres

25.2.6 Incidents on surface roads

As discussed previously, the design of the project has been developed to inherently minimise the likelihood of incidents and crashes. Surface roads and infrastructure have been designed to provide an efficient and safe road network.

WestConnex provides an underground motorway connection for motorists travelling longer distances. In some cases, this results in fewer vehicles on major surface arterial roads across and in the vicinity of the project footprint. The M4-M5 Link would result in reduced traffic on sections of Parramatta Road, City West Link, and Victoria Road between Iron Cove Bridge (eastern abutment) and City West Link, and would also provide some relief for key north–south corridors such as Southern Cross Drive.

A detailed discussion of the impact of the project on traffic volumes is provided in **Chapter 8** (Traffic and transport).

The traffic reductions would result in the following traffic related benefits:

- Improved traffic flow and intersection performance
- Reduced crash rates
- Improved road safety for pedestrians, cyclists and motorists
- Improved travel times for bus services and motorists.

These traffic-related benefits are expected to result in an improved road safety environment.

Further details of the expected changes in traffic volumes on existing and new road infrastructure and improvements to road safety are provided in **Chapter 8** (Traffic and transport). Impacts and improvements to air quality, noise and human health risks are discussed in **Chapter 9** (Air quality), **Chapter 10** (Noise and vibration) and **Chapter 11** (Human health risk), respectively.

25.2.7 Road user and general hazards

Electric and magnetic fields

The Draft Radiation Standard – Exposure Limits for Magnetic Fields (Australian Radiation Protection and Nuclear Safety Agency December 2006) is based on a large body of scientific research since 1989. It proposes a series of exposure standards to replace the Interim Guidelines on Limits of Exposure to 50/60 Hz Electric and Magnetic Fields (National Health and Medical Research Council 1989).

Although the Draft Radiation Standard has never been finalised and published, the exposure limits presented are typically applied when considering electric and magnetic fields from new development. The project would include the provision of five aboveground substations, located at the Darley Road motorway operations complex (MOC1), Rozelle West motorway operations complex (MOC2), Rozelle East motorway operations complex (MOC3), Iron Cove Link motorway operations complex (MOC4) and Campbell Road motorway operations complex (MOC5). As identified in **Appendix F** (Utilities Management Strategy), the project would also require the provision of new high voltage (132kV) utility infrastructure and the relocation, treatment and/or protection of existing high voltage utility infrastructure, within and outside of the project footprint.

The detailed design of project substations and high voltage utility infrastructure would ensure that the exposure limits for the general public in the Draft Radiation Standard – Exposure Limits for Magnetic Fields (Australian Radiation Protection and Nuclear Safety Agency December 2006) would not be exceeded at the boundary of the substation sites or for high voltage utility infrastructure.

Bushfire risks

As outlined in **Chapter 18** (Biodiversity), vegetation in the project footprint comprises ‘urban exotic’ and ‘native cover’ (NSW Office of Environment and Heritage 2013a). No ‘bushland’ as defined in clause 4 of State Environmental Planning Policy No. 19 – Bushland in Urban Areas (SEPP 19) is considered to be present. Therefore, bushfires would not occur within the project footprint.

Notwithstanding, the operational infrastructure of the project is largely invulnerable to direct bushfire attack due to its incombustible nature (road surface materials, retaining walls, road barriers) and the fact that a lot of the infrastructure is in tunnels underground. Indirect bushfire risks to the project, including risks related to damage to communications networks or power supply are discussed in **Chapter 24** (Climate change risk and adaption). The project would not increase the extent of bushfire-prone land.

Aviation risks

The operational design of the project has considered airspace protection and associated risks and hazards. As discussed in **Chapter 2** (Assessment process) and **section 25.1.4**, under the Airports Act, a 'controlled activity' in relation to a prescribed airspace must not be carried out or caused to be carried out without the approval of the Secretary of DIRD or otherwise exempt under the Airspace Regulations.

CASA stipulates requirements for the construction and operation of new infrastructure that has the potential to influence aviation safety. CASA may determine that a plume, as exhausted from a ventilation outlet, is a hazardous object if the vertical velocity of the exhaust exceeds 4.3 metres per second. The Rozelle interchange and associated local road upgrades, the motorway operations complex at the St Peters interchange, and other ancillary infrastructure for the project would be located near flight paths used for Sydney Airport.

No buildings and structures that form part of the project are designed to intrude into prescribed airspace. The proposed ventilation outlets at the Rozelle interchange (at the Rozelle Rail Yards), Victoria Road (near the eastern abutment of Iron Cove Bridge) and at the St Peters interchange, are designed to be below prescribed airspace heights.

The project would include the construction and operation of ventilation facilities at:

- Haberfield, at the corner of Parramatta Road and Walker Avenue (this ventilation facility is being built as part of the M4 East project. The M4-M5 Link project would undertake the electrical and mechanical fitout of the ventilation outlet for the project)
- Rozelle, within the Rozelle Rail Yards
- Victoria Road, Rozelle, near the Iron Cove Link portals at Terry Street
- St Peters, within the St Peters interchange site near Campbell Road.

The exhaust plumes from all of the ventilation facilities have the potential to penetrate either or both the OLS or PANS-OPS levels. The project has been designed to satisfy requirements set by the DIRD in relation to erected structures (such as ventilation outlets), equipment manoeuvring and lighting. To determine whether plume rise resulting from the operation of these ventilation facilities would be a controlled activity as defined in section 183 of the Airports Act, a plume rise assessment would be carried out in accordance with the CASA *Advisory Circular Plume Rise Assessments AC 139-5(1) November 2012* prior to the operation of the project.

Aviation hazard lighting may be required on ventilation outlets at Haberfield, Rozelle, Iron Cove and St Peters. Surface road lighting would include an 'aeroscreen' type lens to minimise upward light spill. Aviation hazard lighting and surface road lighting would be in accordance with the requirements of CASA and Sydney Airport.

25.3 Environmental management measures

The implementation of environmental management measures for the project would avoid, to the greatest extent possible, risk to public safety and achieve the desired performance outcomes in relation to the hazards identified in **Table 25-1**. Environmental management measures relating to hazards and risk are outlined in **Table 25-7**.

In addition to these measures, a Work Health and Safety Plan would be implemented during construction of the project. This would support the management measures and procedures included in the CEMP for the project and would be supplemented by site and activity specific Safe Work Method Statements.

Table 25-7 Environmental management measures – hazards and risks

Impact	No.	Environmental management measure	Timing
Construction			
Spills and leaks from the storage and transport of dangerous goods and hazardous substances	HR1	Storage of dangerous goods and hazardous materials will occur in accordance with suppliers' instructions and relevant Australian Standards and legislation including the: • *Work Health and Safety Act 2011* (NSW) • Storage and Handling of Dangerous Goods Code of Practice (WorkCover NSW 2005) • Environment Protection Manual for Authorised Officers: Bunding and Spill Management, technical bulletin (NSW EPA 1997). Storage methods may include bulk storage tanks, chemical storage cabinets/containers or impervious bunds.	Construction
	HR2	Secure, bunded areas will be provided around storage areas for oils, fuels and other hazardous liquids. Impervious bunds will be of sufficient capacity to contain at least 110 per cent of the volume of the largest stored container.	Construction
	HR3	Management measures to reduce the potential for spills, reduce potential spill volumes and prevent any contamination will be developed and implemented for activities such as vehicle refuelling, servicing, maintenance, washdown, where there is a potential for spills and contamination.	Construction
	HR4	Safety Data Sheets for dangerous goods and hazardous substances will be stored on site prior to their arrival.	Construction
	HR5	Transport of dangerous goods and hazardous substances will be conducted in accordance with relevant legislation and codes, including the Dangerous Goods (Road and Rail Transport) Regulation 2014 (NSW) and the Australian Code for the Transport of Dangerous Goods by Road and Rail (National Transport Commission 2008).	Construction
	HR6	The project will be constructed in accordance with the design requirements of CASA and the Sydney Airport Master Plan 2033, with respect to lighting used during construction.	Construction
Operation			
Potential impacts from fire and safety incidents	OpHR1	The fire and safety systems and measures adopted for the project will be equivalent to or exceed the fire safety measures recommended by National Fire Protection Association 502 (American), Permanent International Association of Road Congresses (European), AS4825 (Australian) and Roads and Maritime standards.	Construction

Impact	No.	Environmental management measure	Timing
	OpHR2	Ongoing consultation will be undertaken with emergency services regarding fire and safety systems and measures adopted for the project.	Operation
	OpHR3	The transport of dangerous goods and hazardous substances will be prohibited through the mainline tunnels and entry and exit ramps.	Operation
	OpHR4	An Incident Response Plan will be developed as part of the Emergency Response Plan for the project and implemented in the event of an accident or incident.	Operation
	OpHR5	The response to incidents within the motorway will be managed in accordance with the memorandum of understanding between Roads and Maritime and the NSW Police Service, NSW Rural Fire Service, NSW Fire Brigade and other emergency services.	Operation
Spills and leaks from the storage and transport of dangerous goods and hazardous substances	OpHR6	Storage of dangerous goods and hazardous materials will occur in accordance with suppliers' instructions and relevant Australian Standards and legislation including the: • *Work Health and Safety Act 2011* (NSW) • Storage and Handling of Dangerous Goods Code of Practice (WorkCover NSW 2005) • Environment Protection Manual for Authorised Officers: Bunding and Spill Management, technical bulletin (NSW EPA 1997). Storage methods may include bulk storage tanks, chemical storage cabinets/containers or impervious bunds.	Operation
	OpHR7	Secure, bunded areas will be provided around storage areas for oils, fuels and other hazardous liquids. Impervious bunds will be of sufficient capacity to contain at least 110 per cent of the volume of the largest stored container.	Operation
	OpHR8	Management measures to reduce the potential for spills, reduce potential spill volumes and prevent any contamination will be developed and implemented for activities such as vehicle refuelling, servicing, maintenance or washdown, where there is a potential for spills and contamination.	Operation
	OpHR9	Material Safety Data Sheets for dangerous goods and hazardous substances will be stored on site prior to their arrival.	Operation
Exposure to electric and magnetic fields	OpHR10	The detailed design of the project substations will ensure that the exposure limits for the general public suggested by the Draft Radiation Standard (Australian Radiation Protection and Nuclear Safety Agency 2006) will not be exceeded at the boundary of the substation sites.	Construction

Impact	No.	Environmental management measure	Timing
Impacts from air emissions	OpHR11	Should the exhaust plumes at any of the M4-M5 Link ventilation outlets be assessed as a ‘controlled activity’ under the Airports Act and the Airspace Regulations, then the project will be operated in accordance with any conditions of approval from the Secretary of DIRD.	Construction and operation
	OpHR12	Aviation hazard lighting (if required), building lighting and surface road lighting will be designed and operated in accordance with the requirements of CASA and the Sydney Airport Master Plan 2033.	Construction and operation

26 Cumulative impacts

26.1 Introduction

This chapter provides an overview of the potential cumulative impacts associated with the construction and operation of the M4-M5 Link project. A detailed cumulative impact assessment methodology is presented in **Appendix C** (Cumulative impact assessment methodology). The methodology outlines the screening criteria applied in determining whether projects should be assessed for cumulative impacts, a list of projects considered but not included in the assessment, and a more detailed description of the projects that have been included.

Further information on the assessment of cumulative impacts can be found in the relevant technical assessments provided in **Appendix H** to **Appendix X**.

Cumulative impacts have been assessed and considered in two categories; impacts related to the overall WestConnex program of works and impacts from other related infrastructure projects or projects in the vicinity of the project. The identification of other developments that could occur in the vicinity of the project included relevant projects listed on the NSW Department of Planning and Environment's Major Projects website as State significant development or State significant infrastructure and known or proposed projects of a relevant scale or impact that involve activities that could result in a cumulative impact with the M4-M5 Link project.

26.2 Projects assessed

Following the application of the screening criteria to identified projects, the projects included in **Table 26-1** have been considered in the assessment of cumulative impacts for the project. The location of these projects is shown in **Figure 26-1**.

The list of projects identified can be broadly categorised as:

- **The WestConnex program of works**: this category includes the approved WestConnex projects of M4 Widening and King Georges Road Interchange Upgrade (completed construction and open to traffic) and the M4 East and New M5 (currently under construction)
- **Related NSW Roads and Maritime Services projects**: this category includes other related NSW Roads and Maritime Services (Roads and Maritime) projects that may interact with, be constructed, or operate within the vicinity of the project, such as the proposed future Sydney Gateway, Western Harbour Tunnel and Beaches Link and F6 Extension projects. As these projects are in the early planning stages, only limited information is available to inform a cumulative impact assessment. As such, a cumulative impact assessment has only been undertaken for key issues such as traffic, noise and vibration, air quality and human health risk
- **Other transport infrastructure projects**: This category includes public transport infrastructure such as light rail and metro such as the Sydney Metro City and Southwest and CBD and South East Light Rail (CSELR)
- **Other projects or strategic developments:** This category primarily includes urban development, other infrastructure and active transport projects. A number of the urban development projects are strategic in nature (ie are conceptual or in the early stages of planning), with limited detail available on specific impacts or timing of the various components.

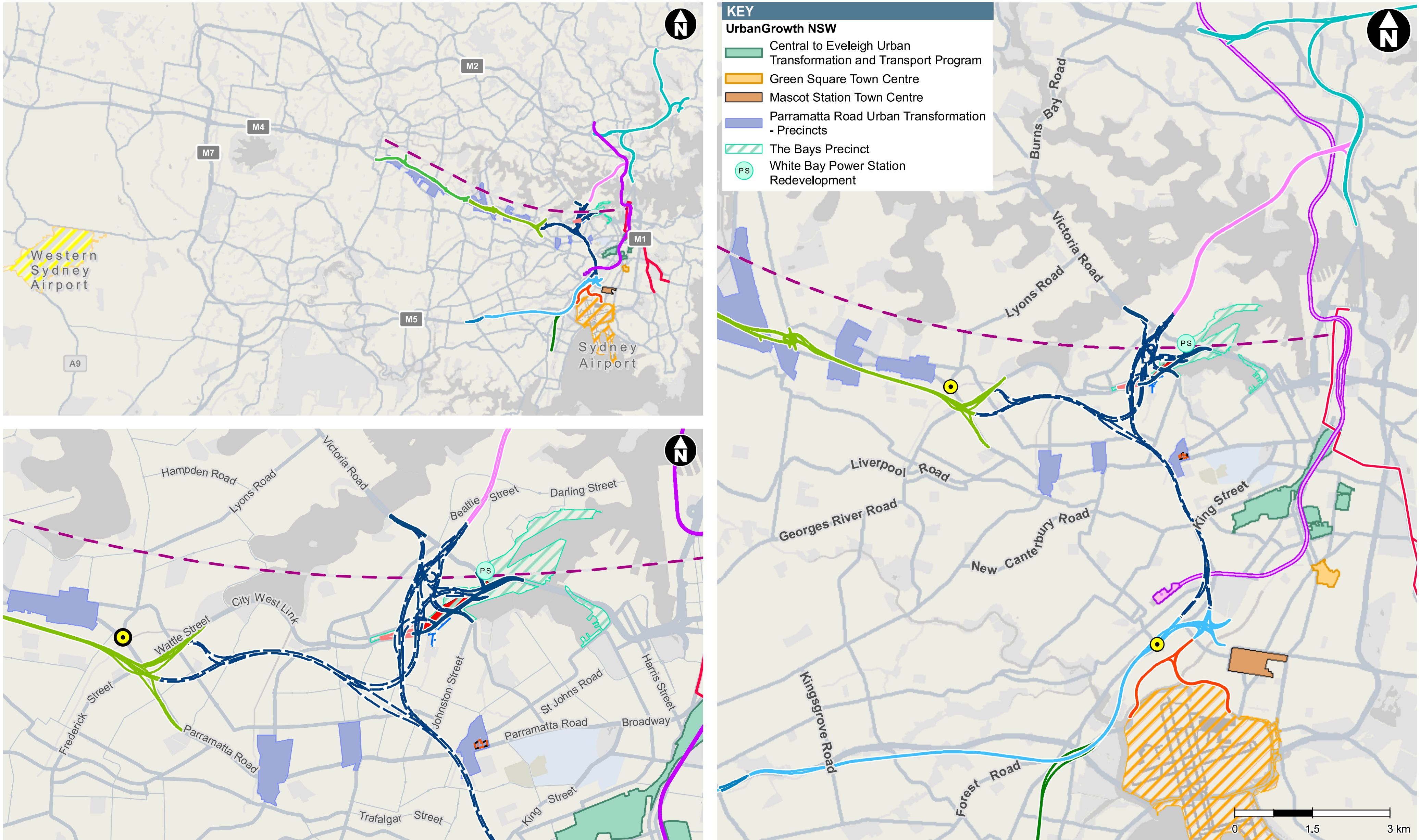
As described in **Appendix C** (Cumulative impact assessment methodology), a number of strategic projects (such as Western Sydney Airport) or land use/urban developments are already captured in the operational traffic modelling informing the cumulative operational assessments for traffic, air quality and noise and vibration and are therefore not discussed in detail in this chapter.

Table 26-1 Projects assessed in the cumulative impact assessment

Project name	Brief project description	Status
WestConnex program of works		
M4 Widening	Widening of the existing M4 Motorway from Parramatta to Homebush.	Planning approval under the *Environmental Planning and Assessment Act 1979* (EP&A Act) granted on 21 December 2014. Open to traffic.
M4 East	Extension of the M4 Motorway in tunnels between Homebush and Haberfield via Concord. Includes provision for a future connection to the M4-M5 Link at the Wattle Street interchange.	Planning approval under the EP&A Act granted on 11 February 2016. Under construction.
King Georges Road Interchange Upgrade	Upgrade of the King Georges Road interchange between the M5 West and the M5 East at Beverly Hills, in preparation for the New M5 project.	Planning approval under the EP&A Act granted on 3 March 2015. Open to traffic.
New M5	Duplication of the M5 East from King Georges Road in Beverly Hills with tunnels from Kingsgrove to a new interchange at St Peters. The St Peters interchange allows for connections to the proposed future Sydney Gateway project and an underground connection to the M4-M5 Link. The New M5 tunnels also include provision for a future connection to the proposed future F6 Extension.	Planning approval under the EP&A Act granted on 20 April 2016. Commonwealth approval under the *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth) granted on 11 July 2016. Under construction.
Other related projects		
Sydney Gateway	A high-capacity connection between the St Peters interchange (under construction as part of the New M5 project) and the Sydney Airport and Port Botany precinct.	Planning underway by Roads and Maritime and subject to separate environmental assessment and approval. For the purposes of this cumulative impact assessment, the Sydney Gateway project is conservatively assumed to be operational by 2023.
Western Harbour Tunnel and Beaches Link	Western Harbour Tunnel: Tunnels connecting to the M4-M5 Link at the Rozelle interchange, crossing underneath Sydney Harbour between the Birchgrove and Waverton areas, and connection with the Warringah Freeway at North Sydney. Beaches Link: Tunnels connecting to the Warringah Freeway, crossing underneath Middle Harbour and connecting with the Burnt Bridge Creek Deviation at Balgowlah and Wakehurst Parkway at Seaforth. It would also involve the duplication of the Wakehurst	Planning underway by Roads and Maritime and subject to separate environmental assessment and approval. For the purposes of this cumulative impact assessment, the Western Harbour Tunnel component is conservatively assumed to be operational by 2023, but construction may continue after the expected

Project name	Brief project description	Status
	Parkway between Seaforth and Frenchs Forest.	opening year of the M4-M5 Link project. For the purposes of this cumulative impact assessment, the Beaches Link component is conservatively assumed to be operational by 2033.
F6 Extension	A proposed future motorway link between the New M5 at Arncliffe and the existing M1 Princes Highway at Loftus, generally along the alignment known as the F6 corridor.	Planning underway by Roads and Maritime and subject to separate environmental assessment and approval. For the purposes of this cumulative impact assessment, the F6 Extension is conservatively assumed to be operational by 2033.
Rozelle Rail Yards Site Management Works	Removal of existing rail and rail related infrastructure from the Rozelle Rail Yards, including vegetation, buildings and waste.	Works have commenced and are expected to take up to 12 months to complete.
Sydney Metro City and Southwest	The project comprises two stages: • Stage 1: Chatswood to Sydenham • Stage 2: Sydenham to Bankstown. The main project feature relevant to the cumulative impact assessment is the southern dive structure (about 400 metres in length) and tunnel portal north of Sydenham Station and south of Bedwin Road at Marrickville (called the Marrickville dive site) for Stage 1.	Stage 1 was approved in January 2017.
CBD and South East Light Rail – Rozelle Maintenance Depot	The CBD and South East Light Rail (CSELR) project includes a light rail vehicle stabling facility in Randwick and a maintenance depot at Rozelle, at the western end of the Rozelle Rail Yards site. When complete, the depot would be used by light rail drivers as well as maintenance facility operators to repair and service light rail vehicles.	Preparatory work for the depot, adjacent to Lilyfield Road and Catherine Street, began in April 2016. The depot is under construction. Works are expected to finish by early 2018.
Parramatta Road Corridor Urban Transformation Strategy (UrbanGrowth NSW 2016) (The strategy)	The corridor spans around 20 kilometres from Granville to Camperdown and includes eight identified urban renewal precincts including the Taverners Hill, Leichhardt and Camperdown precincts. The strategy identifies the 'Camperdown Triangle' at the intersection of Parramatta Road, Pyrmont Bridge Road and Mallett Street as a potential biomedical hub. The strategy identifies a public transport 'super stop' at the intersection of Pyrmont Bridge Road and Parramatta Road.	Future strategic government project.

Project name	Brief project description	Status
The Bays Precinct Urban Transformation Plan (UrbanGrowth NSW 2015) (Bays Precinct Transformation Plan)	The Bays Precinct, located about two kilometres west of the Sydney CBD, encompasses the areas around Blackwattle Bay, Rozelle Bay and White Bay and comprises eight 'destinations', including the Rozelle Rail Yards, White Bay Power Station, White Bay, and Rozelle Bay and Bays Waterways. The plan outlines a vision to transform these destinations over the short to medium term.	Future strategic government project. Preliminary investigation and consultation is underway for the development of the White Bay Power Station site.
Whites Creek naturalisation	Sydney Water is investigating the naturalisation of about 420 metres of Whites Creek about 200 metres west of its outlet at Rozelle Bay in Annandale. The purpose is to devise a restoration plan with a focus on developing naturalising solutions where possible.	Concept design ready (December 2016). The design and construction timelines for these works are not known.



LEGEND

WestConnex
- King Georges Road Interchange Upgrade
- M4 East
- M4 Widening
- New M5
- M4-M5 Link tunnel
- M4-M5 Link surface roads
- Pyrmont Bridge Road tunnel site boundary
- Rozelle Rail Yards Site Management Works

Sydney Metro
- Sydney Metro City and Southwest
- Sydney Metro West
- Sydney Metro Marrickville dive site

Transport for NSW
- CBD and South East Light Rail (CSELR)
- (CSELR) Rozelle maintenance depot

RMS
- Proposed future Beaches Link
- Proposed future F6 Extension
- Proposed future Western Harbour Tunnel
- Proposed future Sydney Gateway
- RMS Pinch Points Program - Easing Sydney's Congestion

Other projects
- Sydney Airport Master Plan 2033
- Western Sydney Airport
- Whites Creek naturalisation

Figure 26-1 Projects included in the cumulative impact assessment

26.3 Nature of cumulative impacts

The assessment of potential cumulative impacts of the project has considered major developments that are proposed, have been approved (but not yet constructed), and/or would be constructed or operated at the same time as the planning, construction or operation of the M4-M5 Link project. Cumulative impacts are considered important to assess because in isolation, a particular impact from one project may be considered minor, but when the impact of multiple projects are considered, the impacts may be more substantial.

Impacts can be either adverse or beneficial. Where an adverse impact is considered likely, mitigation and/or management measures would be implemented to avoid or reduce those impacts. This chapter assumes that the specific mitigation and management measures outlined for the project in the various chapters of this environmental impact statement (EIS) have been applied and therefore focuses on the more strategic measures that may be implemented in coordination with other relevant projects. Project benefits, including the benefits of the overall WestConnex program of works, are discussed in **Chapter 3** (Strategic context and project need).

26.3.1 Construction phase cumulative impacts

Cumulative impacts arise through spatial proximity (ie how close one project might be to another) as well as temporal proximity (ie projects that occur in a similar timeframe or have overlapping schedules). This assessment defines these interactions as concurrent (simultaneous) or consecutive (back-to-back) project activities. Ancillary activities refer to works by utility and service providers to provide new or relocated utilities (such as electricity, telecommunications, water and sewage connections). These activities have been considered and assessed in the EIS (refer to **Appendix F** (Utilities Management Strategy) for further details). These works may also lead to local traffic disruptions, restrictions to access, noise and vibration impacts, potential dust generation and reduced visual amenity.

Indicative programs for construction of the various M4-M5 Link project components and construction ancillary facilities are outlined in **Chapter 6** (Construction work). These have been considered by the various technical specialists and incorporated into the technical working papers of this EIS, with the outcomes presented in the technical assessment chapters of the EIS (**Chapter 8** to **Chapter 27**). Final construction scheduling would be subject to the appointment of the successful construction contractor(s).

A consequence of concurrent or consecutive activities occurring over extended periods of time is the concept of construction fatigue. Construction fatigue can be experienced by receivers that are in the vicinity of concurrent or consecutive project construction activities where the activities overlap or have little or no break between the activities of one project, or multiple adjacent projects.

This cumulative impact assessment identifies three specific geographic areas where construction fatigue from concurrent or consecutive activities is likely to be experienced. These geographic areas are Haberfield/Ashfield, Rozelle and St Peters. **Figure 26-2**, **Figure 26-3** and **Figure 26-4** show these areas and the spatial and temporal overlap with other projects considered. The relevant projects with concurrent or consecutive construction timeframes is presented in **Table 26-2**.

Table 26-2 Projects that may result in construction fatigue with the M4-M5 Link project

Area	Project that may result in construction fatigue with the M4-M5 Link project
Parts of Haberfield/Ashfield	• M4 East
Parts of Rozelle	• Rozelle Rail Yards site management works • CBD and South East Light Rail – Rozelle maintenance depot • Proposed future Western Harbour Tunnel[1]
Parts of St Peters	• New M5 • Sydney Metro city and southwest (Chatswood to Sydenham)

Note: [1] A component of the proposed future Western Harbour Tunnel and Beaches Link project

Haberfield and Ashfield

Construction for the M4 East project is scheduled to continue until 2019. The M4 East construction sites at Haberfield/Ashfield include:

- The Northcote Street tunnel site (called the Northcote Street civil site (C3a) in this EIS)
- The Eastern ventilation facility site (called the Haberfield civil and tunnel site (C2a)/Haberfield civil site (C2b) in this EIS)
- The Wattle Street and Walker Avenue civil and tunnel site (called the Wattle Street civil and tunnel site (C1a) in this EIS)
- The Parramatta Road civil site (adjacent to the Parramatta Road West civil and tunnel site (C1b) in this EIS).

There would be overlap from the M4 East project at Haberfield with construction works associated with the M4-M5 Link project for a period of around six months if the Option B construction ancillary facility sites are used. During this overlap period the M4 East project works would be focussed on activities such as tunnel fitout, commissioning, surface road works, completion of structures such as the vent buildings and site rehabilitation/landscaping. The M4-M5 Link project would be focused on site establishment works such as building demolition, utility works and commencing work on the construction access tunnel.

The residential areas likely to be most impacted by construction fatigue include Wattle Street, Walker Avenue, Ramsay Street, Northcote Street, Wolseley Street, Alt Street, Bland Street and properties along Parramatta Road in the vicinity. Potential impacts include construction traffic, parking, construction noise and vibration, dust and visual impacts. There would be no overlap if the Option A construction ancillary facilities are utilised.

Rozelle

At Rozelle, the site management works at the Rozelle Rail Yards will occur over a period of 12 months and would be completed by mid-2018, prior to start of construction works for the M4–M5 Link project. The CSELR maintenance depot adjoins the proposed Rozelle civil and tunnel site (C5) to the west. Construction works for this project are progressing currently and are due for completion in early 2018, prior to the start of construction works for the M4–M5 Link project.

Details regarding construction of the Western Harbour Tunnel project are not available at this time as the project is in the early stages of design development. For the purposes of this assessment it has been assumed that there would be a construction site within the central portion of the Rozelle Rail Yards site and construction work would commence at the end of 2019 and continue through until approximately 2025. On this basis there may be a period of close to four years during which construction works for the two projects would overlap. The M4-M5 Link EIS has conservatively assumed that construction works for the two projects are occurring concurrently within the Rozelle Rail Yards and has assessed the potential impacts on this basis.

The residential areas likely to be most impacted by construction fatigue associated with these projects are the residential areas along and to the north of Lilyfield Road and users of Easton Park. To a lesser extent, the residential areas of Annandale and Lilyfield to the south of City West Link are also likely to be impacted. Potential impacts include construction traffic, construction noise and vibration, dust and visual impacts associated with building demolition, vegetation removal and construction activity at these sites.

St Peters

At St Peters, construction of the New M5 project is scheduled to continue until 2020. The most relevant New M5 construction sites in this area include:

- Campbell Road construction compound (a portion of which would be used by the M4-M5 Link project (called the Campbell Road civil and tunnel site (C10) in this EIS)
- Landfill closure construction compound

- Sydney Park construction compound
- Burrows Road construction compound.

During this overlap period the New M5 project works would be focussed on activities such as completing construction of the St Peters interchange, road upgrades, construction of the motorway operations complex, completing construction of the shared path and bridge over Campbell Road, demobilisation and landscaping. During this period, the M4-M5 Link project would be focused on initial road works, site establishment works, utility works and commencement of tunnelling works.

The residential areas likely to be most impacted by construction fatigue associated with the two projects include along Campbell Road, Campbell Street, Barwon Park Road and Crown Street in addition to users of Sydney Park. Potential impacts include construction traffic, construction noise and vibration, dust and visual impacts.

The Sydney Metro City and Southwest project Marrickville dive site is located around one kilometre to the northwest of Campbell Road civil and tunnel site. The Marrickville dive site will support two tunnel boring machines (TBMs) and construction of the southern services centre. Construction for the Sydney Metro City and Southwest project is proposed from 2018 to 2024 with main tunnelling works from the Marrickville dive site occurring between 2018 and 2020.

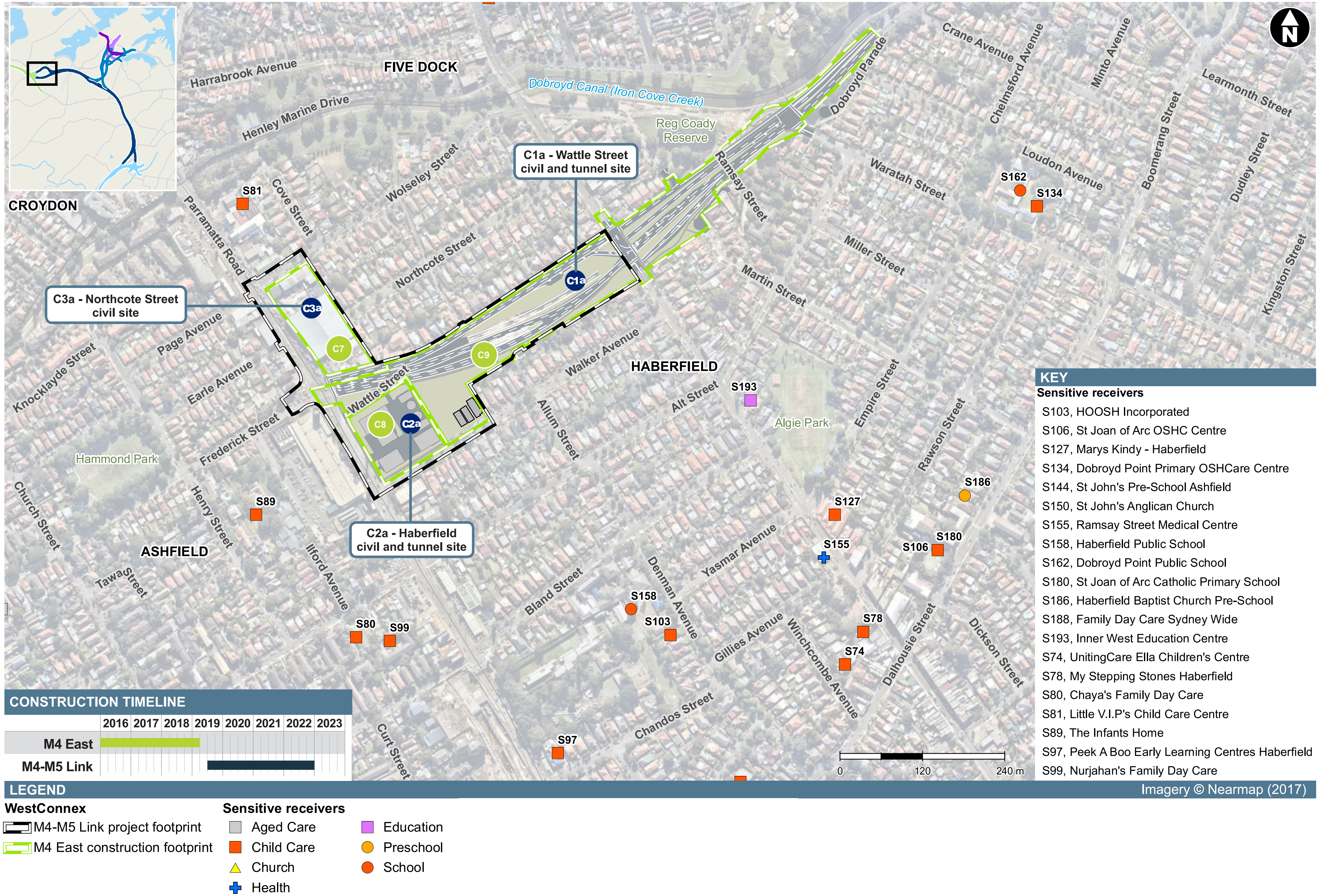


Figure 26-2 Cumulative construction impacts - Haberfield (Option A)

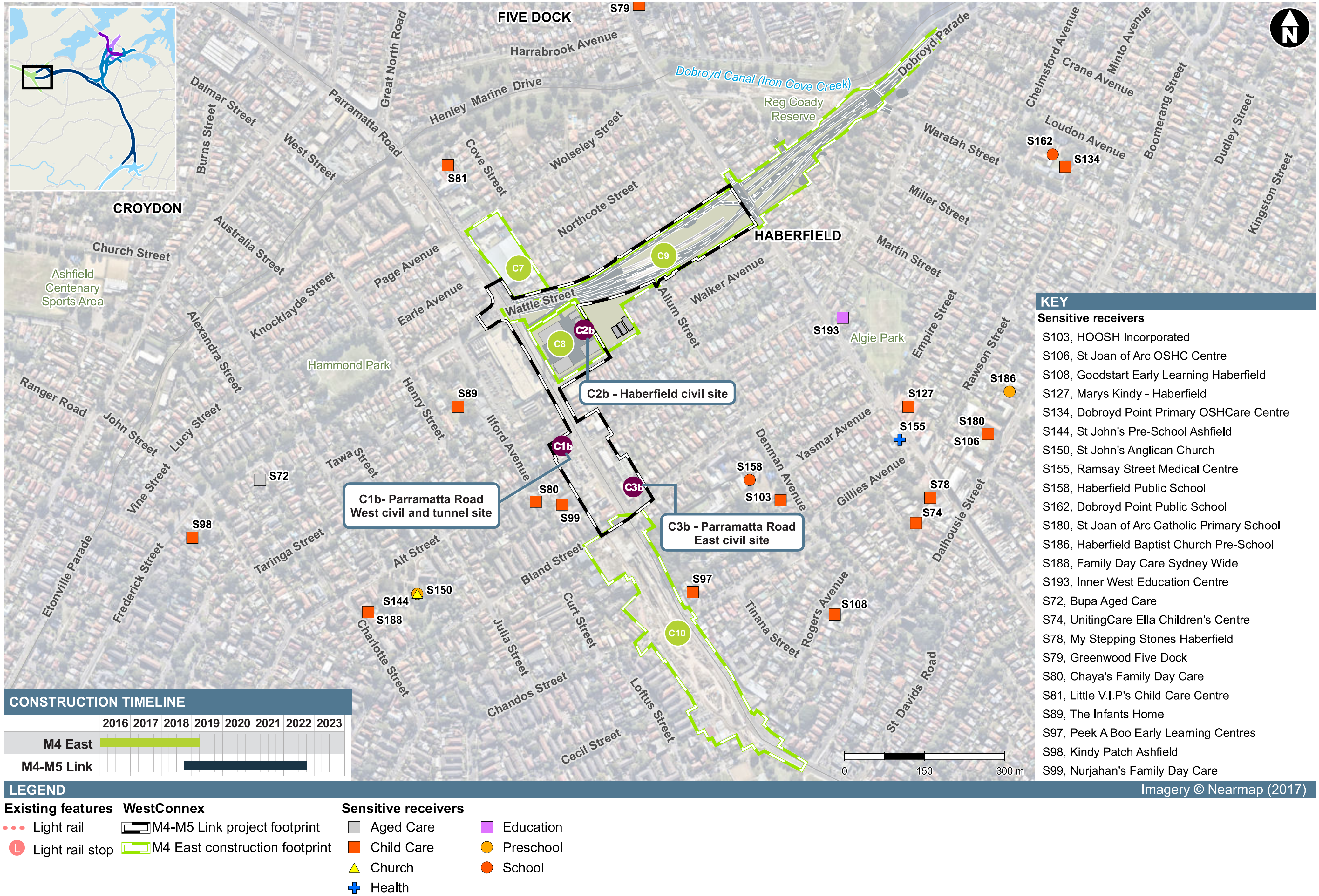


Figure 26-3 Cumulative construction impacts - Haberfield (Option B)

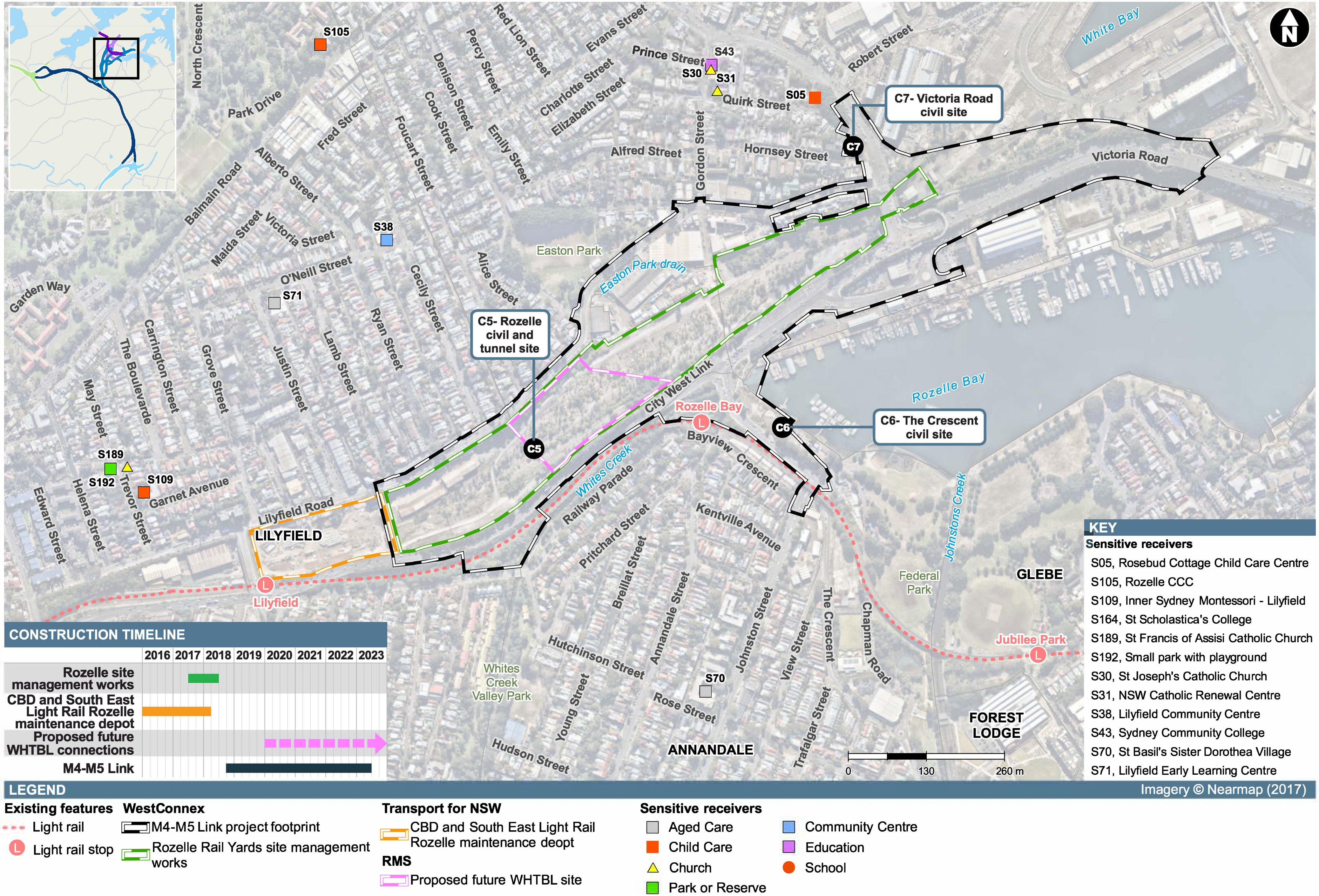


Figure 26-4 Cumulative construction impacts - Rozelle Rail Yards

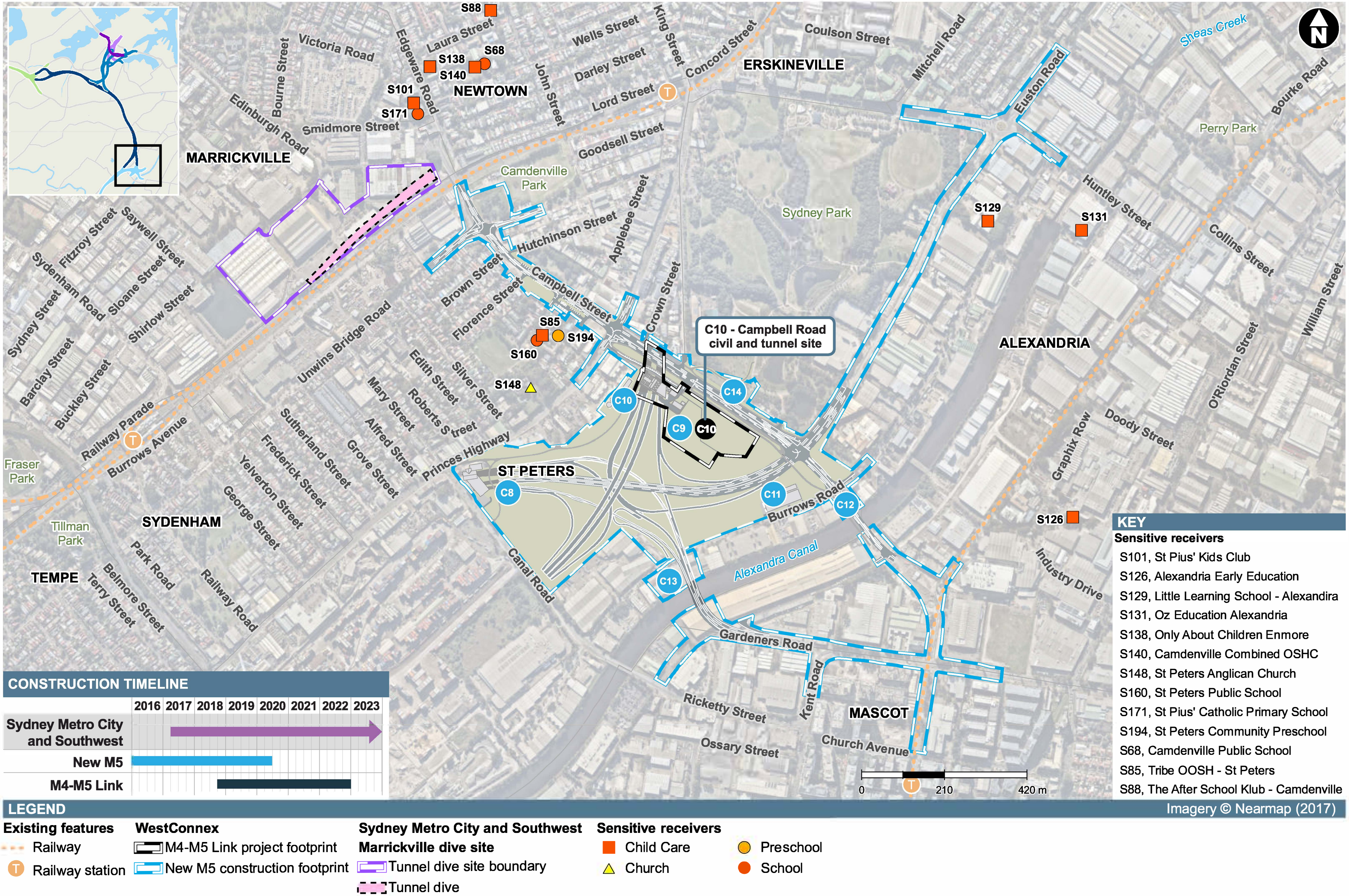


Figure 26-5 Cumulative construction impacts - St Peters

26.3.2 Operational phase cumulative impacts

As described in **Appendix C** (Cumulative impact assessment methodology), a number of strategic projects or land use/urban developments are already captured in the operational traffic modelling informing the cumulative operational assessments for traffic, air quality, noise and vibration, human health risk and social and economic environment and are therefore not discussed in detail in this chapter.

The traffic assessment included modelling of cumulative operational traffic scenarios at 2023 (year of opening) and 2033 (ten years after opening). The modelling predicted traffic from the operation of the approved WestConnex projects and the M4-M5 Link as well as a number of proposed motorway projects, as shown in **Table 26-3**.

The traffic modelling was based on land use and employment forecasts for metropolitan Sydney including forecasts for proposed growth precincts such as the Parramatta Road corridor, Bays Precinct, Central to Eveleigh corridor, Green Square and Mascot town centre. The modelling also included a range of approved and proposed major road and public transport projects including CSELR and Sydney Metro City and Southwest. It also included forecast growth in the Sydney Airport and Port Botany precinct and the Western Sydney Airport at Badgerys Creek.

The cumulative assessment for the quantitative modelling scenarios has been discussed in detail in their respective assessments, such as traffic and transport (**Appendix H** (Technical working paper: Traffic and transport)), air quality (**Appendix I** (Technical working paper: Air quality)) and noise and vibration (**Appendix J** (Technical working paper: Noise and vibration)). This chapter only provides a summary of the key outcomes of the operational cumulative impact assessment.

Table 26-3 Cumulative operational scenarios as defined for the traffic, air quality, noise and human health assessments

Scenario description			Projects included													
Traffic/ Air quality	Noise and vibration	Human health risk	Existing road network	M4 Widening	M4 East	KGRIU(a)	New M5	M4-M5 Link	NorthConnex	Sydney Gateway	Western Harbour Tunnel(b)	Beaches Link(b)	F6 Extension	M4 Widening	M4 East	KGRIU(a)
Do minimum	No Build	Without Project	✓	✓	✓	✓	✓		✓							
2023 – Do Something (DS)	2023 Build Do-something	2023 With project	✓	✓	✓	✓	✓	✓	✓							
2023 – Do Something Cumulative (DSC)	2023 Build Do-something plus	2033 With project cumulative	✓	✓	✓	✓	✓	✓	✓	✓	✓					
2033 – Do Something	2033 Build Do-something	2033 With project	✓	✓	✓	✓	✓	✓	✓							
2033 – Do Something Cumulative	2033 Build Do-something plus	2033 With project cumulative	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Notes:[(a)] KGRIU = King Georges Road Interchange Upgrade [(b)] A component of the proposed future Western Harbour Tunnel and Beaches Link project

26.3.3 Type of assessment

Depending on the environmental issue, the type of assessment undertaken in this EIS could be quantitative (such as predictive through modelling), qualitative, or a combination of both. The projects included in the cumulative impact assessment have been evaluated by technical specialists for the relevant key issues as identified in **Table 26-1**.

As described in **Appendix C** (Cumulative impact assessment methodology), a number of strategic projects (such as Western Sydney Airport) or land use/urban developments are already captured in the operational traffic modelling informing the cumulative operational assessments for traffic, air quality and noise and vibration and are therefore not discussed in detail in this chapter.

In accordance with the Secretary's Environmental Assessment Requirements (SEARs) for the M4-M5 Link project, all key issues have been considered for the approved WestConnex component projects. This is to provide a cumulative impact assessment of the WestConnex program of works to date.

In some cases projects are in the early stages of design development and an EIS has not been prepared. In these cases, reasonable assumptions have been made in assessing potential cumulative impacts and these will need to be confirmed during the EIS assessments for these projects based on available information at that time. In the case of the proposed future Sydney Gateway project, the assumption is that the same design will be assessed as was assessed in the New M5 EIS.

26.4 Assessment of potential cumulative impacts

26.4.1 Traffic and transport

The cumulative traffic and transport assessment examines construction and operational traffic generation for future scenarios and capacity of the road network to manage the predicted changes in traffic volumes, as well as the impact on public and active transport. A detailed assessment of the potential construction and operational cumulative impacts is provided in **Appendix H** (Technical working paper: Traffic and transport).

Construction

Establishment of construction-based ancillary facilities for the project is associated with heavy and light vehicle movements, but only some of these sites (ie the tunnelling sites) would have heavy vehicle movements associated with spoil haulage. The traffic modelling for the cumulative construction assessment was undertaken for the year 2021, as it is considered to be the highest traffic-generating year of construction and therefore assesses the worst case construction traffic scenario.

The construction of the M4 East and New M5 projects are expected to be completed in 2019 and 2020. Therefore there would be an overlap with the construction of the M4-M5 Link project for a period of up to 12-18 months, subject to project approval. During this period of overlaptunnelling construction, the largest generator of heavy vehicle traffic, is unlikely to cause a substantial cumulative impact in terms of additional heavy vehicles on the road network from these three projects being under construction concurrently.

Elements of the construction program for the M4-M5 Link are assumed to occur concurrently with the construction of proposed future Sydney Gateway project, with both projects scheduled for completion in 2023. The EIS for the proposed future Sydney Gateway project would need to consider the cumulative impacts with the M4-M5 Link construction.

The construction of the proposed future Western Harbour Tunnel is assumed to overlap with the M4-M5 Link construction and the likely trip generation for heavy and light vehicles has been added to the cumulative construction assessment presented in this EIS.

Analysis indicates that the impact from additional Western Harbour Tunnel construction traffic on the road network is minimal, with most intersections operating at the same level of service (LoS). A few intersections along Wattle Street and Parramatta Road are forecast to experience a slight worsening in level of service during the AM and PM peak periods as a result of construction traffic, namely:

- Parramatta Road/Wattle Street intersection in the AM peak hour

- Parramatta Road/Harris Road and Parramatta Road/Croydon Road/Arlington Street intersections in the AM peak hour
- Wattle Street/Ramsay Street in the PM peak hour.

These cumulative impacts on the operation of the road network would not be experienced for the duration of the construction period and would be subject to further assessment in the Western Harbour Tunnel EIS.

Elements of the M4-M5 Link construction program would also occur concurrently with the construction of the Sydney Metro City and Southwest project (Stage 1: Chatswood to Sydenham). Construction traffic from the Sydney Metro Marrickville dive site, which is some distance to the west, may use the Princes Highway, which would also be used by traffic from the M4-M5 Link construction site at Campbell Road.

Site management works would occur within the Rozelle Rail Yards before the commencement of construction of the M4-M5 Link. Site management works have commenced, with completion planned for mid-2018. Due to the timing of works, there would be no concurrent traffic impacts with the M4-M5 Link. However, as the works would occur consecutively (ie back-to-back), residents in the vicinity would experience traffic impacts from both projects being undertaken consecutively.

Impacts on public and active transport

On-road public transport in the cumulative construction scenario would generally experience levels of service as they do under the project construction scenario with a small reduction in levels of service in some locations due to the increased demand generated by the Western Harbour Tunnel construction traffic (which would be subject to a separate EIS).

The potential impacts on pedestrians and cyclists at the Rozelle civil and tunnel site, potentially in the form of additional light vehicle movements along Lilyfield Road, would likely be lengthened due to the construction of the proposed future Western Harbour Tunnel.

Operation

Potential cumulative operational traffic impacts for 2023 and 2023 are summarised in **Table 26-4**.

While the construction impact of the proposed future Western Harbour Tunnel and Beaches Link entry and exit ramps connecting to City West Link/The Crescent is assessed, the operational traffic impact of these ramps has not been included. A preliminary assessment with these ramps operational has been carried out and indicates that there is likely to be some reduction in traffic on the Western Distributor and Sydney Harbour Bridge, as more traffic would be able to access the proposed future Western Harbour Tunnel and Beaches Link. However, there is likely to be increased traffic on City West Link, The Crescent and Johnston Street. The impacts of these entry and exit ramps would be assessed in detail as part of future environmental assessment for the proposed future Western Harbour Tunnel and Beaches Link.

Table 26-4 Cumulative operational traffic impacts (2023 and 2033)

Location	Potential cumulative traffic outcomes - 2023	Potential cumulative traffic outcomes - 2033
M4-M5 Link Mainline tunnels	Compared to the 2023 'with project' scenario, the 2023 'cumulative' scenario analysis indicates traffic volumes on the M4-M5 Link mainline tunnels are forecast to generally be denser with a corresponding reduction in level of service (LoS) in the peak hours. However, the M4-M5 Link Motorway are still forecast to generally operate at LoS D or better.	The 2033 'cumulative' scenario analysis indicates forecast traffic flows on the M4-M5 Link mainline tunnels would be denser compared to the 2033 'with project' scenario, with a corresponding reduction in level of service in the peak hours. Sections of the M4-M5 Link mainline tunnels are forecast to operate at LoS E in peak hours, particularly around the merge and diverge locations, such as where the Wattle Street interchange ramps connect with the M4-M5 Link mainline tunnels. Even with this increased density, average motorway speeds are forecast to be 60 km/h or above in the peak hours.
Metropolitan network efficiency	The metropolitan road network productivity improves in 2023, with the inclusion of the proposed future Sydney Gateway and Western Harbour Tunnel. There is a drop in the daily vehicle kilometres travelled (VKT) and vehicle hours travelled (VHT) on the arterial network with an increase in kilometres travelled along the motorway routes, a greater distance could be travelled on the road network in a shorter time.	Metropolitan road network productivity improves in 2033, with the inclusion of the proposed future Sydney Gateway, Western Harbour Tunnel and Beaches Link and the F6 Extension projects. There is a drop in the daily VKT and VHT on the arterial network with an increase in kilometres travelled along the motorway routes. As in 2023, overall, a greater distance could be travelled on the road network in a shorter time.
Parallel routes analysis	See description for 2033.	As a result of the additional road network capacity provided by the project, traffic volumes on parallel routes compared to a 'without project' scenario is predicted to significantly decrease on: • City West Link and Parramatta Road, east of the M4 East • Stanmore Road in Stanmore • Lyons Road in Russell Lea • Southern Cross Drive and the Sydney Harbour Tunnel. The M4-M5 Link would provide alternative parallel options to the roads listed above together with the proposed future Sydney Gateway, Western Harbour Tunnel and Beaches Link and the F6 Extension in the 2023 and 2033 'cumulative' scenarios. A decrease in the daily volume of heavy vehicles on surface roads such as Parramatta Road, City West Link, Stanmore Road, Sydenham Road, Marrickville Road and King Street is also forecast, as heavy vehicles shift onto the M4-M5 Link and the other

Location	Potential cumulative traffic outcomes - 2023	Potential cumulative traffic outcomes - 2033
		motorways included in the 'cumulative' scenarios. In the 2033 'cumulative' scenario, increases are forecast in daily two-way volumes on Johnston Street, north of Parramatta Road in Annandale and Gladesville Bridge in the 'cumulative' scenario. These increases reflect the forecast demand to and from the Rozelle area due to the new connectivity being provided by the Rozelle interchange.
Metropolitan travel time	See description for 2033.	In the 2023 and 2033 cumulative scenarios, peak period travel times are forecast to further reduce, by comparison to a 'with project' scenario, on a number of key travel routes such as between the M4 corridor and the Sydney Airport/Port Botany precinct. This is as a result of traffic shifting from surface roads to the M4-M5 Link and the other motorways included in the 'cumulative' scenarios.
Wattle Street interchange	The 2023 AM peak hour 'cumulative' conditions are forecast to be similar to those for the 'with project' scenario, with the main cause of congestion remaining the forecast demand for City West Link. There would be an increase in average speed on the modelled road network due to the higher proportion of vehicles using the M4-M5 Link in the 'cumulative' scenario. The 2023 PM peak hour 'cumulative' conditions are forecast to be similar to those for the 'with project' scenario, with the main cause of congestion remaining the forecast demand to Frederick Street. As in the 'with project' scenario, significant queues are forecast on the Parramatta Road eastbound approach to Wattle Street and on Wattle Street itself. There would be an increase in average speed on the modelled road network due to the higher proportion of vehicles using the M4-M5 Link in the 'cumulative' scenario. Performance across the majority of the modelled road network is consistent between 'with project' and 'cumulative' scenarios, with intersections performing at the same or better levels of service.	During the 2033 AM peak hour, the 'cumulative' scenario is forecast to experience a minor increase in overall average speed due to a forecast increased demand for the M4-M5 Link mainline tunnels when compared to the 'with project' scenario. Congestion on Wattle Street/Dobroyd Parade would impact motorists approaching the Wattle Street interchange from side roads – this would be experienced in both 'with project' and 'cumulative' scenarios. The 2033 PM peak hour 'cumulative' conditions are forecast to be similar to those for the 'with project' scenario, with the forecast demand for Frederick Street remaining the main cause of congestion. Performance across the majority of the modelled road network would be consistent between 'with project' and 'cumulative' scenarios, with intersections performing at the same or better levels of service.
Rozelle interchange	During the 2023 AM peak hour, an increase in demand is forecast for the 'cumulative' scenario over the 'with project' scenario. In	As in 2023, the 2033 'cumulative' scenario provides some benefit to the Western Distributor and Anzac Bridge, due to the forecast shift in

Location	Potential cumulative traffic outcomes - 2023	Potential cumulative traffic outcomes - 2033
	spite of this increase, the ‘cumulative’ network would provide benefits to the Western Distributor and Anzac Bridge operation as traffic is forecast to shift from the Sydney Harbour Bridge to the proposed future Western Harbour Tunnel, During the 2023 PM peak hour, the forecast demand for the ‘cumulative’ scenario increases by about 10 per cent over the ‘with project’ scenario. In spite of this increase, the modelled network is forecast to operate better than in the ‘cumulative’ case. Again, this is due to traffic being forecast to shift from the Sydney Harbour Bridge to the proposed future Western Harbour Tunnel. The forecast intersection performances in the 2023 ‘cumulative’ scenario are similar to the ‘with project’ scenario.	traffic from the Anzac Bridge and Sydney Harbour Bridge to the proposed future Western Harbour Tunnel. This reassignment results in better flow for northbound traffic on Western Distributor towards Sydney Harbour Bridge with improved network performance. As in 2023, the 2033 ‘cumulative’ network is forecast to perform better compared to the ‘with project’ case, despite a 15 per cent increase in forecast demand, due to the shift in traffic from the Sydney Harbour Bridge to the proposed future Western Harbour Tunnel. The forecast intersection performances in the 2033 ‘cumulative’ scenario are similar to the ‘with project’ scenario.
St Peters interchange	The AM peak hour network performance results in the 2023 cumulative scenario show overall improvement compared to the 2023 ‘with project’ scenario. Despite the higher forecast total demand, total travel time is shorter, indicating less congestion in the modelled network around the St Peters interchange. This is due to the proposed future Sydney Gateway improving connectivity between St Peters interchange and Sydney Airport precinct, removing traffic from the Mascot area. The PM peak hour network performance results show a similar trend to the AM peak hour. Many intersections in the modelled road network are forecast to operate at similar or better levels of service, due to the contribution of the proposed future Sydney Gateway.	In the 2033 AM peak hour, the modelled network is forecast to operate better than the ’with project’ scenario, although not as significant an improvement as in 2023 due to the growth in traffic across the modelled network. Total forecast demand is higher than in the ‘with project’ scenario, however more vehicles are forecast to reach their destination, indicating less congestion than under the ‘with project’ scenario. This is due to the proposed future Sydney Gateway improving connectivity between St Peters interchange and the Sydney Airport precinct, removing traffic from the Mascot area. The 2033 PM peak hour network performance results show improved network operation in the ‘cumulative’ scenario compared to the ‘with project’ scenario. Total travel time in the modelled road network is forecast to be shorter, with a doubling in average speed on the network. Many intersections within the modelled road network are forecast to operate at similar or better levels of service when compared to the ‘with project’ scenario, due to the contribution of the proposed future Sydney Gateway.

Public transport

Potential impacts to public transport in the cumulative scenarios are generally similar to the general traffic network performance assessments. On-road public transport would experience similar levels of service as they do under the 'with project' scenarios with a reduction in levels of service in some locations, due to the increased demand generated by the cumulative projects, and improvements in other locations, where the 'cumulative' network provides benefits to the surface road network.

Active transport

Positive cumulative impacts on active transport include the upgrade, extension and connectivity of pedestrian and cycle routes linking areas of public open space as a result of the combined suite of projects included in this cumulative assessment. This is presented in the active transport strategy presented in **Appendix N** (Technical working paper: Active transport strategy).

26.4.2 Air quality

The cumulative impact assessment for air quality focuses on the cumulative change in airborne pollutants as a result of the construction and operation of the M4-M5 Link project in combination with the other relevant projects presented in **Table 26-1**..

WestConnex projects

Construction

For all construction activities, a key aim is to prevent significant effects on receptors through the use of effective mitigation as described in **section 26.3.1**. There are three geographic locations that will experience a degree of combined construction impacts from multiple projects, these are at Haberfield, Rozelle and St Peters, which are each located within proximity to sensitive receivers.

These overlapping areas may experience extended periods of construction on a site-by-site and activity-by-activity basis. Irrespective of the duration, the generation of dust, which may cause amenity impacts to the surrounding community, can be effectively controlled. Air quality impacts from the activities expected during construction are manageable through well established and effective management and mitigation measures. Cumulative air quality impacts during construction are therefore not expected to be significant.

Operation

The operational component of the air quality assessment examines both in-tunnel air quality as well as surface ambient air quality and the changes under different operational scenarios and is reported on in **Appendix I** (Technical working paper: Air quality).

The project ventilation system is designed for coordinated operation with adjacent tunnel projects (ie the WestConnex M4 East and New M5 projects and the proposed future Western Harbour Tunnel and Beaches Link project), with complete or partial air exchange at project boundaries when necessary to ensure in-tunnel air quality is maintained throughout the tunnel network. The ventilation system is designed to have complete exchange of tunnel air between the proposed future Western Harbour Tunnel and Beaches Link project and the M4-M5 Link project at the Rozelle ventilation facility.

For in-tunnel air quality, the project would meet the in-tunnel criterion for nitrogen dioxide (NO_2) as an average concentration along any route through the tunnel network, and irrespective of contributions from other tunnel projects, therefore cumulative impacts on NO_2 emissions are not relevant.

For ambient air quality, the air quality assessment uses changes in background air quality over time, plus surface traffic flows and emissions from ventilation outlets as key contributors to changes in air quality within and around the project footprint. The assessment presents each of the pollutants in the air quality assessment and uses the 'residential, workplace and recreational (RWR) receptors' as locations to measure the change. The RWR represent 86,375 individual receptors across the modelled network. The sections below summarise the key findings of the assessment for the 'Do something' (DS) and 'Do something cumulative' (DSC) scenarios as compared with the 'Do minimum' (DM) scenario (ie without the project).

Table 26-5 Cumulative operational air quality impacts (2023 and 2033)

Pollutant	Outcomes of the operational cumulative assessment
Carbon monoxide (CO) 1-hour concentration	The one-hour CO criterion for NSW was not exceeded at any of the RWR receptors in any scenario. The highest one-hour concentrations in any DS or DSC scenario was predicted to be 7.7 mg/m^3 as compared to the criterion of 30 mg/m^3.
NO_2 annual mean	The annual mean NO_2 criterion for NSW of 62 µg/m^3 was not exceeded at any of the RWR receptors in the DSC scenario. Only around 0.1 per cent of receptors were predicted to have an increase of greater than 2 µg/m^3 and there was a reduction in annual mean NO_2 at between or around 80 per cent and 85 per cent of receptors, providing a benefit to the majority of receptors.
NO_2 maximum 1-hour mean	The maximum one-hour mean NO_2 concentration was predicted to be exceeded by 3.8 per cent of the RWR receptors in 2023 and less than 1 per cent in the 2033 DSC scenarios. These are compared to the DM scenario where 6.6 per cent of the RWR were predicted to experience an exceedance in 2023 and 2.3 per cent in 2033.
Particulate matter (PM_{10} annual mean)	The concentration at the majority of receptors was below 20 µg/m^3, with only a very small proportion of receptors having a concentration exceeding the criterion of 25 µg/m^3. The 2023 DS predicted 26.5 µg/m^3 while the 2023 DSC scenario was marginally less at 25.9 µg/m^3. For the 2033 DS, the predicted maximum was 26.1 µg/m^3 while for the 2033 DSC, it was marginally less at 25.8 µg/m^3.
Particulate matter (PM_{10} 24-hour mean)	The predicted results for the DSC scenarios were significantly influenced by the high PM_{10} background concentration of about 93 per cent of the criterion for 2023 and 2033. PM_{10} 24 hour mean concentrations at the majority of RWR receptors was above the NSW impact assessment criterion of 50 µg/m^3 both with and without the project.
Particulate matter ($PM_{2.5}$ annual mean)	Similar to the PM_{10} pollutant, the $PM_{2.5}$ background concentration is already very high and at most RWR receptors is close to the NSW criterion of 8 µg/m^3. For the 2023 DSC scenario there is a maximum increase of 2.2 µg/m^3 compared to 1.2 µg/m^3 for the 2023 DS scenario. For the 2033 DSC scenario there is a maximum increase of 2.3 µg/m^3 compared to 1.4 µg/m^3 for the 2033 DS scenario. The predicted maximum values for the decrease in $PM_{2.5}$ annual mean concentrations is similar for the DS and DSC scenarios for both 2023 and 2033.
Particulate matter (24-hour mean $PM_{2.5}$)	Similar to 24-hour mean PM_{10}, as a result of the high background levels, the concentrations predicted at all receptors was above the NSW impact assessment criterion of 25 µg/m^3 for 24 hour mean $PM_{2.5}$ concentrations. Again with the DSC scenarios predicting marginally lower concentrations than the DS scenario for the same year.

Regional air quality

The changes in the total emissions resulting from the project are shown in **Table 26-6**. These changes can be viewed as a proxy for the projects and the cumulative scenario's impact on regional air quality which, on the basis of the results, are likely to be negligible. The graphs show minimal change between the DM, DS and DSC scenarios and all are significantly lower than the 'Base Year (2015)' emissions without any of the projects assessed in the DS or DSC in operation. For example:

- The increases in the oxides of nitrogen (NO_X) emissions for the assessed road network in a given year ranged from 71 to 174 tonnes per year. These values equate to a very small proportion (around 0.3 per cent) of anthropogenic NO_X emissions in the Sydney airshed in 2016 (around 53,700 tonnes)
- The increases in NO_X in a given year are much smaller than the projected reductions in emissions between 2015 and 2033 (around 2,340 tonnes per year).

Overall, it is concluded that the cumulative impacts on regional air quality would be negligible, and undetectable in ambient air quality measurements at background locations.

26.4.3 Noise and vibration

An assessment of the potential construction and operational impact of the M4-M5 Link is provided in **Chapter 10** (Noise and vibration) and is detailed in **Appendix J** (Technical working paper: Noise and vibration).

Construction

Cumulative construction noise impacts can be divided into two groups:

- Concurrent noise impacts, where more than one work activity is carried out at the same time and in the same location, such that the same receiver is potentially impacted. Concurrent construction noise impacts include construction civil and tunnelling sites which may operate simultaneously during any period. These construction areas are anticipated to include relatively stationary noise sources which operate for the majority of the construction period
- Consecutive noise impacts, where receivers are exposed to construction noise impacts from the construction of separate and consecutive nearby projects. Generally construction noise impact assessments consider the duration of a project in isolation, whereas the potential impacts from the identified consecutive projects are likely to be perceived to be longer by affected receivers.

Appendix J (Technical working paper: Noise and vibration) includes an assessment of concurrent construction impacts for each of the M4-M5 Link construction sites along with an assessment of consecutive impacts where approved or currently under construction projects occur within close proximity to an M4-M5 link project site. The following section provides discussion for sites where both consecutive and current construction impacts are predicted to occur.

Table 26-6 Cumulative operational noise impacts

Concurrent construction impacts	Consecutive construction impacts
Cumulative construction noise impacts -	**Haberfield Option A**
Given the number of work sites associated with the project within the Haberfield area, it is likely that receivers would occasionally be subject to potential noise impacts from concurrent activities. This would most likely be apparent during the night-time period where predicted noise levels may exceed the noise management level (NML) by up to 10 dBA.	The M4 East project, together with the M4-M5 Link, tie in to Wattle Street at Haberfield, where receivers would likely be exposed to extended impacts associated with the consecutive construction of both projects. The receivers most likely to be affected by consecutive construction impacts are: • Receivers adjoining the Northcote Street civil site (C3a). This site is currently a tunnel site for the M4 East project, with an acoustic shed constructed across the site • Receivers adjoining Wattle Street and Walker Avenue, which have line of sight to the Wattle Street civil and tunnel site (C1a) and the Haberfield civil and tunnel site (C2a).
Cumulative construction noise impacts –	**Haberfield/Ashfield Option B**
As above, due to the number of construction sites in the Haberfield/Ashfield area, it is likely that receivers would occasionally be subject to night-time period cumulative impacts. This is predicted to exceed the NML by greater than 20 dBA within noise catchment area (NCA) NCA01.	As above, receivers most likely to be affected by consecutive construction impacts from the M4 East and M4-M5 Link projects are: • Receivers adjoining the Parramatta Road West civil and tunnel cite (C1b), Parramatta Road East civil site (C3b) and Haberfield civil site (C2b), between Walker Avenue and Chandos Street.
Cumulative construction noise impacts –	**Rozelle**
Tunnelling works activities for the M4-M5 Link and the proposed future Western Harbour Tunnel project may be carried out simultaneously. Cumulative construction noise impacts may be apparent during out-of-hours works periods where cumulative	The Rozelle area would likely be subject to construction impacts from works associated with other infrastructure projects, including the under construction CBD and South East Light Rail Rozelle maintenance depot. The receivers most likely to be affected by consecutive construction impacts are:

Concurrent construction impacts	Consecutive construction impacts
impacts are predicted to result in NML exceedances of up to 20 dBA during the night-time period.	• Receivers adjoining Lilyfield Road between Justin Street and Ryan Street (NCA16 and NCA19) • Receivers adjoining Brenan Street between Starling Street and White Street (NCA15).
Cumulative construction noise impacts – St Peters	
Given that tunnelling works activities may be carried out simultaneously at St Peters for the New M5 and M4-M5 Link projects, cumulative construction noise impacts may be apparent during out-of-hours works periods where cumulative impacts are predicted to result in NML exceedances of up to 20 dBA during the night-time period.	Excluding short-term works such as pavement and utility works, receivers located within NCA48 and NCA49, which front Campbell Road, are predicted to experience up to 10 dBA exceedances of the project NMLs (during the night-time period) during construction of the M4-M5 Link project. Whilst the magnitude of the predicted exceedance is relatively low, these impacts are predicted at receivers who would likely have been exposed to significant noise impacts from the New M5 project.

Potential management and mitigation measures

For concurrent cumulative construction noise impacts, mitigation (where relevant) could include scheduling use of high noise items of plant during less sensitive periods, increased height of construction hoarding, upgraded acoustic shed performance, noise monitoring, notification and respite offers, where appropriate.

In situations where consecutive long-term construction noise impacts occur, at-receiver noise mitigation could be considered, where appropriate, once options for a- source noise mitigation and management measures have been exhausted. Where it can be determined reasonable and feasible, the implementation of operational mitigation measures such as architectural treatments during construction may reduce cumulative impacts from concurrent construction activities, particularly for areas of overlapping works.

Operation

Potential cumulative operational noise impacts have been evaluated in the ‘Do Something Plus’ scenario (see **Table 26-3**) to represent the impacts of the future traffic from M4-M5 Link in conjunction with traffic from other major road projects.

Maps showing the location of receivers which are predicted to exceed the Roads and Maritime *Noise Mitigation Guideline* (2015b) (NMG) in the cumulative ‘Do Something Plus’ scenario are presented in **Appendix J** (Technical working paper: Noise and vibration).

The key findings of the cumulative assessment indicates that:

- The total number of receivers eligible for consideration of additional noise mitigation is predicted to decrease from 431 in the ‘Do Something’ scenario to 409 in the ‘Do Something Plus’ scenario which is typically due to traffic being removed from surface roads and instead using the M4-M5 Link tunnels
- There are more triggered receivers in the ‘Do Something Plus’ scenario in NCA21 (south of City West Link) compared to the ‘Do Something scenario’. This is due to cumulative traffic volumes of potential future projects anticipated to add traffic to the surface section of the project in this area
- There are less triggered receivers in the ‘Do Something Plus’ scenario in NCA25 (adjacent to Victoria Road and Lilyfield Road) compared to the ‘Do Something scenario’ due to a reduction in traffic for this section
- There are marginal differences between the scenarios elsewhere in the study area.

The majority of noise exceedances (in both the ‘Do Something’ and ‘Do Something Plus’ scenarios) are located in the vicinity of Victoria Road at Iron Cove and Victoria Road near Lilyfield Road and occur in part as a result of the demolition of existing buildings which act as a barrier to noise and as a result of widening of the road carriageway. A range of mitigation options are available to address exceedances from cumulative road traffic noise including use of low noise road pavement, noise barriers or architectural 'at property' treatments.

26.4.4 Human health

The results of the cumulative human health risk assessment discussed in this section is based on the outcomes of the air quality operational assessment, which has been derived from the traffic modelling. Construction fatigue is the main focus of the construction phase, while effects of emissions from the project as a result of the overall WestConnex program of works and other related projects are the focus of the operational phase.

Further details are provided in **Chapter 11** (Human health risk) and **Appendix K** (Technical working paper: Human health risk assessment).

Construction

As described in **section 26.3.1**, construction fatigue relates to receivers that experience construction impacts from multiple projects over an extended period of time with few or no breaks between construction periods. Other impacts on health and wellbeing are associated with cumulative traffic impacts (including spoil vehicle movements, partial and/or complete closure of roads and active transport links, reduced street parking, and relocation of bus stops). Impacts on views and visual amenity from multiple concurrent or consecutive projects may also increase the levels of stress and anxiety experienced by community receptors.

Operation

This section provides a summary of the potential impacts to human health that may be experienced from air quality impacts under the cumulative modelling scenario for 2023 (opening year) and 2033, assuming the projects outlined in **Table 26-1**are operational.

In-tunnel air quality

While concentrations of pollutants from vehicle emissions are higher within the tunnel (compared with outside the tunnel), and with the completion of a number of tunnel projects (approved or proposed) there is the potential for exposures to occur within a network of tunnels over varying periods of time, depending on the journey. The assessment of potential exposures inside these tunnels, has indicated:

- Where windows are up and ventilation is on recirculation, exposure to nitrogen dioxide inside vehicles is expected to be below the current health based guidelines. In congested conditions inside the tunnels, it is not considered likely that significant adverse health effects would occur. Placing ventilation on recirculation with windows closed is also expected to minimise exposures to particulates during travel through the tunnels
- For motorcyclists, where there is no opportunity to minimise exposures through the use of ventilation, there is the potential for higher levels of exposure to NO_2 and particulates. These exposures, under normal conditions, are not expected to result in adverse health effects. When the tunnels are congested it is expected that motorcyclists would spend less time in the tunnels than passenger vehicles and trucks (due to lane filtering), limiting the duration of exposure and the potential for adverse health effects
- For individuals who regularly use tunnels for commuting or as part of their employment there is the potential for repeated exposures to higher levels of NO_2 and particulates during the day. While these exposures are not likely to be additive, in terms of potential health effects, it is important that these road users utilise ventilation on recirculation whenever they are using the tunnels.

Where advice to place ventilation on recirculation when using the tunnel or the proposed network of tunnels is followed, it is not expected to result in carbon dioxide levels inside the vehicle that may adversely affect driver safety. However, where Roads and Maritime provides specific advice to drivers entering road tunnels to put ventilation on recirculation, it is recommended that further advice is provided that recirculation should be switched off at some point after using the tunnel network and not left on for an extended period of time.

Ambient air quality

The human health risk assessment evaluated the principal pollutants from the air quality assessment and determined that these pollutants, including VOCs, PAHs, CO and NO_2, were not associated with any acute or chronic risk issues in the local community, when considered cumulatively with other projects. The cumulative health risk assessment concludes that predicted changes for ground level particulate matter (PM_{10} and $PM_{2.5}$) due to the 'cumulative' scenario (compared to the 'with project' scenario) are unlikely to be measureable.

For receptors located at elevated heights, such as in high rise buildings, the assessment concluded that at a height of 10 metres the maximum predicted change in $PM_{2.5}$ in the 'cumulative' scenario (compared to the 'with project' scenario) is lower than at ground level.

At a height of 30 metres, the maximum predicted change in $PM_{2.5}$ in the 'cumulative' scenario (compared to the 'with project' scenario) is significantly greater than at a height of 10 metres. Predicted levels at this height are considered unacceptable for future high-rise development in the vicinity. The impacts identified at 30 metres above ground are localised and close to the ventilation outlets, with the maximum increases more specifically located adjacent to the Campbell Road ventilation facility at the St Peters interchange. Conversely, at the closest existing residential area, the maximum increase at a height or 30 metres is considered to result in a risk which is tolerable/acceptable.

Planning controls (including re-zonings) for land in the vicinity of the proposed Campbell Road ventilation facility at St Peters interchange are required to ensure future developments at heights 30 metres or higher are not adversely impacted by the ventilation outlets. Development of planning controls would be supported by detailed modelling addressing all relevant pollutants and averaging periods.

Mitigation and management measures for cumulative human health impacts are the same for project impacts and are outlined in **Chapter 11** (Human health risk).

26.4.5 Urban design and visual amenity

The urban design and visual impact cumulative assessment focuses on the changes to the landscape character and visual amenity that result from the combined effects of the WestConnex projects and other relevant projects as outlined in **Table 26-1**.. This is summarised below and is supported by further detail in **Appendix O** (Technical working paper: Landscape and visual impact).

M4 East

The majority of the works associated with the M4 East project at Haberfield and Ashfield would either be completed or close to completion when the M4-M5 Link construction period commences. The overlapping projects would result in a large number of nearby residents in Haberfield and Ashfield being subject to a further four to five years of motorway construction work within their neighbourhood. This would also affect motorists who regularly travel through the area. This would result in a high cumulative visual amenity impact on affected Haberfield and Ashfield residents due to the continued presence of visible construction facilities and construction activities over this period.

New M5

The majority of the works associated with the New M5 project at St Peters would be almost complete when the M4-M5 Link construction period commences. The completed New M5 works would provide substantial levels of amenity for local residents within the vicinity of the construction site, notwithstanding the early stage of landscape development. New motorway infrastructure including the interchange, ventilation outlets, motorway operations complex and associated infrastructure would be visible together with the open space area along the south side of Campbell Road and the extensive landscape setting.

The number of sensitive residential receptors affected by the project is considered likely to be relatively small. However, for this small group of residents, the project would result in a further prolonged period of construction. The project is also likely to extend impacts on users of Sydney Park and motorists who regularly drive through this area.

Rozelle Rail Yards site management works

Once the site management works are completed, the landscape character of the site would be altered through the removal of vegetation, structures and redundant rail infrastructure, and subsequent increase in the extent of open land and a largely vacant site. While the site management works are unlikely to result in a significant impact, there is a potential for cumulative visual impacts when considered in conjunction with the M4-M5 Link project because of the change to the existing environment. Once the M4-M5 Link is completed, part of the site will be used for operational infrastructure associated with the motorway and the balance of the land will be made available for use as open space and landscaping.

Western Harbour Tunnel

As limited information is available on the project, for the purposes of this EIS, it is assumed that the construction of the Western Harbour Tunnel will involve surface works at the Rozelle Rail Yards during construction of the M4-M5 Link and beyond 2023. This suggests that visual impacts associated with construction activities from the M4-M5 Link would occur concurrently and consecutively.

This would result in the proposed open space area at Rozelle Rail Yards being delivered in stages – the first stage in late 2023 and the next stage some time post 2023 after completion of the Western Harbour Tunnel construction. This would extend the visual impacts associated with construction for a longer duration at Rozelle.

CSELR – Rozelle Maintenance Depot

The CSELR Rozelle maintenance depot at the western end of the Rozelle Rail Yards may result in cumulative impacts when considered in conjunction with the M4-M5 Link project. Removal of vegetation, which has been undertaken as part of the CSELR project, has provided unfiltered views at some locations to the construction areas and could lead to more prominent views to parts of the M4-M5 Link project for sensitive receptors such as the residences along Lilyfield Road.

The Bays Precinct Transformation

Due to The Bays Precinct only being in its early strategic planning stages, no detailed assessment of landscape and visual impacts has been undertaken. The sensitivity of The Bays Precinct to change can be considered low due to the existing poor amenity provided by the current industrial and port related land uses and in some areas, derelict, built form.

The M4-M5 Link project would create a significant area of open space and improved active transport connectivity which would be available to service people working, living and visiting The Bays Precinct. There is an opportunity for integration between the sites to ensure a balanced outcome from a visual amenity, active transport and heritage perspective. Roads and Maritime has been working with UrbanGrowth NSW to ensure their plans for The Bays Precinct have been considered in relation to the design of the Rozelle interchange.

26.4.6 Social and economic

This summary of cumulative social and economic impacts is supported by the findings in **Appendix P** (Technical working paper: Social and economic). The focus of the cumulative social and economic impacts associated with transport and infrastructure projects include:

- Construction fatigue, entailing extended periods of construction, impacting local amenity, disruption to traffic and pedestrian networks
- Incremental loss or severance of open space
- Impact on property value or rent return due to ongoing project works as a result of multiple projects
- Economic effects, including changes to business operation and revenues
- Construction traffic from multiple projects placing additional pressure on road networks and parking capacity.

The assessment of cumulative impacts includes those activities that may overlap with the timing of the construction of the M4-M5 Link project, or have recently been completed. These are outlined in **Table 26-1**.

When completed, WestConnex is predicted to deliver beneficial cumulative impacts to the community, including increased travel speeds and reduced travel time through local streets, improved connectivity and reliability and opportunities for urban renewal. WestConnex, while delivering longer-term benefits, is likely to result in some adverse social and economic cumulative impacts for the community during the construction phases of the various component projects. The health effects of construction fatigue through annoyance, stress and anxiety have been covered in the health risk assessment section.

At Haberfield and Ashfield, the overlap between the M4 East and M4-M5 Link projects is likely to result in continuous construction activity for around seven years, which is expected to contribute further to traffic delays for customers and staff of businesses in the locality, in addition to extended periods of amenity impacts due to increases in noise and dust levels and changes in visual amenity.

At St Peters, residents and businesses located in areas of overlap with the New M5 project and the M4-M5 Link, could experience cumulative amenity impacts due to increases in traffic, changes in traffic patterns, parking, construction noise and vibration, and changes in visual amenity due to new infrastructure associated with these projects.

Coordination between and the projects in the planning of possible disruptions would assist in minimising potential cumulative impacts.

Positive cumulative impacts to local businesses and the economy would likely result from the concurrent construction activity associated with the WestConnex program of works and related projects such as the proposed future Sydney Gateway, Western Harbour Tunnel and Beaches Link and F6 Extension projects, which is likely to intensify employment and stimulus impacts. The demand for labour for major projects such as WestConnex and other similar projects in the area would increase employment opportunities for local residents. There is potential for wages to increase due to high demand for construction workers and opportunities for local businesses to supply goods or services for construction of these projects. Business turnover is also likely to increase due to demand.

As a result, there would be cumulative benefits of the projects, resulting in significant increases in travel speeds through the local road network, a reduction in average travel times and improved business and freight connectivity.

26.4.7 Non-Aboriginal heritage

This assessment of the potential cumulative impacts is supported by **Appendix U** (Technical working paper: Non-Aboriginal heritage).

The projects included in this assessment and their overall heritage impact rating are presented in **Table 26-1**.

Table 26-7 Overall heritage impact ratings for the WestConnex projects

WestConnex project	Overall heritage impact rating
New M5	Moderate adverse
King Georges Road Interchange Upgrade	Nil
M4 Widening	Nil
M4 East	Major adverse
M4-M5 Link	Moderate adverse
Other relevant projects	**Overall heritage impact rating**
CSELR	Nil
Rozelle Rail Yards site management works	Minor adverse
Combined	Major adverse

The WestConnex program of works as a whole has potentially wide reaching impacts on the urban fabric of greater metropolitan Sydney, including on items and areas of heritage significance. The overall cumulative impacts of the entire WestConnex program of works to date can be described as major and irreversible given the scale of the project, primarily the impacts to the Haberfield area heritage conservation area from the M4 East project.

The site management works and M4-M5 Link project at the Rozelle Rail Yards would permanently remove evidence of the rail infrastructure heritage and character of the site. However, the project would reuse and incorporate heritage elements in the urban design and landscape plan for Rozelle, acknowledging heritage themes and interpretation of area.

The heritage fabric, features and values of the items and areas in which these projects are located are being subjected to increased development pressures. While these projects will be transformative and place-making, they will lead to impacts on heritage items and the associated cultural and social values that they provide.

26.4.8 Biodiversity

The cumulative impact assessment for biodiversity focuses on the identification of conservation significant species found within the broader study areas of each of the relevant WestConnex and related projects and also assesses the extent to which their habitat has been removed. The assessment only examines the species which are in common across two or more projects, these are the threatened Grey-headed Flying Fox, the Eastern Bentwing-bat and the Yellow-bellied Sheathtail-bat.

A detailed assessment of the potential construction and operational impact of the M4-M5 Link is provided in **Chapter 18** (Biodiversity) and is supported by **Appendix S** (Technical working paper: Biodiversity).

Table 26-8 provides a summary of the impacts to the biodiversity features as a result of the combined relevant projects examined as part of this cumulative assessment. While very little native vegetation would be removed collectively, the removal of exotic and planted vegetation that species use for foraging has been identified as a contributor to the overall impact of the WestConnex program of works.

Table 26-8 Summary of cumulative impacts

Project	Area (hectares)			
	Native vegetation	Non-native vegetation (urban exotic and native cover)	Grey-headed Flying-fox	Microbats (Eastern Bentwing-bat and Yellow-bellied Sheathtail-bat)
M4 East	-	15.70	15.70	15.70
M4 Widening	0.54	8.84	8.84	8.84
New M5	3.31	10.80	14.11	-
King Georges Road Interchange Upgrade	0.01	3.23	3.23	3.23
M4-M5 Link	-	4.49	4.49	3.78[1]
WestConnex Subtotal	**3.86**	**43.06**	**Up to 46.37**	**Up to 31.55**
Rozelle Rail Yards site management works	-	7.12[2]	7.12[2]	7.12[2]
Total	**Around 3.86**	**Around 50.18**	**Up to 53.49**	**Up to 38.67**

Notes:
[1] Habitat for the microbats was only considered to be present within the vicinity of the Rozelle Rail Yards and not across the whole project footprint.
[2] Area estimated for this cumulative impact assessment

The impacts of the WestConnex program of works and other related projects have been assessed and consistent management measures have been identified. In total, approximately 3.86 hectares of native vegetation would be impacted by the WestConnex program of works, which is not significant in the context of existing native vegetation across the Sydney Basin. No native vegetation is to be removed as part of the M4-M5 Link project.

Around 50.18 hectares of exotic and planted vegetation (mapped as ‘urban exotic and native cover’) would be removed and represents potential foraging habitat for the Grey-headed Flying-fox. A total of 4.49 hectares of urban exotic and native cover is to be removed by the M4-M5 Link project and a further 7.12 hectares is to be removed by the Rozelle Rail Yards site management works.

Some 38.67 hectares of the native vegetation and urban and exotic vegetation to be removed has also been identified as potential foraging habitat for the Eastern Bentwing-bat and Yellow-bellied Sheathtail-bat.

The cumulative impacts to Grey-headed Flying-fox and the threatened microbats would not result in a significant impact. No camps or breeding sites would be impacted and the removal of potential feed trees and foraging habitat would be negligible in the context of existing available foraging habitat for these species. Offset for individual trees would be integrated into landscape plans for the individual projects, and would provide foraging habitat for species such as the Grey-headed Flying-fox and microbats.

26.4.9 Soil and water quality

The cumulative impacts assessment for soil and water quality focuses on the potential for contaminated soil and water to cross project boundaries.. Cumulative impacts of this nature are unlikely to occur during the operations phase or on projects that are widely separated. This section therefore addresses the construction phase for projects that overlap or are in close proximity to each other.

Review of EIS documents for the various approved projects located in proximity to the M4-M5 Link project, including M4 East and New M5 indicate that the disturbance and management of contaminated soil, fill, sediment, surface water and groundwater as a result of construction and operational activities are unlikely to have a more significant impact on ecological and human health receptors or sensitive environments than they would if undertaken as discrete projects, provided the proposed management and mitigation measures documented in the respective EISs are implemented, maintained and monitored.

There are minimal adverse cumulative contamination impacts anticipated to occur as part of the construction or operation of the M4-M5 Link project. Risks to human health and the environment would be mitigated through implementation of management measures outlined in **Chapter 11** (Human health risk) and **Appendix K** (Technical working paper: Human health risk assessment).

The construction and operation of the M4-M5 Link project is not anticipated to create additional soil or groundwater contamination to that already identified within the project footprint as a result of historical land use activities. The appropriate management of contamination and waste materials disturbed during the construction phase of the project would likely result in an overall improvement in the condition of the land at project completion. The project would incorporate remediation and management of existing contamination as part of the construction phase, and to make the land suitable for the proposed final land use. Site suitability for the proposed land use(s) would be determined by an independent NSW EPA accredited site auditor engaged for the project.

Further assessment of cumulative impacts associated with contamination and groundwater contamination are discussed in **Appendix R** of the EIS (Technical working paper: Contamination) and **Appendix T** of the EIS (Technical working paper: Groundwater).

26.4.10 Surface water flooding and drainage

This cumulative assessment focusses on the capacity of the drainage network to accommodate the M4-M5 Link project in combination with other relevant projects. A detailed assessment of the potential construction and operational impact of the M4-M5 Link is provided in **Chapter 17** (Flooding and drainage) and is supported by **Appendix Q** (Technical working paper: Surface water and flooding).

WestConnex projects

Table 26-14 provides a summary of the findings of the cumulative impact assessment for the M4-M5 Link project in relation to surface water and flooding in the context of other WestConnex projects.

Table 26-9 Summary of impacts on surface water and flooding – WestConnex program of works

Project name	Key assessment findings	Project impact
M4 Widening and King Georges Road Interchange Upgrade	• No surface water receptors in common with the M4-M5 Link project therefore no direct cumulative impacts on surface water bodies or water quality • Potential for cumulative water quality impacts on downstream sensitive environments such as the Parramatta River Estuary, Cooks River and Botany Bay • No common surface catchments with the M4-M5 Link project there no potential cumulative flood impacts are anticipated.	Negligible impact
M4 East	• Potential cumulative surface water quality impacts could impact on the one common receptor, Dobroyd Canal (Iron Cove Creek) and downstream environments (including Iron Cove and the Parramatta River Estuary) • Impacts are associated with increased pollutant loading to Dobroyd Canal (Iron Cove Creek) from stormwater runoff or the discharge of poorly treated tunnel water • The M4-M5 Link connection to the Wattle Street interchange will not alter the surface layout or levels. Accordingly, there are no cumulative flooding impacts expected at the Wattle Street interchange.	Negligible impact
New M5	• Potential cumulative surface water quality impacts could impact on one common receptor the M4-M5 Link ie. Alexandra Canal as well as downstream sensitive environments such as the Cooks River and Botany Bay • The M4-M5 Link connection to the St Peters interchange will not alter the surface layout or levels. Accordingly, there are no cumulative flooding impacts expected at the St Peters interchange • Slight increase in tunnel wastewater discharging from the Arncilffe operational water treatment plant to the Cooks River due to the portion of M4-M5 Link tunnel drainage draining to the New M5 system.	Negligible impact

Other relevant projects

Cumulative impacts considered for other approved or proposed projects proposed in the vicinity of the M4-M5 Link project footprint are summarised in **Table 26-10**.

Table 26-10 Summary of impacts on surface water and flooding – other relevant projects

Project name	Key assessment findings	Potential residual impact
CBD and South East Light Rail Rozelle maintenance depot	• Surface water from the depot will be discharged to the Rozelle Rail Yards as surface flow	Low impact

Project name	Key assessment findings	Potential residual impact
Sydney Metro City and Southwest	• Waterloo Station, part of the Sydney Metro project, is located within the Alexandra Canal catchment and could therefore impact on Alexandra Canal and downstream sensitive environments (Cooks River and Botany Bay) • The aboveground station infrastructure would have a negligible impact on the existing surface hydrology or existing flood behaviour.	Negligible impact
Whites Creek naturalisation	• Potential sedimentation of Whites Creek during earthworks • Flooding impacts during operation are not expected.	Low impact

The approved WestConnex component projects are considered unlikely to have a significant cumulative impact on receiving water receptors or sensitive environments provided the proposed management measures are implemented, maintained and monitored. There are minor adverse cumulative surface water quality or flooding impacts anticipated and the residual risk to common receptors and sensitive environments downstream would be low.

The flood modelling for the M4-M5 Link included the anticipated surface discharge from the CSELR Rozelle maintenance depot adjacent to the Rozelle Rail Yards. The modelling results were fed into the concept design for the Rozelle interchange, which accommodates flows across the site into Rozelle Bay. The detailed design for M4-M5 Link would need to consider the final design of the Rozelle maintenance depot drainage system further.

The Sydney Metro City and Southwest project, specifically the proposed Waterloo Station, would have negligible surface water impacts with the implementation of appropriate measures, therefore there are no anticipated cumulative water quality or flooding impacts with the M4-M5 Link.

The M4-M5 Link project works at Whites Creek together with the proposed naturalisation works by Sydney Water could have potential impacts on flooding and sedimentation of the channel, however this is expected to be a low impact, as suitable measures will be put in place during detailed design and construction.

26.4.11 Groundwater

The potential cumulative impact on groundwater focuses on impacts related to the quality and quantity of the groundwater resource and how it can affect groundwater dependent ecosystems. This typically arises from groundwater drawdown which as it draws in water from surrounding locations, it can have a potential effect on groundwater quality. This is discussed in detail in **Appendix T** (Technical working paper: Groundwater).

This cumulative impact assessment quantitatively assesses (through modelling) the potential impacts of other WestConnex tunnel projects (ie the M4 East and New M5 projects) and qualitatively assesses the potential impacts of other relevant projects such as the Sydney Metro City and Southwest, as outlined below. The construction and operational groundwater impacts of the M4-M5 Link are described in **Chapter 19** (Groundwater).

WestConnex projects

During construction, cumulative impacts on groundwater would be greatest at either end of the mainline tunnel alignment where the M4-M5 Link tunnels would overlap with the tunnels for the M4 East tunnels at the Wattle Street interchange and with the New M5 tunnels at the St Peters interchange.

Once all three of these WestConnex tunnel projects are operational, groundwater drawdown due to the cumulative impact of the three tunnel projects is not expected to be greater than in any one section of the overall project footprint. The tunnels and associated lining for each project would be designed and constructed to comply with the groundwater inflow criterion of one litre per second per kilometre for any kilometre length of tunnel. Consequently, the groundwater inflows along the tunnels would vary within a known range. A comprehensive groundwater monitoring program would be required for each project to confirm that the actual inflows do not exceed the criterion and drawdown does not exceed predictions.

Long term cumulative groundwater tunnel inflows due to the WestConnex tunnel projects may cause groundwater salinity to increase due to surface water from tidal reaches being drawn into or towards the tunnels. Initially, the saline water would be a small fraction of total tunnel ingress but this is expected to increase over time as water is drawn from further afield, although it is expected to always be a minor component of total inflow volume.

Other relevant projects

The Sydney Metro City and Southwest rail tunnels are to be constructed as undrained (tanked) tunnels that would cross the M4-M5 Link project alignment near St Peters. As the twin Sydney Metro tunnels are to be constructed as tanked tunnels, there will be negligible impacts on groundwater drawdown. The station boxes are to be constructed and operated as drained shafts and will extract groundwater from the local hydrogeological regime over time. The closest drained structure is proposed at Marrickville Station which is some distance to the west of the M4-M5 Link, and as such is considered unlikely to have significant cumulative impacts on groundwater drawdown.

There is potential for the concrete lined tunnels of the Sydney Metro project to create a partial hydraulic barrier to groundwater flow, however the risk is considered low since the tunnels are constructed below the water table.

The Western Harbour Tunnel project has potential to have cumulative groundwater impacts with the M4-M5 Link project in the Rozelle area. At this stage only limited information is available about the proposed design and construction methodology for the Western Harbour Tunnel project and as a result no meaningful analysis of impacts is possible at this time. Cumulative groundwater impacts should be addressed in the future as part of the EIS for the Western Harbour Tunnel project.

26.4.12 Aboriginal heritage

Potential cumulative impacts on Aboriginal heritage relates to the extent and number of registered AHIMS sites likely to be disturbed by the construction activities of a number of projects, including the M4-M5 Link, as outlined below. Further details on these potential cumulative impacts are provided in **Appendix V** (Technical working paper: Aboriginal heritage).

Potential impacts of the M4-M5 Link on Aboriginal heritage are summarised in **Chapter 21** (Aboriginal heritage). The findings of the assessment indicated no significant impacts on Aboriginal heritage items.

None of the approved component projects of the WestConnex program of works have any significant impact on Aboriginal heritage, therefore there are no cumulative impacts associated with these projects and the M4-M5 Link. No other projects were identified that could result in potential cumulative impacts on Aboriginal heritage.

26.5 Management of cumulative impacts

Construction impacts would be minimised through further consideration during detailed design and construction planning, application of appropriate management and mitigation measures, and consultation with affected residents and stakeholders. The construction strategy for the project (and the broader WestConnex program of works) focuses on balancing the need for construction to occur in a safe and efficient manner while managing constructability constraints and minimising cumulative impacts on the community, environment, road users and the surrounding road network.

The design of the project has carefully considered minimising construction fatigue as far as practical. The intent is to reduce the overall cumulative or consecutive impacts on the community over a longer period.

Each of the study disciplines presented in this EIS have identified site specific management measures to reduce the potential impact to acceptable levels. This cumulative assessment has been undertaken assuming that those management measures are implemented at the appropriate time.

Assuming that the practical mitigation measures for each key factor are already in place, the cumulative mitigation focussed on a broader level, focussing on the opportunities around inter-project coordination and communication with stakeholders. Mitigation and management measures for the cumulative scenario are constrained by only being able to be applied to the M4-M5 Link project and not those others that have already been approved.

Table 26-11 presents a summary of mitigation and management measures aimed at facilitating the reduction of cumulative impacts from the M4-M5 Link project and the other relevant projects included in this assessment.

Table 26-11 Proposed mitigation and management measures for cumulative impacts

Issues	Potential cumulative impact	Proposed mitigation measures
Social and economic; traffic and transport; air quality; noise and vibration	Ongoing construction impacts on the local community throughout the construction phase of the M4-M5 Link	• The effective management of cumulative impacts on the affected community requires oversight and direction from one overarching body such as a government department/agency or local council • Multi-party engagement and cooperation is needed to ensure all contributors to impacts are working together to minimise the effects or enhance the benefits of multiple projects occurring concurrently or consecutively • Communication strategies across the various projects should be managed to be consistent in their messaging to the community to avoid confusion.

27 Sustainability

This chapter explains how sustainability aims and principles have been applied to the design, construction and operation of the M4-M5 Link project (the project). This chapter:

- Provides an overview of the concept of sustainability, as context for the sustainability principles that have been adopted during the concept design of the project
- Presents the sustainability policy framework that has been applied to the project
- Details the proposed Sustainability Management Plan for the project (which would be developed and implemented during detailed design) and specific sustainability initiatives that would guide the management and implementation of sustainability objectives during design, construction and operation of the project.

The Secretary of the NSW Department of Planning and Environment (DP&E) has issued environmental assessment requirements for the project. These are referred to as the Secretary's Environmental Assessment Requirements (SEARs). **Table 27-1** sets outs these requirements and the associated desired performance outcomes that relate to sustainability and identifies where they have been addressed in this environmental impact statement (EIS).

Table 27-1 SEARs – sustainability

Desired performance outcomes	SEARs	Where addressed in the EIS
15. Sustainability The project reduces the NSW Government's operating costs and ensures the effective and efficient use of resources. Conservation of natural resources is maximised.	1. The Proponent must assess the sustainability of the project in accordance with the Infrastructure Sustainability Council of Australia (ISCA) Infrastructure Sustainability Rating Tool and recommend an appropriate target rating for the project.	The assessment of the sustainability of the project in accordance with the ISCA Infrastructure Sustainability Rating Tool is discussed in **section 27.3**.
	2. The Proponent must assess the project against the current guidelines including targets and strategies to improve government efficiency in use of water, energy and transport.	Discussion of the sustainability framework and relevant documents is provided in **section 27.2**. The sustainable use of water and energy resources is discussed in **Table 27-3** in **section 27.2.11** and in **Chapter 23** (Resource use and waste minimisation).

27.1 What is sustainability?

The *World Commission on Environment and Development report, Our Common Future* (Brundtland 1987), identifies sustainable development as being 'development which meets the needs of the present, without compromising the ability of future generations to meet their own needs'. Although this early definition of sustainable development is succinct, the concept of sustainable development is dynamic, and changes in response to the limitations imposed on environmental resources as a result of technology, social organisation and the ability of the biosphere to absorb the effects of human activities.

The Australian Government refers to ecologically sustainable development as 'using, conserving and enhancing the community's resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be increased' (Australian Government Department of the Environment 1992).

The provision of properly functioning infrastructure is essential for sustained economic growth, international competitiveness, public health and overall quality of life (Mirza 2006). The Infrastructure Sustainability Council of Australia (ISCA) defines sustainable infrastructure as that which is 'designed, constructed and operated to optimise environmental, social and economic outcomes over the long term' (ISCA 2012).

27.2 Sustainability policy framework

The sustainability policy framework relevant to the project is made up of the following documents:

- *NSW Long Term Transport Master Plan* (Transport for NSW 2012a)
- *A Plan for Growing Sydney* (DP&E 2014)
- *Towards our Greater Sydney 2056* (Greater Sydney Commission 2016)
- *Draft Central District Plan* (Greater Sydney Commission 2016)
- *NSW Climate Change Policy Framework* (NSW Office of Environment and Heritage (OEH) November 2016)
- *NSW Government Resource Efficiency Policy* (OEH 2014a)
- *NSW Waste Avoidance and Resource Recovery Strategy 2014-21* (NSW Environment Protection Authority (NSW EPA) 2014b)
- *Transport Environment and Sustainability Policy* (Transport for NSW 2015)
- *NSW Sustainable Design Guidelines Version 3.0* (Transport for NSW 2013)
- Roads and Maritime Environmental Sustainability Strategy *2015–2019* (NSW Roads and Maritime Services (Roads and Maritime) 2016)
- WestConnex Sustainability Strategy (Sydney Motorway Corporation 2015).

Together, these documents provide the sustainability principles that inform the design of the project and against which the construction and operation of the project would be measured in terms of sustainability. Strategic planning documents applicable to the project are also discussed in **Chapter 3** (Strategic context and project need).

27.2.1 Long Term Transport Master Plan

The *NSW Long Term Transport Master Plan* (Transport for NSW 2012a) (Transport Master Plan) is the guiding transport planning and policy document and aligns with objectives for metropolitan Sydney as outlined in A Plan for Growing Sydney. The Plan provides a framework for delivering an integrated, modern transport system by identifying NSW's transport actions and investment priorities for the next 20 years.

The WestConnex program of works is identified in the Transport Master Plan as a critical link in Sydney's motorway network and an immediate priority for the NSW Government. The Transport Master Plan states that 'promoting sustainability and protecting the environment in our transport planning, decisions and projects' is a state-wide challenge that must be addressed. The Transport Master Plan focuses on achieving the following environmental and sustainability objectives:

- Enhancing environmental and sustainability outcomes
- Minimising damage to our environment
- Adapting our transport infrastructure to be resilient (to climate change and natural disasters)
- Maintaining Sydney's air quality
- Reducing emissions and managing energy use.

In addition, the Transport Master Plan includes the following relevant specific environmental and sustainability 'actions':

- Develop and promote *Transport Infrastructure Sustainable Design Guidance* (including application of the Infrastructure Sustainability Rating Tool)
- Incorporate sustainability principles in procurement policy
- Consider the air quality impacts of transport projects
- Assess transport climate resilience
- Mitigate noise from road projects.

27.2.2 A Plan for Growing Sydney

The *Greater Sydney Region Plan, A Plan for Growing Sydney* (NSW Government 2014), presents the NSW Government's vision and goals for the metropolitan Sydney area for the next 20 years. The plan outlines key directions and actions to guide Sydney's growth, and defines four goals. The most relevant goals to sustainability and the project are:

- Goal 1: A competitive economy with world-class services and transport
- Goal 4: A sustainable and resilient city that protects the natural environment and has a balanced approach to the use of land and resources.

Goal 1 – A competitive economy with world-class services and transport

Several directions under Goal 1 of A Plan for Growing Sydney are relevant to the project and WestConnex more broadly. The project, in combination with the M4 East and the M4 Widening projects, would support access for goods and services to the new 'priority growth area' that extends from Greater Parramatta to the Olympic Peninsula, identified in Direction 1.3 of A Plan for Growing Sydney.

Direction 1.5.2 seeks to minimise the impacts of the movement of freight on the communities through which that freight travels. The project would assist in reducing these impacts by providing a motorway alternative for heavy freight trucks and other through traffic, reducing the use of Parramatta Road between Haberfield and the Sydney central business district (CBD). This is expected to lead to associated improvements in local air quality and lower traffic noise. The Iron Cove Link would reduce traffic, including freight vehicles, on Victoria Road between Iron Cove Bridge and City West Link.

For Sydney to continue to be a competitive economy, improved transport connections are required between all the major centres that form part of Sydney's economic corridor (termed the 'global economic corridor' in Direction 1.6), which includes areas such as the Sydney CBD, Parramatta CBD, Sydney Airport, Port Botany and Sydney Olympic Park. WestConnex would assist in increasing productivity between centres in the global economic corridor by improving road connections and reliability of journey times for the transport of goods and services and business travel.

WestConnex, along with the M4 Motorway, M5 Motorway, M7 Motorway and the proposed M12 Motorway (between the M7 Motorway at Cecil Hills and The Northern Road at Luddenham), would provide a motorway standard link to the Western Sydney Airport, which is a key focus for economic growth in Sydney over the medium to long term.

Goal 4 – A sustainable and resilient city that protects the natural environment and has a balanced approach to the use of land and resources

The project is being designed in line with the WestConnex Sustainability Strategy (Sydney Motorway Corporation 2015), which outlines an integrated approach to sustainability through design, delivery and operation. In construction, the project would be required to achieve a rating of 'Excellent' under the ISCA rating system. Resilience to climate change has been taken into account as part of the design of the project.

The overarching sustainability objectives for the project are summarised in **Table 27-3**. **Chapter 24** (Climate change risk and adaptation) outlines potential project adaptation measures. **Chapter 4** (Project development and alternatives) describes the design considerations in the evolution of the project and the options and alternatives considered to minimise environmental and social impacts. Further discussion of how the project aligns with each of the four goals is provided in **Chapter 3** (Strategic context and project need).

27.2.3 Towards our Greater Sydney 2056

Towards our Greater Sydney 2056 (Greater Sydney Commission 2016) is the proposed amendment to A Plan for Growing Sydney and was released as a draft for public exhibition in November 2016. Due to the magnitude of the changes associated with the new 'three cities' approach, and the expected population and commercial growth in western Sydney, *Towards our Greater Sydney 2056* identifies the need for a sustainable supporting transport network.

The project, as part of the WestConnex program of works, complements this vision by providing improved connectivity between the Sydney CBD and western Sydney. Further discussion on *Towards our Greater Sydney 2056* is provided in **Chapter 3** (Strategic context and project need).

Towards our Greater Sydney 2056 identifies three metropolitan priorities for a sustainable Greater Sydney. These metropolitan priorities and their aims are summarised below:

- A city in its landscape: associated with improving the health of waterways; protecting and enhancing biodiversity, local open space systems and scenic and cultural landscapes; increasing access to open space; conserving the natural environment and enabling heathy lifestyles
- An efficient city: aims to minimise and mitigate environmental impacts though the efficient use of energy and resources
- A resilient city: associated with adapting to climate change, minimising exposure to natural hazards and strengthening social, organisational and infrastructure capacity.

The project complements these aims by minimising impacts on environmental values such as water, biodiversity and heritage through the design of the project; recommending management measures to further minimise residual impacts and minimise resources use and waste generation; assess the risk and vulnerability of the project to climate change; creating new active transport links and the provision of new open space.

Further discussion of these environmental values and the proposed management measures is provided in **Chapter 15** (Soil and water quality), **Chapter 18** (Biodiversity), **Chapter 20** (Non-Aboriginal heritage), **Chapter 21** (Aboriginal heritage), **Chapter 23** (Resource use and waste minimisation) and **Chapter 24** (Climate change risk and adaptation).

27.2.4 Draft Central District Plan

In late 2016 the Greater Sydney Commission released draft District Plans to allow for integrated planning of land use, transport and infrastructure between state and local governments, in alignment with the *Towards our Greater Sydney 2056*. The *draft Central District Plan* (Greater Sydney Commission 2016) sets out priorities and actions across the areas of productivity, liveability and sustainability for Greater Sydney's Central District, which encompasses the project and most of the broader WestConnex program of work. Outcomes for each of these priority areas, as relevant to the project, include:

- Productivity:
  - Options for east–west public transport connections
  - Improved connections and amenity along the WestConnex corridor, with increased walking and cycling connectivity and greater open space provision
- Liveability:
  - Coordinated infrastructure planning and delivery for growing communities
  - Design-led planning to support high quality urban design

- Improved health outcomes and increased walking and cycling
- Conservation and enhancement of environmental heritage including Aboriginal, European and natural
- Planning for shared spaces, increasing the provision of community facilities, including open space

- Sustainability:
  - Embedding the *NSW Climate Change Policy Framework* into local planning decisions for improved energy efficiency, reduced emissions and improved environmental performance
  - Supporting the development of environmental performance targets and benchmarks
  - Improved land use and transport decision making
  - Increased provision of open space.

27.2.5 NSW Climate Change Policy Framework

The *NSW Climate Change Policy Framework* (OEH 2016a) aims to maximise the economic, social and environmental wellbeing of NSW in the context of a changing climate. The framework outlines policy directions for implementing the government's long-term objectives of achieving net zero emissions by 2050, and improving the resilience of NSW to a changing climate.

As part of the implementation of this framework, two additional draft plans have been released for public consultation:

- *Draft Climate Change Fund Strategic Plan 2017–2022* (OEH 2016b)
- *A Draft Plan to Save NSW Energy and Money* (OEH 2016c).

The *Draft Climate Change Fund Strategic Plan 2017–2022* sets out priority investment areas for funding over the next five years, including the provision of up to $100 million in new funding for actions to prepare NSW for a changing climate.

As part of this priority investment area, the draft plan identifies actions for reducing the costs to public and private assets arising from climate change; reducing the impacts of climate change on health and wellbeing, particularly for vulnerable communities; and managing the impacts of climate change on natural resources, natural ecosystems and communities. **Chapter 24** (Climate change risk and adaptation) and **Appendix X** (Climate change risk assessment framework) identify climate change risks to the project and the adaptation measures implemented during design to improve the resilience of the project to climate change.

The *Draft Plan to Save NSW Energy and Money* is proposed to meet the NSW Government's energy efficiency target of 16,000 gigawatt hours of annual energy savings by 2020, and contribute to achieving net zero emissions by 2050.

The draft plan summarises the preferred options for achieving the state's energy savings target, which include opportunities for implementing energy standards for State significant developments and major infrastructure projects such as road tunnels. **Chapter 22** (Greenhouse gas) and **Chapter 23** (Resource use and waste minimisation) outline the proposed energy efficiency measures to reduce the project's energy consumption and contribution to greenhouse gas emissions.

27.2.6 NSW Government Resource Efficiency Policy

The *NSW Government Resource Efficiency Policy* (NSW Government 2014) aims to drive resource efficiency, with a focus on energy, water and waste, and a reduction in harmful air emissions. The policy aims to ensure NSW Government agencies show leadership by incorporating resource efficiency in decision-making.

The policy includes specific measures, targets and minimum standards to drive resource efficiency. Refer to **Chapter 22** (Greenhouse gas) and **Chapter 23** (Resource use and waste minimisation) for information regarding how the project aligns with the policy.

27.2.7 NSW Waste Avoidance and Resource Recovery Strategy 2014-21

The *NSW Waste Avoidance and Resource Recovery Strategy 2014-21* (NSW Government 2014) provides a framework for waste management.

The *NSW Waste Avoidance and Resource Recovery Strategy 2014-21* includes the following six key result areas: avoid and reduce waste generation; increase recycling; divert more waste from landfill; manage problem wastes better (including asbestos); reduce litter; and reduce illegal dumping.

Chapter 23 (Resource use and waste minimisation) provides information regarding how the project aligns with the key result areas of the *NSW Waste Avoidance and Resource Recovery Strategy 2014-21*, particularly for the avoidance, recycling and recovery of waste generated during the construction period. The management of contaminated waste, including contaminated spoil, in accordance with this strategy is discussed in **Chapter 16** (Contamination) and **Chapter 23** (Resource use and waste minimisation), along with mitigation measures, including the ways in which disposal of contaminated waste would be managed.

27.2.8 Transport Environment and Sustainability Policy Framework and Statement

The *Transport Environment and Sustainability Policy* (Transport for NSW 2015) outlines the commitment of Transport for NSW and its key agencies to deliver transport services, projects, operations and programs in a manner that balances economic, environmental and social issues to ensure a sustainable transport system for NSW. Roads and Maritime is one of the key agencies identified in this policy. Specific sustainability commitments for Roads and Maritime, in line with the *Transport Environment and Sustainability Policy Framework,* are discussed in **section 27.2.8**.

The *Transport Environment and Sustainability Policy Framework* provides a collective and coordinated approach to deliver the NSW Government's environmental and sustainability agenda across the transport network. The framework outlines a number of indicators and targets across three themes: energy management, pollution control and resource management. Actions relevant to the project as outlined in the *Transport Environment and Sustainability Policy Framework* include:

- Pollution control:
  - Establish practices, where practicable, to mitigate noise from transport (an assessment of potential noise impacts from the project has been carried out and management measures have been recommended for the project – refer to **Chapter 10** (Noise and vibration))
- Climate change resilience:
  - High level analysis of climate change risks to transport operations and projects (an assessment of climate change risks for the project has been carried out – refer to **Chapter 24** (Climate change risk and adaption))
  - Develop climate change risk and action plan (a detailed climate change risk assessment would be carried out during detailed design and mitigation measures implemented – refer to **Chapter 24** (Climate change risk and adaption))
- Resource management:
  - Implement best resource management practices (resource management for the project is discussed in **Chapter 23** (Resource use and waste minimisation))
- Biodiversity:
  - Develop and implement practices that mitigate transport's impact on biodiversity (an assessment of potential impacts on biodiversity has been carried out and management measures have been recommended for the project – refer to **Chapter 18** (Biodiversity))

- Heritage:
  - Develop and implement practices that mitigate transport's impact on heritage (an assessment of potential impacts on heritage has been carried out and management measures have been recommended for the project – refer to **Chapter 20** (Non-Aboriginal heritage) and **Chapter 21** (Aboriginal heritage))
- Liveable communities:
  - Develop and implement practices which integrate transport with surrounding land use activities (an assessment of potential impacts on land use has been carried out and management measures have been recommended for the project – refer to **Chapter 12** (Land use and property), **Chapter 13** (Urban design and visual amenity) and **Appendix N** (Technical working paper: Active transport strategy))
- Corporate sustainability:
  - Measure and report on transport environment and sustainability annually (the project would report on sustainability performance through the use of the Infrastructure Sustainability Rating Tool).

27.2.9 NSW Sustainable Design Guidelines

The *NSW Sustainable Design Guidelines* (Transport for NSW 2013) provide guidance to embed sustainability initiatives into the design and construction of transport infrastructure projects and are aimed at projects being delivered by Transport for NSW, namely rail infrastructure projects.

While these guidelines and the corresponding checklist are not specifically applicable to road projects, the sustainability initiatives outlined in the guidelines are consistent with sustainability objectives identified by Roads and Maritime (see **section 27.2.10**) and as part of the WestConnex Sustainability Strategy (see **section 27.2.11**). The compulsory sustainability initiatives identified in the guidelines address the following sustainability themes:

- Energy and greenhouse gases
- Climate resilience
- Materials and waste
- Biodiversity and heritage
- Water
- Pollution control
- Community benefit.

Discussion of how the project would meet each of these themes, in line with the corresponding Roads and Maritime focus areas and WestConnex Sustainability Strategy targets and commitments, is provided in **section 27.2.10** and **section 27.2.11** respectively.

27.2.10 Roads and Maritime Services Environmental Sustainability Strategy 2015–2019

The *Roads and Maritime Services Environmental Sustainability Strategy 2015–2019* (Roads and Maritime 2016) outlines nine sustainability focus areas for integrating sustainability into Roads and Maritime operations and services, and aligns with the *Transport Environment and Sustainability Policy Framework* (Transport for NSW 2013).

Table 27-2 presents the Roads and Maritime sustainability focus areas and outlines how the project is consistent with these.

Table 27-2 Project consistency with Roads and Maritime sustainability focus areas

Sustainability focus area	Comment
Energy and carbon management	An energy efficiency and greenhouse gas emissions strategy would be prepared as part of the project's Sustainability Management Strategy, as discussed in **Chapter 22** (Greenhouse gas). The strategy would identify initiatives to be implemented during design and construction of the project to reduce carbon emissions, energy use and embodied life cycle impacts.
Climate change resilience	A climate change risk assessment has been prepared as part of the environmental impact assessment for the project to identify risks and adaptation opportunities to improve the project's resilience to future climate change and is included in **Chapter 24** (Climate change risk and adaptation).
Air quality	Details of how the project ventilation design ensures that concentrations of air emissions meet NSW, national and international best practice for in-tunnel and ambient air quality are presented in **Chapter 9** (Air quality).
Resource use and waste management	During construction of the project, unnecessary resource consumption would be avoided by making realistic predictions of the required quantities of resources such as construction materials. The management of construction waste would include reuse, recycling, and reprocessing of waste, where possible. Further details are provided in **Chapter 23** (Resource use and waste minimisation).
Pollution control	An acoustic impact assessment has been prepared for the project to identify and mitigate potential noise impacts (refer to **Chapter 10** (Noise and vibration)). An assessment has also been prepared for the project to identify and mitigate potential air quality impacts (refer to **Chapter 9** (Air quality)). The EIS includes an assessment of the project's potential impact on soil and water and is provided in **Chapter 15** (Soil and water quality). The project would also include measures for the abatement, avoidance and/or containment of pollution and waste.
Biodiversity	A biodiversity assessment has been prepared for the project to identify and consider measures to avoid and minimise potential impacts on biodiversity. Project impacts would be managed in accordance with the Roads and Maritime Biodiversity Guidelines. Additional detail is provided in **Chapter 18** (Biodiversity) and **Appendix S** (Technical working paper: Biodiversity).
Heritage	Items of Aboriginal and non-Aboriginal heritage significance were identified early in the project design and assessment. Impacts on these items have been minimised, avoided and mitigated where practicable and management measures to be implemented throughout construction of the project have been provided. Refer to **Chapter 20** (Non-Aboriginal heritage) and **Chapter 21** (Aboriginal heritage). The Technical working paper: Non-Aboriginal heritage and Technical working paper: Aboriginal heritage are provided in **Appendix U** and **Appendix V** respectively.
Liveable communities	The project would contribute to reducing traffic on the existing road network and improve connectivity across Sydney (refer to **Chapter 8** (Traffic and transport)). The project would provide and facilitate improvements in pedestrian and cyclist connections, creating new active transport linkages and linking existing active transport networks with new connections. The project would also improve the amenity of streetscapes, providing a net increase in publicly accessible open space and creating opportunities for future urban renewal. Additional detail is provided in **Chapter 8** (Traffic and transport), **Chapter 12** (Land use and property), **Chapter 13** (Urban design and visual amenity) and **Appendix N** (Technical working paper: Active transport strategy).

Sustainability focus area	Comment
Sustainable procurement	A project specific Sustainability Management Plan would be prepared to guide the implementation of sustainability throughout the design and construction phases, and to facilitate the achievement of an ISCA Infrastructure Sustainability (IS) rating of 'Excellent' (refer to **section 27.3** for discussion of the IS rating scheme).

27.2.11 WestConnex Sustainability Strategy

The WestConnex Sustainability Strategy (Sydney Motorway Corporation 2015) describes how sustainability initiatives are being integrated into the design, construction and operation of projects across the WestConnex program of works. The WestConnex Sustainability Strategy outlines a sustainability vision, commitments, guiding principles, objectives and overarching targets across a range of sustainability themes, and was prepared to align with the *Transport for NSW Environment and Sustainability Policy Framework* (Transport for NSW 2013) as well as other relevant government sustainability instruments (as described in the sections above).

Due to the large scale of the WestConnex program of works, and because it would be delivered as a series of projects over several years, the WestConnex Sustainability Strategy aims to ensure that sustainability is consistently applied across all projects and teams.

The WestConnex Sustainability Strategy provides a framework for implementing sustainability objectives and targets through the project's contract requirements, competitive tender evaluation process and project specific sustainability management plans/strategies during the design and construction stage.

The WestConnex Sustainability Framework is shown in **Figure 27-1**. Details of the project sustainability measures, how the project is consistent with the WestConnex Sustainability Framework, and how the project would meet or, where possible, exceed the objectives and targets outlined in the WestConnex Sustainability Strategy, are summarised in **Table 27-3**.The measures identified in **Table 27-3** include a summary of management measures identified for other technical disciplines, as relevant to sustainability. Environmental management measures for the project are further summarised in **Chapter 29** (Summary of environmental management measures).

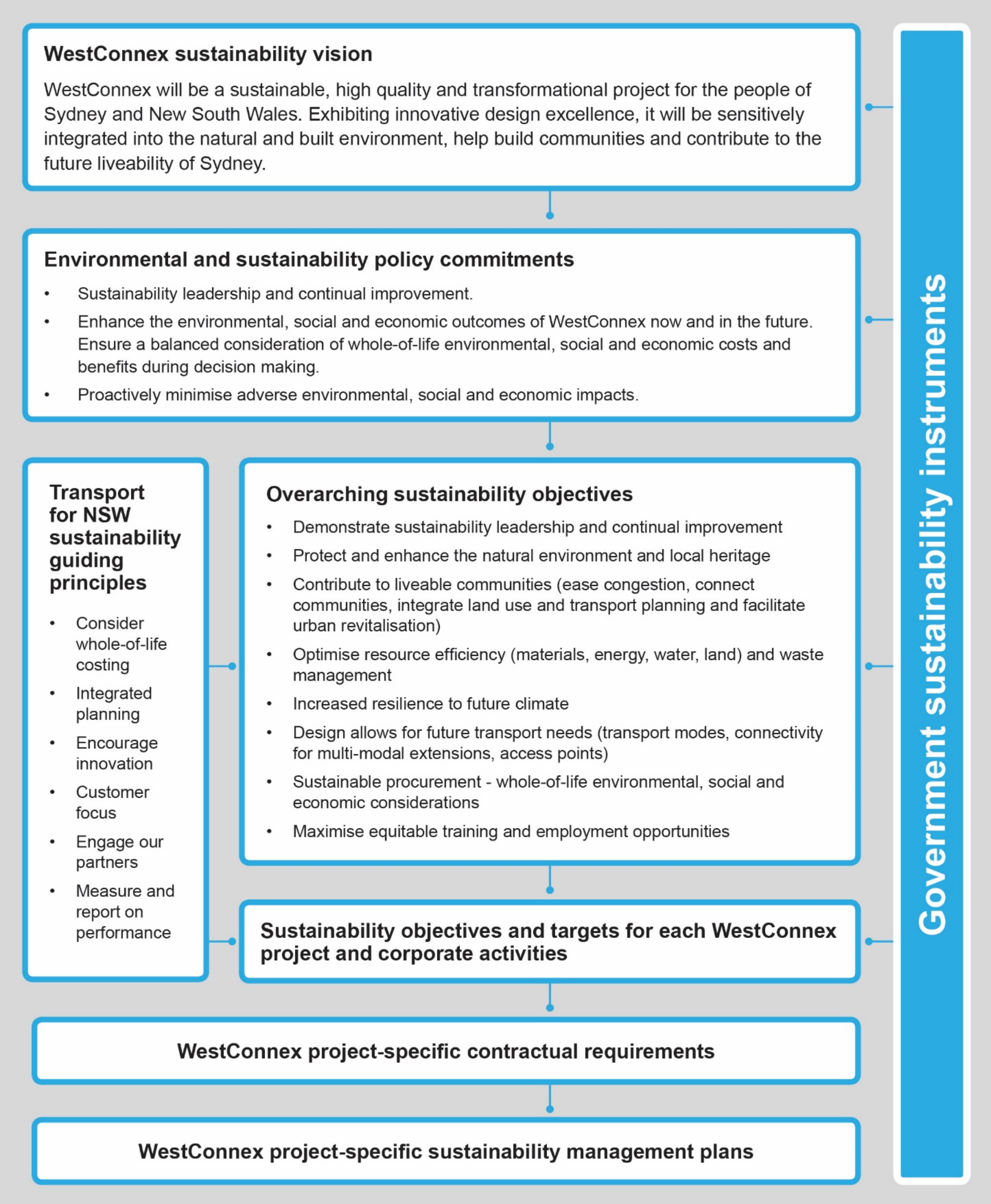


Figure 27-1 WestConnex Sustainability Framework

Table 27-3 Project consistency with the WestConnex Sustainability Framework objectives and targets

Sustainability targets	Project consistency
Overarching sustainability objective: Demonstrate sustainability leadership and continual improvement	
• Achieve an IS rating of at least 'Excellent' for the design and construction phases • Prepare quarterly project progress reports and an annual WestConnex Sustainability Report • Annual review of the WestConnex Sustainability Report and WestConnex Environment and Sustainability Policy by Senior Management • Share sustainability knowledge and lessons learnt across WestConnex component projects and other Roads and Maritime projects. Participate in sustainability workshops during design and construction phases and document lessons learnt • Appoint a Sustainability Representative with relevant experience to drive the achievement of sustainability outcomes.	• An IS rating of at least 'Excellent' would be achieved for the design and construction phases of the project • Quarterly project progress reports and an annual WestConnex Sustainability Report would be prepared during the design and construction phases • Senior Management would review the WestConnex Sustainability Report and WestConnex Environment and Sustainability Policy on an annual basis • During the design and construction phases, knowledge and lessons learnt would be shared across the WestConnex component projects through participation at regular sustainability workshops • The Sustainability Representative would drive the achievement of sustainability outcomes during design and construction phases.
Overarching sustainability objective: Protect and enhance the natural environment and local heritage	
• Ensure no serious pollution incidents occur during construction • Proactively manage any impacts on flora and fauna in accordance with the Roads and Maritime Biodiversity Guidelines • Heritage items are avoided where possible and proactively managed during construction.	• Construction activities would be managed in line with the mitigation measures outlined in this EIS to avoid serious pollution incidents • Development of detailed design would include consideration of biodiversity and heritage values, in order to avoid or minimise potential impacts • The project's design considers opportunities for an increase in publicly accessible open space, parkland and community uses at the Rozelle Rail Yards site • Easton Park was removed from the project footprint to minimise impacts on open space and heritage, and the Blackmore Park wetland was avoided to minimise potential biodiversity impacts • A biodiversity assessment has been prepared in accordance with the *Framework for Biodiversity Assessment* (OEH 2014b) and the *NSW Biodiversity Offset Policy for Major Projects* (OEH 2014c). This considers measures to avoid and minimise impacts on biodiversity in a biodiversity assessment report (BAR) • While the project would have minimal impact on biodiversity, as assessed in **Chapter 18** (Biodiversity), project impacts would be managed in accordance with the Roads and Maritime Biodiversity Guidelines. Additional detail is provided in **Chapter 18** (Biodiversity) and in **Appendix S** (Technical working paper: Biodiversity) • The removal of the Camperdown interchange component of the project was influenced

Sustainability targets	Project consistency
	by potential impacts on heritage conservation areas and heritage items such as the University of Sydney and Victoria Park (both nominated for state heritage listing) and a locally listed sandstone retaining wall on the northern side of Parramatta Road. Its removal facilitated the realignment of the mainline tunnels, which avoid potential impacts on these items • Items of Aboriginal and non-Aboriginal heritage significance were identified early in the project design and assessment. Impacts on identified items have been avoided and mitigated where practicable and management measures would be implemented throughout construction to minimise unavoidable impacts of the project, as described in this EIS • An assessment of potential impacts and proposed mitigation and management measures with regards to non-Aboriginal and Aboriginal heritage are provided in **Chapter 20** (Non-Aboriginal heritage) and **Chapter 21** (Aboriginal heritage) respectively. The Technical working paper: Non-Aboriginal heritage and Technical working paper: Aboriginal heritage are provided in **Appendix U** and **Appendix V** respectively. A discussion of refinements to the project design and a description of alternatives are provided in **Chapter 4** (Project development and alternatives).
Overarching sustainability objective: Contribute to liveable communities (ease congestion, connect communities, integrate land use and transport planning and facilitate urban revitalisation)	
• Design the motorway to reduce road congestion and travel times • Ensure appropriate air quality outcomes. The tunnel ventilation systems for the WestConnex program of works would be designed and operated to comply with best practice criteria for in-tunnel and ambient air quality • Maintain or improve pedestrian and cyclist paths and connections • Create/enhance public open space.	• The project would contribute to reducing traffic on the existing road network and increasing road capacity and travel times on certain roads • The project would link the M4 East and the New M5, improving connectivity across Sydney • The project would facilitate improvements to the broader road network as part of ongoing network evaluations to manage traffic congestion on local roads • Consideration has been given to the potential traffic changes resulting from the project to ensure that the project is effectively integrated with the road network. Refer to **Chapter 8** (Traffic and transport) for more information • Details of how the project ventilation design ensures that concentrations of air emissions meet NSW, national and international best practice for in-tunnel and ambient air quality are presented in **Chapter 9** (Air quality) • The project would provide and facilitate improvements in pedestrian and cyclist connections, linking existing connections by integrating the Iron Cove active transport network with a dedicated active transport corridor along Victoria Road, and creating new pedestrian and cyclist links within the Rozelle Rail Yards for connection to the

Sustainability targets	Project consistency
	Bays Precinct and the Sydney CBD • The project would increase active transport connectivity as discussed in **Appendix N** (Technical working paper: Active transport strategy), and would capitalise on the reduction in traffic to improve the amenity of local streets for pedestrians and cyclists, including: – Across the intersection of City West Link and The Crescent, providing improved access to the Rozelle Bay light rail stop – Through Rozelle Rail Yards, in a north–south direction linking Easton Park and Bicentennial Park, and from east–west to provide connection between the proposed Lilyfield Road Regional Bike Route and The Bays Precinct – A connection along Victoria Road to the existing Iron Cove active transport network – New connections through the St Peters interchange (that would be delivered as part of the New M5 project) • The Iron Cove Link masterplan and Rozelle Rail Yards masterplan are discussed in **Chapter 13** (Urban design and visual amenity) and **Appendix L** (Technical working paper: Urban design). Potential traffic and active transport impacts are discussed in **Chapter 8** (Traffic and transport) and **Appendix H** (Technical working paper: Traffic and transport) and an active transport strategy report is provided in **Appendix N** (Technical working paper: Active transport strategy) • A commitment has been made that the project would provide new open space for the community (up to 10 hectares), including areas of open space within the Rozelle Rail Yards • New open space would be provided at St Peters as part of the New M5 project, which would, in addition to the landscaping that would be carried out as part of the project at this location, result in a substantial amount of open space being created by the WestConnex program of works • The types of recreational uses for the new open space generated by the project would be decided in consultation with local communities, UrbanGrowth NSW and relevant councils during detailed design and documented in an Urban Design and Landscape Plan. A discussion of usage options for residual land is provided in **Chapter 12** (Land use and property).

Sustainability targets	Project consistency
Overarching sustainability objective: Optimise resource efficiency (materials, energy, water, land) and waste management	
Materials: • Identify and implement opportunities to reduce material use and maximise the use of materials with low environmental impact • Maximise the use of timber products from either reused/recycled timber or from sustainably managed forests that have obtained Forest Management Certification • Optimise the amount of cement replacement material (measured by mass) used in concrete • Optimise the amount of recycled material used in road base and sub-base.	• The use of construction materials to optimise resource efficiency and waste management would be considered in detailed design. Locally sourced materials and prefabricated assets would be selected where possible, to reduce greenhouse gas emissions • In instances where it is cost and performance competitive, recycled products would be used during construction of the project. This would reduce the demand on resources. This may include the use of fly ash and slag within concrete mixes • All wastes would be managed using the hierarchy approach of waste avoidance and waste reuse before consideration of waste disposal • Resource recovery principles would be applied to the construction of the project, including recovery of resources for reuse, recycling and reprocessing, where possible • The project would seek to reuse or recycle at least 95 per cent of uncontaminated spoil generated for beneficial purposes, either within the project or at other locations. A Construction Waste Management Plan would be prepared for the project, detailing appropriate procedures for waste management, as discussed in **Chapter 23** (Resource use and waste minimisation) • About 80 per cent of construction and demolition waste is anticipated to be reused and/or recycled as part of the project • During construction, non-potable water sources would be given preference over potable sources where appropriate (see below). Additional detail is provided in **Chapter 22** (Greenhouse gas) and **Chapter 23** (Resource use and waste minimisation).
Energy and carbon: • Prepare an Energy Efficiency and Greenhouse Gas Emissions Strategy detailing processes and methods to improve energy efficiency and reduce greenhouse gas emissions • Percentage of energy sourced from renewable energy generated onsite and/or accredited GreenPower. The current target is to source a minimum of 20 per cent of construction energy and six per cent of operational energy from renewable energy generated onsite and/or accredited GreenPower • Optimise the design and operation of the motorway to	• A Sustainability Strategy including strategies for energy efficiency and greenhouse gas emissions would be prepared during detailed design. The strategy would identify initiatives to be implemented during construction of the project to reduce carbon emissions, energy use and embodied life cycle impacts • Initiatives would include the selection of energy efficient equipment for tunnelling and construction activities, including the selection of roadheaders for tunnel excavation as opposed to a tunnel boring machine, thereby reducing energy consumption, material use and spoil generation • Where possible, a minimum of 20 per cent of electricity required for construction of the project would be sourced from renewable sources and/or an accredited GreenPower energy supplier. A target minimum of six per cent of construction electricity requirements would be offset, with any offset undertaken in accordance with the Australian Government National Carbon Offset Standard

Sustainability targets	Project consistency
minimise energy used by vehicles using the motorway.	• A minimum of six per cent of operational electricity requirements for the project would be sourced from renewable sources and/or an accredited GreenPower energy supplier. Opportunities for operational energy offset, in accordance with the Australian Government National Carbon Offset Standard, would be considered during detailed design. Measures to improve energy efficiency are discussed in **Chapter 22** (Greenhouse gas) and design development of the project is discussed in **Chapter 4** (Project development and alternatives).
Water: • Undertake a Water Balance Study and identify opportunities to reduce water use (in particular potable water use) and reuse water (eg rainwater, stormwater, wastewater and groundwater) during construction and operation • Reuse, recycle or reclaim water (eg rainwater, stormwater, wastewater, groundwater, tunnel inflow water) generated/collected.	• A water balance for surface water for construction and operation of the project is summarised in **Chapter 17** (Flooding and drainage) and detailed in **Appendix Q** (Technical working paper: Surface water and flooding). Refer to **Chapter 19** (Groundwater) and **Appendix T** (Technical working paper: Groundwater) for the detailed groundwater balance • Water efficiency measures would be implemented with a focus on achieving water savings and targeting water recycling and reuse • During construction, non-potable water sources would be given preference over potable sources where appropriate. Water would be sourced from: – Non-potable sources including stormwater harvesting at construction ancillary facilities, and on-site construction water treatment and reuse – The mains supply (potable water) • The extent to which non-potable water can be used during the project would be reviewed and refined during detailed design • Construction water would either be reused on site wherever feasible, or treated and discharged into the local stormwater system in accordance with the requirements of an Environment Protection Licence • Preference would be given to reusing as much water as practicable before discharging. Additional information regarding surface water and water quality is provided in **Chapter 15** (Soil and water quality). Indicative wastewater reuse volumes are provided in **Chapter 23** (Resource use and waste minimisation) • The indicative layouts of the temporary construction ancillary facilities have taken into consideration the flood risk posed to the land. This includes identifying opportunities to provide setback from areas at risk of flooding or considering locating uses considered more vulnerable to flooding – such as stockpile areas, storage of chemicals, tunnel dives and deep excavations – away from areas of highest risk. Refer to **Chapter 17** (Flooding and drainage) and **Appendix Q** (Technical working paper: Surface water and flooding) for further detail

Sustainability targets	Project consistency
	• The layout of the operational sites has taken into consideration the flood risk posed to the sites and how to manage these risks. The process for establishing flood risk for the project is outlined in **Chapter 17** (Flooding and drainage). Mitigation measures have already been included as a consequence of the evolution of the concept design, as discussed in **Chapter 17** (Flooding and drainage) and **Appendix Q** (Technical working paper: Surface water and flooding) • The design includes a number of bioretention basins and wetlands, including a 4,300 square metre wetland within the Rozelle Rail Yards site which would receive and treat stormwater runoff from the Rozelle Rail Yards as well as groundwater effluent from the water treatment plant • Opportunities to reuse treated groundwater during project operation would be considered in preference to discharge to the stormwater system or receiving waterbodies. This could include irrigation of landscaped areas within the project such as the new open space at the Rozelle interchange.
Land: • Minimise the project's surface land footprint and acquisition of properties • Identify contaminated sites within the project footprint and remediate to a standard for post construction use (as applicable).	• The project has been designed to maximise the use of land already owned by the NSW Government, and operational elements of the project would be located within existing road corridors as much as feasible • The project has been designed to maximise use of land currently being used for construction of the M4 East and New M5 projects. Additional land required to accommodate the project is discussed in **Chapter 12** (Land use and property) • The project has been designed to minimise the number of additional known and potentially contaminated sites that would be impacted by the project • Design optimisation included the refinement of the Rozelle interchange to reduce the impact of tunnelling through sites of contaminated fill, including at the Rozelle Rail Yards • Contaminated land within the project footprint would be rehabilitated to a standard suitable for post-construction use. Potential future uses of land are described in **Chapter 12** (Land use and property) and **Chapter 16** (Contamination).
Waste and spoil: • Reuse/recycle a minimum of 80 per cent usable spoil (uncontaminated surplus excavated material) • Reuse/recycle a minimum of 80 per cent of construction and demolition waste (uncontaminated) • Implement packaging take-back arrangements with suppliers (lead contractor to pass target onto sub-	• The project would seek to reuse or recycle at least 95 per cent of uncontaminated spoil, above the minimum target of 80 per cent as identified in the WestConnex Sustainability Strategy • Usable spoil (uncontaminated surplus excavated material) would be reused and/or recycled as part of the project, where possible. A Spoil Management Strategy would be developed for the project prior to the commencement of construction and would identify spoil disposal sites and the management of excess spoil. The management and disposal of excess spoil is discussed further in **Chapter 23** (Resource use and waste

Sustainability targets	Project consistency
contractors, where practical).	minimisation) • At least 80 per cent of construction and demolition waste is anticipated to be reused and/or recycled as part of the project • A Construction Waste Management Plan would be prepared as part of the Construction Environmental Management Plan for the project, detailing the appropriate procedures for waste management. All wastes would be managed using the hierarchy approach of waste avoidance and waste reuse before consideration of waste disposal. Resource recovery principles would be applied to the construction of the project, including recovery of resources for reuse, recycling and reprocessing, where possible. Residual waste that cannot be reused or recycled would be disposed of to a suitably licenced landfill or waste management facility. Additional detail regarding resource management and waste minimisation is provided in **Chapter 23** (Resource and waste minimisation).
Overarching sustainability objective: Increased resilience to future climate	
• Undertake a climate change risk assessment • Identify and implement adaptation measures to mitigate all ‘high’ and ‘extreme’ rated residual climate change risks.	• An initial climate change risk assessment has been prepared as part of the environmental impact assessment for the project in line with relevant standards and current guidelines and is included in **Chapter 24** (Climate change risk and adaptation) • The climate change risk assessment will be reviewed and updated during detailed design and where extreme, high or medium risks are identified, a review of the design will occur. Climate change adaptation measures incorporated into this stage of the design and additional measures to manage potential climate risks are provided in **Chapter 24** (Climate change risk and adaptation).
Overarching sustainability objective: Design allows for future transport needs (transport modes, extensions, access points)	
• Preserve an area of land for future safe pedestrian and cyclist connectivity across and adjacent to the motorway • Allow for future extensions to the road network and access points.	• The project has been designed to maintain and improve pedestrian and cyclist paths and connections between existing assets, and does not preclude potential future upgrades of, or additions to, pedestrian and cyclist paths • The project would increase active transport connectivity as discussed in **Appendix N** (Technical working paper: Active transport strategy), including: – Across Victoria Road, providing improved access to bus services – Across the intersection of City West Link and The Crescent, providing improved access to the Rozelle Bay light rail stop – Through Rozelle Rail Yards, in a north–south direction linking Easton Park and Bicentennial Park, and from east–west to provide connection between the proposed Lilyfield Road Regional Bike Route, The Bays Precinct and the CBD – A connection along Victoria Road to the existing Iron Cove active transport network

Sustainability targets	Project consistency
	– New connections through the St Peters interchange (being constructed as part of the New M5 project) • Future revitalisation and growth would be made possible as a result of the project reducing traffic on parts of Victoria Road, including improved local amenity, improved public transport services, upgraded active transport facilities, generation of residual land along Victoria Road and increased accessible public open space at Rozelle • The Iron Cove Link masterplan and Rozelle Rail Yards masterplan are discussed in **Chapter 13** (Urban design and visual amenity) and **Appendix L** (Technical working paper: Urban design) • The Rozelle interchange would include tunnels to provide for connections to the proposed future Western Harbour Tunnel and Beaches Link, ensuring future opportunities for improved connectivity can be realised.
Overarching sustainability objective: Sustainable procurement - whole of life environmental, social and economic considerations	
• Incorporate sustainability criteria into project contracts and tender evaluation criteria • Prepare and implement an Australian Industry Participation Plan.	• A number of sustainability specific criteria were used in the design development for the project. Specifically, the design has been developed to consider: – How the project would meet an ‘Excellent’ rating for the Design and As-Built components of the project under the ISCA IS rating scheme – How sustainability initiatives would be implemented throughout the project – How sustainability targets would be achieved or improved on throughout the project • A project specific Sustainability Management Plan would be prepared to guide the implementation of sustainability throughout the design and construction phases, to ensure the IS rating of Excellent is achieved (refer to **Figure 27-1**) • An Australian Industry Participation Plan has been developed for the overall WestConnex program of works.
Overarching sustainability objective: Maximise equitable training and employment opportunities	
• Maximise employment and training opportunities for young people, disadvantaged groups, Aboriginal and Torres Strait Islanders, the unemployed, local residents and people who live in western Sydney and along the project's alignment • Provide structured training to 20 per cent of the construction workforce • Provide initiatives to improve Aboriginal and Torres Strait Islander participation in construction and provide opportunities to Aboriginal and Torres Strait Islander enterprises.	• A Training Management Plan would be prepared before construction, detailing initiatives to maximise employment and training opportunities (including apprenticeships/traineeships/structured training), in particular for young people, disadvantaged groups, Aboriginal and Torres Strait Islanders, the unemployed, locals and people who live in western Sydney • Sydney Motorway Corporation is in the process of developing a Reconciliation Action Plan to guide activities needed to improve outcomes for Aboriginal and Torres Strait Islander people, to align with the NSW Government’s Plan for Aboriginal Affairs, Opportunity, Choice, Healing, Responsibility, and Empowerment.

27.2.12 Additional strategic planning documents

In line with the integrated planning principles identified in the strategies above, the project has been designed with consideration of additional strategic planning documents:

- The *NSW Freight and Ports Strategy* (Transport for NSW 2013) outlines two main objectives: to deliver a freight network that efficiently supports the projected growth of the NSW economy, and to balance freight needs with those of the broader community and the environment
- The *Parramatta Road Corridor Urban Transformation Strategy* (UrbanGrowth NSW 2016) identifies WestConnex as a catalyst for the restoration of the Parramatta Road corridor and aims to guide urban renewal opportunities to create an environment with good design, land use mix, housing choice and infrastructure, as well as improved access to community facilities and services and access to public and active transport
- The *Transformation Plan: The Bays Precinct Sydney* (UrbanGrowth NSW 2015) outlines the NSW Government's ambition for The Bays Precinct, which is intended to be staged and coordinated with the planning and delivery of WestConnex, the Inner West Light Rail line and the long term considerations of The Bays Precinct's port uses. The project is expected to improve accessibility to the precinct, with improvements to local amenity and user experience
- The *City of Sydney's Sustainable Sydney 2030 Plan* outlines the City's vision for a green, global and connected city and presents 10 strategic directions for the achievement of these goals towards 2030 and beyond. The project corresponds with the City's vision for:
  - Integrated transport for a connected city, with the project contributing to a reduction in traffic on some roads, and improved management of freight through Sydney as part of an integrated motorway network
  - A city for pedestrians and cyclists, with the project providing and facilitating improved pedestrian and cyclist connections, linking existing and proposed active transport networks, increasing publicly accessible green space and improving amenity for users
  - Sustainable development, renewal and design, with the project's design developed to create improved urban design opportunities (as discussed in **Chapter 13** (Urban design and visual amenity)), including a reduction in traffic which would enhance the amenity of streetscapes and create opportunities for urban renewal in some areas, such as Parramatta Road
- The City of Sydney currently hosts Resilient Sydney, a project to develop and implement a resilience strategy for metropolitan Sydney, as part of the Rockefeller Foundation's 100 Resilient Cities initiative. Outcomes of the Resilient Sydney project to date include the preparation of a *City Context Report* (Resilient Sydney 2016a) and the development of a Preliminary Resilience Assessment (Resilient Sydney 2016b), which identifies the key shocks and stresses facing Sydney, including acute shocks such as extreme weather events and infrastructure failures (such as power outages), and chronic stresses such as a lack of transport diversity. The project's contribution to improving Sydney's resilience is discussed in **section 27.4.2**.

27.3 Infrastructure Sustainability Rating Scheme

The IS rating scheme was developed and is administered by ISCA. The IS rating scheme is a comprehensive rating system for evaluating sustainability across the design, construction and operation of infrastructure.

The project is seeking an IS 'Design' and 'As-Built' rating of 'Excellent' in line with the WestConnex Sustainability Strategy targets. An 'Excellent' rating is the second highest rating level.

Sustainability workshops and meetings were held during EIS development with planning and design teams to assess and progress initiatives for achieving IS Design and As-Built rating criteria, and sought to preserve opportunities in future detailed design development. Specific workshops were held to drive sustainable outcomes for key components of the project design, including:

- The M4-M5 Link tunnelling works
- The M4-M5 Link surface works, with particular focus given to the Rozelle interchange and Iron Cove Link portals.

The workshops instigated discussion of applicable urban design initiatives and their impact on achieving project sustainability targets and requirements, with initiatives identified under the following headings:

- Energy and water, including initiatives for achieving efficiencies in energy and water use, as well as the management and reuse of spoil during construction
- Access and movement, including initiatives for active transport and improved connectivity
- Natural landscape and environment, including initiatives for the protection or provision of green space
- Cultural heritage and identity, including initiatives for the preservation of heritage values.

A number of actions were documented for planning and design consideration to embed specific sustainability commitments and targets for implementation by the construction contractor, with requirements for regular sustainability inspections and reporting during the construction period. Commitments and targets align with those identified in the WestConnex Sustainability Strategy, outlined in **Table 27-3**. The construction contractor would be responsible for ensuring that enough credits are achieved to meet the IS 'Excellent' rating.

A project specific Sustainability Management Plan would be prepared to guide the implementation of sustainability throughout the design and construction phases, and to facilitate the achievement of the IS rating.

27.4 Ecologically sustainable development

In NSW, the commitment to the concept of environmental sustainability is expressed in current legislation. It is an object of the *Environmental Planning and Assessment Act 1979* (NSW) (EP&A Act) (section 5(a)(vii)) to encourage ecologically sustainable development through the implementation of the following four principles:

- The precautionary principle
- Inter-generational equity
- Conservation of biological diversity and ecological integrity
- Improved valuation and pricing and incentive mechanisms.

The principles of ecologically sustainable development have been an integral consideration throughout the design of the project. This includes the effective integration of the economic and environmental considerations in the decision making process, as defined by section 6(2) of the *Protection of the Environment Administration Act 1991* (NSW).

The four main principles of ecologically sustainable development, including how they would be incorporated throughout the design, construction and operation phases of the project, are discussed below.

27.4.1 Precautionary principle

The precautionary principle deals with certainty in decision making. It provides that if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.

The precautionary principle has been applied during the design and development of the project. Potential environmental impacts associated with the project were considered in the alternatives and options analysis. This included identifying opportunities to avoid and minimise surface disturbance. Refer to **Chapter 4** (Project development and alternatives) for additional detail regarding the options considered as part of the project’s design.

This EIS details the evaluation of environmental impacts associated with the project. The EIS was prepared adopting a conservative approach, which included assessing the worst case impacts and scenarios. It has been undertaken using the best available technical information and has adopted best practice environmental standards, goals and measures to minimise environmental risks. The environmental assessment has been undertaken in collaboration with key stakeholders and relevant statutory and agency requirements.

The threat of serious or irreversible environmental damage is one of the essential preconditions to the engagement of the precautionary principle. Potential environmental risks associated with the project were identified and considered to ensure that an appropriate amount of time was afforded for detailed specialist reports as part of the environmental assessment (refer to **Chapter 28** (Environmental risk analysis) for more detail). Safeguards and management measures have been developed to manage and reduce impacts identified in these assessments.

Sustainability workshops and meetings were held during EIS development with planning and design teams, which sought to preserve opportunities for the implementation of sustainability initiatives in future detailed design development. Specific workshops were held to drive sustainable outcomes for key components of the project design, as discussed in **section 27.3**.

27.4.2 Inter-generational equity

In broad terms, the notion of inter-generational equity refers to the premise that the present generation should ensure that the health, diversity and productivity of the environment are maintained or enhanced for the benefit of future generations.

The project tunnels would have a design life of about 100 years and would be designed to meet the needs of both current and future generations. The project has been considered in terms of inter-generational equity, with the management of potential environmental impacts discussed throughout this EIS.

As part of WestConnex, the project delivers on the NSW Government’s plans to deliver an integrated transport solution, comprising roads and public transport, to address congestion on Sydney’s roads and to cater for the diverse travel needs of Sydney’s growing population. Improvements to road infrastructure remain a critical part of the overall solution, with the project proposed to contribute to inter-generational equity through improved connectivity, reduced congestion, and facilitating urban renewal and future economic growth.

The project, as part of the WestConnex program of works, would contribute to improving Sydney’s transport network, accommodating forecast traffic growth, allowing for connections to the proposed future Sydney Gateway project (via the St Peters interchange) and proposed future Western Harbour Tunnel and Beaches Link.

By providing a motorway link between the M4 East at Haberfield and the New M5 at St Peters, the project would help to connect major employment centres, which are critical in supporting the creation of jobs and businesses. As a result, the project would improve access to employment centres for people living in western Sydney, with spatial inequality recognised as one of the key socio-economic challenges for the city. East–west connectivity and access to established and emerging employment areas in western Sydney would also improve. Improved connectivity to employment centres would include the ‘global economic corridor’, which extends from Port Botany and Sydney Airport to the Norwest Business Park and Parramatta CBD via the Sydney and North Sydney CBDs, as well as the future Western Sydney Airport at Badgerys Creek.

The project would support Sydney’s long-term economic growth through improved motorway access and connections linking Sydney’s international gateways and western Sydney and places of business across the city. With improved connectivity, the project would also enhance the productivity of commercial and freight generating land uses located near and along transport infrastructure.

The project would contribute to building the resilience of metropolitan Sydney by addressing some of the key chronic stresses facing the city, including the need for improved connectivity and reduced congestion.

The project would give consideration to redundancy in power supply through provision of back-up power for operation of the project's essential equipment, as discussed in **Chapter 5** (Project description). Additional redundancy in drainage infrastructure designed to meet or improve the capacity of existing drainage systems and account for future climate change would also be provided as part of the project, The project's resilience to future climate change is considered in **Chapter 24** (Climate change risk and adaptation), which identifies potential climate risks to the project, adaptation incorporated in the project's design development and recommended next steps for the development of adaptation options during detailed design.

During construction and operation of the project, opportunities would be taken to reduce material use and maximise the use of materials with low embodied environmental impact, where practical. For example:

- Recycled products would be used during construction of the project to reduce the demand on resources, in instances where the use of such materials is cost and performance competitive
- At least 20 per cent of electricity required for construction and at least six per cent of electricity required for operation of the project would be sourced from an accredited GreenPower energy supplier
- Water efficiency measures would be implemented with a focus on achieving water savings and targeting water recycling and reuse, with a minimum target of five per cent of water (rainwater, stormwater, wastewater, groundwater, tunnel inflow water) proposed to be reused, recycled or reclaimed during operation of the project
- The project would seek to reuse or recycle around 95 per cent of uncontaminated spoil generated for beneficial purposes, either within the project or at other locations
- At least 80 per cent of construction and demolition waste is anticipated to be reused and/or recycled as part of the project.

The project ventilation system has been designed and would be operated so that it would achieve some of the most stringent standards in the world for in-tunnel air quality, and would be effective at maintaining local and regional ambient air quality. A large mainline tunnel cross-sectional area would permit greater volumetric air throughput and reduce the pollutant concentration for a given emission into the tunnel volume. Increased tunnel height would reduce the risk of incidents involving high vehicles blocking the tunnel and disrupting traffic, reducing the risk of higher pollutant concentrations associated with traffic flow breakdown.

Under expected traffic conditions the contribution of project tunnel ventilation outlets to pollutant concentrations was found to be negligible for all sensitive receivers identified. Exceedances of some air quality criteria were predicted to occur at a small proportion of sensitive receivers both with and without the project. However, the total number of receivers with exceedances decreased slightly with the project and in the cumulative scenarios. Where increases in pollutant concentrations at receptors were predicted, these were mostly small.

There are predicted to be substantial reductions in concentrations of criteria pollutants along Dobroyd Parade/City West Link and Parramatta Road to the southeast of the Parramatta Road ventilation facility due to traffic being diverted through the M4-M5 Link tunnel, as well as along General Holmes Drive, the Princes Highway and the M5 East Motorway. There would also be substantial reductions in pollutant concentrations along the Victoria Road corridor south of Iron Cove at Rozelle, due to traffic being diverted through the Iron Cove Link.

Some small increases in concentration of criteria pollutants were predicted to the north of Iron Cove Link and near Anzac Bridge as a result of the general increase in traffic due to the project. Pollutant concentrations were also predicted to increase along Canal Road, which would be used to access the St Peters interchange, and other roads associated with the proposed future Sydney Gateway project. Impacts associated with the proposed future Sydney Gateway project are based on a strategic concept and are therefore indicative only, would be subject to further design, as well as separate planning and approval. More detail regarding the air quality assessment is provided in **Chapter 9** (Air quality) and **Appendix I** (Technical working paper: Air quality).

The project aims to reduce construction and operational greenhouse gas emissions. A greenhouse gas assessment has been undertaken to quantify emissions and identify mitigation measures to reduce emissions. The operational road use assessment undertaken as part of the greenhouse gas assessment (refer to **Chapter 22** (Greenhouse gas)) notes that emissions estimated to be generated during construction and the annual emissions from the operation and maintenance of road infrastructure would be offset against emissions savings as a result of improved road performance in 2033.

Despite increases to overall daily vehicle kilometres travelled (VKT) on motorways, improvements to traffic flow and congestion are achieved through increased speeds and reduced frequency of stopping, as well as reduced daily VKT and vehicle hours travelled (VHT) on alternate routes and non-motorway roads, which results in improved fuel efficiency and subsequently reduced greenhouse gas emissions associated with road use. Further information on greenhouse gas emissions and savings is provided in **Chapter 22** (Greenhouse gas).

Traffic analysis identifies a number of key benefits and improvements as a result of the project:

- Non-motorway roads in the Inner West local government area are forecast to experience faster trips with the daily average speed increasing by about 10 per cent. Similarly, the vehicle distance travelled on non-motorway roads is forecast to reduce by about 12 per cent. This indicates that on average, these trips are fewer in number and faster
- Improved network productivity on the metropolitan network, with more trips forecast to be made or longer distances travelled on the network in a shorter time. The forecast increase in VKT and reduction in VHT is mainly due to traffic using the new motorway, with reductions in daily VKT and VHT also forecast on non-motorway roads
- Reduced travel times are forecast on key corridors, such as between the M4 Motorway corridor and the Sydney Airport/Port Botany precinct
- Reduced traffic is forecast on sections of major arterial roads including City West Link, Parramatta Road, Victoria Road, King Street and Sydenham Road
- Almost 2,000 heavy vehicles are forecast to be removed from Parramatta Road, east of the M4 East Parramatta Road ramps, each weekday.

Where the project would connect to the existing road network, increased congestion is forecast in parts of Mascot, along Frederick Street at Haberfield, Victoria Road north of Iron Cove Bridge, Johnston Street at Annandale and on the Western Distributor. A number of these areas are forecast to improve when the WestConnex program of works and the proposed future Sydney Gateway and Western Harbour Tunnel and Beaches Link project are completed. Roads and Maritime proposes to investigate the use of queuing and capacity monitoring, management of lane use and lane utilisation and ‘Smart Motorway’ operations to manage the forecast demand, where required.

A Smart Motorway uses technology to monitor, provide intelligence and control the motorway to ease congestion and keep traffic flowing more effectively. Technology, including lane use management signs, vehicle detection equipment, closed-circuit television cameras and entry ramp signals, allows road operators to manage, in real time, traffic using the motorway. Further detail regarding the scenarios modelled and the operational performance of the project is provided in **Chapter 8** (Traffic and transport) and **Appendix H** (Technical working paper: Traffic and transport).

Notwithstanding the project benefits and the renewable energy targets that would apply, the project may have an impact on inter-generational equity through the consumption of non-renewable fuel resources during operation.

Roads and Maritime understands that it is prudent to consider that oil production may peak and then decline, which could increase the cost and reduce the availability of transport fuels and construction materials derived from oil. For transport, the solutions to the problem of ‘peak oil’ are similar to those for climate change. Alternatives to fossil fuels are needed and transport must become more energy efficient. There are moves to establish alternatives to oil as a fuel for transport and to improve energy efficiency. For example, the *Australian Bureau of Statistics Motor Vehicle Census* published on 31 January 2016 reports an increase in the number of hybrid and electric vehicles registered in Australia. The NSW State Transit bus fleet uses compressed natural gas to power buses (State Transit 2014), and the CBD and South East Light Rail project would include a fleet of around 30 electric-powered light rail vehicles (Parsons Brinckerhoff 2013). This would enable the economic benefits provided by road transport to continue to be delivered with a reduced need for fossil fuels.

Government and industry initiatives relevant to peak oil, but outside the scope of this project, include the *NSW Government Resource Efficiency Policy* (OEH 2014a) and the participation of Roads and Maritime, Austroads and industry in research, with the goal of developing more sustainable road construction materials and practices, thereby reducing reliance on products derived from oil.

As road transport is a significant and necessary element of the NSW economy that also provides many social benefits, Roads and Maritime would continue to ensure that all potential impacts on this system, such as peak oil, are identified and action is taken to manage these risks. Peak oil in the context of operational resource consumption is discussed in **Chapter 23** (Resource use and waste minimisation).

27.4.3 Conservation of biological diversity and ecological integrity

Conservation of biological diversity and ecological integrity is a fundamental consideration of the project. The design and assessment of the project has been undertaken with the aim of identifying, avoiding, minimising and mitigating impacts.

The biodiversity study area is entirely modified and disturbed and contains exotic species, weeds and planted native or non-indigenous species. The project footprint is considered to be in a poor ecological condition, with little ecological value and unlikely to have any native resilience or recovery potential.

These facts notwithstanding, construction of the project may impact potential foraging habitat of non-native vegetation for the Grey-headed Flying-fox, Eastern Bentwing-bat and Yellow-bellied Sheathtail-bat, and may have indirect impacts on Microchiropteran bat species. However, these residual impacts are not expected to have a significant negative effect on any local populations of native biota, including any threatened fauna species that may occur in the study area.

This EIS provides a detailed biodiversity assessment, which identifies potential impacts on biodiversity, and provides a range of mitigation measures to further avoid and minimise potential impacts on biodiversity.

Potential impacts on biodiversity are detailed further in **Chapter 18** (Biodiversity) and **Appendix S** (Technical working paper: Biodiversity).

27.4.4 Improved valuation and pricing and incentive mechanisms

Environmental factors should be included in the valuation of assets and services, including:

- Polluter pays (ie those who generate pollution and waste should bear the cost of containment, avoidance or abatement)
- The users of goods and services should pay prices based on the full life cycle of costs of providing the goods
- Environmental goals, having been established, should be pursued in the most cost-effective ways.

Environmental factors have been considered throughout the concept design stage for the design, construction and operation of the project. As a consequence, environmental impacts have been avoided or minimised where practical during the design development for the project.

Mitigation measures outlined in this EIS will be implemented during construction and operation of the project. These mitigation measures would be revised and updated as required during the detailed design stage of the project and as the project passes through the assessment process.

The value placed on avoiding and minimising environmental impacts is demonstrated in the design features incorporated into the project, including opportunities for the creation of additional green space and the realignment of the mainline tunnels to avoid impacts on heritage conservation areas and heritage items (as discussed in **Table 27-3**), as well as the extent of environmental investigations undertaken to inform this EIS. Additionally, the costs associated with the planning and design of measures to avoid/minimise adverse environmental impacts and the costs to implement them have been included in the overall project costs.

The project creates the potential for improvements in local amenity and opportunities for urban revitalisation. Opportunities for improved urban design created by the project include the beneficial reuse of remaining land not required by the project along Victoria Road and at the Rozelle Rail Yards. Reuse and renewal of these areas would allow opportunities for future revitalisation and growth, increasing publicly accessible green and/or community space and improving access and amenity for users.

The Iron Cove Link masterplan and Rozelle Rail Yards masterplan are discussed in **Chapter 13** (Urban design and visual amenity) and **Appendix L** (Technical working paper: Urban design). The project would also contribute to the delivery of the Residual Land Management Plan for the M4 East project at Haberfield and the New M5 project at St Peters, through ensuring compliance with the conditions of approval related to residual land for those projects (refer to **Chapter 12** (Land use and property)).

The project would also provide improvements to pedestrian and cyclist connections, linking existing active transport networks with new connections or improving existing connections through a reduction in traffic, which would improve the amenity of streetscapes and create opportunities for urban renewal. The project would also include measures for the abatement, avoidance and/or containment of pollution and waste.

27.5 Sustainability management on the project

The overarching sustainability objectives for the project (see **Table 27-3**) would be met through the implementation of a Sustainability Management Plan and project specific sustainability initiatives. The implementation of these initiatives would contribute to the project achieving an IS rating of ‘Excellent’.

27.5.1 Sustainability Management Plan

While sustainability is considered throughout design, the WestConnex sustainability objectives and targets would be met through the implementation of a project specific Sustainability Management Plan and sustainability initiatives.

The construction contractor would develop and implement a Sustainability Management Plan during detailed design. The Sustainability Management Plan would establish governance structures, processes and systems that ensure integration of all sustainability considerations (vision, commitments, principles, objectives and targets), initiatives, monitoring and reporting during the detailed design and construction phases of the project.

The aims of the Sustainability Management Plan would be to:

- Demonstrate sustainability leadership and continuous improvement
- Protect and enhance the natural environment and local heritage
- Contribute to liveable communities and facilitate urban revitalisation by easing congestion, connecting communities and integrating land use and transport planning
- Optimise resource efficiency (materials, energy, water and land) and waste management
- Increase resilience to future climate
- Design for future transport needs
- Procure sustainably, considering whole of life environmental, social and economic factors
- Maximise equitable/fair training and employment opportunities.

Principles in the Sustainability Management Plan would extend across the whole project, through the detailed design, construction and operation phases. These principles would also be embedded across all management disciplines throughout detailed design and the construction contractor’s project team, ensuring that decision making processes consider environmental, social and economic costs and benefits over the life of the project.

The Sustainability Management Plan would form part of the integrated management system to be implemented on the project. The plan would be revised and updated regularly to reflect changing designs and sustainability initiatives through each of the project phases.

The Sustainability Management Plan would include an ISCA IS Rating Management Sub-plan to guide the achievement of an IS rating of 'Excellent' for the project. The Sub-plan would detail implementation protocols, including:

- ISCA IS assessment and registration process and timeframes
- Proposed consultation and engagement with ISCA and other stakeholders
- The IS rating process and requirements for the provision of documentation to ISCA
- Key sustainability management roles and responsibilities.

28 Environmental risk analysis

An environmental risk analysis for the M4-M5 Link project (the project) was carried out as part of this environmental impact statement (EIS). This chapter outlines the environmental risk analysis process and identifies the key environmental issues as determined by the analysis.

The Secretary of the NSW Department of Planning and Environment (DP&E) has issued environmental assessment requirements for the project. These are referred to as Secretary's Environmental Assessment Requirements (SEARs). **Table 28-1** sets outs these requirements and the associated desired performance outcomes that relate to environmental risk analysis, and identifies where they have been addressed in this EIS.

Table 28-1 SEARs – environmental risk analysis

Desired performance outcome	SEAR	Where addressed in the EIS
2. Environmental Impact Statement The project is described in sufficient detail to enable clear understanding that the project has been developed through an iterative process of impact identification and assessment and project refinement to avoid, minimise or offset impacts so that the project, on balance, has the least adverse environmental, social and economic impact, including its cumulative impacts.	1. The EIS must include, but not necessarily be limited to, the following: (j) the identification and assessment of key issues as provided in the 'Assessment of Key Issues' performance outcome.	The identification of key issues is outlined in **section 28.3**. A summary of the assessment of key issues is provided in the **Executive Summary** and **Appendix A** (Project synthesis).
3. Assessment of Key Issues* Key issue impacts are assessed objectively and thoroughly to provide confidence that the project will be constructed and operated within acceptable levels of impact. * Key issues are nominated by the Proponent in the CSSI project application and by the Department in the SEARs. Key issues need to be reviewed throughout the preparation of the EIS to ensure any new key issues that emerge are captured. The key issues identified in this document are not exhaustive but are key issues common to most CSSI projects.	1. The level of assessment of likely impacts must be proportionate to the significance of, or degree of impact on, the issue, within the context of the proposal location and the surrounding environment. The level of assessment must be commensurate to the degree of impact and sufficient to ensure that the Department and other government agencies are able to understand and assess impacts.	An assessment of the key issues identified for the project is provided in **Chapter 8** to **Chapter 27** and **Appendix H** to **Appendix X**. A summary of the impacts for each key issue is presented in the **Executive Summary** and **Appendix A** (Project synthesis).
	2. For each key issue the Proponent must: (c) identify, describe and quantify (if possible) the impacts associated with	Impacts associated with each key issue are described, and where possible quantified, in **Chapter 8** to **Chapter 27**

Desired performance outcome	SEAR	Where addressed in the EIS
	the issue, including the likelihood and consequence of the impact (comprehensive risk assessment), and the cumulative impacts of: (i) concurrent project construction activities; and (ii) proposed and approved projects (where information is available at the time of writing). (d) demonstrate how potential impacts have been avoided (through design, or construction or operation methodologies); (e) detail how likely impacts that have not been avoided through design will be minimised, and the predicted effectiveness of these measures (against performance criteria where relevant); and (f) detail how any residual impacts will be managed or offset, and the approach and effectiveness of these measures.	and **Appendix H** to **Appendix X**. A summary of the environmental risk analysis is provided in **section 28.3** including a likelihood and consequence analysis. Further detailed discussion in regards to cumulative impacts is provided in **Chapter 26** (Cumulative impacts).

28.1 Environmental risk analysis process

The environmental risk analysis process carried out for the project included:

- A preliminary environmental assessment, that was carried out as part of the State significant infrastructure (SSI) application report (NSW Roads and Maritime Services (Roads and Maritime) 2016) and subsequent addendums to the SSI application report (Addendum 1 (Roads and Maritime 2016b) and Addendum 2 (Roads and Maritime 2017)) to allow early identification of the key environmental issues and to inform the SSI application
- An assessment of the key issues identified in the SEARs for the project (refer to the SEARs in **Appendix B** (Secretary's Environmental Assessment Requirements checklist))
- An environmental risk review undertaken to confirm the impacts based on the results of the detailed investigations presented in this EIS.

Through the environmental risk analysis process, issues that may be associated with the project were identified and categorised as a 'key issue' or 'other' (see **Table 28-2**). This enabled the identification of any matters that might be considered as additional key issues, and provided a basis for an appropriately detailed assessment of these additional key issues in this environmental assessment.

Table 28-2 Environmental risk categories

Risk category	Description
Key issue	Potential for high or moderate impacts (actual or perceived) requiring further investigation to identify specific management and mitigation measures
Other	Potential for low impacts that can be managed effectively with standard and/or best practice management and mitigation measures

As required by the SEARs, this process of key issue identification and analysis continued during the course of preparing the EIS. Emphasis was placed on using the detailed information gathered for the project to identify and review potential environmental issues. More specifically, the analysis:

- Identified environmental issues, including key issues in the SEARs, and any other issues
- Examined potential impacts and proposed management and mitigation measures in relation to the identified issues

- Identified the impacts likely to remain after management and mitigation measures are applied (ie the residual impacts).

The identified environmental issues are described and assessed in **Chapter 8** to **Chapter 27** and **Appendix H** to **Appendix X**. As required by the SEARs, a risk analysis, including a likelihood and consequence analysis, has been undertaken. An assessment of cumulative impacts is presented in **Chapter 26** (Cumulative impacts).

As part of the environmental risk analysis for the project, a residual impact assessment has been undertaken as provided in **Table 28-6**. This assessment provides an analysis of project impacts post-mitigation (ie after management and mitigation measures are applied to manage the impact) based on the risk assessment approach described in **section 28.1.1**.

28.1.1 Likelihood and consequence analysis

To determine the residual impacts for each potential key issue, the following risk assessment approach has been undertaken. The likelihood of an impact occurring following the implementation of management and mitigation measures is assessed using the categories provided in **Table 28-3**.

Table 28-3 Likelihood categories

Likelihood	Description
Certain	Expected to happen routinely during the project life.
Likely	Could easily happen and has occurred on a previous similar project.
Unlikely	Possible, but not anticipated.

The consequence of the impact occurring following the implementation of management and mitigation measures is assessed using the categories provided in **Table 28-4**.

Table 28-4 Consequence categories

Consequence	Description
Minor	Minor effects on biological, social, economic or physical environment, both built and natural. Minor short to medium term damage to small area of limited significance, easily rectified.
Moderate	Moderate effects on biological, social, economic or physical environment, both built and natural. Moderate short to medium term widespread impacts. More difficult to rectify.
Major	Serious effects on biological, social, economic or environment, both built or natural. Relatively widespread medium to long term impacts. Rectification difficult or impossible.

Based on the assessment of the likelihood and consequence of a given impact occurring with the proposed management and mitigation measures in place, a residual risk rating is derived from the risk matrix as presented in **Table 28-5**.

Table 28-5 Risk matrix

	Residual risk rating		
	Consequence		
Likelihood	Minor	Moderate	Major
Certain	Medium	High	High
Likely	Low	Medium	High
Unlikely	Low	Low	Medium

If an identified residual risk is not lowered or remains high, consideration of additional management and mitigation measures will be identified and implemented, or justification provided for the risk.

28.2 Identification of key issues and risks

The environmental risk analysis has been undertaken following the assessment of likely impacts for each of the key issues identified by the SEARs as well as other environmental matters that have been identified as potentially being impacted by the project. The environmental issues are described and assessed in detail in **Chapter 8** to **Chapter 27** and **Appendix H** to **Appendix X**.

28.3 Risk analysis approach

For each of the identified issues, a level of assessment was undertaken commensurate with the potential degree of impact the project may have on that issue. This included an assessment of whether the identified impacts could be avoided or minimised (for example, through design amendments). Where impacts could not be avoided, environmental management measures have been recommended to manage impacts to acceptable levels. These are detailed in full in **Chapter 29** (Summary of environmental management measures).

Environmental management measures will be implemented through the management frameworks put in place by the Construction Environmental Management Plan (CEMP) and Operational Environmental Management Plan (OEMP), and relevant sub-plans. In addition to incorporating management measures, these plans will include details of how the measures will be implemented, monitored and audited for compliance.

The assessment of key issues has been undertaken based on a concept design, as identified in **Chapter 1** (Introduction). The identified management measures will be reassessed during the detailed design for their appropriateness. In relation to managing impacts, the following hierarchy has been implemented during the concept design and will also be implemented during the detailed design. The hierarchy will avoid environmental impacts where possible through design. Where impacts cannot be avoided, feasible and reasonable measures are recommended to minimise these impacts to the greatest extent practicable. As a result, the following assessment does not detail residual risks that are considered low, or the beneficial impacts of the project.

Chapter 8 to **Chapter 27** and **Appendix H** to **Appendix X** of the EIS provide a description of the potential unmitigated impacts of the project. The environmental risk analysis process detailed in **section 28.1** has then been applied to the key project impacts as assessed in **Chapter 8** to **Chapter 27** and **Appendix H** to **Appendix X** to provide a post-mitigation residual risk rating for each identified key risk as outlined in **Table 28-6**.

The numerical codes provided in the management and mitigation measures column refers to the identification (ID) number (eg AQ10) for the relevant environmental management measure, as summarised in **Chapter 29** (Summary of environmental management measures).

Table 28-6 Environmental risk analysis of key issues

Summary of key impacts	Construction/ Operation	Management and mitigation measures	Likelihood	Consequence	Residual risk
Traffic and transport – refer to **Chapter 8** (Traffic and transport)					
Construction impacts on road network performance including public transport and active transport.	Construction	• A Construction Traffic and Access Management Plan (CTAMP) will be prepared and will include the guidelines, general requirements and principles of traffic management to be implemented during construction. It will be prepared in accordance with *Austroads Guide to Road Design* (with appropriate Roads and Maritime supplements). Alternative public transport and activities transport facilities to be provided where possible (TT01).	Likely	Moderate	Medium
Traffic-related safety incidents (involving both workers and road users) during construction.	Construction	• Construction staging and temporary works to be implemented to minimise conflicts with the existing road network and maximise spatial separation between work areas and travel lanes (TT03).	Unlikely	Major	Medium
Temporary impacts to property access during construction.	Construction	• Maintain property access where possible. Manage local road closures in consultation with Roads and Maritime, local councils and property owners likely to be impacted (TT14).	Likely	Minor	Low
Damage or impacts to road infrastructure resulting from construction works.	Construction	• Road dilapidation reports to be prepared for potentially impacted road infrastructure. Mechanisms to repair damage to the road network caused by the project will be identified (TT18).	Likely	Minor	Low
Operational road network performance impacts including potential increased traffic on some parts of the network as a result of the project.	Operation	• A review of operational network performance will be undertaken 12 months and five years from the opening of the project to confirm the network operational impacts of the project (OpTT1) • A network integration strategy will be prepared in consultation with local council regarding optimisation measures. This may include measures to improve traffic flow on areas experiencing higher flow as a result of the project (OpTT2 – OpTT3).	Likely	Moderate	Medium

Summary of key impacts	Construction/ Operation	Management and mitigation measures	Likelihood	Consequence	Residual risk
Air quality - refer to **Chapter 9** (Air quality)					
Dust generated by construction.	Construction	• A Construction Air Quality Management Plan (CAQMP) will be developed that will include measures that will be implemented to manage potential air quality impacts associated with the construction for the project. The plan will be implemented for the duration of construction (AQ1 – AQ25).	Likely	Minor	Low
Effects of poor in tunnel air quality on human health.	Operation	• Ventilation systems will be operated to manage emissions level in tunnels and ventilate emissions to atmosphere in a manner that meets relevant NSW Environment Protection Authority (NSW EPA) air quality criteria.	Unlikely	Minor	Low
Impacts to ambient air quality.	Operation	• Design and construct ventilation outlets to achieve the regulatory outlet discharge limits and modelled dispersion outcomes for pollutant concentrations at ground level.	Unlikely	Minor	Low
Increase in modelled pollutant concentrations on Victoria Road to the north of Iron Cove Link, near Anzac Bridge and Canal Road at Mascot, as a result of the general increase in traffic at that location due to the project.	Operation	• While the project cannot control the general increase in traffic growth over time and related increase in vehicle emissions, the progressive introduction of more stringent vehicle emissions regulations will continue over the life of the project.	Likely	Moderate	Medium
Noise and vibration - refer to **Chapter 10** (Noise and vibration)					
Construction noise and vibration impacts upon sensitive receivers around all construction sites.	Construction	A Construction Noise and Vibration Management Plan (CNVMP) will be prepared for the project. The plan will (NV1): • Identify relevant performance criteria in relation to noise and vibration • Identify noise and vibration sensitive receivers and features in the vicinity of the project • Include standard and additional mitigation measures from the	Likely	Moderate	Medium

Summary of key impacts	Construction/ Operation	Management and mitigation measures	Likelihood	Consequence	Residual risk
		CNVG and details about when each will be applied • Describe the process(es) that will be adopted for carrying out location and activity specific noise and vibration impact assessments to assist with the selection of appropriate mitigation measures • Include protocols that will be adopted to manage works required outside standard construction hours in accordance with relevant guidelines • Detail monitoring that will be carried out to confirm project performance in relation to noise and vibration performance criteria. The CNVMP will be implemented for the duration of construction of the project.			
Noise and vibration impacts outside of standard construction hours.	Construction	An Out-of-hours Works Protocol will be developed for the construction of the project. The protocol will include (NV5): • Details of works required outside standard construction hours, including justification of why the activities are required outside standard construction hours • Measures that will be implemented to manage potential impacts associated with works outside standard construction hours • Location and activity specific noise and vibration impact assessment process(es) that will be followed to identify potentially affected receivers, clarify potential impacts and select appropriate management measures • Details of the approval process (internal and external) for works proposed outside standard construction hours. The protocol will be prepared in consultation with DP&E and the NSW EPA, endorsed by the acoustic advisor for the project and implemented during construction of the project.	Likely	Moderate	Medium

Summary of key impacts	Construction/ Operation	Management and mitigation measures	Likelihood	Consequence	Residual risk
Receivers on Victoria Road near Iron Cove Bridge may receive up to 15 dBA increases in noise from road traffic as a result of the project.	Operation	• The use of low noise pavement to further reduce road traffic noise at the source will be investigated during detailed design taking into account whole-life engineering considerations and the overall social, economic and environmental effects. If low noise pavement is found to be appropriate, it will be considered as a management measure when assessing operation noise impacts based on the detailed design (NV10) • The area in the vicinity of the western portal of the Iron Cove Link at Rozelle will be assessed further during development of the detailed design to identify appropriate noise mitigation measures to address predicted increases in road traffic noise to the project. The measures that will be considered will include low road noise pavement, noise barriers, at-property treatments and the project design (NV11) • Receivers that qualify for assessment at receiver treatment in relation to operational noise that are also predicted to experience significant exceedances of noise management levels due to construction will be given priority preference for assessment. When at receiver treatments are found to be appropriate, the application of the treatment will be expedited (NV12) • Within 12 months of the commencement of the operation of the project, actual operational noise performance will be compared to predicted operational noise performance. The need for any additional management measures to address any identified operational performance issues and meet relevant operational noise criteria will be assessed and implemented where reasonable and feasible (NV14).	Likely	Moderate	Medium
Human Health – Refer to C**hapter 11** (Human health risk)					
A separate risk assessment was undertaken for human health risks in accordance with a range of international guidance documents as endorsed or accepted by Australian health and environment authorities. Refer to **Chapter 11** (Human health risk) for a full list of guidelines. Changes in the urban environment associated with the project have the potential to result in a range of impacts on health and wellbeing of the community. The potential for changes to result in impacts on health and wellbeing is complex. Changes that may occur have the potential to result in both positive and					

<table>
<tr><th>Summary of key impacts</th><th>Construction/ Operation</th><th>Management and mitigation measures</th><th>Likelihood</th><th>Consequence</th><th>Residual risk</th></tr>
<tr><td colspan="6">negative impacts. Positive impacts include economic benefits, traffic improvements in some areas and increased public open space in the Rozelle Rail Yards site. Negative impacts may occur as a result of traffic disruption during construction, property acquisitions, visual changes, noise impacts and changes in access/cohesion of local areas. These may result in increased levels of stress and anxiety. In many cases the impacts identified are either short term (associated with construction only) and/or management measures have been identified to minimise the impacts on the community. Reference is made to the residual risk assessment for traffic and transport, noise and vibration, air quality. Land use, property, social and economic impacts that relate to potential human health impacts as detailed in Chapter 11 (Human health risk).</td></tr>
<tr><td colspan="6">Land use and property - refer to Chapter 12 (Land use and property)</td></tr>
<tr><td>Ground settlement resulting in damage to buildings, structures or utility infrastructure.</td><td>Construction/ Operation</td><td>Ground settlement will be managed to comply with the following criteria where possible (PL6):
<table>
<tr><th>Beneath structure/facility</th><th>Maximum settlement</th><th>Maximum angular distortion</th><th>Limiting tensile strain (per cent)</th></tr>
<tr><td>Buildings – Low or non-sensitive properties (ie less than or equal to two levels and carparks).</td><td>30 mm</td><td>1 in 350</td><td>0.1</td></tr>
<tr><td>Buildings – High or sensitive properties (ie greater than or equal to 3 levels and carparks).</td><td>20 mm</td><td>1 in 500</td><td>0.1</td></tr>
<tr><td>Roads and parking areas.</td><td>40 mm</td><td>1 in 250</td><td>N/A</td></tr>
<tr><td>Parks.</td><td>50 mm</td><td>1 in 250</td><td>N/A</td></tr>
</table>
A Settlement Monitoring Plan will be prepared and implemented. The plan will include provisions for the development of management measures that will be implemented depending on</td><td>Likely</td><td>Moderate</td><td>Medium</td></tr>
</table>

Summary of key impacts	Construction/ Operation	Management and mitigation measures	Likelihood	Consequence	Residual risk
		the outcomes of the settlement monitoring results (PL8).			
Urban design and visual amenity - refer to **Chapter 13** (Urban design and visual amenity)					
Impacts to visual amenity from construction ancillary facilities.	Construction	• Ancillary facilities, including the locations of visible structures and plant and perimeter fencing and treatments, will be developed to minimise visual impacts for adjacent receivers where feasible and reasonable (LV1) • Regular maintenance of site hoarding and perimeter site areas should be undertaken, including the prompt removal of graffiti (LV3) • Hoarding and temporary noise walls will be erected as early as possible within the site establishment phase to provide visual screening (LV5) • The detailed design will explore opportunities to design acoustic sheds to be visually recessive, such as the use of mid-toned colours and materials to minimise the intrusiveness and potential glare of the sheds, or the use of transparent materials where feasible to minimise potential overshadowing impacts (LV6).	Likely	Moderate	Medium
Antisocial behaviour around construction ancillary facilities and operational infrastructure.	Construction and operation	• Specific design measures at construction ancillary facilities will be identified to prevent crime, based on principles of Crime Prevention Through Environmental Design (LV10).	Likely	Minor	Low
Impacts to visual amenity and landscape character at and around the Rozelle Rail Yards.	Operation	• Integrate the new open space at Rozelle with the Lilyfield Road streetscape through considered street tree planting and associated landscape works (LV13) • Implement urban design and landscaping measures that allow permeable views between the City West Link carriageway and the new open space to provide a sense of openness and connection with the open space for motorists and the community (LV14)	Likely	Moderate	Medium

Summary of key impacts	Construction/ Operation	Management and mitigation measures	Likelihood	Consequence	Residual risk
		• Investigate measures to minimise view impacts of the project to sensitive residential receptors in the vicinity of the Rozelle Rail Yards as described in this assessment and include in the UDLP where reasonable and feasible (LV15) • Develop a design that aims to incorporate the ventilation outlets at the Rozelle Rail Yards as an integral component of the larger open space composition, with reference and consideration to the Ventilation Facility Design Review (Annexure 2 of **Appendix L** (Technical working paper: Urban design)) (LV16) • Consult with UrbanGrowth NSW regarding the interface between the project footprint and the White Bay Power Station precinct. Design the interface to ensure compatibility between the two areas from a landscaping, visual, heritage and active transport connectivity perspective (LV17). • Investigate measures to retain the mature trees of high retention value adjacent to the light rail corridor at the corner of The Crescent and City West Link, or provide screen planting alongside the retaining wall edge of the light rail corridor, to minimise landscape and visual impacts (LV18).			
Impacts to visual amenity and landscape character at and around the Iron Cove Link.	Operation	• Investigate vegetative and other screening measures along Victoria Road to improve the visual amenity of the streetscape and reduce impacts associated with the ventilation outlet and increased glare from the portals to residential dwellings to the north of Victoria Road (LV19). • Provide a well-articulated, integrated car parking and landscape design for the bioretention facility in Manning Street that is place sensitive, and enhances the interface between the project and both King George Park and adjacent residences (LV20).	Likely	Minor	Low

Summary of key impacts	Construction/ Operation	Management and mitigation measures	Likelihood	Consequence	Residual risk
Social and economic - refer to **Chapter 14** (Social and economic)					
Impacts to businesses as a result of changes in traffic, access, parking and amenity.	Construction	• Prepare and implement Business Management Plans to reduce the overall effects on potentially impacted businesses and commercial operations (SE1).	Likely	Moderate	Medium
Impacts to the community access and connectivity.	Construction	• Implement the CTAMP, which will include measures aimed at minimising disruptions as a result construction changes to traffic flow, parking and local amenity (TT01 – TT12) • Implement the Community Communication Strategy (SE2), which will include measures: – Procedures and mechanisms that will be implemented by the in response to the key social impacts identified for the project – Property acquisition support services that will be provided – Procedures and mechanisms to communicate to project stakeholders (including affected communities), the access and connectivity enhancements and new community and social facilities that will be delivered as part of the project through the Social Infrastructure Plan and to update stakeholders on delivery progress – Procedures and mechanisms that will be used to engage with affected business owners to identify potential access, parking, business visibility and other impacts to develop measures to address potential impacts on a case by case basis.	Likely	Moderate	Medium
Acquisition of property required for the project.	Construction	• Land acquisition for the project will be undertaken in accordance with the *Land Acquisition (Just Terms Compensation) Act 1991* (NSW) and the *Roads and Maritime Services land acquisition information guide* (Roads and Maritime 2014b) and the land acquisition reforms announced by the NSW Government in 2016. A property acquisition factsheet that outlines the process and provides further information for concerned residents will	Certain	Minor	Medium

Summary of key impacts	Construction/ Operation	Management and mitigation measures	Likelihood	Consequence	Residual risk
		continue to be made available online and in hard copy at project information centres (SE3) • Affected households will continue to have access to a counselling service that assists people through the property acquisition process (SE4) • An independent service will continue to be provided to vulnerable households (eg elderly, those suffering an illness) to assist with relocation. Assistance could include finding a suitable house for relocation, arranging removalists, disconnecting services and attending appointments with solicitors or other representatives (SE5) • A community relations support toll-free telephone line will be operated to respond to any community concerns or requests for translation services (SE6).			
Soil and water quality – refer to **Chapter 15** (Soil and water quality)					
Impacts on water quality in project catchments due to the water discharge, including discharge of treated surface and groundwater.	Construction	• Construction water treatment facilities will be designed and managed so that treated water will be of suitable quality for discharge to the receiving environment. The level of treatment provided will consider the characteristics of the waterbody, any operational constraints or practicalities and associated environmental impacts and be developed in accordance with ANZECC (2000) and with consideration to the relevant NSW WQOs and *Protection of the Environment Operations Act 1997* (NSW). The discharge criteria for the treatment facilities will be finalised and included in the Construction Soil and Water Management Plan (CSWMP). An ANZECC (2000) species protection level of 90 per cent is considered appropriate for adoption as discharge criteria for toxicants where practical and feasible. The discharge criteria for the treatment facilities will be included in the CSWMP (SW10).	Unlikely	Moderate	Low

Summary of key impacts	Construction/ Operation	Management and mitigation measures	Likelihood	Consequence	Residual risk
Impacts on local soil and water quality due to disturbance of actual or potential acid sulfate soils and/or acid drainage discharge.	Construction	• Appropriate stockpiling and management of contaminated materials will be implemented (CM05) • Washing water and waste will be appropriately contained, treated and disposed of (CM10) • The CSWMP prepared for the project will include measures for the management of acid sulfate soils if encountered (CM07) • Procedures, prepared in accordance with the requirements of the *Acid Sulfate Soil Manual* (Acid Sulfate Soil Management Advisory Committee 1998), will be included in the CSWMP and implemented in the event that acid sulfate soils, rocks or monosulfidic black oozes are encountered during construction of the project (SW11).	Likely	Minor	Low
Contamination – refer to **Chapter 16** (Contamination)					
Impacts to site workers and local community through direct contact, inhalation and/or ingestion of dust from contaminated soil or hazardous building materials exposed through demolition and ground disturbance.	Construction	• Further investigation of contamination areas will be undertaken and a Remediation Action Plan will be prepared where necessary (CM01) • A site specific asbestos management plan will be prepared and include details of specific management measures to be implemented for asbestos or asbestos containing materials (CM02) • A hazardous materials assessment will be carried out prior to and during demolition of buildings. Subsequent demolition works will be undertaken in accordance with the relevant Australian Standards and relevant NSW WorkCover Codes of Practice, including the Work Health and Safety Regulation 2011 (NSW) (CM03).	Unlikely	Moderate	Low
Increased contamination in areas through cross contamination associated with the incorrect handling or	Construction	• Stockpile management procedures will be implemented to control dust, odour and cross contamination (CM05) • An unexpected find and hazardous materials procedure will be implemented and plant, equipment and supplies will be managed to prevent spills and leaks (CM06 and HR3) • Suitable areas will be identified to allow for contingency	Likely	Minor	Low

Summary of key impacts	Construction/ Operation	Management and mitigation measures	Likelihood	Consequence	Residual risk
disposal of spoil/unexpected finds and/or potential leaks and spills from construction equipment and plant.		management of unexpected waste materials, including contaminated materials. Suitable areas will be required to be hardstand or lined areas that are appropriately stabilised and bunded, with sufficient area for stockpile storage (RW9) • Safety Data Sheets for dangerous goods and hazardous substances will be stored on site prior to their arrival (HR4) • Transport of dangerous goods and hazardous substances will be conducted in accordance with relevant legislation and codes, including the Dangerous Goods (Road and Rail Transport) Regulation 2014 (NSW) and the Australian Code for the Transport of Dangerous Goods by Road and Rail (National Transport Commission 2008) (HR5).			
Flooding and drainage - refer to **Chapter 17** (Flooding and Drainage)					
Impacts on surrounding properties due to the potential alterations of flood levels and behaviour due to construction ancillary facilities and due to new operational facilities.	Construction and operation	• A Flood Mitigation Strategy identifying potential flood risks to and from the project and measures to minimise risks will be prepared and implemented (FD01, FD02 and FD03) • Further hydrological and hydraulic modelling of detailed design to assess potential flood impact, design out where possible or otherwise mitigate potential flooding impacts (FD06) • Floor level surveys will be carried for buildings where peak in the 100 year ARI design flood are predicted to increased due to the project, and further design refinements will be made to minimise impacts (FD08).	Unlikely	Moderate	Low
Impacts on flood levels and behaviour due to sea level rise and potential increase in rainfall intensity due to future climate change.	Operation	• The detailed assessment of potential climate change related flood risks to the project will be revised for the detailed design and design changes or management measures implemented to limit climate induced risks to flooding and drainage (FD07).	Unlikely	Major	Medium

Summary of key impacts	Construction/ Operation	Management and mitigation measures	Likelihood	Consequence	Residual risk
Biodiversity - refer to **Chapter 18** (Biodiversity)					
Loss of foraging habitat for the Grey-headed Flying-fox and loss of habitat for microbats.	Construction and operation	• A Construction Flora and Fauna Management Plan (CFFMP) will be developed and implemented during construction. Management measures and environmental controls to be implemented before and during construction including (B1): – An unexpected threatened species finds procedure – Section 3.3.2 Standard precautions and mitigation measures of the *Policy and Guidelines for Fish Habitat Conservation and Management Update 2013* (DPI-Fisheries NSW 2013) – Tree assessment and management protocols consistent with *AS 4970-2009 Protection of trees on development sites* – Weed management protocols • Foraging tree species for the Grey-headed Flying-fox to be considered in the Urban Design and Landscape Plan to provide compensatory planting (OB9) • Prior to the commencement of any works associated with the modification of the Victoria Road bridge, an inspection will be carried out by a suitably qualified and experienced ecologist to confirm the presence of roosting microbats. If roosting microbats are identified, measures to manage potential impacts will be developed in consultation with an appropriate microbat expert and included in the CFFMP prior to the commencement of any work with the potential to disturb the roosting locations (as confirmed by the microbat expert). The plan will include management measures outlined in the Biodiversity Assessment Report and from any additional assessments carried out during detailed design and project delivery as relevant (B2).	Likely	Minor	Low
Impacts to aquatic habitat in Whites Creek and Rozelle Bay.	Construction	• The proposed road bridge at Whites Creek will be designed with consideration of *Policy and Guidelines for Fish Habitat Conservation Update 2013* (DPI, 2013) and *Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings* (NSW Fisheries 2003) (B3)	Unlikely	Minor	Low

Summary of key impacts	Construction/ Operation	Management and mitigation measures	Likelihood	Consequence	Residual risk
		• Site-specific Erosion and Sediment Control Plans (ESCPs) will be prepared for each work location associated with or in the vicinity of waterways and culverts that will be modified as part of the project. The ESCPs would contain measures to stabilise all surfaces disturbed as a result of the project as soon as possible following the disturbance to prevent erosion and to minimise sedimentation in adjacent aquatic environments (B4).			
Groundwater - refer to **Chapter 19** (Groundwater)					
High groundwater inflows (in excess of the one litre per second per kilometre design criterion) which could result in increased groundwater drawdown.	Construction	• Groundwater inflows within the tunnels will be minimised by designing the final tunnel alignment to minimise intersections with known palaeochannels and alluvium present in the project footprint (GW1) • Appropriate waterproofing measures will be identified and included in the detailed design to permanently reduce the inflow into the tunnels to below one litre per second per kilometre for any kilometre length of the tunnel (GW2) • Appropriate measures will be investigated and implemented at dive structures and shafts and for cut-and-cover sections of the tunnel to minimise groundwater inflow (GW3) • A detailed groundwater model will be developed by the construction contractor. The model will be used to predict groundwater inflow rates and volumes within the tunnels and groundwater levels (including drawdown) in adjacent areas during construction and operation of the project (GW7) • Groundwater inflow within and groundwater levels in the vicinity of the tunnels will be monitored during construction and compared to model predictions and groundwater performance criteria applied to the project. The groundwater model will be updated based on the results of the monitoring as required and proposed management measures to minimise potential groundwater impacts adjusted accordingly to ensure that groundwater inflow performance criteria are met (GW8).	Unlikely	Moderate	Low

Summary of key impacts	Construction/ Operation	Management and mitigation measures	Likelihood	Consequence	Residual risk
Non-Aboriginal heritage - refer to **Chapter 20** (Non-Aboriginal heritage)					
Full or partial loss, or damage to historical heritage items due to demolition.	Construction	• Construction Heritage Management Plan (CHMP) will be prepared and implemented as part of the Construction Environmental Management Plan. The CHMP will include (NAH01): – Measures that will be implemented to manage potential impacts to items of heritage significance – Inclusion of heritage awareness and management training for relevant personnel involved in site works – Details regarding the conservation and curation of any historical artefacts recovered during works • A Heritage Salvage Strategy will be prepared to identify the salvage potential of the fabric and features from heritage items and potential heritage items that will be demolished to facilitate the project. This could include timber joinery, fireplaces, stained glass, stairs, decorative tiles, bricks, steel truss structures, windows etc. The strategy will also identify options and a process for dissemination of salvaged items to owners, community groups and interested parties (NAH09).	Certain	Minor	Medium
Potential impact on features of heritage significance associated with the White Bay Power Station.	Construction	• The railway cutting on the eastern side of Victoria Road, associated with the White Bay Power Station, will be considered during the development of the detailed design for the realigned Victoria Road and associated bridge. The final design will seek to avoid impact to the railway cutting and maintain the visual relationship between the cutting and the White Bay Power Station site. Landscaping sympathetic to the relationship, developed in consultation with a heritage specialist, will be included in the Urban Design and Landscape Plan for the project (NA11) • A condition assessment of the southern penstock (and its associated water channels) will be carried out by a heritage	Unlikely	Moderate	Low

Summary of key impacts	Construction/ Operation	Management and mitigation measures	Likelihood	Consequence	Residual risk
		specialist and a structural engineer prior to any works in the vicinity with the potential impact upon the item. If required any conservation works required to limit potential impacts on deteriorated fabric (loose bricks, corroded steel) will be identified and implemented prior to construction (NA12) • The southern penstock and its associated water channels (location and extent unknown) will be protected during works associated with the reconstruction of the Victoria Road Bridge (NA13).			
Aboriginal heritage - refer to **Chapter 21** (Aboriginal heritage)					
Potential impact on previously unidentified Aboriginal heritage items (unexpected finds).	Construction	• Any items of potential Aboriginal archaeological or cultural heritage conservation significance or human remains discovered during construction will be managed in accordance with the Unexpected Heritage Finds and Humans Remains Procedure developed for the project (AH1).	Unlikely	Moderate	Low
Impacts to Aboriginal Heritage Information Management System (AHIMS) site #45-6-2278.	Construction	• Verification of the presence and condition of by a AHIMS site #45-6-2278 by a suitably qualified archaeologist, subject to access (AH2) • If the AHIMS site #45-6-2278 is verified, an assessment will be completed by a suitably qualified and experienced person prior to the commencement of any vibration intensive construction activities in the vicinity. The assessment will consider all vibration intensive activities that will occur in the vicinity, the likely vibration levels and relevant vibration criteria and identify the management measures, including monitoring, that will be implemented to prevent and reduce potential impacts. A final condition assessment will be carried out at the completion of construction detailing recommendations for remediation measures if required (AH2 – AH3).	Unlikely	Moderate	Low

Summary of key impacts	Construction/ Operation	Management and mitigation measures	Likelihood	Consequence	Residual risk
Greenhouse gas - refer to **Chapter 22** (Greenhouse gas)					
Emissions of greenhouse gases during construction.	Construction	• An Energy Efficiency and Greenhouse Gas Emissions Strategy and Management Plan will be prepared for the project. The strategy will identify initiatives to be implemented during construction and operation of the project to improve energy efficiency, reduce Green House Gas (GHG) emissions, energy use and embodied life cycle impacts (GHG1).	Certain	Minor	Low
Greenhouse gas emissions generated during operation.	Operation	• An Energy Efficiency and Greenhouse Gas Emissions Strategy and Management Plan will be prepared for the project. The strategy will identify initiatives to be implemented during construction and operation of the project to improve energy efficiency, reduce GHG emissions, energy use and embodied life cycle impacts (GHG1).	Certain	Minor	Low
Greenhouse gas emissions from operational road use.	Operation	• The tunnel will be designed with appropriate vertical alignments and grades to allow vehicles to maintain constant speeds and minimise fuel use to reduce potential greenhouse gas emissions (OGHG7).	Certain	Minor	Low
Resource use and waste minimisation - refer to **Chapter 23** (Resource use and waste minimisation)					
Excessive consumption of resources during construction.	Construction	• Construction material will be sourced in accordance with the relevant aims of the *WestConnex Sustainability Strategy* (Sydney Motorway Corporation 2015) and a Sustainability Strategy (that will be developed during detailed design), including to optimise resource efficiency and waste management, and the selection of locally sourced materials and prefabricated assets where possible, to reduce greenhouse gas emissions. Unnecessary resource consumption will be avoided through the detailed design of the project and by making realistic predictions about the required quantities of resources, such as	Unlikely	Minor	Low

Summary of key impacts	Construction/ Operation	Management and mitigation measures	Likelihood	Consequence	Residual risk
		construction materials (RW1).			
Impacts associated with poor waste management during construction.	Construction	• Wastes will be managed and disposed of in accordance with relevant NSW legislation and government policies (RW2) • A Construction Waste Management Plan will be prepared as part of the CEMP and regularly updated during detailed design and construction, detailing appropriate procedures for waste management. The plan will include the waste management measures described in this EIS (RW3) • Waste management measures will be based on the waste hierarchy principles (RW4).	Unlikely	Minor	Low
Impacts associated with unexpected waste volume or types during construction.	Construction	• Suitable areas will be identified to allow for contingency management of unexpected waste materials, including contaminated materials. Suitable areas will be required to be hardstand or lined areas that are appropriately stabilised and bunded, with sufficient area for stockpile storage (RW9).	Unlikely	Minor	Low

Summary of key impacts	Construction/ Operation	Management and mitigation measures	Likelihood	Consequence	Residual risk
Climate change and risk adaption - refer to **Chapter 24** (Climate change risk and adaptation)					
A separate risk assessment was undertaken for climate change risks in accordance with the Roads and Maritime Draft *Technical Guide for Climate Change Adaptation for the State Road Network,* with risks assessed using the likelihood and consequence criteria and risk assessment approach outlined in the Technical Guide. Refer to **Chapter 24** (Climate change risk and adaptation) for a summary of the risk assessment approach and **Appendix X** (Detailed climate change risk assessment) for the full risk assessment.					
Hazards and risk - refer to **Chapter 25** (Hazard and risk)					
Impacts associated with the incorrect storage of dangerous goods.	Construction and operation	• Storage of dangerous goods and hazardous materials will occur in accordance with suppliers' instructions and relevant Australian Standards and legislation including the (HR1): – *Work Health and Safety Act 2011* (NSW) – Storage and Handling of Dangerous Goods Code of Practice (WorkCover NSW 2005) – Environment Protection Manual for Authorised Officers: Bunding and Spill Management, technical bulletin (NSW EPA 1997) • Storage methods may include bulk storage tanks, chemical storage cabinets/containers or impervious bunds (OpHR6).	Unlikely	Moderate	Low
Impacts associated with the incorrect transportation of dangerous goods.	Construction and operation	• Transport of dangerous goods and hazardous substances will be conducted in accordance with relevant legislation and codes, including the Dangerous Goods (Road and Rail Transport) Regulation 2014 and the Australian Code for the Transport of Dangerous Goods by Road and Rail (National Transport Commission 2008) (HR5) • The transport of dangerous goods and hazardous substances will be prohibited through the mainline tunnels and entry and exit ramps (OpHR6).	Unlikely	Moderate	Low
Impacts associated with fires or other	Operation	• The fire and safety systems and measures adopted for the project will be equivalent to or exceed the fire safety measures	Unlikely	Moderate	Medium

Summary of key impacts	Construction/ Operation	Management and mitigation measures	Likelihood	Consequence	Residual risk
incidents in project tunnels.		recommended by NFPA502 (American), Permanent International Association of Road Congresses (PIARC) (European), AS4825 (Australian) and Roads and Maritime standards (OpHR1) • An Incident Response Plan will be developed as part of the Emergency Response Plan for the project and implemented in the event of an accident or incident. The plan will include management and response measures to be implemented in the event of an incident (OpHR4) • The response to incidents within the motorway will be managed in accordance with the memorandum of understanding between Roads and Maritime and the NSW Police Service, NSW Rural Fire Service, NSW Fire and Rescue and other emergency services (OpHR5).			
Impacts associated with asbestos.	Construction	• An asbestos survey will be undertaken of buildings to be demolished as part of the project in accordance with an Asbestos Management Plan as part of the Work Health and Safety Plan. The survey will be conducted by a suitably qualified person (RW13) • Asbestos handling and management will be undertaken in accordance with an Asbestos Management Plan as part of the Work Health and Safety Plan and relevant NSW legislation, government policies and Australian Standards. The plan will include prior notification to adjacent communities about potential hazards (RW14).	Likely	Minor	Low
Sustainability - refer to **Chapter 27** (Sustainability)					
An assessment of the sustainability of the project was undertaken in **Chapter 27** (Sustainability). The sustainability of the project was assessed against four principles of ecologically sustainable development: • The precautionary principle • Inter-generational equity • Conservation of biological diversity and ecological integrity • Improved valuation and pricing and incentive mechanisms.					

Summary of key impacts	Construction/ Operation	Management and mitigation measures	Likelihood	Consequence	Residual risk
The assessment reviewed the sustainability of the project and concluded that the project is consistent with the principles of ecologically sustainable development, In order to ensure the principles of ecologically sustainable development are incorporated into the project, a Sustainability Management Plan will be prepared and include measures such as governance structures, processes and systems that ensure integration of all sustainability considerations (vision, commitments, principles, objectives and targets), initiatives, monitoring and reporting during the detailed design and construction phases of the project. With the proposed Sustainability Management Plan in place there is a low residual risk of the principles of ecologically sustainable development not being implemented across all elements of the project.					

28.4 Risk analysis outcomes

28.4.1 Medium residual risk

A number of medium level residual risks have been identified in this residual risk assessment. Through the detailed design of the project there is further opportunity to:

- Resolve impacts through detailed design refinement
- Develop effective construction methodologies and planning with the construction contractor to ensure that management and mitigation measures are effectively implemented
- Implement a process of review, correction and audit for the CEMP and OEMP as detailed in **Chapter 29** (Summary of environmental management measures). This is a process of continuous improvement that will form part of the CEMP and OEMP and allow for management measures to be updated or improved during construction and operational phases where practical.

Following the implementation of the above, medium residual risk level items would be further reviewed during the detailed design development and where necessary additional measures implemented to ensure these risks are suitably mitigated.

28.4.2 Low residual risk

Other impacts identified as having a low residual risk are considered to have already been managed to a reasonable and feasible level. Regardless of the low risk rating, the same level of review, correction and continual improvement would be applied to the measures identified to address these impacts as will be detailed in the CEMP and OEMP.

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29 Summary of environmental management measures

This chapter collates the environmental management measures for the M4-M5 Link (the project) that were identified through the impact assessment process, as described in **Chapter 8** through to **Chapter 28**.

The environmental management measures outlined in this environmental impact statement (EIS) would be incorporated into the detailed design, construction and operation phases of the project and are consistent with the NSW Roads and Maritime Services (Roads and Maritime) principles for managing impacts associated with the WestConnex program of works, which include:

- Manage in-tunnel air quality so as to meet community expectations and NSW Environment Protection Authority (NSW EPA) standards
- Manage tunnel ventilation emissions to ensure local air quality meets NSW EPA standards
- Maintain regional air quality
- Minimise adverse air quality and noise impacts at a local level
- Manage noise in accordance with the NSW Road Noise Policy and realise opportunities to reduce or mitigate noise impacts
- Minimise construction and operational energy use
- Provide for improvements to social and visual amenity
- Minimise impacts on natural systems including biodiversity
- Minimise impact on Aboriginal and non-Aboriginal cultural heritage
- Minimise impacts on surface and groundwater sources and water quality including management of contaminated areas
- Reduce susceptibility to, and minimise the impacts of, flooding
- Integrate sustainability considerations throughout the design, construction and operation of the project, including achieving an “excellent” rating for each component WestConnex project when applying the Infrastructure Sustainability Council of Australia (ISCA) Sustainability Rating tool scorecard.

The implementation of environmental management measures during the design, construction and operation of the project would minimise any potential adverse impacts arising from the proposed works on the surrounding environment.

Construction environmental management measures would be captured in a Construction Environmental Management Plan (CEMP) and associated sub-plans as well as in standalone construction management plans and strategies for the project. Operational environmental management measures would be captured in an Operation Environmental Management Plan (OEMP) or Environment Management System (EMS) for the project. The environmental management plan framework for the project is shown in **Figure 29-1**.

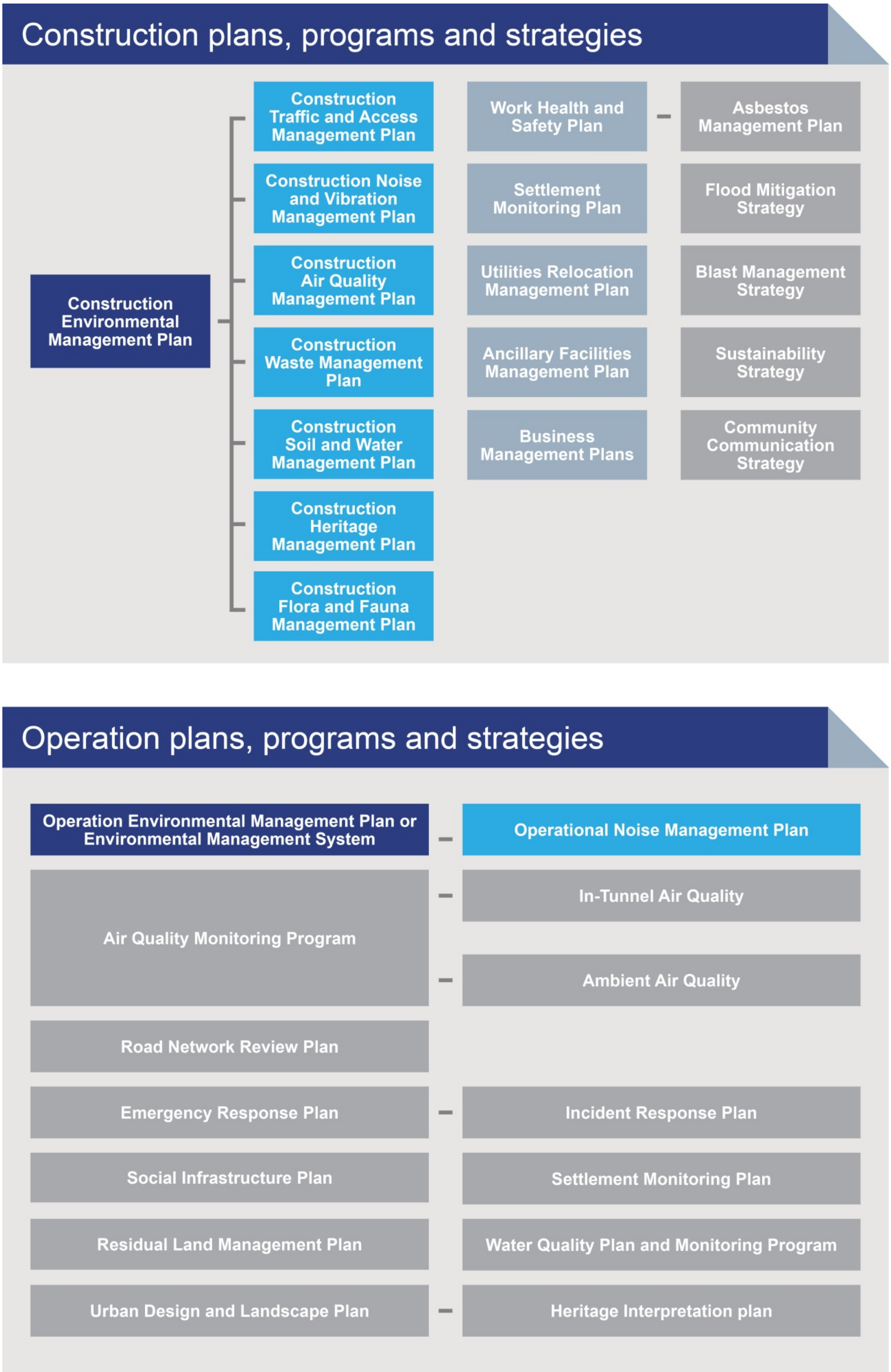

Figure 29-1 Environmental management plan framework for the project

Environmental management measures applicable to the project are summarised in **Table 29-1**. The responsibility for implementation of the management measures would be assigned to the following parties:

- Detailed design team
- Construction contractor
- Environmental representative
- Sydney Motorway Corporation (SMC)
- Roads and Maritime
- Others (as required).

The indicative timing for the implementation of the management measure refers to the following project stages:

- Construction (including detailed design and 'pre-construction' activities)
- Operation.

Table 29-1 Summary of safeguards and management measures

Impact	Ref #	Environmental management measure	
Traffic and transport			
Delays and disruptions to the road network during construction	TT01	A Construction Traffic and Access Management Plan (CTAMP) will be prepared as part of the CEMP. The CTAMP will include the guidelines, general requirements and principles of traffic management to be implemented during construction. It will be prepared in accordance with *Austroads Guide to Road Design* (with appropriate Roads and Maritime supplements), the RTA Traffic Control at Work Sites Manual and AS1742.3: Manual of uniform traffic control devices – Part 3: Traffic control for works on roads, and any other relevant standard, guide or manual. The overarching strategy of the CTAMP will be to: • Ensure all stakeholders are considered during all stages of the project • Provide safe routes for pedestrians and cyclists during construction • Design the permanent works and develop construction methodologies so that interaction with existing road users is minimised thereby creating a safer work and road user environment • Plan and stage works to minimise the need for road occupancy, where possible • Develop project staging plans in consultation with relevant traffic and transport stakeholders • Minimise the number of changes to the road users' travel paths and, where changes are required, implement a high standard of traffic controls which effectively warn, inform and guide. This will minimise confusion by providing clear and concise traffic management schemes • Comprehensively communicate changes to roads or paths to emergency services, public transport operators, other road user groups and any other affected stakeholders • Identify measures to manage the movements of construction-related traffic to minimise traffic and access disruptions in the public road network • Propose a car parking strategy for construction staff at the various worksites, in consultation with local councils and stakeholders associated with any facilities adjacent to the project site. This will include the promotion of public transport and carpooling to reduce worksite-related vehicle movements. The strategy will be developed to limit impacts on the surrounding communities and will include the parking management measures that will be implemented on adjacent local streets. The strategy will also be developed in consultation with the M4 East and New M5 contractors to identify opportunities to use existing parking arrangements associated with those projects during their respective construction periods and once those periods are completed.	Construction
Delays and disruptions to the road network during construction	TT02	Identify potential road user delays during the planning and consultation phases.	Construction

Impact	Ref #	Environmental management measure	
Impacts on road network performance (delays) and safety	TT03	Develop construction staging and temporary works that minimises conflicts with the existing road network and maximises spatial separation between work areas and travel lanes.	Construction
Parking on local streets around construction sites	TT04	Investigate potential offsite areas that could be used for construction workforce parking, including government owned land and other potential areas near to the construction ancillary facilities, and secure them for use during construction where required and possible.	Construction
Impacts on road network performance (delays) and safety	TT05	Isolate work areas from general traffic.	Construction
Impacts on road network performance (delays) and safety	TT06	Develop alternative work methods to minimise delays and road user impacts, for example utilising more efficient plant and equipment, and applying different design solutions.	Construction
Impacts on road network performance (delays) and safety	TT07	Provide temporary closed-circuit television (CCTV) and Variable Message Signs (VMS) to link with the existing Transport Management Centre (TMC) network to facilitate monitoring and management of impacts and traffic safety.	Construction
Impacts on road network performance (delays) and safety	TT08	During construction, work with the TMC to observe traffic flows and incidents from CCTV footage and modify sites and activities where possible to address any identified issues.	Construction
Impacts on road network performance (delays) and safety	TT09	Provide a mechanism for the community to report incidents and delays, for example a project phone number. Advertise details along the construction site's interface with the road network.	Construction
Impacts on road network performance (delays) and safety	TT10	Schedule construction-related transport movements to avoid peak traffic periods and adversely affecting congestion, where possible.	Construction
Impacts on road network performance (delays) and safety	TT11	Develop and adopt robust community and stakeholder communication protocols regarding altered traffic conditions.	Construction
Impacts on pedestrian and cycle paths	TT12	Minimise impacts on the pedestrian paths and cycle lanes, and provide timely alternatives during construction where practical and safe to do so.	Construction
Impacts on public transport	TT13	Identify impacts on bus stops and provide alternative locations and access in consultation with Transport for NSW.	Construction
Impact on property access	TT14	Manage local road closures and maintain adequate property access. This will be undertaken in consultation with Roads and Maritime, local councils and property owners likely to be impacted.	Construction

Impact	Ref #	Environmental management measure	
Impacts on road network from spoil transport	TT15	Identify haulage routes and communicate, along with site access requirements and restrictions, to all relevant drivers.	Construction
Impacts on road network from spoil transport	TT16	Identify potential truck marshalling areas and use where possible, to minimise potential queueing and traffic and access disruptions in the local area.	Construction
Impacts on receivers from spoil transport during night time periods	TT17	Monitor heavy vehicle movements to and from sites to ensure compliance with road traffic noise criteria at night.	Construction
Impacts on road infrastructure	TT18	Prepare a road dilapidation report, in consultation with relevant councils and road owners, identifying existing conditions of local roads and mechanisms to repair damage to the road network caused by heavy vehicle movements associated with the project.	Construction
Road network performance constraints	OpTT1	A review of operational network performance will be undertaken 12 months and five years from the opening of the project to confirm the operational impacts of the project on surrounding arterial roads and major intersections in proximity to the Wattle Street interchange, Rozelle interchange and St Peters interchange. The assessment will be based on updated traffic surveys at the time and the methodology used will be comparable with that used in this assessment.	Operation
Road network performance constraints	OpTT2	To manage potential performance constraints at the Wattle Street interchange, Roads and Maritime will investigate the implementation of the following in consultation with local councils: • Queuing and capacity monitoring and management on the Frederick Street/Milton Street corridor • Managing lane use and utilisation to improve the operation of the corridor.	Operation
	OpTT3	Roads and Maritime will develop a strategy to ensure appropriate network integration in the areas surrounding the Rozelle interchange. The strategy will include a review of: • Capacity improvement measures • Project staging options • Demand management measures.	Operation
Air Quality			
Impacts on ambient air quality from dust generation and deposition during construction	AQ1	A Construction Air Quality Management Plan will be developed and implemented to monitor and manage potential air quality impacts associated with the construction for the project. The Plan will be implemented for the duration of construction.	Construction
	AQ2	Regular communication to be carried out with sites in close proximity to ensure that measures are in place to manage cumulative dust impacts.	Construction
	AQ3	Regular site inspections will be conducted to monitor for potential dust issues. The site inspection, and issues arising, will be recorded.	Construction

Impact	Ref #	Environmental management measure	
	AQ4	Construction activities with the potential to generate dust will be modified or ceased during unfavourable weather conditions to reduce the potential for dust generation.	Construction
	AQ5	Measures to reduce potential dust generation, such as the use of water carts, sprinklers, dust screens and surface treatments, will be implemented within project sites as required.	Construction
	AQ6	Unsealed access roads within project sites will be maintained and managed to reduce dust generation.	Construction
	AQ7	Where reasonable and feasible, appropriate control methods will be implemented to minimise dust emissions from the project site.	Construction
	AQ8	Storage of materials that have the potential to result in dust generation will be minimised within project sites at all times.	Construction
	AQ9	All construction vehicles and plant will be inspected regularly and maintained to ensure that they comply with relevant emission standards.	Construction
	AQ10	Engine idling will be minimised when plant is stationary, and plant will be switched off when not in use to reduce emissions.	Construction
	AQ11	The use of mains electricity will be favoured over diesel or petrol-powered generators where practicable to reduce site emissions.	Construction
	AQ12	Haul roads will be treated with water carts and monitored during earthworks operations, ceasing works if necessary during high winds where dust controls are not effective.	Construction
	AQ13	Suitable dust suppression and/or collection techniques will be used during cutting, grinding or sawing activities likely to generate dust in close proximity to sensitive receivers.	Construction
	AQ14	The potential for dust generation will be considered during the handling of loose materials. Equipment will be selected and handling protocols developed to minimise the potential for dust generation.	Construction
	AQ15	All vehicles loads will be covered to prevent escape of loose materials during transport.	Construction
	AQ16	Demolition activities will be planned and carried out to minimise the potential for dust generation.	Construction
	AQ17	Adequate dust suppression will be applied during all demolition works required to facilitate the project.	Construction
	AQ18	All potentially hazardous material will be identified and removed from buildings in an appropriate manner prior to the commencement of demolition.	Construction
	AQ19	Areas of soil exposed during construction will be minimised at all times to reduce the potential for dust generation.	Construction
	AQ20	Exposed soils will be temporarily stabilised during weather conditions conducive to dust generation and prior to extended periods of inactivity to prevent dust generation.	Construction

Impact	Ref #	Environmental management measure	
	AQ21	Exposed soils will be permanently stabilised as soon as practicable following disturbance to minimise the potential for ongoing dust generation.	Construction
	AQ22	Ensure sand and other aggregates are stored in bunded areas and are not allowed to dry out, unless this is required for a particular process, in which case ensure that appropriate additional control measures are in place.	Construction
	AQ23	Ensure fine materials are stored and handled to minimise dust.	Construction
	AQ24	Deposits of loose materials will be regularly removed from sealed surfaces within and adjacent to project sites to reduce dust generation.	Construction
	AQ25	During establishment of project ancillary facilities, controls such as wheel washing systems and rumble grids will be installed at site exits to prevent deposition of loose material on sealed surfaces outside project sites to reduce potential dust generation.	Construction
Impacts to air quality within project tunnels during operation	AQ26	Tunnel infrastructure will be designed in such a way that the generation of pollutant emissions by the traffic using the tunnel is minimised. The main considerations are minimising gradients and ensuring that lane capacity remains constant or increases from entry to exit point.	Construction
	AQ27	An in-tunnel air quality monitoring system will be included in the detailed design. The system will monitor oxides of nitrogen, nitrogen dioxide, carbon monoxide and visibility (as a minimum) throughout the tunnel. Monitoring of each pollutant will be undertaken throughout the tunnel. The locations of monitoring equipment will generally be at the beginning and end of each ventilation section. This will include, for example, monitors at each entry ramp, exit ramp, merge point and ventilation exhaust and supply point. The location of monitors will be governed by the need to meet the in-tunnel air quality criteria for all possible journeys through the tunnel system, especially for nitrogen dioxide. This will require sufficient, appropriately placed monitors to calculate a journey average.	Construction
	AQ28	Velocity monitors will be placed in each tunnel ventilation section and at portal entry and exit points. The specific location of velocity monitors will be subject to the detailed design of the project. The velocity monitors in combination with the air quality monitors will be used to modulate the ventilation within the tunnel to manage air quality and to ensure net air inflow at all tunnel portals.	Construction

Impact	Ref #	Environmental management measure	
Noise and vibration			
Impacts from the generation of noise and vibration	NV1	A suitably qualified and experienced acoustics advisor, who is independent of the design and construction personnel, will be engaged for the duration of construction of the project. The acoustics advisor will be responsible for: • Reviewing management plans related to noise and vibration and endorsing that they address all relevant conditions of approval and requirements of all applicable guidelines • Providing advice to the Proponent, the construction contractor(s) and the Secretary regarding the management of potential noise and vibration impacts associated with the project and compliance with relevant conditions of approval.	Construction
	NV2	A Construction Noise and Vibration Management Plan (CNVMP) will be prepared for the project. The plan will: • Identify relevant performance criteria in relation to noise and vibration • Identify noise and vibration sensitive receivers and features in the vicinity of the project • Include standard and additional mitigation measures from the *Construction Noise and Vibration Guideline* (CNVG) (Roads and Maritime 2016) and details about when each will be applied • Describe the process(es) that will be adopted for carrying out location and activity specific noise and vibration impact assessments to assist with the selection of appropriate mitigation measures • Include protocols that will be adopted to manage works required outside standard construction hours in accordance with relevant guidelines • Detail monitoring that will be carried out to confirm project performance in relation to noise and vibration performance criteria. The CNVMP will be implemented for the duration of construction of the project.	Construction
	NV3	Detailed noise assessments will be carried out for all ancillary facilities required for construction of the project. The assessment will consider the proposed site layouts and noise generating activities that will occur at the facilities and assess predicted noise levels against the relevant noise management levels determined in accordance with the requirements of the *Interim Construction Noise Guideline* (ICNG) (NSW Department of Environment and Climate Change NSW (DECC) 2009). The assessments will be used to determine the appropriate heights and configurations of noise barriers, and other appropriate noise management measures, consistent with the requirements of the ICNG and the CNVG. Noise barriers, as confirmed through the noise assessments, will be installed as early as possible during site establishment and as a minimum prior to the commencement of excavation associated with tunnel access.	Construction

Impact	Ref #	Environmental management measure	
	NV4	Location and activity specific noise and vibration impact assessments will be carried out prior to (as a minimum) activities: • With the potential to result in noise levels above 75 dBA at any receiver • Required outside standard construction hours likely to result in noise levels greater than the relevant noise management levels • With the potential to exceed relevant performance criteria for vibration. The assessments will clarify predicted impacts at relevant receivers in the vicinity of the activities to assist with the selection of appropriate management measures, consistent with the requirements of ICNG and CNVG that will be implemented during the works.	Construction
Out-of-hours impacts	NV5	An out-of-hours works protocol will be developed for the construction of the project. The protocol will include: • Details of works required outside standard construction hours, including justification of why the activities are required outside standard construction hours • Measures that will be implemented to manage potential impacts associated with works outside standard construction hours • Location and activity specific noise and vibration impact assessment process(es) that will be followed to identify potentially affected receivers, clarify potential impacts and select appropriate management measures • Details of the approval process (internal and external) for works proposed outside standard construction hours. The protocol will be prepared in consultation with NSW Department of Planning and Environment and the NSW EPA, endorsed by the acoustic advisor for the project and implemented during construction of the project.	Construction
Noise monitoring	NV6	Monitoring will be carried out at the commencement of new noise and vibration intensive activities and works in new locations to confirm that actual noise and vibration levels are consistent with noise and vibration impact predictions and that the management measures that have been implemented are appropriate.	Construction
Acoustic sheds	NV7	Acoustic sheds will be designed within consideration of the activities that will occur within them and the relevant noise management levels in adjacent areas. Monitoring will be carried out to confirm that the actual acoustic performance of the sheds is consistent with predicted acoustic performance.	Construction

Impact	Ref #	Environmental management measure	
Blast Management Strategy	NV8	A Blast Management Strategy will be prepared and implemented for the project if blasting is proposed. The strategy will: • Identify relevant performance criteria in relation to potential noise and vibration impacts due to blasting with reference to (as a minimum) *Technical Basis for Guidelines to Minimise Annoyance Due to Blasting Overpressure and Ground Vibration* (Australian and New Zealand Environment Conservation Council (ANZECC), 1990) and Australian Standard AS 2187.2-2006 Explosives - Storage, transport and use, Part 2: Use of explosives • Describe trials that will be carried out to confirm vibration levels from blasting and facilitate development of predictive tools to allow potential noise and vibration impacts to be identified • Include details of management measures that will be implemented to ensure compliance with relevant performance criteria. The Blast Management Strategy will be implemented for all blasting carried out as part of the project.	Construction
Operational noise impacts	NV9	Receivers that qualify for assessment for at receiver treatment in relation to operational noise that are also predicted to experience significant exceedances of noise management levels due to construction will be given priority preference for assessment. When at receiver treatments are found to be appropriate, the application of the treatment will be expedited.	Construction
	NV10	Where reasonable and feasible, operational noise mitigation such as noise barriers, berms and at-property treatments identified during detailed design should be installed early in the project so as to provide a benefit to receivers during the construction phase of the project.	Construction
Road traffic noise	NV11	The use of low noise pavement to further reduce road traffic noise at the source will be investigated during detailed design taking into account whole life engineering considerations and the overall social, economic and environmental effects. If low noise pavement is found to be appropriate, it will be considered as a management measure when assessing operation noise impacts based on the detailed design.	Construction
	NV12	The area in the vicinity of the western portal of the Iron Cove Link, Rozelle, will be assessed further during development of the detailed design to identify appropriate noise mitigation measures to address predicted increases in road traffic noise to the project. The measures that will be considered will include low road noise pavement, noise barriers, at-property treatments and the project design.	Construction
Operational noise performance	NV13	Potential operational noise performance of the project based on the detailed design will be assessed and appropriate management measures will be confirmed and implemented.	Construction
	NV14	Within 12 months of the commencement of the operation of the project, actual operational noise performance will be compared to predicted operational noise performance. The need for any additional management measures to address any identified operational performance issues and meet relevant operational noise criteria will be assessed and implemented where reasonable and feasible.	Operation

Impact	Ref #	Environmental management measure	
Human health			
		Management measures to minimise impacts on human health during construction and operation of the project are provided in the following sections of this table: • Traffic and transport • Air quality • Noise and vibration • Land use and property • Social and economic.	
Land use and property			
Acquisition of property required for the project	PL1	Land acquisition for the project will be undertaken in accordance with the *Land Acquisition (Just Terms Compensation) Act 1991* (NSW) and the *Roads and Maritime Services Land Acquisition Information Guide* (Roads and Maritime 2014) and the land acquisition reforms announced by the NSW Government in 2016.	Construction
Impacts on property access	PL2	The requirement for temporary changes to property access will be minimised during development of the detailed construction methodology. Affected landowners will be consulted when temporary, short-term changes to access to their property will occur. This will include advanced notification of relevant project schedules, construction works and changes to access arrangements.	Construction
Uncertain future land use	PL3	A Residual Land Management Plan will be prepared in consultation with relevant local councils and other key stakeholders. The plan will: • Identify and illustrate all remaining project land following construction of the project, including the physical location, land use characteristics, size and adjacent land uses • Identify feasible uses for remaining project land including justification for the selected use • Identify timeframes for implementation of the actions in relation to the identified feasible uses.	Construction

Impact	Ref #	Environmental management measure	
Overshadowing of residential properties	PL4	Existing residential properties (and approved residential developments) that are affected by overshadowing from the final detailed design of the project (including any noise mitigation measures) are to receive a minimum of three hours of direct sunlight in habitable rooms and in at least 50 per cent of the principal private open space area between 9.00 am and 3.00 pm on 21 June. Such properties must be identified for further consideration by the Proponent in a Solar Access and Overshadowing Report which addresses compliance with these requirements: • Where existing residential development currently receives less than the required amount of solar access, existing access to sunlight during operation should not be unreasonably reduced • Where affected properties include dwellings held under strata or community title, these requirements must be interpreted in relation to individual units within those properties.	Construction
	PL5	Detailed design of the ventilation facility building at the Iron Cove Link motorway operations complex (MOC4) will include consideration of treatments to minimise overshadowing on properties south of Victoria Road. This may include reducing the height of the building and/or increasing building setbacks or recessing the building.	Construction

<table>
<tr><th>Impact</th><th>Ref #</th><th>Environmental management measure</th><th></th></tr>
<tr><td>Ground settlement</td><td>PL6</td><td>Ground settlement will be managed to comply with the following criteria where possible:
<table>
<tr><th>Beneath structure/facility</th><th>Maximum settlement</th><th>Maximum angular distortion</th><th>Limiting tensile strain (per cent)</th></tr>
<tr><td>Buildings – Low or non-sensitive properties
(ie less than or equal to two levels and carparks)</td><td>30 mm</td><td>1 in 350</td><td>0.1</td></tr>
<tr><td>Buildings – High or sensitive properties
(ie greater than or equal to 3 levels and carparks)</td><td>20 mm</td><td>1 in 500</td><td>0.1</td></tr>
<tr><td>Roads and parking areas</td><td>40 mm</td><td>1 in 250</td><td>N/A</td></tr>
<tr><td>Parks</td><td>50 mm</td><td>1 in 250</td><td>N/A</td></tr>
</table></td><td>Construction and operation</td></tr>
<tr><td></td><td>PL7</td><td>Further assessment of potential settlement impacts, including numerical modelling, will be undertaken during detailed design. In areas where ground movement in excess of settlement criteria are predicted, feasible and reasonable measures will be investigated and implemented to ensure predicted settlement is within the criteria. Measures that will be considered may include (but are not limited to):

Review of the proposed tunnel design including:

the depth and alignment of tunnels
the proximity of multiple tunnels to each other
the proposed tunnel support system
the tunnel lining to manage groundwater inflows

Rationalising the layout of the proposed ventilation tunnels including the number, location and length of tunnels
Review of the proposed construction methodology
Consideration of ground improvement options.
</td><td>Construction</td></tr>
<tr><td></td><td>PL8</td><td>A Settlement Monitoring Plan will be prepared that will provide details on:

Settlement criteria and predictions
Location of monitoring points
Duration of monitoring
Data collection and review
Triggers and corrective actions.
</td><td>Construction</td></tr>
</table>

Impact	Ref #	Environmental management measure	
	PL9	Settlement monitoring will be carried out in accordance with the Settlement Monitoring Plan for the period starting prior to commencement of tunnel construction through to until all settlement has stabilised following completion of tunnel construction. The results of settlement monitoring will be compared to predicted settlement. Where actual settlement is greater than predicted settlement, the assessment and the proposed measures to reduce settlement will be reviewed. The revised measures will be implemented to ensure that settlement does not exceed the criteria.	Construction
	PL10	Building condition surveys will be offered to property owners within the zone of influence of tunnel settlement (within 50 metres from the edges of the tunnels and ramps). In the event that damage occurs to a property as a result of the construction of the project, the damage will be appropriately rectified.	Construction
	PL11	An Independent Property Impact Assessment Panel, comprising geotechnical and engineering experts, will be established prior to the commencement of works with the potential to result in ground movement and settlement. The panel will be responsible for: • Independently verifying building condition survey reports • Resolving any property damage disputes • Establishing on-going settlement monitoring requirements.	Construction
	PL12	Interface agreements will be entered into with the owners of infrastructure and utility services likely to be impacted by construction of the project. The agreements will likely identify: • Minimum separation distances and appropriate settlement criteria for utility infrastructure • Settlement monitoring requirements during construction • Contingency actions in the event that settlement limits are exceeded.	Construction
Urban design and visual amenity			
Urban design of project infrastructure	UD1	Prepare Urban Design and Landscape Plans (UDLPs) for operational project infrastructure including final landscape works and architectural design in consultation with relevant councils, stakeholders and the community.	Construction
Potential for crime at or near construction ancillary facilities	UD2	Specific design measures at construction ancillary facilities will be identified and implemented to prevent crime, based on principles of Crime Prevention Through Environmental Design (CPTED).	Construction
Potential for crime at or near operational infrastructure (CPTED)	UD3	Specific design measures at surface operational infrastructure will be identified and implemented to prevent crime, based on principles of CPTED.	Construction
Disorientation while navigating project operational infrastructure	UD4	As part of the project UDLPs, wayfinding for the project will be developed and installed in accordance with relevant Roads and Maritime endorsed guidelines.	Construction

Impact	Ref #	Environmental management measure	
General impacts to landscape and visual amenity	LV1	Ancillary facilities, including the locations of visible structures and plant and perimeter fencing and treatments, will be developed to minimise visual impacts for adjacent receivers where feasible and reasonable.	Construction
	LV2	Site lighting will be designed to minimise glare issues and light spillage in adjoining properties and will be generally consistent with the requirements of Australian Standard 4282-1997 Control of the obtrusive effects of outdoor lighting.	Construction
	LV3	Regular maintenance of site hoarding and perimeter site areas should be undertaken, including the prompt removal of graffiti.	Construction
	LV4	Construction worksites and construction ancillary facilities will be established to minimise the need to remove screening vegetation wherever practicable.	Construction
	LV5	Hoardings and temporary noise walls will be erected as early as possible within the site establishment phase to provide visual screening.	Construction
	LV6	Acoustic sheds will be designed to be visually recessive and minimise potential overshadowing impacts where possible.	Construction
	LV7	Where necessary, construction lighting will comply with the requirements of the Civil Aviation Safety Authority (CASA) and Sydney Airport at all times.	Construction
	LV8	Visible elements of operational facilities will be designed to satisfy functional requirements and adopt the design principles detailed in the M4-M5 Link Urban Design Report. The proposed designs will be documented in the UDLP for the project.	Construction
	LV9	The slopes of vegetated batters that form part of the final urban design and landscaping solution will be limited to no more than 1:4 where possible in order to maximise the impact of vegetation on these batters and minimise maintenance.	Construction
	LV10	Where construction ancillary facilities are located in close proximity to sensitive residential receivers such as residents and users of recreational space, high quality fencing suitable for parks and public spaces should be considered.	Construction
Impacts to visual amenity as a result of the Darley Road motorway operations complex	LV11	Investigate options for planting of vegetation to screen residents on the southern side of Darley Road from the Darley Road motorway operations complex. Include feasible and reasonable measures in the relevant UDLP.	Construction
	LV12	Architectural design and detailing of the water treatment facility, substation and front fencing should achieve articulation, visual interest, and integrate with the streetscape.	Construction
Impacts to visual amenity at the Rozelle interchange	LV13	Integrate the new open space at Rozelle with the Lilyfield Road streetscape through considered street tree planting and associated landscape works.	Construction

Impact	Ref #	Environmental management measure	
	LV14	Implement urban design and landscape measures that allow permeable views between the City West Link carriageway and the new open space to provide a sense of openness and connection with the open space for motorists and the community.	Construction
	LV15	Investigate measures to minimise view impacts of the project to sensitive residential receptors in the vicinity of the Rozelle Rail Yards as described in this assessment and include in the UDLP where reasonable and feasible.	Construction
	LV16	Develop a design that aims to incorporate the ventilation outlets at the Rozelle Rail Yards as an integral component of the larger open space composition, with reference and consideration to the Ventilation Facility Design Review (Annexure 2 of **Appendix L** (Technical working paper: Urban design)).	Construction
	LV17	Consult with UrbanGrowth NSW regarding the interface between the project footprint and the White Bay Power Station precinct. Design the interface to ensure compatibility between the two areas from a landscaping, visual, heritage and active transport connectivity perspective.	Construction
	LV18	Investigate measures to retain the mature trees of high retention value adjacent to the light rail corridor at the corner of The Crescent and City West Link, or provide screen planting alongside the retaining wall edge of the light rail corridor, to minimise landscape and visual impacts.	Construction
Impacts to visual amenity at Iron Cove Link	LV19	Investigate vegetative and other screening measures along Victoria Road to improve the visual amenity of the streetscape and reduce impacts associated with the ventilation outlet and increased glare from the portals to residential dwellings to the north of Victoria Road.	Construction
	LV20	Provide a well-articulated, integrated car parking and landscape design for the bioretention facility in Manning Street that is place sensitive, and enhances the interface between the project and both King George Park and adjacent residences.	Construction
Impacts to visual amenity at St Peters interchange	LV21	The UDLP for the area adjoining Campbell Road motorway operations complex is to be consistent with the New M5 UDLP at St Peters.	Construction
Visual amenity impacts associated with design of ventilation outlets at Rozelle, Iron Cove Link and St Peters	LV22	Investigate measures during detailed design to reduce the height, bulk, scale and enhance the landscape setting of the ventilation outlets, subject to achieving desired ventilation outcomes, and in accordance with the design principles detailed in the M4-M5 Link Urban Design Report.	Construction

Impact	Ref #	Environmental management measure	
Social and economic			
Impacts on businesses	SE1	A Business Management Plan will be prepared and will include: • Identification of businesses that have the potential to be adversely affected by construction activities that will occur as part of the project • Management measures that will be implemented to maintain appropriate vehicular and pedestrian access during business hours and visibility of the business to potential customers during construction, including alternative arrangements for times when access and visibility cannot be maintained. These will be determined in consultation with the owners of the identified businesses.	Construction
Changes to community access and connectivity	SE2	A Community Communication Strategy will be prepared that details: • Procedures and mechanisms that will be implemented in response to the key social impacts identified for the project • Property acquisition support services that will be provided • Procedures and mechanisms to communicate to project stakeholders (including affected communities), the access and connectivity enhancements and new community and social facilities that will be delivered as part of the project through the Social Infrastructure Plan and to update stakeholders on delivery progress • Procedures and mechanisms that will be used to engage with affected business owners to identify potential access, parking, business visibility and other impacts to develop measures to address potential impacts on a case by case basis.	Construction
Property acquisition	SE3	Property acquisition will continue to be undertaken in accordance with the *Roads and Maritime Services Land Acquisition Information Guide* (Roads and Maritime 2014), the *Land Acquisition (Just Terms Compensation) Act 1991* (NSW) and the land acquisition reforms announced by the NSW Government in 2016 (NSW Government 2016). A property acquisition factsheet that outlines the process and provides further information for concerned residents will continue to be made available online and in hard copy at project information centres.	Construction
	SE4	Affected households will continue to have access to a counselling service that assists people through the property acquisition process.	Construction
	SE5	An independent service will continue to be provided to vulnerable households (eg elderly, those suffering an illness) to assist with relocation. Assistance could include finding a suitable house for relocation, arranging removalists, disconnecting services and attending appointments with solicitors or other representatives.	Construction
	SE6	A community relations support toll-free telephone line will be operated to respond to any community concerns or requests for translation services.	Construction

Impact	Ref #	Environmental management measure	
Impacts on social infrastructure and facilities	OSE8	A Social Infrastructure Plan will be prepared that details: • Measures that will be delivered as part of the project to improve community connectivity in areas affected by the project, including pedestrian and cyclist access • Community and social facilities, for example open space, that will be delivered or enhanced as part of the project • Community initiatives and programs that will receive support as part of the project, including the manner in which support will be provided. The Social Infrastructure Plan will be prepared by a suitably qualified and experienced person in consultation with the community and relevant councils and implemented as part of the project.	Construction and operation
Soil and water quality			
Impacts on surface water quality	SW01	A Construction Soil and Water Management Plan (CSWMP) will be prepared for the project. The plan will include the measures that will be implemented to manage and monitor potential surface water quality impacts during construction. The CSWMP will be developed in accordance with the principles and requirements in *Managing Urban Stormwater – Soils and Construction, Volume 1* (Landcom 2004) and Volume 2D (NSW Department of Environment, Climate Change and Water 2008), commonly referred to as the 'Blue Book'.	Construction
	SW02	A program to monitor potential surface water quality impacts due to the project will be developed and included in the CSWMP. The program will include the water quality monitoring parameters and the monitoring locations identified in Annexure E of **Appendix Q** (Technical working paper: Surface water and flooding) to the EIS where appropriate. The monitoring program will commence prior to any ground disturbance to establish appropriate baseline conditions and continue for the duration of construction, as well as for a minimum of three years following the completion of construction or until the affected waterways are certified by a suitably qualified and experienced independent expert as being rehabilitated to an acceptable condition (or as otherwise required by any project conditions of approval). Further details to be included in the program are outlined in **Appendix Q** (Technical working paper: Surface water and flooding).	Construction
Sedimentation of waterways	SW03	Erosion and Sediment Control Plans (ESCPs) will be prepared for all work sites in accordance with the Blue Book. ESCPs will be implemented in advance of site disturbance and will be updated as required as the work progresses and the sites change.	Construction
	SW04	A soil conservation specialist will be engaged for the duration of construction to provide advice regarding erosion and sediment control.	Construction
	SW05	The extent of ground disturbance and exposed soil will be minimised to the greatest extent practicable to minimise the potential for erosion.	Construction
	SW06	Disturbed ground and exposed soils will be temporarily stabilised prior to extended periods of site inactivity to minimise the potential for erosion.	Construction

Impact	Ref #	Environmental management measure	
	SW07	Disturbed ground and exposed soils will be permanently stabilised and proposed landscaped areas will be suitably profiled and vegetated as soon as possible following disturbance to minimise the potential erosion.	Construction
Impacts on the form and aquatic habitat of Whites Creek	SW08	The proposed bridge crossing over and widening of Whites Creek, including all associated temporary and permanent infrastructure, will be designed and constructed in a manner consistent with: • *Controlled Activities on Waterfront Land, Guidelines for watercourse crossings on waterfront land* (NSW Department of Primary Industries (DPI) 2012) • *Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings* (Fairfull and Witheridge 2003) • *Policy and Guidelines for Fish Friendly Waterway Crossings* (NSW Fisheries February 2004) • *Policy and Guidelines for Fish Habitat Conservation and Management Update 2013* (DPI-Fisheries 2013). Appropriate fish passage will be provided for crossings of fish habitat streams.	Construction
	SW09	Consultation will be undertaken with Sydney Water regarding the timing of the works at Whites Creek and compatibility of the proposed design and Sydney Water's naturalisation works.	Construction
Impacts on water quality from the discharge of treated wastewater	SW10	Temporary construction water treatment plants will be designed and managed so that treated water will be of suitable quality for discharge to the receiving environment. The level of treatment provided will consider the characteristics of the waterbody, any operational constraints or practicalities and associated environmental impacts and be developed in accordance with ANZECC (2000) and with consideration to the relevant NSW Water Quality Objectives (WQOs) and *Protection of the Environment Operations Act 1997* (NSW). An ANZECC (2000) species protection level of 90 per cent is considered appropriate for adoption as discharge criteria for toxicants where practical and feasible. The discharge criteria for the treatment facilities will be included in the CSWMP.	Construction
Impacts on water quality from disturbance of acid sulfate soils	SW11	Procedures, prepared in accordance with the requirements of the *Acid Sulfate Soil Manual* (Acid Sulfate Soil Management Advisory Committee 1998), will be included in the CSWMP and implemented in the event that acid sulfate soils, rocks or monosulfidic black oozes are encountered during construction of the project.	Construction
Impacts on surface water quality	OSW12	Stormwater from the project will be treated prior to discharge. Where space is available, bioretention systems or constructed wetlands will be installed. Where space is not available, other smaller devices, such as proprietary stormwater treatment devices, will be installed. The final design of treatments will be supported by MUSIC modelling and water sensitive urban design principles.	Construction and operation

Impact	Ref #	Environmental management measure	
	OSW13	Maintenance requirements for all stormwater treatment systems and devices installed as part of the project will be identified and included in relevant operational maintenance schedules/systems.	Construction and operation
	OSW14	Spill containment will be provided on the motorway. Spill management and emergency response procedures will be documented in the Operation Environmental Management Plan (OEMP) or Emergency Response Plan.	Construction and operation
	OSW15	The constructed wetland at the Rozelle interchange will be appropriately designed to cater for the continuous flow of treated groundwater from the water treatment plant and onsite stormwater flows.	Construction and operation
	OSW16	The operational water treatment facilities will be designed such that effluent will be of suitable quality for discharge to the receiving environment. Discharge criteria will be developed in accordance with the ANZECC (2000) and relevant NSW WQOs, including the following discharge criteria: • 0.3 milligrams per litre for iron • 1.8 milligrams per litre for manganese. The discharge criteria for the treatment facilities will be included in the OEMP.	Construction and operation
Sedimentation or scouring effects at discharge locations	OSW17	New discharge outlets will be designed with appropriate energy dissipation and scour protection measures as required to minimise the potential for sediment disturbance and resuspension in the receiving waters. Outlet design and energy dissipation/scour protection measures will be informed by drainage modelling.	Construction
	OSW18	Existing drainage outlets that will be subject to increased inflow from the project will be assessed. If necessary, energy dissipation or scour protection will be added to prevent sediment disturbance and resuspension in receiving waters.	Construction

Impact	Ref #	Environmental management measure	
Contamination			
Impacts on site workers and/or local community through disturbance and mobilisation of contaminated material	CM01	Potentially contaminated areas directly affected by the project will be investigated and managed in accordance with the requirements of guidance endorsed under section 105 of the *Contaminated Land Management Act 1997* (NSW) (CLM Act). This includes further investigations in areas of potential contamination identified in the project footprint. If contamination posing a risk to human or ecological receptors is identified, a Remediation Action Plan will be prepared.	Construction
	CM02	Asbestos handling and management will be undertaken in accordance with an Asbestos Management Plan (as part of the Work Health and Safety Plan) as described in **Chapter 23** (Resource use and waste minimisation).	Construction
	CM03	A hazardous materials assessment will be carried out prior to and during the demolition of buildings. Demolition works will be undertaken in accordance with the relevant Australian Standards and relevant NSW WorkCover Codes of Practice, including the Work Health and Safety Regulation 2011 (NSW).	Construction
	CM04	The Construction Waste Management Plan for the project, prepared as described in **Chapter 23** (Resource use and waste minimisation), will include procedures for handling and storing potentially contaminated substances.	Construction
	CM05	Stockpile management procedures will be implemented to control dust, odour and cross contamination.	Construction
	CM06	The discovery of previously unidentified contaminated material will be managed in accordance with an unexpected contaminated lands discovery procedure, as outlined in the *Guideline for the Management of Contamination* (Roads and Maritime 2013) and detailed in the CEMP. The procedure will include: • Cease work in the vicinity • Initial assessment by an appropriately qualified environmental consultant • Further assessment and management of contamination, if confirmed, in accordance with section 105 of the CLM Act.	Construction

Impact	Ref #	Environmental management measure	
Impacts on soil and water quality through incorrect handling of contaminated material	CM07	A Construction Soil and Water Management Plan will be prepared for the project including procedures to manage potentially contaminated stormwater runoff and acid sulfate soils, as described in **Chapter 15** (Soil and water quality).	Construction
	CM08	Measures identified in **Chapter 25** (Hazard and risk) will be implemented to appropriately store dangerous goods and reduce the potential for environmental contamination due to spills and leaks.	Construction
Accidental spills during operation	OpCM01	Procedures to address spills, leaks and tunnel washing will be developed as part of an OEMP and implemented during operation of the project.	Operation

Impact	Ref #	Environmental management measure	
Flooding and drainage			
Impacts on flood behaviour from construction and operation	FD01	A Flood Mitigation Strategy (FMS) will be prepared by a suitably qualified and experienced person in consultation with directly affected landowners, DPI-Water, NSW Office of Environment and Heritage (OEH), State Emergency Services (SES), Sydney Water and the relevant local councils. It will include but not be limited to: • Identification of flood risks to the project and adjoining areas, including consideration of local drainage catchment assessments and climate change implications on rainfall, drainage and tidal characteristics • Identification of design and mitigation measures to protect proposed operations and not worsen existing flooding characteristics during construction and operation, including soil erosion and scouring • Identification of drainage system upgrades • The 100 year annual recurrence interval (ARI) flood level will be adopted in the assessment of measures which are required to mitigate flood risk to the project, as well as any adverse impacts on surrounding property • Changes in flood behaviour under probable maximum flood (PMF) conditions will also be assessed in order to identify impacts on critical infrastructure and significant changes in flood hazards as a result of the project • Consideration of limiting flooding characteristics to the following levels: - A maximum increase in inundation time of one hour in a 100 year ARI rainfall event - No inundation of floor levels which are currently not inundated in a 100 year ARI rainfall event - A maximum increase of 10 mm in inundation at properties where floor levels are currently exceeded in a 100 year ARI rainfall event - A maximum increase of 50 mm in inundation at properties where floor levels will not be exceeded in a 100 year ARI rainfall event - Or else provide alternative flood mitigation solutions consistent with the intent of these limits - Consideration of the EIS documents.	Construction
	FD02	Hydrologic and hydraulic assessments will be carried out for all temporary project components (including ancillary facilities) and permanent design features that have the potential to affect flood levels in the vicinity of the project. The results of the assessment will inform the preparation of the Flood Mitigation Strategy (FD01) as well as the design development of temporary and permanent works.	Construction

Impact	Ref #	Environmental management measure	
	FD03	Measures developed to manage potential flood impacts, as identified in the Flood Mitigation Strategy, will be incorporated into the design of temporary and permanent project components and construction and operational management systems as relevant.	Construction
	FD04	All entries (portals) into the tunnels will be designed so that they are located above the peak level of the PMF or the 100 year ARI design flood plus 0.50 metres, whichever is greater. The same hydrological standard will be applied to tunnel ancillary facilities such as tunnel ventilation and emergency response facilities, electrical substations and water treatment plants where the ingress of floodwaters will also have the potential to flood the tunnels.	Construction
	FD05	Bridge crossings over existing waterways and proposed drainage channels will be designed for the underside of bridge structure to be above the peak 100 year ARI design flood level.	Construction
	FD06	The need to maintain flood conveyance will be factored into construction planning associated with the new bridge structure over Whites Creek.	Construction
	FD07	Parts of the site that will be adversely affected by floodwaters, such as tunnel dive shafts, portals and cut and cover sections, will be protected from floodwater ingress during construction. The flood level adopted for design of temporary protection will be informed by consideration of both mainstream and local overland flows, the potential risk to the environment, safety and the potential disruption and damage to project works.	Construction
	FD08	The Pyrmont Bridge Road tunnel site (C9) will be designed with consideration of and to appropriately manage the existing surface water flow path on Bignell Road.	Construction
	FD09	The permanent surface water conveyance solution within the Rozelle Rail Yards will be implemented as soon as possible.	Construction
	FD10	Flood contingency measures will be prepared and implemented where construction ancillary facilities and vulnerable temporary facilities (including fuel storages, water treatment plants and substations) are located in the 20 year ARI design flood extent.	Construction

Impact	Ref #	Environmental management measure	
Impacts on stormwater drainage systems	FD11	Further hydrological and hydraulic modelling based on the detailed design will be undertaken to determine the ability of the receiving drainage systems to effectively convey drainage discharges from the project once operational. The modelling must be undertaken in consultation with the relevant council(s). It will include, but not be limited to: • Confirming the location, size and capacity of all receiving drainage systems affected by the operation of the project • Assessing the potential impacts of drainage discharges from the project drainage systems on the receiving drainage systems • Identifying all feasible and reasonable mitigation measures to be implemented where drainage from the project is predicted to adversely impact on the receiving drainage systems.	Construction
	FD12	Where drainage systems are to be upgraded or replaced during the project, existing systems will be left in place and remain operational during the process wherever possible.	Construction
	FD13	Runoff generated from project construction and operational facilities will be managed to mitigate risk of overloading the receiving drainage system.	Construction
	FD14	Entry points to the stormwater used by or immediately downgradient from the project sites will be inspected regularly for blockages and cleaned as required to maintain performance.	Construction
Impacts on flood behaviour from future climate change	FD15	Hydrological and hydraulic assessments of the permanent design will consider the climate change related flood risk to the project and flood impacts from the project, and will confirm requirements for any management measures. The assessment will be undertaken in accordance with the *Practical Considerations of Climate Change – Floodplain Risk Management Guideline* (DECC 2007).	Construction

Impact	Ref #	Environmental management measure	
Impacts on property	FD16	Where peak levels in the 100 year ARI design flood are predicted to increase at any residential, commercial and/or industrial buildings due to construction or operation of the project, a floor level survey will be carried out. If the survey indicates flood impacts in excess of the limits set in FD01, further refinements will be made to the temporary or permanent designs as required to minimise impacts.	Construction
	FD17	A Flood Review Report will be prepared after the first defined flood event affecting the project works for any of the following flood magnitudes – the five year ARI event, 20 year ARI event and 100 year ARI event - to assess the actual flood impact against those predicted in the design reports or as otherwise altered by the FMS. The Flood Review Report(s) must be prepared by an appropriately qualified person(s) and include: • Identification of the properties and infrastructure affected by flooding during the reportable event • A comparison of the actual extent, level, velocity and duration of the flooding event against the impacts predicted in the design reports or as otherwise altered by the FMS • Where the actual extent and level of flooding exceeds the predicted level with the consequent effect of adversely impacting of property(ies), structures and infrastructure, identification of the measures to be implemented to reduce future impacts of flooding related to the M4-M5 Link project including the timing and responsibilities for implementation. Flood mitigation measures will be developed in consultation with the affected property, structure and/or infrastructure owners, OEH and the relevant council(s).	Construction and operation
Biodiversity			
Impact on biodiversity values	B1	A Construction Flora and Fauna Management Plan (CFFMP) will be developed and implemented during construction. The CFFMP will include the following: • Identification of guidelines relevant to construction, the matters they apply to and what is required to ensure compliance • Pre-disturbance inspection requirements to identify features of biodiversity conservation significance and select appropriate management measures and environmental controls • Management measures and environmental controls to be implemented before and during construction including: – An unexpected threatened species finds procedure – Section 3.3.2 Standard precautions and mitigation measures of the *Policy and Guidelines for Fish Habitat Conservation and Management Update 2013* (DPI-Fisheries 2013) – Tree assessment and management protocols consistent with AS 4970-2009 Protection of trees on development sites – Weed management protocols.	Construction

Impact	Ref #	Environmental management measure	
Disturbance of threatened microbats	B2	Prior to the commencement of any works associated with the modification of the Victoria Road bridge, an inspection will be carried out by a suitably qualified and experienced ecologist to confirm the presence of roosting microbats. If roosting microbats are identified, measures to manage potential impacts will be developed in consultation with an appropriate microbat expert and included in the CFFMP prior to the commencement of any work with the potential to disturb the roosting locations (as confirmed by the microbat expert). The plan will include management measures outlined in **Appendix S** (Technical paper: Biodiversity assessment report) and from any additional assessments carried out during detailed design and project delivery as relevant.	Construction
Aquatic impacts	B3	The proposed road bridge at Whites Creek will be designed with consideration of *Policy and Guidelines for Fish Habitat Conservation Update 2013* (DPI-Fisheries 2013) and *Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings* (NSW-Fisheries 2003).	Construction
	B4	Site-specific Erosion and Sediment Control Plans (ESCPs) will be prepared for each work location associated with or in the vicinity of waterways and culverts that will be modified as part of the project. The ESCPs will contain measures to stabilise all surfaces disturbed as a result of the project as soon as possible following the disturbance to prevent erosion and to minimise sedimentation in adjacent aquatic environments.	Construction
Loss of trees	B5	The CFFMP will include measures to manage potential impacts on trees. Measures will include: • The establishment of tree protection zones • Ground protection measures for trees to be retained.	Construction
	B6	As many trees as possible will be retained during construction. In the event that tree removal cannot be avoided, a tree replacement strategy will be prepared. Replacement trees will be included in the UDLP to be developed and implemented for the project.	Construction
	B7	The CFFMP will include tree management protocols and provision for the development of tree management plans (in accordance with the requirements of AS 4970-2009) where required for specific trees. Protection of trees on development sites will be carried out in consultation with an arborist with a minimum Australian Qualifications Framework (AQF) Level 5 qualification in arboriculture for each tree proposed for retention where works associated with the project have the potential to impact on the tree root zone.	Construction
	B8	Tree removal, pruning and maintenance work will be carried out by an arborist with a minimum AQF Level 3 qualification in accordance with AS 4373-2007 Pruning of Amenity Trees and the NSW WorkCover Code of Practice for the Amenity Tree Industry (1998) and advice provided by an arborist with a minimum AQF Level 5 qualification in arboriculture (or equivalent).	Construction

Impact	Ref #	Environmental management measure	
Loss of trees	OB9	A UDLP will be prepared and implemented to guide the compensatory planting for trees removed by the project. The plan will include: • A tree replacement strategy • Species recommendations for the landscape design to consider, including foraging trees for the Grey-headed Flying-fox • Relevant project specific rehabilitation and revegetation measures associated with the M4 East and New M5 projects, where there is an overlap in use of project footprint.	Operation
Loss of aquatic habitat	OB10	Consultation will be undertaken with Sydney Water regarding integration of naturalisation works at Whites Creek, including re-establishment of vegetation where possible following construction activities. Vegetation re-establishment will be undertaken in accordance with Guide 3: Re-establishment of native vegetation of the *Biodiversity Guidelines: Protecting and Management Biodiversity on RTA Projects* (NSW Roads and Traffic Authority 2011).	Operation
Groundwater			
High groundwater inflows in excess of the one litre per second per kilometre design criterion, which will cause significant groundwater inflows and groundwater drawdown	GW1	Groundwater inflows within the tunnels will be minimised by designing the final tunnel alignment to minimise intersections with known palaeochannels and alluvium present in the project footprint.	Construction
	GW2	Appropriate waterproofing measures will be identified and included in the detailed design to permanently reduce the inflow into the tunnels to below one litre per second per kilometre for any kilometre length of the tunnel.	Construction
	GW3	Appropriate measures will be investigated and implemented at dive structures and shafts and for cut-and-cover sections of the tunnel to minimise groundwater inflow.	Construction
Corrosion of building materials by sulfate reducing bacteria	GW4	Further assessment of the risk posed by the presence of sulfate reducing bacteria and groundwater aggressivity will be undertaken prior to construction. A corrosion assessment will be undertaken by the construction contractor to assess the impact on building materials that may be used in the tunnel infrastructure such as concrete, steel, aluminium, stainless steel, galvanised steel and polyester resin anchors. The outcomes of the corrosion assessment will be considered when selecting building materials likely to encounter groundwater.	Construction

Impact	Ref #	Environmental management measure	
Groundwater drawdown impacting a water supply well water level by more than two metres	GW5	In accordance with the Aquifer Interference Policy, measures will be taken to 'make good' the impact on an impacted water supply bore by restoring the water supply to pre-development levels. The measures taken will be dependent upon the location of the impacted bore but could include, for example, deepening the bore, providing a new bore or providing an alternative water supply.	Construction
Alteration of groundwater flows and levels due to the installation of subsurface project components	GW6	Potential impacts associated with subsurface components of the project intercepting and altering groundwater flows and levels will be considered during detailed design. Measures to reduce potential impacts will be identified and included in the detailed construction methodology and the detailed design as relevant.	Construction
Actual groundwater inflows and drawdown in adjacent areas exceed expectations	GW7	A detailed groundwater model will be developed by the construction contractor. The model will be used to predict groundwater inflow rates and volumes within the tunnels and groundwater levels (including drawdown) in adjacent areas during construction and operation of the project.	Construction
	GW8	Groundwater inflow within and groundwater levels in the vicinity of the tunnels will be monitored during construction and compared to model predictions and groundwater performance criteria applied to the project. The groundwater model will be updated based on the results of the monitoring as required and proposed management measures to minimise potential groundwater impacts adjusted accordingly to ensure that groundwater inflow performance criteria are met.	Operation
Impacts on groundwater quality or groundwater levels	OGW9	A groundwater monitoring program will be prepared and implemented to monitor groundwater inflows in the tunnels and groundwater levels as well as groundwater quality in the three main aquifers and inflows during construction. The program will identify groundwater monitoring locations, performance criteria in relation to groundwater inflow and levels and potential remedial actions that will be considered to address any non-compliances with performance criteria. As a minimum, the program will include manual groundwater level and quality monitoring monthly and inflow volumes and quality weekly. The monitoring program will be developed in consultation with the NSW EPA, DPI-Fisheries, DPI-Water, City of Sydney Council and Inner West Council.	Operation

Impact	Ref #	Environmental management measure	
	OGW10	The groundwater monitoring program prepared and implemented during construction will be augmented and continued during the operational phase. Groundwater will be monitored during the operations phase for three years or as otherwise required by the project conditions of approval and will include trigger levels for response or remedial action based on monitoring results and relevant performance criteria. At least three monitoring wells and vibrating wire piezometers (VWPs) should be constructed as close as possible to the tunnel centrelines to allow for the comparison of pore pressures and standing water levels. The wells could be constructed about 5-10 metres above the top of the tunnel crown to allow for groundwater drawdown monitoring in the Hawkesbury Sandstone. The operational groundwater monitoring program will be developed in consultation with the NSW EPA, DPI-Fisheries, DPI-Water and the Inner West and City of Sydney councils and documented in the OEMP or EMS.	Operation
Corrosive groundwater could adversely impact the tunnel and associated infrastructure	OGW11	Where the corrosion assessment that will be carried out prior to construction indicates potential issues, corrosion and other associated impacts of highly aggressive groundwater on the tunnel infrastructure will be monitored during operations. The monitoring program will be documented in the OEMP or EMS. Corroded or otherwise impacted infrastructure will be repaired or replaced as required to maintain operational integrity of the road infrastructure.	Operation
Groundwater drawdown due to the project may exceed two metres in registered bores or at other receptors	OGW12	In accordance with the *NSW Aquifer Interference Policy* (DPI-Water 2012), measures will be taken to ‘make good’ the impact on an impacted water supply bore by restoring the water supply to pre-development levels. The measures taken will be dependent upon the location of the impacted bore but could include, for example, deepening the bore, providing a new bore or providing an alternative water supply.	Operation
Non-Aboriginal heritage			
General heritage impacts	NAH01	Construction Heritage Management Plan (CHMP) will be prepared and implemented as part of the Construction Environmental Management Plan. The CHMP will include: • Measures that will be implemented to manage potential impacts to items of heritage significance • Inclusion of heritage awareness and management training for relevant personnel involved in site works • Details regarding the conservation and curation of any historical artefacts recovered during works.	Construction

Impact	Ref #	Environmental management measure	
	NAH02	An Interpretation Strategy will be developed and implemented to identify and interpret the key heritage values and stories of the heritage areas affected by the project and inform the development of the Urban Design and Landscape Plan for the project, in accordance with *Interpreting Heritage Places and Items Guideline* (NSW Heritage Office 2005). The Interpretation Strategy will: • Build on themes, stories and initiatives proposed as part of other stages of WestConnex to ensure a consistent approach to heritage interpretation for the project • Include themes and stories including the Rozelle railways historic functions, trains and trams transport, industrialisation and The Rozelle-Darling Harbour Goods Line • Identify how the rail related infrastructure salvaged from the Rozelle Rail Yards will be reused.	Construction
	NAH03	Photographic recording will be undertaken of: • Infrastructure associated with the White Bay Power Station site that could be affected by the project. • Whites Creek Stormwater Channel (in the area to be impacted) • Stormwater Canal off Lilyfield Road • 'Cadden Le Messurier' at 84 Lilyfield Road • Former Hotel at 78 Lilyfield Road • Victoria Road overbridge • Each house at 260–266 Victoria Road • Each house at 248–250 Victoria Road • Former Bank of NSW (164 Parramatta Road). It will be undertaken in accordance with the NSW Heritage Office guidelines *Photographic Recording of Heritage Items Using Film or Digital Capture* (2006). The photographic recording will occur prior to any works that have the potential to impact upon the items and the report development process will include the identification of appropriate stakeholders to receive copies of the documentation.	Construction

Impact	Ref #	Environmental management measure	
	NAH04	As part of the CHMP, a Historical Archaeological Research Design (HARD) will be prepared before the start of proposed works within each of the following Historical Archaeological Management Units (HAMUs): HAMU 3, HAMU 6, HAMU 7, HAMU 9, HAMU 10, and HAMU 11. The HARD will be prepared by a qualified archaeologist in consultation with the NSW Heritage Council and will include: • Descriptions of clear significance thresholds for possible archaeological items that may be uncovered during works • A methodology and scope for a program of archaeological excavation, investigation, and recording of any historical archaeological remains that will be impacted by the project • Requirement for post-excavation reporting, including artefact analysis and additional historical research, where necessary, and long term management of records • Details of what will happen with any artefacts uncovered and associated reports.	Construction
	NAH05	Before excavation of archaeological management sites, a suitably qualified Excavation Director who complies with Criteria for Assessment of Excavation Directors (Heritage Council of NSW 2011) will be engaged to advise on matters associated with historic archaeology. Where archaeological excavation is required, the Excavation Director will oversee excavation and advise on archaeological matters.	Construction
Heritage impacts due to vibration	NAH06	Potential vibration impacts to features of heritage significance will be managed in accordance with the CNVMP prepared for the project.	Construction
Heritage impacts due to settlement	NAH07	Potential heritage impacts due to settlement and ground movement caused by the project will be managed in accordance with the relevant measures identified in land use and property section of this table and monitored in accordance with the Settlement Monitoring Plan.	Construction
Impacts to unexpected items of potential heritage conservation significance or human remains	NAH08	Any items of potential heritage conservation significance or human remains discovered during construction will be managed in accordance with an Unexpected Heritage Finds and Humans Remains Procedure developed for the project in accordance with relevant guidance provided by the Heritage Council of NSW, the NSW Heritage Division of OEH and the *Standard Management Procedure Unexpected Archaeological Finds* (Roads and Maritime 2015a). The procedure will detail requirements regarding notification of relevant agencies and the NSW Police and will be implemented for the duration of construction.	Construction

Impact	Ref #	Environmental management measure	
Loss of heritage where items are required to be demolished	NAH09	A Heritage Salvage Strategy will be prepared to identify the salvage potential of the fabric and features from heritage items and potential heritage items that will be demolished to facilitate the project. This could include timber joinery, fireplaces, stained glass, stairs, decorative tiles, bricks, steel truss structures, windows etc. The strategy will also identify options and a process for dissemination of salvaged items to owners, community groups and interested parties.	Construction
	NAH10	Sandstone kerbing in the vicinity of 32 and 34 Victoria Road, Rozelle that will be removed to facilitate the project will be salvaged and provided to Inner West Council.	Construction
Potential impact to White Bay Power Station	NAH11	The railway cutting on the eastern side of Victoria Road, associated with the White Bay Power Station, will be considered during the development of the detailed design for the realigned Victoria Road and associated bridge. The final design will seek to avoid impact to the railway cutting and maintain the visual relationship between the cutting and the White Bay Power Station site. Landscaping sympathetic to the relationship, developed in consultation with a heritage specialist, will be included in the UDLP for the project.	Construction
	NAH12	A condition assessment of the southern penstock (and its associated water channels) will be carried out by a heritage specialist and a structural engineer prior to any works in the vicinity with the potential impact upon the item. If required any conservation works required to limit potential impacts on deteriorated fabric (loose bricks, corroded steel) will be identified and implemented prior to construction.	Construction
	NAH13	The southern penstock and its associated water channels (location and extent unknown) will be protected during works associated with the reconstruction of the Victoria Road Bridge.	Construction
Potential impact to Whites Creek Stormwater Channel No 95	NAH14	The new bridge over the Whites Creek Stormwater Channel must not impact the extant significant heritage fabric of the channel and should be a solely independent structure.	Construction
Potential impacts to heritage items at Leichhardt (Darley Road)	NAH15	Landscaping, following the construction of the substation, should consider screening the substation and water treatment plant, from the Leichhardt (Charles Street) Underbridge. The design and location of the landscaping will be informed by a heritage specialist and should seek to create a visual separation between the new structure and the heritage item.	Construction

Impact	Ref #	Environmental management measure	
Aboriginal heritage			
Impacts on unexpected finds of Aboriginal objects	AH1	Any items of potential Aboriginal archaeological or cultural heritage conservation significance or human remains discovered during construction will be managed in accordance with the Unexpected Heritage Finds and Humans Remains Procedure developed for the project.	Construction
Vibration impacts on Aboriginal items	AH2	Subject to gaining access from the relevant landholder, a suitably qualified archaeologist will visit AHIMS site #45-6-2278 prior to the commencement of any vibration intensive construction activities in the vicinity of the site to verify the site to confirm and record its current condition.	Construction
	AH3	If the AHIMS site #45-6-2278 is verified, an assessment will be completed by a suitably qualified and experienced person prior to the commencement of any vibration intensive construction activities in the vicinity. The assessment will consider all vibration intensive activities that will occur in the vicinity, the likely vibration levels and relevant vibration criteria and identify the management measures, including monitoring, that will be implemented to prevent and reduce potential impacts. A final condition assessment will be carried out at the completion of construction detailing recommendations for remediation measures if required.	Construction
Greenhouse Gas			
Emission of greenhouse gases during construction	GHG1	An Energy Efficiency and Greenhouse Gas Emissions Strategy and Management Plan will be prepared for the project as part of the project's Sustainability Management Plan and will be implemented to assist in achieving 'Design' and 'As Built' ratings of Excellent under the Infrastructure Sustainability Council of Australia infrastructure rating tool.	Construction and operation
	GHG2	Undertake an updated greenhouse gas (GHG) assessment based on detailed design for ongoing monitoring and review of emissions during construction.	Construction
	GHG3	Opportunities to use low emission construction materials, such as recycled aggregates in road pavement and surfacing, and cement replacement materials will be investigated and incorporated where feasible and cost-effective.	Construction
	GHG4	Construction plant and equipment will be operated and maintained to maximise efficiency and reduce emissions, with construction planning used to minimise vehicle wait times and idling onsite and machinery turned off when not in use.	Construction
	GHG5	Locally produced goods and services will be procured where feasible and cost effective to reduce transport fuel emissions.	Construction

Impact	Ref #	Environmental management measure	
	GHG6	At least 20 per cent of construction energy required for the project will be sourced from an accredited GreenPower energy supplier, where possible. Six per cent of construction electricity requirements will be offset, with any offset undertaken in accordance with the Australian Government National Carbon Offset Standard.	Construction
Emission of greenhouse gases during operation	OGHG7	The tunnel will be designed with appropriate vertical alignments and grades to allow vehicles to maintain constant speeds and minimise fuel use to reduce potential greenhouse gas emissions.	Construction and operation
	OGHG8	Energy efficiency will be considered during the design of mechanical and electrical systems such as the tunnel ventilation system, tunnel lighting, water treatment systems and electronic toll and surveillance systems. Energy efficient systems will be installed where reasonable and practicable.	Operation
	OGHG	At least six per cent of operational energy required for the project will be sourced from an accredited GreenPower energy supplier and/or through renewable energy generated onsite. Opportunities for operational energy offset, in accordance with the Australian Government National Carbon Offset Standard, will be considered during detailed design.	Operation
Resource use and waste minimisation			
Resource consumption	RW1	Construction material will be sourced in accordance with the relevant aims of the *WestConnex Sustainability Strategy* (Sydney Motorway Corporation 2015) and a Sustainability Strategy (that will be developed during detailed design), including to optimise resource efficiency and waste management, and the selection of locally sourced materials and prefabricated assets where possible, to reduce greenhouse gas emissions. Unnecessary resource consumption will be avoided through the detailed design of the project and by making realistic predictions about the required quantities of resources, such as construction materials.	Construction
Waste generation and disposal	RW2	Wastes will be managed and disposed of in accordance with relevant NSW legislation and government policies.	Construction
	RW3	A Construction Waste Management Plan will be prepared as part of the CEMP and regularly updated during detailed design and construction, detailing appropriate procedures for waste management. The plan will include the waste management measures described in this EIS.	Construction

Impact	Ref #	Environmental management measure	
	RW4	Wastes will be managed using the waste hierarchy principles of: • Avoidance of unnecessary resource consumption to reduce the quantity of waste being generated • Recovery of resources for reuse on-site or off-site for the same or similar use, without reprocessing • Recovery of resources through recycling and reprocessing so that waste can be processed into a similar non-waste product and reused • Disposal of residual waste.	Construction
	RW5	Resource recovery will be applied to the management of construction waste and will include: • Recovery of resources for reuse – reusable materials generated by the project will be segregated for reuse on site, or off site where possible, including the reuse of the major waste streams (VENM) • Recovery of resources for recycling – recyclable resources (such as metals, plastics and other recyclable materials) generated during construction and demolition • Resources will be segregated for recycling and sent to an appropriate recycling facility for processing • Recovery of resources for reprocessing – cleared vegetation will be mulched or chipped on-site and used for landscaping, in the absence of a higher beneficial use being identified.	Construction
	RW6	Options identified for the off-site reuse of waste will comply with relevant NSW EPA resource recovery exemptions and requirements.	Construction
	RW7	The Construction Waste Management Plan will document anticipated volumes of spoil that will be generated by the project, spoil storage locations within project sites and likely spoil disposal sites. The Construction Waste Management Plan and spoil reuse opportunities will be regularly reviewed and updated during detailed design and project construction.	Construction
	RW8	The project will reuse or recycle around 95 per cent of uncontaminated spoil generated for beneficial purposes, either within the project or at other locations in accordance with the project spoil management hierarchy.	Construction
	RW9	Suitable areas will be identified to allow for contingency management of unexpected waste materials, including contaminated materials. Suitable areas will be required to be hardstand or lined areas that are appropriately stabilised and bunded, with sufficient area for stockpile storage.	Construction

Impact	Ref #	Environmental management measure	
Exposure to unexpected contaminated land	RW10	The discovery of previously unidentified contaminated material will be managed in accordance with an unexpected contaminated lands discovery procedure, as outlined in the *Guideline for the Management of Contamination* (Roads and Maritime 2013) and detailed in the CEMP.	Construction
Dust generation, erosion and sedimentation of stockpiles	RW11	Spoil stockpiles will be provided with appropriate environmental controls and managed to reduce potential impacts associated with dust generation, erosion and sedimentation.	Construction
Generation of general waste	RW12	General wastes from site offices such as putrescibles, paper, cardboard, plastics, glass and printer cartridges will be separated and collected for recycling off-site wherever practicable.	Construction
Exposure to asbestos	RW13	An asbestos survey will be undertaken of buildings to be demolished as part of the project in accordance with an Asbestos Management Plan as part of the Work Health and Safety Plan. The survey will be conducted by a suitably qualified person.	Construction
	RW14	Asbestos handling and management will be undertaken in accordance with an Asbestos Management Plan as part of the Work Health and Safety Plan and relevant NSW legislation, government policies and Australian Standards. The plan will include prior notification to adjacent communities about potential hazards.	Construction
Waste generation and disposal	OpRW1	The project will be operated in accordance with the relevant aims of the *WestConnex Sustainability Strategy* (Sydney Motorway Corporation 2015) and a Sustainability Strategy will be developed during detailed design to outline ways to optimise resource efficiency and waste management.	Operation
	OpRW2	Waste will be managed and disposed of in accordance with relevant NSW legislation and government policies and the mitigation measures described in this EIS.	Operation
Wastewater use and discharge	OpRW3	Opportunities to reuse treated groundwater during project operation will be considered in preference to discharge to the stormwater system or receiving waterbodies. This could include irrigation of landscaped areas within the project footprint such as new open spaces at the Rozelle interchange.	Operation
	OpRW4	In order to reduce demand on local water supplies, options will be investigated to provide water for the deluge system from wastewater produced through the tunnel drainage system, where it meets appropriate quality parameters.	Operation
Climate change and risk adaption			
Impacts of climate change	CC1	In the refinement of construction Work Health and Safety Management Plans, consider the increased potential for heat stress among construction personnel and implement measures for greater awareness and education of personnel around health and wellbeing during periods of extreme heat.	Construction

Impact	Ref #	Environmental management measure	
	CC2	This initial climate change risk assessment will inform a detailed climate change risk assessment, which will be undertaken during detailed design, in accordance with AS 5334-2013 Climate change adaptation for settlements and infrastructure – A risk based approach. The assessment will identify and implement adaptation measures to address high and extreme risks. The decision to implement adaptation measures for medium risks will also be considered during detailed design.	Construction
	CC3	Adaptation measures will be identified and implemented to address high and extreme climate change risks. Adaptation measures for medium risks will also be considered further during detailed design and implemented where reasonable and feasible.	Construction
	CC4	The impact of climate change on potential flood risks will be considered during development of the detailed design in accordance with relevant guidelines as described in **Chapter 17** (Flooding and drainage) and **Appendix Q** (Technical working paper: Surface water and flooding).	Construction
	CC5	Increased flood risks due to climate change will be considered in the detailed design of drainage systems. Drainage network features will be developed and installed to mitigate potential increased flood risks as described in **Chapter 17** (Flooding and drainage) and **Appendix Q** (Technical working paper: Surface water and flooding).	Construction
	CC6	Potential changes to sea levels due to climate change will be considered during the design of operational water treatment plants that will discharge to waterways. Discharge outlets and relevant plant features will be designed and constructed accordingly.	Construction
	CC7	Consider the projected increase in the intensity and frequency of extreme rainfall during detailed design, which may lead to exacerbated risk of road incidents. Consider implementation of operational procedures for surface connections to increase safety during extreme rainfall events, such as use of variable speed signs and reduced speed limits.	Construction and operation
Hazard and risk			
Spills and leaks from the storage and transport of dangerous goods and hazardous substances	HR1	Storage of dangerous goods and hazardous materials will occur in accordance with suppliers' instructions and relevant Australian Standards and legislation including the: • *Work Health and Safety Act 2011* (NSW) • Storage and Handling of Dangerous Goods Code of Practice (WorkCover NSW 2005) • Environment Protection Manual for Authorised Officers: Bunding and Spill Management, technical bulletin (NSW EPA 1997). Storage methods may include bulk storage tanks, chemical storage cabinets/ containers or impervious bunds.	Construction

Impact	Ref #	Environmental management measure	
	HR2	Secure, bunded areas will be provided around storage areas for oils, fuels and other hazardous liquids. Impervious bunds will be of sufficient capacity to contain at least 110 per cent of the volume of the largest stored container.	Construction
	HR3	Management measures to reduce the potential for spills, reduce potential spill volumes and prevent any contamination will be developed and implemented for activities such as vehicle refuelling, servicing, maintenance, washdown, where there is a potential for spills and contamination.	Construction
	HR4	Safety Data Sheets for dangerous goods and hazardous substances will be stored on site prior to their arrival.	Construction
	HR5	Transport of dangerous goods and hazardous substances will be conducted in accordance with relevant legislation and codes, including the Dangerous Goods (Road and Rail Transport) Regulation 2014 (NSW) and the Australian Code for the Transport of Dangerous Goods by Road and Rail (National Transport Commission 2008).	Construction
	HR6	The project will be constructed in accordance with the design requirements of CASA and the Sydney Airport Master Plan 2033, with respect to lighting used during construction.	Construction
Potential impacts from fire and safety incidents	OpHR1	The fire and safety systems and measures adopted for the project will be equivalent to or exceed the fire safety measures recommended by National Fire Protection Association 502 (American), Permanent International Association of Road Congresses (European), AS4825 (Australian) and Roads and Maritime standards.	Construction
	OpHR2	Ongoing consultation will be undertaken with emergency services regarding fire and safety systems and measures adopted for the project.	Operation
	OpHR3	The transport of dangerous goods and hazardous substances will be prohibited through the mainline tunnels and entry and exit ramps.	Operation
	OpHR4	An Incident Response Plan will be developed as part of the Emergency Response Plan for the project and implemented in the event of an accident or incident.	Operation
	OpHR5	The response to incidents within the motorway will be managed in accordance with the memorandum of understanding between Roads and Maritime and the NSW Police Service, NSW Rural Fire Service, NSW Fire Brigade and other emergency services.	Operation

Impact	Ref #	Environmental management measure	
Spills and leaks from the storage and transport of dangerous goods and hazardous substances	OpHR6	Storage of dangerous goods and hazardous materials will occur in accordance with suppliers' instructions and relevant Australian Standards and legislation including the: • *Work Health and Safety Act 2011* (NSW) • Storage and Handling of Dangerous Goods Code of Practice (WorkCover NSW 2005) • Environment Protection Manual for Authorised Officers: Bunding and Spill Management, technical bulletin (NSW EPA 1997). Storage methods may include bulk storage tanks, chemical storage cabinets/ containers or impervious bunds.	Operation
	OpHR7	Secure, bunded areas will be provided around storage areas for oils, fuels and other hazardous liquids. Impervious bunds will be of sufficient capacity to contain at least 110 per cent of the volume of the largest stored container.	Operation
	OpHR8	Management measures to reduce the potential for spills, reduce potential spill volumes and prevent any contamination will be developed and implemented for activities such as vehicle refuelling, servicing, maintenance or washdown, where there is a potential for spills and contamination.	Operation
	OpHR9	Material Safety Data Sheets for dangerous goods and hazardous substances will be stored on site prior to their arrival.	Operation
Exposure to electric and magnetic fields	OpHR10	The detailed design of the project substations will ensure that the exposure limits for the general public suggested by the Draft Radiation Standard (Australian Radiation Protection and Nuclear Safety Agency 2006) will not be exceeded at the boundary of the substation sites.	Construction
Impacts from air emissions	OpHR11	Should the exhaust plumes at any of the M4-M5 Link ventilation outlets be assessed as a 'controlled activity' under the Airports Act and the Airspace Regulations, then the project will be operated in accordance with any conditions of approval from the Secretary of Department of Infrastructure and Regional Development.	Construction and operation
	OpHR12	Aviation hazard lighting (if required), building lighting and surface road lighting will be designed and operated in accordance with the requirements of CASA and the Sydney Airport Master Plan 2033.	Construction and operation

Impact	Ref #	Environmental management measure	
Cumulative impacts			
Ongoing construction impacts on the local community throughout the construction phase of the M4-M5 Link	C1	• The effective management of cumulative impacts on the affected community requires oversight and direction from one overarching body such as a government department/agency or local council • Multi-party engagement and cooperation is needed to ensure all contributors to impacts are working together to minimise the effects or enhance the benefits of multiple projects occurring concurrently or consecutively • Communication strategies across the various projects should be managed to be consistent in their messaging to the community to avoid confusion.	Construction and operation
Sustainability			
Unsustainable use of resources during the construction and operation of the project	S1	The construction contractor will develop and implement a Sustainability Management Plan during detailed design. The Sustainability Management Plan will establish governance structures, processes and systems that ensure integration of all sustainability considerations (vision, commitments, principles, objectives and targets), initiatives, monitoring and reporting during the detailed design and construction phases of the project.	Construction and operation

30 Project justification and conclusion

This chapter presents a justification for the project and a conclusion to the environmental impact statement (EIS). The justification is based on the strategic need for the project and in particular, how it would fulfil the project objectives outlined in **Chapter 3** (Strategic context and project need).

The Secretary of the NSW Department of Planning and Environment (DP&E) has issued environmental assessment requirements for the project. These are referred to as the Secretary's Environmental Assessment Requirements (SEARs). **Table 30-1** sets outs these requirements and the associated desired performance outcomes that relate to the justification of the project and where these have been addressed in the EIS.

Table 30-1 SEARs – strategic need and justification for the project

Desired performance outcome	SEARs	Where addressed in the EIS
2. Environmental Impact Statement The project is described in sufficient detail to enable clear understanding that the project has been developed through an	1. The EIS must include, but not necessarily be limited to, the following:	The project objectives are listed in **Chapter 3** and **section 30.1.2**. A description of how the project would meet the objectives of the overall WestConnex program is provided in **Table 30-2**.
iterative process of impact identification and assessment and project	(c) a statement of the objective(s) of the project, including how it meets the objectives of the overall WestConnex program;	
refinement to avoid, minimise or offset impacts so that the project, on balance, has the least adverse environmental, social and economic impact, including its cumulative impacts.	(d) a summary of the strategic need for the project with regard to its State significance and relevant State Government policy;	The need and justification for the project, with regard to its State significance, is discussed in **Chapter 3** and **section 30.1**. State Government policy relevant to the project is discussed in **Chapter 2** (Assessment process).
	(g) description of how alternatives to and options within the project were analysed to inform the selection of the preferred alternative/option. The description must contain sufficient detail to enable an understanding of why the preferred alternative to, and options(s) within, the project were selected, including: – a justification for the preferred proposal taking into consideration the objects of the *Environmental Planning and Assessment Act 1979* (EP&A Act);	A demonstration of how the project meets the objectives of the EP&A Act is provided in and **section 30.1.3**.
	(p) statutory context of the project as a whole, including: – how the project meets the provisions of the EP&A Act and EP&A Regulation; and – a list of any approvals that must be obtained under any other Act or law before the project may lawfully be carried out.	**Table 30-3** outlines how the project meets the provisions of the EP&A Act and the Environmental Planning and Assessment Regulation 2000 (NSW). A list of approvals required for the project is provided in **Chapter 2** (Assessment process).

30.1 Justification

30.1.1 Summary of strategic need and justification

The transport network in Sydney is expected to be put under increasing pressure over the next 20 years. *A Plan for Growing Sydney* (NSW Government 2014) indicated that from 2011 to 2031, Sydney's population is forecast to increase from 4.3 to 5.9 million, which equates to an average of 80,000 additional residents per year. Moreover, by 2036, the number of trips made around Sydney each day is forecast to increase by 31 per cent, from 16 to 21 million vehicle trips. This growth will place increasing pressure on the NSW transport network and the key travel demand corridors connecting regional cities and major centres across the greater Sydney metropolitan area.

The road network in the study area for the traffic and transport assessment currently functions under high levels of traffic demand, which often exceeds the operational capacity, especially citybound during the AM peak period. This includes some of the most highly congested road corridors in Sydney. Major routes in the study area, such as Parramatta Road, City West Link, Victoria Road, Anzac Bridge/Western Distributor, Southern Cross Drive, Princes Highway and King Street experience significant congestion, with resultant increases in travel time and variability, which can cause typical morning and evening peak hours to spread over longer periods.

The current congestion on arterial roads and the missing links in the motorway network impede the efficient flow of traffic to the important economic centres along Sydney's Global Economic Corridor. The project is listed as a 'high priority initiative' in the *Australian Infrastructure Plan: The Infrastructure Priority List* (Infrastructure Australia 2016a). The project is also part of the NSW Government's commitment to deliver WestConnex for Sydney in response to the recommendations from the *State Infrastructure Strategy 2012–2032* (Infrastructure NSW 2012), the *State Infrastructure Strategy Update 2014* (Infrastructure NSW 2014), the *NSW Long Term Transport Master Plan* (Transport for NSW 2012a), the NSW State Priorities announced in September 2015 (NSW Government 2015) and the *NSW Freight and Port Strategy* (Transport for NSW 2013b).

In addition, *A Plan for Growing Sydney* (NSW Government 2014) presents a vision for Sydney as a strong global city and the nation's economic and financial powerhouse. It emphasises the need to improve access to major employment hubs and global gateways. The project, as part of the WestConnex program of works, would aid in the delivery of these strategies and plans as it would:

- Provide a new motorway link between the M4 East at Haberfield and the New M5 at St Peters
- Reduce future traffic volumes on north–south and east–west road corridors, including City West Link and parts of Victoria Road
- Enhance the benefits achieved by the operation of the M4 East and New M5 projects by reducing traffic volumes on Parramatta Road, Southern Cross Drive, the Princes Highway, King Georges Road and the M5 East Motorway
- Enable future opportunities for improved connectivity in Sydney's transport network to be realised by allowing for connections to the proposed future Western Harbour Tunnel and Beaches Link to the north, and the proposed future Sydney Gateway (via the St Peters interchange) and the proposed future F6 Extension (via the New M5) to the south
- Reduce travel times and improve reliability for bus services, business, personal and freight journeys along the Sydney road network
- Improve road safety by reducing traffic congestion on Sydney's arterial roads
- Facilitate opportunities for future urban renewal in precincts adjoining the project, including The Bays Precinct (in accordance with *The Bays Precinct Transformation Plan* (UrbanGrowth NSW 2015)), along Parramatta Road east of Haberfield (in accordance with the *Parramatta Road Corridor Urban Transformation Strategy* (UrbanGrowth NSW 2016a)), and along Victoria Road between Iron Cove Bridge and The Crescent, by reducing surface road traffic on sections of Victoria Road
- Improve community connectivity through new and upgraded active transport links at Rozelle and Lilyfield

- Provide new open space within the Rozelle Rail Yards, the design and landscaping of which would be further developed in consultation with relevant councils, stakeholders and the community to provide beneficial urban design outcomes and local amenity.

As part of the broader WestConnex program of works, the project would support NSW's major sources of economic activity and provide a strategic response to the future transport demands on the already congested road network.

30.1.2 Achieving WestConnex program objectives

The project is needed to contribute to meeting the objectives of the WestConnex program of works as stated in the *WestConnex Updated Strategic Business Case* (Sydney Motorway Corporation 2015a).

As the project is part of the WestConnex program of works, the objectives of the project are consistent with those of WestConnex, as stated in the *WestConnex Updated Strategic Business Case*. **Table 30-2** outlines how the project would meet the broader WestConnex objectives.

Table 30-2 How the project meets the WestConnex program objectives

WestConnex program objectives	How the project meets the WestConnex objectives
Support Sydney's long-term economic growth through improved motorway access and connections linking Sydney's international gateways with western Sydney and places of business across the city.	The project is a critical motorway link that (together with the M4 East and New M5 projects and the proposed future Sydney Gateway project) contributes to connecting western Sydney's population and growth centres with employment and business opportunities in the Sydney CBD and the Sydney Airport and Port Botany precinct. Further detail on the economic impacts and opportunities provided by the project is provided in **Chapter 14** (Social and economic) and **Appendix P** (Technical working paper: Social and economic).
Relieve road congestion so as to improve the speed, reliability and safety of travel on the M4 Motorway, M5 Motorway and Sydney CBD/Sydney Airport/Port Botany corridors, including parallel arterial roads.	The traffic assessment undertaken for the project demonstrates that the project has the potential to reduce vehicle movements on Parramatta Road (east of Haberfield), Victoria Road (east of Iron Cove Bridge), City West Link, King Street, King Georges Road and Sydenham Road. The M4-M5 Link, combined with the proposed future Sydney Gateway, would improve the speed, reliability and safety of travel between Sydney's international gateways (Sydney Airport and Port Botany), western Sydney and places of business across the Sydney region. Further detail on traffic impacts, including improvements to road safety and travel times, is provided in **Chapter 8** (Traffic and transport). The road and tunnel design, in conjunction with clear wayfinding (ie navigation signage/roadway markers), would provide a safe, legible and easily navigable series of tunnels that provide a high quality customer experience. The speed limit in the mainline tunnels would be 80 kilometres per hour with provision for variable speed limits to suit changes in travel conditions, and the tunnels would be monitored by video cameras 24 hours a day, seven days a week through the coordinated traffic control room to an ensure immediate response to any incidents within the tunnels. Further details of the operation of the motorway are provided in **Chapter 5** (Project description). Provision has also been made for Smart (or Managed) Motorway infrastructure in the M4-M5 Link design. A Smart Motorway uses technology to monitor, provide intelligence and control the motorway to ease congestion and keep traffic flowing more effectively.

WestConnex program objectives	How the project meets the WestConnex objectives
Cater for the diverse travel demands along these corridors that are best met by road infrastructure.	The key customers who would benefit from the project include: • Highly dispersed and long distance passengers • Heavy and light freight and commercial services • Businesses whose travel patterns are highly dispersed and diverse. The transport demands of these customers are best served by an efficient motorway connection. The project would meet this WestConnex objective by relieving congestion within and in proximity to the project footprint and facilitating efficient passenger and freight movements through Sydney. The addition of the M4-M5 Link provides a significant overall improvement to network productivity. An overall increase in daily vehicle kilometres travelled (VKT) and a reduction in daily vehicle hours travelled (VHT) on the road network are forecast. This means that more trips could be made or longer distances travelled on the network in a shorter time. The forecast increase in VKT and reduction in VHT is mainly due to traffic using the new motorway, with reductions in daily VKT and VHT forecast on the non-motorway roads. The reduction in traffic demand on the major parallel traffic routes such as the A3 corridor (Centenary Drive/King Georges Road), Sydenham Road and King Street, St Peters is likely to improve speed, journey reliability and safety on these corridors compared to a 'without project' scenario. The project would also provide additional route options along the corridor and therefore increase network resilience in the event of accidents or network disturbances. Further detail is provided in in **Chapter 8** (Traffic and transport).

WestConnex program objectives	How the project meets the WestConnex objectives
Create opportunities for urban renewal, improved liveability, and public and active transport improvements along and around Parramatta Road.	The urban renewal and active transport improvements associated the project would be created principally within the Rozelle Rail Yards and surrounds. The project would create new open space and active transport links and connect previously disconnected communities on either side. By reducing traffic along Parramatta Road (east of Haberfield) and Victoria Road (east of Iron Cove Bridge), the project would facilitate opportunities for urban renewal and liveability improvements in communities along those road corridors. A reduction in vehicles on those corridors may result in greater safety for cyclists and pedestrians, making these alternative modes of transport more desirable. The Parramatta Road corridor is an important bus route servicing the inner west. As demand for public transport is forecast to grow, the WestConnex program of works has explored opportunities to facilitate the integrated use of public transport options on the road network. The reduction in traffic along sections of Parramatta Road as a result of the project facilitates the opportunity for the future development of on-road public transport improvements as envisaged by the NSW Government. The project also includes the use of land at Annandale, at the junction of Parramatta Road and Pyrmont Bridge Road, as a temporary construction ancillary facility. This location is subject to the *Parramatta Road Corridor Urban Transformation Strategy* (UrbanGrowth NSW 2016a). This site would be rehabilitated for future redevelopment once construction of the project is complete. A description of the active transport improvements created by the project is provided in **Appendix N** (Technical working paper: Active transport strategy). An overview of potential land use and property impacts is provided in **Chapter 12** (Land use and property).
Enhance the productivity of commercial and freight-generating land uses strategically located near and along transport infrastructure.	By connecting the New M5 and M4 East motorways and providing connections to the proposed future Sydney Gateway, the project would provide improved access for commercial vehicles transporting freight from the Sydney Airport and Port Botany precinct to western Sydney. Reducing travel time may lead to increased business productivity and reduced costs. The project would also contribute to improved profitability for commercial and freight businesses through reduced transport costs, in terms of money and time lost to congestion and fuel consumption. Daily heavy vehicle volumes on Parramatta Road and City West Link are forecast to drop by 40 to 50 per cent, as trucks shift to using the new motorway connection.
Fit within the financial capacity of the State and Federal Governments, in partnership with the private sector.	The project, as part of WestConnex, is being funded by the NSW and Australian governments, as well as private sector debt and equity capital, raised against tolls on completed stages of WestConnex.

WestConnex program objectives	How the project meets the WestConnex objectives
Optimise user pays contributions to support funding in a way that is affordable, equitable and fair.	A tolled motorway would facilitate user pays contributions and reduce the overall burden on the wider community in NSW. Inclusion of a toll makes construction of the project affordable and equitable, as the cost is shared between tax payers and individual users of the M4-M5 Link. The project comprises tolled and untolled components. Use of the mainline tunnel and Rozelle interchange for long distance trips would be tolled. Iron Cove Link would remain untolled to provide an alternative for motorists using this section of Victoria Road. After opening in 2023, the project would provide a journey using the M4 Motorway straight through to Anzac Bridge, via the M4-M5 Link, for a toll capped (for the entire WestConnex motorway) at $8.60 ($2017). This would provide significant time and cost savings for motorists. Further information on project tolling is provided in **Chapter 14** (Social and economic).
Integrate with the preceding and proposed future stages of WestConnex projects without creating significant impacts on the surrounding environment or duplicating any potential issues across the construction periods.	As the project would link the M4 East and New M5 projects, opportunities for minimising impacts at both ends of the project have informed the design development process and high level construction program. The project has been designed to minimise the project footprint and maximise the use of land already disturbed or being used for road infrastructure (such as at Haberfield, the Rozelle Rail Yards and St Peters).
	The potential impacts from consecutive construction activities across various WestConnex component projects are discussed in **Chapter 26** (Cumulative impacts) as these activities affect specific local communities.
Provide the ability for an additional Sydney Harbour tunnel road crossing, the Western Harbour Tunnel and Beaches Link (subject to approval), to connect to WestConnex.	The project scope includes the civil construction of ramps, tunnels and associated infrastructure for connections to the proposed future Western Harbour Tunnel and Beaches Link at the Rozelle interchange. These works include: • Tunnels that would allow for underground connections between the M4 East and New M5 motorways and the proposed future Western Harbour Tunnel and Beaches Link (via the M4-M5 Link mainline tunnels) • Entry and exit ramps extending north from the Rozelle interchange at the Rozelle Rail Yards below ground. This would enable future surface connections between the realigned City West Link/The Crescent intersection and the proposed future Western Harbour Tunnel and Beaches Link tunnels • A ventilation outlet and ancillary facilities for the Western Harbour Tunnel and Beaches Link as part of the Rozelle ventilation facility. Further description of how the project would provide the ability to connect to the proposed future Western Harbour Tunnel and Beaches Link is provided in **Chapter 5** (Project description) and **Chapter 6** (Construction work).

WestConnex program objectives	How the project meets the WestConnex objectives
Support improved connectivity between Sydney, the Sutherland Shire, and the Illawarra, with the ability for the proposed future F6 Extension to connect to WestConnex.	While the project would not directly link to the proposed future F6 Extension, by connecting the Rozelle interchange to the New M5 (which would connect to the F6 Extension), the project would provide a connection between the Sydney CBD and the northern suburbs (via Iron Cove Link and the proposed future Western Harbour Tunnel and Beaches Link) and Sutherland Shire and the Illawarra region. A description of this connectivity and the potential impact on traffic flow is discussed in **Chapter 8** (Traffic and transport).

Table 30-3 Meeting the project objectives

M4-M5 Link objectives	How the project meets the objectives
Linking the M4 East and New M5 motorways and enabling their connection to the future proposed Sydney Gateway, so that the further benefits and opportunities of WestConnex can be realised.	The project is a critical motorway link that contributes (together with the M4 East and New M5 projects) to connecting western Sydney's population and growth centres with employment and business opportunities in the Sydney CBD and its international gateways; Sydney Airport and the Port Botany precinct, through a direct connection to the future proposed Sydney Gateway at St Peters. Further detail on the economic impacts and opportunities provided by the project is provided in **Chapter 14** (Social and economic) and **Appendix P** (Technical working paper: Social and economic).
Enable long-term Sydney motorway network development by providing a connection to the proposed future Western Harbour Tunnel and Beaches Link project to the north.	The project would provide a direct underground tunnel connection to the proposed future Western Harbour Tunnel at Rozelle and the New M5 and M4 East via the Inner West subsurface interchange.
Improve traffic conditions on key arterial roads in proximity to the project.	The traffic assessment undertaken for the project demonstrates that the project has the potential to reduce vehicle movements and improve travel times on Parramatta Road (east of Haberfield), Victoria Road (east of Iron Cove Bridge), City West Link, Southern Cross Drive, King Street and the Princes Highway and the A3 corridor. Further detail on traffic impacts, including improvements to road safety and travel times, is provided in **Chapter 8** (Traffic and transport) and **Appendix H** (Technical working paper: Traffic and transport).

M4-M5 Link objectives	How the project meets the objectives
Cater for the diverse travel demands along these corridors that are best met by road infrastructure.	The key customers who would benefit from the project include: • Highly dispersed and long distance passengers • Heavy and light freight and commercial services • Businesses whose travel patterns are highly dispersed and diverse. The transport demands of these customers are best served by an efficient motorway connection. The project would meet this WestConnex program and project objective by relieving congestion on parallel arterial corridors and in facilitating efficient passenger and freight movements through Sydney.
Facilitate urban renewal in areas where the project would reduce traffic.	By reducing traffic along Parramatta Road (east of Haberfield) the project would facilitate an opportunity for urban renewal and liveability improvements in communities along the Parramatta Road corridor. A reduction in vehicles on this corridor may result in greater safety for cyclists and pedestrians, making these alternative modes of transport more desirable. The project also includes use of land at Annandale, at the junction of Parramatta Road and Pyrmont Bridge Road, as a temporary construction ancillary facility. This location is subject to the *Parramatta Road Corridor Urban Transformation Strategy* (UrbanGrowth NSW 2016a). This site would be rehabilitated and made available for future redevelopment once construction of the project is complete. The urban design and landscaping works to be implemented as part of the project within the Rozelle Rail Yards and the Iron Cove Link surface works would assist in creating opportunities for improved connectivity to these possible future urban renewal projects, including improved connectivity and permeability for pedestrians and cyclists to locations such as The Bays Precinct.
Minimise impacts on communities associated with property acquisition of residential properties.	The project has been developed to minimise the need for surface property acquisition by designing the majority of the project to be underground, with ramps connecting to the surface (refer to **Chapter 5** (Project description) for further detail). Government-owned land has been used where possible to minimise acquisition of private property. The need to reduce these impacts has been balanced with maximising opportunities for beneficial re-use of the areas required for construction that would be surplus to the operational needs of the project. Notwithstanding this design intent, construction and operation of the project would result in temporary and permanent impacts on property. As at August 2017, the project would require 51 total property acquisitions. Of these properties, 26 are residential, one is mixed use and 24 are commercial or industrial land uses. Property acquisition will continue to be undertaken in accordance with the *Land Acquisition Information Guide* (Roads and Maritime 2014) and the *Land Acquisition (Just Terms Compensation) Act 1991 (*NSW). Refer to **Chapter 12** (Land use and property) for further details of property acquisitions and minimisation of impacts.

M4-M5 Link objectives	How the project meets the objectives
Deliver a project with a beneficial urban design outcome.	The project would provide new open space at the Rozelle Rail Yards, and a network of increased pedestrian and cyclist connections, which would provide increased opportunities for the community to meet and interact. The Rozelle Rail Yards currently act as a significant physical barrier between the communities of Annandale, Rozelle and Lilyfield. The project would transform this area into public open space with a network of active transport links, which would improve social cohesion and community connectivity for the communities of Annandale, Rozelle, Lilyfield, Glebe and Balmain. A number of the larger arterial roads, including City West Link, Victoria Road and Parramatta Road are physical and psychological barriers between communities in the study area. The project would reduce this barrier effect by reducing traffic volumes on sections of these roads and increasing and/or improving pedestrian and cyclist networks. The active transport facilities include an upgraded pedestrian footpath and separated cycleway between Springside Street and the Bay Run at Byrnes Street, on the western side of Victoria Road at Rozelle. This connection would assist in improving connectivity along Victoria Road, including connections to King George Park and the Bay Run. Overall, the project is expected to increase community cohesion, which is a positive urban design outcome for a large number of local residents across the study area.

30.1.3 Objectives of the *Environmental Planning and Assessment Act 1979* (NSW)

Table 30-4 Objectives of the *Environmental Planning and Assessment Act 1979* (NSW)

Environmental Planning and Assessment Act 1979 objectives	Comment
To encourage the proper management, development and conservation of natural and artificial resources, including agricultural land, natural areas, forests, minerals, waters, cities, towns and villages for the purpose of promoting the social and economic welfare of the community and a better environment.	Where possible, the project has been designed to conserve natural and artificial resources. During construction and operation of the project, opportunities would be taken to reduce material use and maximise the use of materials with low embodied environmental impact, where practical. For example: • Recycled products would be used during construction of the project to reduce the demand on resources, in instances where the use of such materials is cost and performance competitive • At least 20 per cent of electricity required for construction and at least six per cent of electricity required for operation of the project would be sourced from an accredited GreenPower energy supplier Water efficiency measures would be implemented with a focus on achieving water savings and targeting water recycling and reuse, with a minimum target of five per cent of water (rainwater, stormwater, wastewater, groundwater, tunnel inflow water) proposed to be reused, recycled or reclaimed during operation of the project. • The project would seek to reuse or recycle around 95 per cent of uncontaminated spoil generated for beneficial purposes, either within the project or at other locations • At least 80 per cent of construction and demolition waste is anticipated to be reused and/or recycled as part of the project • There would be minimal impact on existing open space and a net improvement as a result of the provision of up to 10 hectares of open space. The improved efficiency of the road network and the predicted travel time savings would result in a reduction in fuel use in the future. Additionally, the project would result in a long-term reduction in greenhouse gas emissions due to the smoother traffic flow and lower gradients that would be provided by the project (refer to **Chapter 22** (Greenhouse gas)). The GHG emissions saving for the project of 504,750 t CO_2-e in 2033 would represent around 0.09 per cent of the Australian National inventory for the financial year 2015-2016, and 0.39 per cent of the NSW inventory for 2014. A reduction in emissions contributes to improved sustainability, including minimising the use of resources and supporting inter-generational equity and climate change outcomes. Where reasonable and feasible, the project has been designed to avoid impacts on the natural environment and to minimise the need for land acquisition, as well as impacts on existing development and local communities. The project would provide improved traffic conditions, safety and efficiency on parts of Parramatta Road and Victoria Road, as well as other arterial roads, and would result in improvements to local amenity in terms of noise and vibration, air quality and traffic. Measures would be implemented to ensure that impacts of the project on the natural and built environment are minimised.

Environmental Planning and Assessment Act 1979 objectives	Comment
To encourage the promotion and coordination of the orderly and economic use and development of land.	The improved efficiency of the road network and the forecast travel time savings would result in economic benefits for NSW. The project has been designed to minimise impacts to the surrounding natural and built environments, and to minimise disruption to existing development patterns. Provision of a mostly underground motorway is an orderly and economic approach to support major planning renewal and growth areas, including The Bays Precinct and precincts in the Parramatta Road corridor. Use of the Rozelle Rail Yards for provision of new open space is consistent with the strategic objectives for the The Bays Precinct, which expressly contemplates use of part of this land for WestConnex purposes. New open space at this location would also provide for improved connectivity and would be coordinated with the development of neighbouring areas which would be developed as part of The Bays Precinct.
To encourage the protection, provision and co-ordination of communication and utility services.	The project has been designed to minimise impacts on communications and utility services, where possible. Utility services would be relocated, adjusted or protected where affected by the construction of the project. Trunk utility works proposed have been assessed in the EIS and works would be subject to the recommended environmental management measures contained in the EIS, as described in the Utilities Management Strategy (**Appendix F**), which provides the framework for how utility works would be managed, including requirements for environmental constraints analysis and environmental risk assessment to confirm the potential impacts associated with the works. A Utility Coordination Committee would be established to ensure better planning for, and coordination of, individual utility works.
To encourage the provision and coordination of community services and facilities.	The mainline tunnels, Rozelle interchange and the location of construction ancillary facilities have been designed and located to minimise direct impacts to community facilities and areas of public open space (refer to **Chapter 14** (Social and economic)). The project would enable a net benefit of up to 10 hectares of community open space and active transport links, improving community connectivity and facilities in the Rozelle/Lilyfield area. The planned reduction in trucks and cars travelling longer distances on Parramatta Road would facilitate future urban renewal along the corridor through improved urban amenity and liveability characteristics, supported by improved public transport, active transport such as walking and cycling, and local vehicle travel. The project would enhance the connections between key housing and employment areas.
To encourage the protection of the environment, including the protection and conservation of native animals and plants, including threatened species, populations and ecological communities, and their habitats.	The project is located in a highly modified urban area and would not result in the clearing of native vegetation. While construction would not result in the clearing of native vegetation, areas of planted vegetation would be removed. Where impacts are unavoidable, mitigation measures have been proposed to minimise the potential for indirect impacts. No threatened flora or fauna is likely to be significantly affected by the project. Biodiversity is considered further in **Chapter 18** (Biodiversity).

Environmental Planning and Assessment Act 1979 objectives	Comment
To encourage ecologically sustainable development.	The project is consistent with the four principles of ecologically sustainable development: • The precautionary principle • Inter-generational equity • Conservation of biological diversity and ecological integrity • Improved valuation and pricing and incentive mechanisms. Ecologically sustainable development is further considered in **Chapter 27** (Sustainability).
To encourage the provision and maintenance of affordable housing.	Not directly applicable. Potential future development and use of remaining project land would be determined in accordance with a Residual Land Management Plan that would be prepared for the project (refer to **Chapter 12** (Land use and property)).
To promote the sharing of the responsibility for environmental planning between different levels of government in the State.	Consultation has been undertaken with the relevant local councils and government agencies throughout the development of the project and the preparation of this environmental impact statement. All levels of government have been encouraged to be actively involved in and to contribute to the evolution of the project and this environmental impact statement through historical and continuing consultation activities.
To provide increased opportunity for public involvement and participation in environmental planning and assessment.	Community consultation has been carried out through all stages of the project development, with targeted consultation commencing in January 2016. In particular, two rounds of targeted community consultation of design development have been undertaken. Community feedback has been considered at each stage of the project development to inform the selection of the preferred corridor alignment and subsequent design development and refinements. Community consultation would continue through the detailed design, construction and operational stages, should the project be approved. Details of community involvement are provided in **Chapter 7** (Consultation).

30.2 Conclusion

This EIS addresses the key issues identified in the SEARs issued under Part 5.1 of the EP&A Act and the relevant provisions of Schedule 2 of the Environmental Planning and Assessment Regulation 2000 (NSW). A checklist showing where the Secretary's environmental assessment requirements are addressed in this EIS is provided in **Appendix B** (Secretary's Environmental Assessment Requirements checklist)**.**

The project is part of the NSW Government's commitment to deliver WestConnex for Sydney. Together with the other components of the WestConnex program of works and the proposed future Sydney Gateway, the project would facilitate improved connections between western Sydney, Sydney Airport and Port Botany and south and south-western Sydney, as well as better connectivity between the important economic centres along Sydney's Global Economic Corridor and local communities.

The merits of the M4-M5 Link were considered in the context of a range of other strategic alternatives, based on the extent to which they could meet the project objectives and how well they performed with reference to other transport, environmental, engineering, social and economic factors.

The following strategic alternatives were considered:

- Alternative 1 – improvements to the existing arterial road network

- Alternative 2 – investment in alternative transport modes
- Alternative 3 – demand management (reducing the number of vehicle kilometres travelled on the network
- Alternative 4 – the ‘do nothing’/‘do minimum’ case
- Alternative 5 – development of the M4-M5 Link.

These options were considered and assessed which resulted in Alternative 5 – development of the M4-M5 Link as part of the WestConnex program of works, being determined as the preferred strategic alternative.

The project is considered to be in the public interest by providing the following keys and opportunities:

- Easing congestion on surface roads by providing an underground motorway alternative and allowing for increased use of surface roads by pedestrians and cyclists and for public transport
- Reducing through traffic on sections of major arterial roads including City West Link, Parramatta Road, Victoria Road, King Street, King Georges Road and Sydenham Road, facilitating urban renewal opportunities to be realised along parts of the Parramatta Road and Victoria Road corridors
- Improving network productivity on the metropolitan network, with more trips forecast to be made or longer distances travelled on the network in a shorter time. The forecast increase in VKT and reduction in VHT is mainly due to traffic using the new motorway, with reductions in daily VKT and VHT also forecast on some non-motorway roads
- Reducing travel times on key corridors, such as between the M4 Motorway corridor and the Sydney Airport/Port Botany precinct
- Delivering up to 10 hectares of new open space including at the Rozelle Rail Yards, which would provide an open space link between Bicentennial Park at Glebe and Easton Park at Rozelle
- Delivering new north–south and east–west pedestrian and cycleway connections to link Rozelle and Lilyfield with Annandale, Balmain, Glebe and The Bays Precinct
- Facilitating future growth in Sydney’s transport network by allowing for connections to the proposed future Western Harbour Tunnel and Beaches Link project.

As part of the WestConnex program of works, the project would enable future opportunities for improved connectivity in Sydney’s transport network to be realised by providing connections to proposed motorway projects, including the Western Harbour Tunnel and Beaches Link project to the north, the Sydney Gateway project via the St Peters interchange and the F6 Extension (via the New M5 Motorway) to the south.

The project would support NSW’s major sources of economic activity and provide a strategic response to the future transport demands on the already congested road network. With demonstrated consistency with these policies, there is a clear strategic justification for the project to proceed and a strategic need to meet the growing infrastructure requirements of Sydney Greater Metropolitan Area associated with the provision of a more efficient road network.

The project, as part of the WestConnex program of works, would also act as a catalyst for urban renewal along parts of Parramatta Road and Victoria Road and would support the development of The Bays Precinct, as outlined in *The Bays Precinct Transformation Plan* (UrbanGrowth NSW 2015b). In addition, the project would deliver local benefits through substantial new open space and passive recreational facilities at Rozelle, including within the Rozelle Rail Yards and along Victoria Road near Iron Cove Bridge, and improved connectivity for motorists, pedestrians and cyclists to surrounding inner west suburbs and the Sydney CBD.

The need to reduce impacts on property has been balanced with maximising opportunities for beneficial re-use of the areas required for construction that would be surplus to the operational needs of the project. The majority of the project, including a large part of the Rozelle interchange and Iron Cove Link, would be constructed underground and has been designed to minimise the need for surface property acquisition. In addition, construction ancillary facilities at Haberfield and St Peters that are being used by the M4 East and New M5 projects would be used for the M4-M5 Link, to minimise additional property acquisition at these locations for construction. The project would also seek to maximise the use of use government owned land, including land already owned by Roads and Maritime.

Notwithstanding this, construction and operation of the project would result in temporary and permanent impacts on property. As of August 2017, the project would require 51 property acquisitions. In addition to the properties affected by surface activities, land (or interests in land, such as easements) below the surface of the ground would be acquired.

Subject to detailed design and the requirements of the project, parts of the project footprint not required for operational infrastructure and/or the provision of open space and landscaping may be contemplated for separate future redevelopment. Where this is the case, the land would be rehabilitated at the end of construction and made suitable for potential development for permissible uses under land use zoning provisions and relevant urban renewal strategies. Future development/use would be subject to separate assessment and approval, and the restrictions of the relevant consent authority.

The construction of the project would result in air quality and noise impacts (over the duration of the construction period). However, these impacts would be minimised through the development and implementation of a construction environmental management plan and careful planning of the construction schedule and methodologies.

Adverse cumulative impacts could be encountered during the construction phases of the different WestConnex projects, especially from construction fatigue around the Haberfield and St Peters construction sites. In particular:

- The M4 East project is expected to be finished in 2019, and may overlap with the construction period of the M4-M5 Link project by around six months
- The New M5 project is expected to be finished in 2020, and may overlap with the construction period of the M4-M5 Link project by around 12 months.

Significant cumulative impacts with other planned developments in the area are not considered likely. Operational impacts of the project such as noise would be further investigated during detailed design to confirm appropriate mitigation measures or, where relevant, design refinements. When completed, the WestConnex program of works is expected to deliver beneficial cumulative impacts including significant increases in travel speeds through sections of the surface road network, increased reliability, and a reduction in average travel times.

This EIS includes a suite of management measures that aim to ensure the best possible environmental outcomes are achieved during its construction and operation.

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