WestConnex

Australian Government
BUILDING OUR FUTURE

NSW GOVERNMENT

M4-M5 Link

Environmental Impact Statement

August 2017

Appendices Q to S

Volume 2H

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Arabic

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وذلك لمشاهدة الفيديوهات الخاصة بالمشروع باللغة العربية وقراءة المزيد عن وست كونكس. إذا كنت في حاجة إلى مترجم، اتصل بخدمة الترجمة الخطية والشفهية على الرقم **131 450.**

Chinese

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Hindi

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www.westconnex.com.au/yourlanguage व (हिन्दी) म इ
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दुभाषियािसेवा ो **131 450** र फ़ोप करें।

Greek

Μάθετε περισσότερα επισκεπτόμενοι το **www.westconnex.com.au/yourlanguage** για να δείτε τα βίντεο του έργου στα ελληνικά και να διαβάσετε περισσότερα για το WestConnex. Εάν χρειάζεστε διερμηνέα, καλέστε την Υπηρεσία Μετάφρασης και Διερμηνείας στο **131 450**.

Italian

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Korean

www.westconnex.com.au/yourlanguage 를 방문하여한국어로 된 프로젝트 비디오를 보고 WestConnex 에 관해 읽고 배우세요. 통역이 필요하시면 번역 및 통역 서비스 **131 450** (TIS) 으로 전화 하십시오.

Vietnamese

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Volume 2H

Appendices

WestConnex

Appendix Q

Technical working paper: Surface water and flooding

WestConnex

Roads and Maritime Services

WestConnex – M4-M5 Link

Technical working paper: Surface water and flooding

August 2017

Client: Roads and Maritime Services

ABN: 76 236 371 088

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Glossary of terms and abbreviations

Term	Definition
A	
Acid Sulfate Soils	Naturally occurring soils, sediments or organic substrates (eg peat) that are formed under waterlogged conditions. These soils contain iron sulfide minerals (predominantly as the mineral pyrite) or their oxidation products. In an undisturbed state below the water table, acid sulfate soils are benign. However, if the soils are drained, excavated or exposed to air by a lowering of the water table, the sulfides react with oxygen to form sulfuric acid
AEP	Annual exceedance probability. The probability of a rainfall or flood event exceeding a nominated level in a year. For example, a one per cent AEP is the probability of an event exceeding a nominated level in 100 years
Afflux	An increase in water level resulting from obstacles in the flow path
AHD	Australian Height Datum. The standard reference level used to express the relative height of various features. A height given in metres AHD is the height above sea level. Mean sea level is set as zero metres elevation
Alluvial	Relating to, consisting of, or formed by sediment deposited by flowing water
Alluvial material (alluvium)	Relatively recent deposits of sedimentary material within river/creek beds, floodplains, lakes or at the base of mountain slopes
ANZECC	Australian and New Zealand Environment and Conservation Council
Aquatic ecology	Flora and fauna that live in or on water for all or a substantial part of the life span (generally restricted to fresh/inland waters)
Aquifer	A groundwater bearing formation sufficiently permeable to transmit and yield groundwater or water bearing rock
AR&R	Australian Rainfall & Runoff
ARI	Average recurrence interval. An indicator used to describe the frequency of floods. The average period in years between the occurrence of a flood of a particular magnitude or greater. In a long period of say 1,000 years, a flood equivalent to or greater than a 100 year ARI event would occur 10 times. The 100 year ARI flood has a one per cent chance (i.e. a one-in-100 chance) of occurrence in any one year. Floods generated by runoff from the study catchments are referred to in terms of their ARI, for example the 100 year ARI flood
B	
Batter	The constructed side slope of road embankments and cuttings usually expressed as a ratio of horizontal distance to a vertical height value of one eg 2H: 1V. A fill batter is where the road is above the existing surface on a filled embankment and refers to the sloping sides of the embankment. A cut batter is where the road is below the existing surface
BBWQIP	Botany Bay and Catchment Water Quality Improvement Program
Bedrock	Rock of a substantial thickness and extent underlying a relatively soft and variable surface
Bioretention	Treatment process involving retention and filtration of stormwater through a filter media to remove contaminants and sediments
Biota	All organisms in a given area (including flora and fauna), considered as a unit
BOD	Biological Oxygen Demand
BoM	Bureau of Meteorology
Box culvert	A culvert of rectangular cross section
Bund	A small embankment designed to retain water
BTEX	Benzene, toluene, ethylbenzene and xylenes
C	
Campbell Road civil and tunnel site	A construction ancillary facility for the M4-M5 Link project at St Peters

Term	Definition
Campbell Road ventilation facility	Ventilation supply and exhaust facilities, axial fans, ventilation outlets and ventilation tunnels. Located at St Peters, within the St Peters interchange site
Catchment	The land area draining through the main stream, as well as tributary streams, to a particular site. It always relates to an area above a specific location
CBD	Central business district
CEMP	Construction Environmental Management Plan. A site specific plan developed for the construction phase of the project to ensure that all contractors and sub-contractors comply with the environmental conditions of approval for the project and that the environmental risks are properly managed
Climate change	A change in the state of the climate that can be identified (eg by statistical tests) by changes in the mean and/or variability of its properties, and that persists for an extended period of time, typically decades or longer (CSIRO and BoM 2015)
Climate projection	A climate projection is the simulated response of the climate system to a scenario of future emission or concentration of greenhouse gases and aerosols, generally derived using climate models. Climate projections are distinguished from climate predictions by their dependence on the emission/concentration/radiative forcing scenario used, which in turn is based on assumptions concerning, for example, future socio-economic and technological developments that may or may not be realised (CSIRO and BoM 2015)
CMA	Catchment Management Authority
Concept design	Initial functional layout of a road/road system or other infrastructure. Used to facilitate understanding of a project, establish feasibility and provide basis for estimating and to determine further investigations needed for detailed design
Confluence	A point at which streams combine
Construction ancillary facilities	Temporary facilities during construction that include, but are not limited to construction sites (civil and tunnel), sediment basins, temporary water treatment plants, pre-cast yards and material stockpiles, laydown areas, parking, maintenance workshops and offices
CDS	CPB Contractors, Dragados, Samsung Joint Venture (CDS). Contractor responsible for the New M5 Project
CSJ	CPB Contractors, Samsung, John Holland Joint Venture (CSJ). Contractor responsible for the M4 East Project
CSWMP	Construction Soil and Water Management Plan
CRC	Cooks River catchment
Cul-de-sac	A street or road that is open for vehicular traffic at one end only
Culvert	An enclosed channel for conveying water below a road
Cumulative impacts	Impacts that, when considered together, have different and/or more substantial impacts than a single impact assessed on its own
Cut-and-cover	A method of tunnel construction whereby the structure is built in an open excavation and subsequently covered
Cutting	Formation resulting from the construction of the road below existing ground level, the material is cut out or excavated
D	
Darley Road civil and tunnel site	A construction ancillary facility for the M4-M5 Link project at Leichhardt
DCP	Development Control Plan
DEC	NSW Department of Environment and Conservation (now OEH and the NSW EPA)
DECC	NSW Department of Environment and Climate Change (now OEH and NSW EPA)

Term	Definition
DECCW	NSW Department of Environment, Climate Change and Water (now OEH and the NSW EPA)
Detailed design	The phase of the project following concept design where the design is refined, and plans, specifications and estimates are produced.
Dewatering	The removal of water from solid material or soil by wet classification, centrifugation, filtration or similar solid-liquid separation processes
Discharge	The rate of flow of water measured in terms of volume per unit time, for example, cubic metres per second (m^3/s). Discharge is different from the speed or velocity of flow, which is a measure of how fast the water is moving (eg metres per second [m/s])
DLWC	NSW Department of Land and Water Conservation (now part of DPI)
DoP	NSW Department of Planning (now NSW Department of Planning and Environment)
DP&E	NSW Department of Planning and Environment
DP&I	NSW Department of Planning and Infrastructure (now NSW Department of Planning and Environment)
DPI	NSW Department of Primary Industries
DPI (Water)	NSW Department of Primary Industries (Water), formerly the NSW Office of Water
DPWS	NSW Department of Public Works and Services
Drainage	Natural or artificial means for the interception and removal of surface or subsurface water
Drawdown	Reduction in the height of the water table caused by changes in the local environment
DRAINS	A stormwater drainage system design and analysis program for estimating water flows. It is a successor to the ILSAX program which has been widely used for urban stormwater system design and analysis
E	
Earthworks	All operations involved in loosening, excavating, placing, shaping and compacting soil or rock
Ecosystem	A functional unit of energy transfer and nutrient cycling in a given place. It includes all relationships within the biotic community and between the biotic components of the system
EIA	Effective Impervious Area
EIS	Environmental Impact Statement
Electrical conductivity	The measure of a material’s ability to accommodate the transport of an electric charge
Embankment	An earthen structure where the road (or other infrastructure) subgrade level is above the natural surface
Enabling works	Works which are required to enable the commencement of the main construction works
Erosion	A natural process where wind or water detaches a soil particle and provides energy to move the particle
EP&A Act	*Environmental Planning and Assessment Act 1979* NSW
EP&A Regulation	Environmental Planning and Assessment Regulation 2000 (NSW)
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth)
Ephemeral creek	A creek that only exists for a short duration of time following rainfall
EPL	Environment Protection Licence under the *Protection of the Environment Operations Act 1997* (NSW)
ESCP	Erosion and Sedimentation Control Plan
Extreme rainfall	There is no consistent global definition for extreme rainfall. It can be defined by either relative rainfall at a location (amount relative to averages), or absolute rainfall amounts (eg over 100 millimetres in a single day). In this report, an extreme rainfall event is defined as the wettest day in 20 years

Term	Definition
F	
Feasible and reasonable	Consideration of standard or good practice taking into account the benefit of proposed measures and their technological and associated operational application in the NSW and Australian context. 'Feasible' relates to engineering considerations and what is practical to build. 'Reasonable' relates to the application of judgement in arriving at a decision, taking into account mitigation benefits and cost of mitigation versus benefits provided, community expectations and nature and extent of potential improvements
Fill	The material placed in an embankment
Flash flooding	Flooding which is sudden and unexpected. It is often caused by sudden local or nearby heavy rainfall. It is often defined as flooding which peaks within six hours of the rain event
Flood	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland flooding associated with major drainage before entering a watercourse, and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences excluding tsunami
Flood immunity	Relates to the level at which a particular structure would be clear of a certain flood event
Flood planning level (FPL)	The combinations of flood levels and freeboards selected for floodplain risk management purposes, as determined in flood studies and floodplain risk management studies and plans
Flood prone land	Land susceptible to flooding by the probable maximum flood. Note that the flood prone land is also known as flood liable land
Flood storage area	Those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood. The extent and behaviour of flood storage areas may change with flood severity, and loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation. It is necessary to investigate a range of flood sizes before defining flood storage areas
Floodplain	Area of land which is inundated by floods up to and including the probable maximum flood event (ie flood prone land)
FMS	Flood mitigation strategy
Floodplain Risk Management Plan	A management plan developed in accordance with the principles and guidelines in the NSW Floodplain development manual (NSW Department of Infrastructure, Planning and Natural Resources 2005). Usually includes both written and diagrammatic information describing how particular areas of flood prone land are to be used and managed to achieve defined objectives
FM Act	*Fisheries Management Act 1994* (NSW)
Footprint	The extent of direct impact that a development makes on the land.
FBA	Framework for Biodiversity Assessment
Freeboard	A factor of safety typically used in relation to the setting of floor levels, levee or crest levels. It is usually expressed as the difference in height between the adopted FPL and the peak height of the flood used to determine the flood planning level. Freeboard provides a factor of safety to compensate for uncertainties in the estimation of flood levels across the floodplain, such as wave action, localised hydraulic behaviour and impacts that are specific event related, such as levee and embankment settlement, and other effects such as 'greenhouse' and climate change. Freeboard is included in the Flood Planning Level
G	
Geomorphology	The study of shaping of the landscape by water, wind and other processes. Commonly used to describe the condition of streams as they are shaped by erosion and/or accretion of sediments
GIS	Geographical Information System

Term	Definition
GPT	Gross pollutant trap
Grade	Rate of longitudinal rise (or fall) with respect to the horizontal expressed as a percentage or ratio
Groundwater	Water that is held in the rocks and soil beneath the earth's surface.
Groundwater dependent ecosystem (GDE)	Refers to communities of plants, animals and other organisms whose extent and life process are dependent on groundwater, such as wetlands and vegetation on coastal sand dunes
H	
ha	Hectare(s)
Haberfield civil and tunnel site/ Haberfield civil site	Construction ancillary facilities for the M4-M5 Link project located at the Wattle Street interchange
Hazard	A source of potential harm or a situation with a potential to cause loss of human life or damage to physical assets
Habitat	The place where a species, population or ecological community lives (whether permanently, periodically or occasionally). Habitats are measurable and can be described by their flora and physical components.
Hydrology	The study of rainfall and surface water runoff processes
I	
IFD	Intensity-Frequency-Duration
Impact	Influence or effect exerted by a project or other activity on the natural, built and community environment
Infiltration	The downward movement of water into soil and rock. It is largely governed by the structural condition of the soil, the nature of the soil surface (including presence of vegetation) and the antecedent moisture content of the soil
Inner West Council	The amalgamation of the former local government areas of Ashfield, Leichhardt and Marrickville, proclaimed on 12 May 2016
Interchange	A grade separation of two or more roads with one or more interconnecting carriageways
Iron Cove Link	Around one kilometre of twin tunnels that would connect Victoria Road near the eastern abutment of Iron Cove Bridge and Anzac Bridge
Iron Cove Link civil site	A construction ancillary facility for the M4-M5 Link project located at Rozelle
Iron Cove Link ventilation facility	Ventilation supply and exhaust facilities, axial fans, ventilation outlets and ventilation tunnels. Located at Rozelle
IPCC	Intergovernmental Panel on Climate Change
J	
K	
King Georges Road Interchange Upgrade	A component of the WestConnex program of works. 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
kL	Kilolitres
kL/day	Kilolitres per day
L	
L/s/km	Litres per second per kilometre
Leachate	Liquid that 'leaches' (drains) from a landfill
LGA	Local government area
LiDAR	Light Detection and Ranging
LLS	Local Land Services
Localised flooding	Localised flooding occurs when components of the drainage system are undersized or blocked and cannot accommodate the incoming overland surface flows, resulting in the flooding of a localised area
M	
M	Metres
m/day	Metres per day

Term	Definition
m^2	Square metres
m^3	Cubic metres
mg/L	Milligrams per litre
ML	Megalitres
ML/day	Megalitres per day
ML/year	Megalitres per year
M4 East Motorway/project	A component of the WestConnex program of works. 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
M4 East mainline tunnel stubs	Eastbound and westbound extensions of the M4 East mainline tunnel being built as part of the M4 East project (to connect with the M4-M5 Link)
M4 East mainline connection	The underground connection between the M4-M5 Link mainline tunnels and the M4 East mainline stub tunnels
M4 Widening	A component of the WestConnex program of works. Widening of the existing M4 Motorway from Parramatta to Homebush
M4-M5 Link	The project which is the subject of this EIS. A component of the WestConnex program of works
M5 East Motorway	Part of the M5 Motorway corridor. Located between Beverly Hills and Sydney Airport (General Holmes Drive)
M5 Motorway corridor	The M5 East Motorway and the M5 South West Motorway
M5 South West Motorway	Part of the M5 Motorway corridor. Located between Prestons and Beverly Hills
Mainline tunnels	The M4-M5 Link mainline tunnels connecting with the M4 East Motorway at Haberfield and the New M5 Motorway at St Peters
Mainstream flooding	Inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam
MUS	Managing urban stormwater
Mean rainfall	The arithmetically averaged total amount of precipitation recorded during a calendar month or year
Median	The central reservation which separates carriageways from traffic travelling in the opposite direction
microSiemens per centimetre (mS/cm)	A measure of electrical conductivity. Commonly used to measure the salinity of water
Motorway	Fast, high volume controlled access roads. May be tolled or untolled
MUSIC	Model for Urban Stormwater Improvement Conceptualisation
N	
New M5 Motorway/project	A component of the WestConnex program of works. Located from Kingsgrove to St Peters (under construction)
New M5 mainline stub tunnels	Northbound and southbound extensions of the New M5 mainline tunnel being built as part of the New M5 project (to connect with the M4-M5 Link)
New M5 mainline connection	The underground connection between the M4-M5 Link mainline tunnels and the New M5 mainline stub tunnels
Northcote Street civil site	A construction ancillary facility for the M4-M5 Link project located at Haberfield
NSW EPA	NSW Environment Protection Authority
NSW State Flood Plan	A plan that deals specifically with flooding and is a sub-plan of an EMPLAN. Flood Sub Plans describe agreed roles, responsibilities, functions, actions and management arrangements for the conduct of flood operations and for preparing for them. They are prepared at State, Region and Local Government levels

Term	Definition
NSW Water Quality and River Flow Objectives	The NSW Water Quality and River Flow Objectives (DECCW 2006) are consistent with the agreed national framework of the ANZECC Water Quality Guidelines and are primarily aimed at maintaining and improving water quality, for the purposes of supporting aquatic ecosystems, recreation and where applicable water supply and the production of aquatic foods suitable for consumption and aquaculture activities
NSW WQOs	NSW Water Quality Objectives. See also NSW Water Quality and River Flow Objectives
NWQMS	National Water Quality Management Strategy
O	
OEH	NSW Office of Environment and Heritage (formerly DECCW)
OEMP	Operational Environmental Management Plan
Off-ramp	A ramp by which one exits a limited-access highway/tunnel
On-ramp	A ramp by which one enters a limited-access highway/tunnel
Outside shoulder	The area of pavement outside the traffic lanes that is closest to the 'slow' lane
Overbridge	Bridge which conveys another road, rail or pedestrians over the described road.
Overland flooding	Inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam
P	
Parcel of land	Refers to an individual lot number (lot) and deposited plan (DP)
Parramatta Road corridor	The Parramatta Road corridor is the area from Parramatta CBD to Sydney CBD, generally between the Main Western Rail line in the south and the Parramatta River to the north
Parramatta Road East civil site	A construction ancillary facility for the M4-M5 Link project at Haberfield
Parramatta Road ventilation facility	A ventilation facility located on the south-eastern corner of the Parramatta Road/Wattle Street intersection (referred to as the Eastern ventilation facility in the M4 East project EIS). The facility is being built as part of the M4 East project. As part of the M4-M5 Link project, fitout works would be carried out on a section of this facility
Parramatta Road West civil and tunnel site	A construction ancillary facility for the M4-M5 Link project at Ashfield
Pavement	The portion of a carriageway placed above the subgrade for the support of, and to form a running surface for vehicular traffic
Peak discharge	The maximum discharge occurring during a flood event
Peak flood level	The maximum water level occurring during a flood event
pH	Numeric scale ranging from zero to 14 used to specify the acidity or alkalinity of an aqueous solution. Solutions with a pH less than seven are acidic and solutions with a pH greater than seven are alkaline. Pure water has a pH of seven and is neutral
POEO Act	*Protection of the Environment Operations Act 1997* (NSW)
Pollutant	Any measured concentration of solid or liquid matter that is not naturally present in the environment
Portals	The locations where a tunnel meets a surface road
Probability	A statistical measure of the expected chance or likelihood of occurrence
PMF	Probable Maximum Flood. The flood that occur as a result of the probable maximum precipitation on a study catchment. The probable maximum flood is the largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation coupled with the worst flood producing catchment conditions. Generally, it is not physically or economically possible to provide complete protection against this event. The probable maximum flood defines the extent of flood prone land (ie the floodplain)

Term	Definition
Portal	The entry and/or exit to a tunnel
Project	A new multi-lane road link between the M4 East Motorway at Haberfield and the New M5 Motorway at St Peters. The project would also include an interchange at Lilyfield and Rozelle (the Rozelle interchange) and a tunnel connection between Anzac Bridge and Victoria Road, east of Iron Cove Bridge (Iron Cove Link). In addition, construction of tunnels, ramps and associated infrastructure to provide connections to the proposed future Western Harbour Tunnel and Beaches Link project would be carried out at the Rozelle interchange
Project footprint	The land required to construct and operate the project. This includes permanent operational infrastructure (including the tunnels), and land required temporarily for construction
Proprietary stormwater treatment device	Pre-fabricated device designed for removal of pollutants from stormwater. These are usually installed underground and connected to the pipe drainage network
Publicly available	Available for inspection in hard copy and/or electronic format by a member of the general public (for example available on the project website)
Pyrmont Bridge Road tunnel site	A construction ancillary facility for the M4-M5 Link project at Annandale
Q	
R	
RCBC	Reinforced concrete box culvert
Revegetation	To revegetate an area by direct seeding with non-native species or cover crops and / or native species using manual or mechanical means such as hydromulching, straw mulching and tractor seeding
Riparian	The part of the landscape adjoining rivers and streams that has a direct influence on the water and aquatic ecosystems within them
Rising main	A pipe through which water from a pump is delivered to an elevated location
Roads and Maritime	NSW Roads and Maritime Services
RTA	NSW Roads and Traffic Authority. Now NSW Roads and Maritime Services
Rozelle civil and tunnel site	A construction ancillary facility for the M4-M5 Link project located at Lilyfield and Rozelle
Rozelle interchange	A new interchange at Lilyfield and Rozelle that would connect the M4-M5 Link mainline tunnels with City West Link, Anzac Bridge, the Iron Cove Link and the proposed future Western Harbour Tunnel and Beaches Link
Rozelle Rail Yards	The Rozelle Rail Yards is bound by City West Link to the south, Lilyfield Road to the north, Balmain Road to the west, and White Bay to the east. Note that the project only occupies part of the Rozelle Rail Yards site
Rozelle Rail Yards site management works	The preparation of a project site prior to construction commencement. It may include the installation of fencing, temporary site offices, signage, and erosion and sediment controls; and involve the delineation of equipment laydown, material stockpile, spoil transfer, and waste management areas
Rozelle ventilation facility	Ventilation supply and exhaust facilities, axial fans, ventilation outlets and ventilation tunnels. Located at the Rozelle Rail Yards, the ventilation supply facility is located at the Rozelle West motorway operations complex and a ventilation exhaust facility at the Rozelle East motorway operations complex
Runoff	The part of the rainfall on a catchment which flows as surface discharge past a specified point
S	
Scour	The erosion of material by the action of flowing water
SEARs	Secretary's Environmental Assessment Requirements Requirements and specifications for an environmental assessment prepared by the Secretary of the NSW Department of Planning and Environment under section 115Y of the *Environmental Planning and Assessment Act 1979* (NSW)

Term	Definition
Sediment	Material, both mineral and organic, that is being or has been moved from its site of origin by the action of wind, water or gravity and comes to rest either above or below water level
Sedimentation	Deposition of sediment usually by water
Sedimentation basin	A stormwater detention system that promotes the settling of sediments trough the reduction of flow velocities and temporary detention. Key elements include purpose designed inlet and outlet structures, settling pond and high flow, overflow structures
Sensitive receiver/receptor	Includes residences, educational institutions (including preschools, schools, universities, TAFE colleges), health care facilities (including nursing homes, hospitals), religious facilities (including churches), child care centres, passive recreation areas (including outdoor grounds used for teaching), active recreation areas (including parks and sports grounds), commercial premises (including film and television studios, research facilities, entertainment spaces, temporary accommodation such as caravan parks and camping grounds, restaurants, office premises, retail spaces and industrial premises)
SES	NSW State Emergency Service
SHPRC	Sydney Harbour and Parramatta River Catchment
SHWQIP	Sydney Harbour Water Quality Improvement Plan
SMC	Sydney Motorway Corporation
SMCMA	Sydney Metropolitan Catchment Management Authority
Socio-economic	Involving combination of social and economic matters
Spoil	Surplus excavated material
St Peters interchange	A component of the New M5 project, located at the former Alexandria Landfill site at St Peters. Approved and under construction as part of the New M5 project. Additional construction works proposed as part of the M4-M5 Link project
St Peters motorway operations complex	New M5 motorway operations complex located near the western corner of the St Peters interchange, adjacent to the Prince Highway/Canal Road intersection. Contains operational ancillary infrastructure that is required for operation of the project
Staging	Refers to the division of the project into multiple contract packages for construction purposes, and/or the construction or operation of the overall project in discrete sections
Stockpile	Temporarily stored materials such as soil, sand, gravel and spoil/waste
Strahler stream ordering process	A stream classification system where waterways are given an ‘order’ according to the number of additional tributaries associated with each waterway. This is used as a measure of system complexity and therefore the potential for fish habitat to be present. Flow paths at the top of a catchment are assigned the number one
Strata	Geological layers below the ground surface
Stream order	A classification system which assigns an ‘order’ to waterways according to the number of additional tributaries associated with each waterway, to provide a measure of system complexity
Surface road widening works	Located between the M5 East Motorway, east of King Georges Road and the new tunnel portals
Surface water	Water flowing or held in streams, rivers and other wetlands in the landscape
Swale	A shallow, grass-lined drainage channel
T	
Terrestrial	Living or growing on land (i.e. terrestrial flora or fauna)
Thalweg	The lowest point along the length of a stream bed
The Blue Book	*Managing Urban Stormwater – Soils and Construction* Volumes 1 and 2, NSW Government 2004 and 2006

Term	Definition
The Crescent civil site	A construction ancillary facility for the M4-M5 Link project located at Annandale
Threatened	As defined under the *Threatened Species Conservation Act 1995* (NSW), a species, population or ecological community that is likely to become extinct or is in immediate danger of extinction
Toxicity	The degree of danger posed by a substance to human, animal or plant life.
TPH	Total Petroleum Hydrocarbon
Transverse drainage	Existing drainage lines (typically) that cross linear infrastructure such as roads
Tributary	A river or stream flowing into a larger river or lake
TRH	Total recoverable hydrocarbons
TSS	Total Suspended Solids
TUFLOW	A 1D/2D finite difference numerical model that simulates hydrodynamic behaviour in rivers, floodplain and urban drainage environments
Tunnel stub	Driven tunnels constructed to connect to potential future motorway links
Turbidity	A measure of light penetration through a water column containing particles of matter in suspension
U	
Urban design	The process and product of designing human settlements, and their supporting infrastructure, in urban and rural environments
V	
Ventilation facility	Facility for the mechanical removal of air from the mainline tunnels, or mechanical introduction of air into the tunnels. May comprise one or more ventilation outlets
Victoria Road civil site	A construction ancillary facility for the M4-M5 Link project located at Rozelle
W	
WAL	Water access licence
Water Act 1912	*Water Act 1912* (NSW)
WM Act	*Water Management Act 2000* (NSW)
Waterway	Any flowing stream of water, whether natural or artificially regulated (not necessarily permanent)
Wattle Street civil and tunnel site	A construction ancillary facility for the M4-M5 Link project located at Haberfield
Wattle Street interchange	An interchange to connect Wattle Street (City West Link) with the M4 East and the M4-M5 Link tunnels. Approved and under construction as part of the M4 East project. Additional construction works proposed as part of the M4-M5 Link project
WestConnex program of works	A program of works that includes the M4 Widening, King Georges Road Interchange Upgrade, M4 East, New M5 and M4-M5 Link projects
Wetland	Wetlands are areas of land that are wet by surface water or groundwater, or both, for long enough periods that the plants and animals in them are adapted to, and depend on, moist conditions for at least part of their lifecycle. They include areas that are inundated cyclically, intermittently or permanently with fresh, brackish or saline water, which is generally still or slow moving except in distributary channels such as tidal creeks which may have higher peak flows. Wetlands may be constructed for the purposes of removing pollutants from runoff
WQIP	Water Quality Improvement Plan
WQPMP	Water Quality Plan and Monitoring Program
WSUD	Water sensitive urban design
WTP	Water treatment plant
X	
Y	
Z	

Executive summary

NSW Roads and Maritime Services (Roads and Maritime) is seeking approval to construct and operate the WestConnex M4-M5 Link, which would comprise:

- About 7.5 kilometres of twin motorway tunnels (that is, two mainline tunnels located side-by-side) between the M4 East at Haberfield and the New M5 at St Peters
- An underground connection between the mainline tunnels and the Wattle Street interchange at Haberfield. The Wattle Street interchange is being constructed as part of the WestConnex M4 East project
- An underground connection between the mainline tunnels and the St Peters interchange. The St Peters interchange is being built as part of the WestConnex New M5 project
- A new interchange at Lilyfield and Rozelle (the Rozelle interchange) that would include dive structures and tunnel portals to connect the mainline tunnels to the surface road network at City West Link and Victoria Road/Anzac Bridge
- Construction of connections to the proposed future Western Harbour Tunnel and Beaches Link project as part of the Rozelle interchange
- A new tunnel connection between the Rozelle interchange and Victoria Road at the eastern abutment of Iron Cove Bridge (the Iron Cove Link)
- A dive structure and tunnels portals on Victoria Road at Rozelle, east of Iron Cove Bridge
- Upgrades and improvements to the surface road network at Lilyfield and Rozelle
- Ventilation facilities at the Rozelle interchange, Iron Cove tunnel portals and the St Peters interchange.

This technical working paper presents the assessment of potential impacts during construction and operation of the project on surface water including flooding, drainage, water quality, water quantity and geomorphology. The majority of the project footprint is located within the Sydney Harbour and Parramatta River catchment (SHPRC) with the southern portion within proximity to the St Peters interchange located within the Cooks River catchment (CRC). The predominant waterways within the SHPRC traversed or affected by the project footprint include Hawthorne Canal, Whites Creek, Rozelle Bay, Johnstons Creek as well as Dobroyd Canal (also known as Iron Cove Creek) and Easton Park drain. Dobroyd Canal and Hawthorne Canal discharge to Iron Cove while Whites Creek, Johnstons Creek and Easton Park drain discharge to Rozelle Bay. Alexandra Canal is the main waterway downstream of the project footprint within the CRC. The catchments are highly urbanised and the waterways are all artificial, hard lined stormwater channels, with the exception of Alexandra Canal which has an unlined base and hard lined banks. Existing water quality in all waterways was indicative of a highly urbanised catchment.

The investigation undertaken for the M4-M5 Link project found that the local stormwater drainage systems that control runoff from these catchments are of limited capacity. As a result, the project corridor is presently impacted by both main stream flooding and overland flows. **Section 4.4** of this report provides a brief description of the existing flood behaviour at each of the main surface features of the project. This takes into consideration the works currently undertaken as part of the M4 East and New M5 projects which adjoin the M4-M5 Link. **Table 4-1** provides a summary of the existing flood risk, based on available flood information.

Construction impacts

The majority of the construction ancillary facilities assessed in the environmental impact statement (EIS) would be affected by either main stream or overland flows. 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 (resulting in displacement of water) or impacts on the conveyance of floodwaters.

The likelihood of flooding and a summary of the potential impacts of construction sites and associated construction activities on flood risk is provided in **Table 5-1** in **section 5.2**. The assessment found that a number of the construction ancillary facilities would be affected by flooding during relatively frequent storms events. In particular, the Rozelle civil and tunnel site (C5) is affected by both mainstream flooding from Whites Creek and major overland flows through the Rozelle Rail Yards.

Construction activities also have the potential to exacerbate flooding conditions in adjacent developments. This arises due to the need to locate temporary measures on the floodplain outside the road footprint. A preliminary investigation was undertaken to assess the potential construction impacts on the characteristics of flooding. The key findings of the investigation are also summarised in **Table 5-1**.

During construction, the potential surface water quality, hydrology and geomorphology impacts would be associated with:

- Erosion of soils, sedimentation of waterways and exposure of contaminated soils and groundwater
- Accidental leaks or spills of chemicals, fuels and oils during construction
- Direct disturbance of waterway channel and riparian areas, or increased scour due to increased discharge flow rates and volumes
- Discharge of poorly treated water during construction, which could potentially impact on water quality of receiving waterways.

Potential impacts on surface water quality, geomorphology and hydrology during construction of the project are considered minor and manageable with the application of standard mitigation measures.

Operational impacts

If unmanaged, inundation of the project by floodwater during its operation has the potential to cause damage to infrastructure; impact on the safe operation of the motorway tunnels and pose a safety risk to road users and motorway operations staff. The project also has the potential to exacerbate flooding and drainage conditions in adjacent developments.

An assessment was undertaken of the flood risk to the project in its operational phase, as well as the impact it would have on the characteristics of flooding in adjacent development. **Section 6.2.1** provides an overview of the operational flood risks at the main project surface features. The assessment has shown that the Rozelle interchange, Iron Cove Link and Darley Road site are partially located within the Probable Maximum Flood (PMF) flood extent, which has the potential to impact on the interchange and tunnel portals.

A recommended level of flood protection to each project element has been identified with due consideration of the consequences of flooding in accordance with the *NSW Floodplain Development Manual* (NSW Department of Infrastructure, Planning and Natural Resources 2005) and current Roads and Maritime standards. The design criterion is to prevent flooding of the portals for events up to the PMF or the 100 year Average Recurrence Interval (ARI) event plus 0.5 metres freeboard (whichever is greater).

The investigation found that once constructed, the project would have only a minor impact on flooding behaviour in adjacent developments for storms with ARI's up to 100 years. While it will be necessary to undertake further design development during detailed design aimed at further reducing the residual impacts of the project on flooding behaviour, it is concluded that the minor nature of the changes in flooding patterns attributable to the project would not have a significant impact on the future development potential of land located outside the project footprint.

Potential impacts of future climate change on flooding

Future climate change could lead to sea level rise and potential increase in rainfall intensity and frequency. This could affect flood behaviour over the life of the project. An assessment of the potential impact of climate change on flood behaviour in the vicinity of the M4-M5 Link project has therefore been undertaken, in accordance with the NSW Office of Environment and Heritage's (OEH) *Floodplain Risk Management Guideline – Practical Considerations of Climate Change* (NSW Department of Environment and Climate Change (DECC) 2007) and current best practice. **Section 6.2.2** provides an overview of the climate change scenarios that were assessed, considering different combinations of design storm rainfalls and sea level conditions under 2050 and 2100 conditions.

The investigation found that changes in the flood behaviour under future climate change conditions would not lead to a significant increase in the flood risk to the project. **Section 6.2.2** summarises the potential impact future climate change could have on peak flood levels at key locations along the project corridor.

During operation, potential surface water quality, hydrology and geomorphology impacts would be associated with:

- Increases in impervious surfaces generating increased runoff and pollutant loads
- Accidental spills or leaks of fuels and/or oils from vehicle accidents or from operational plant and equipment
- Erosion of vegetated surfaces
- Scour at outlets to waterways
- Discharges of treated tunnel wastewater
- Poor erosion protection treatments within the proposed naturalised sections of Whites Creek.

Management of potential impacts

The assessment of flood impacts associated with the project has provided an understanding of the scale and nature of the flood risk to the project infrastructure and its operation, as well as the risks for the surrounding environment. The layouts of the different interchanges have been influenced by flood risk and drainage considerations. A range of potential flood mitigation measures which would reduce/manage the flood impacts during the project's operational phase is provided in **section 8.1.3**.

A Flood Mitigation Strategy (FMS) would be prepared for flood prone or flood affected land within the project footprint prior to construction, to demonstrate that the existing flooding characteristics would not be exacerbated as a consequence of the project. The FMS would identify flood risks to the project and adjoining areas, design and mitigation measures that would be implemented to protect proposed operations and not worsen existing flood characteristics and required drainage system upgrades.

Bridge crossings over existing waterways and proposed drainage channels would be designed for the underside of bridge structure to be above the peak 100 year ARI design flood level. All entry points into the tunnels would 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 would 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 would also have the potential to flood the tunnels.

Further impact assessments based on the detailed design would be undertaken to determine the ability of the receiving drainage systems to effectively convey drainage discharges from the project once operational.

During the construction phase, some of the works would occur within the extent of various flood event magnitudes as outlined in **section 5.2**. Flood management plans would be developed prior to construction as part of the Construction Environmental Management Plan (CEMP), to guide the design of construction ancillary facilities and thereby minimise potential impacts of flooding. This would be in line with minimising risk to the surrounding environment.

Further assessment of the construction of ancillary facilities and measures to manage flooding onsite and mitigate flood impacts during construction would be undertaken during detailed design. A range of potential flood mitigation measures which would reduce/manage the impact of construction activities on flooding behaviour are set out in **Table 8-1**.

The CEMP would control potential surface water quality impacts during construction. A Construction Soil and Water Management Plan (CSWMP) including a water quality monitoring program would be prepared as part of the CEMP, construction water treatment plants would be established during the construction phase to treat water to a quality suitable for discharge to the environment. Works within or adjacent to waterways would be managed in accordance with the *Controlled Activities on Waterfront Land Guidelines* (NSW Department of Primary Industries (DPI) 2012).

Suitable treatment devices would be provided to treat stormwater runoff from impervious surfaces that result from the project. The final design of treatment facilities would be undertaken during detailed design including investigation of potential opportunities to achieve annual stormwater pollutant load reduction targets through the treatment of external catchments.

Operational water quality monitoring would be conducted for three years post-construction or as otherwise required by project conditions of approval.

An assessment of risk of spills on the motorway, with emphasis placed on the receiving environment, would be undertaken. If warranted in areas of higher sensitivity, such as upstream of Rozelle Bay and Iron Cove, containment facilities would be provided. This would be determined during detailed design. Spill management and emergency response procedures would also be documented in an Operational Environmental Management Plan (OEMP). Proposed landscaped areas would be suitably profiled, vegetated and stabilised to control erosion.

New discharge outlets would be designed with appropriate energy dissipation and scour protection measures. The presence and suitability of energy dissipation and scour protection measures at existing outlets would also be assessed during detailed design and appropriate improvements incorporated as required.

Water treatment plants would be permanently established at Rozelle interchange and Darley Road, Leichhardt to treat tunnel groundwater inflows as well as discharges collected via the tunnel drainage system and sump. Treated water would be discharged at a rate of up to 22 litres per second into the Rozelle Bay and 23 litres per second to Hawthorne Canal. The tunnel operational water treatment facilities would be designed such that effluent will be of suitable quality for discharge to the receiving environment with consideration to the characteristics of the discharge and receiving waterbody, any operational constraints or practicalities and associated environmental impacts, Australian and New Zealand Environment and Conservation Council (ANZECC) (2000) and relevant NSW Water Quality Objectives (NSW WQOs).

The proposed constructed wetland at Rozelle will provide ‘polishing’ treatment to the treated groundwater flows. As no constructed wetland is proposed at Darley Road, opportunities to incorporate other forms of nutrient treatment within the plant at Darley Road will be investigated during detailed design.

Minor increases in storm flow to Rozelle Bay, Whites Creek, White Bay, Iron Cove, Alexandra Canal and Hawthorne Canal associated with an increase in impervious surface and the increase in base flow to Hawthorne Canal and Rozelle Bay associated with treated tunnel flows are considered to pose a negligible impact on the natural flow variability of the tidal waterways. Naturalisation works on Whites Creek would incorporate surface treatments which provide suitable erosion protection once constructed and established.

Conclusion

The project has the potential to impact on the surface water environment as a result of construction and operation activities, altered hydrology within the catchment, as well as the discharge of treated groundwater. The implementation of management measures would reduce or manage these impacts to an appropriate level.

1 Introduction

NSW Roads and Maritime Services (Roads and Maritime) is seeking approval to construct and operate the WestConnex M4-M5 Link (the project), which would comprise a new multi-lane road link between the M4 East Motorway at Haberfield and the New M5 Motorway at St Peters. The project would also include an interchange at Lilyfield and Rozelle (the Rozelle interchange) and a tunnel connection between Anzac Bridge and Victoria Road, east of Iron Cove Bridge (Iron Cove Link). In addition, construction of tunnels, ramps and associated infrastructure to provide connections to the proposed future Western Harbour Tunnel and Beaches Link project would be carried out at the Rozelle interchange.

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.

Approval is being sought under Part 5.1 of the *Environmental Planning and Assessment Act 1979* (NSW) (EP&A Act) for the project. A request has been made for the NSW Minister for Planning to specifically declare the project to be State significant infrastructure and also critical State significant infrastructure. An environmental impact statement (EIS) is therefore required.

1.1 Overview of WestConnex and related projects

The M4-M5 Link is part of the WestConnex program of works. Separate planning applications and assessments have been completed for each of the approved WestConnex projects. Roads and Maritime has commissioned Sydney Motorway Corporation (SMC) to deliver WestConnex, on behalf of the NSW Government. However, Roads and Maritime is the proponent for the project.

In addition to linking to other WestConnex projects, the M4-M5 Link would provide connections to the proposed future Western Harbour Tunnel and Beaches Link, the Sydney Gateway (via the St Peters interchange) and the F6 Extension (via the New M5).

The WestConnex program of works, as well as related projects, are shown in **Figure 1-1** and described in **Table 1-1**.

Table 1-1 WestConnex and related projects

Project	Description	Status
WestConnex program of works		
M4 Widening	Widening of the existing M4 Motorway from Parramatta to Homebush.	Planning approval under the 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.

Project	Description	Status
M4-M5 Link (the project)	Tunnels connecting to the M4 East at Haberfield (via the Wattle Street interchange) and the New M5 at St Peters (via the St Peters interchange), a new interchange at Rozelle and a link to Victoria Road (the Iron Cove Link). The Rozelle interchange also includes ramps and tunnels for connections to the proposed future Western Harbour Tunnel and Beaches Link project.	The subject of this EIS.
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.
Western Harbour Tunnel and Beaches Link	The Western Harbour Tunnel component would connect to the M4-M5 Link at the Rozelle interchange, cross underneath Sydney Harbour between the Birchgrove and Waverton areas, and connect with the Warringah Freeway at North Sydney. The Beaches Link component would comprise a tunnel that would connect to the Warringah Freeway, cross underneath Middle Harbour and connect with the Burnt Bridge Creek Deviation at Balgowlah and Wakehurst Parkway at Seaforth. It would also involve the duplication of the Wakehurst Parkway between Seaforth and Frenchs Forest.	Planning underway by Roads and Maritime and subject to separate environmental assessment and approval.
F6 Extension	A proposed 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.

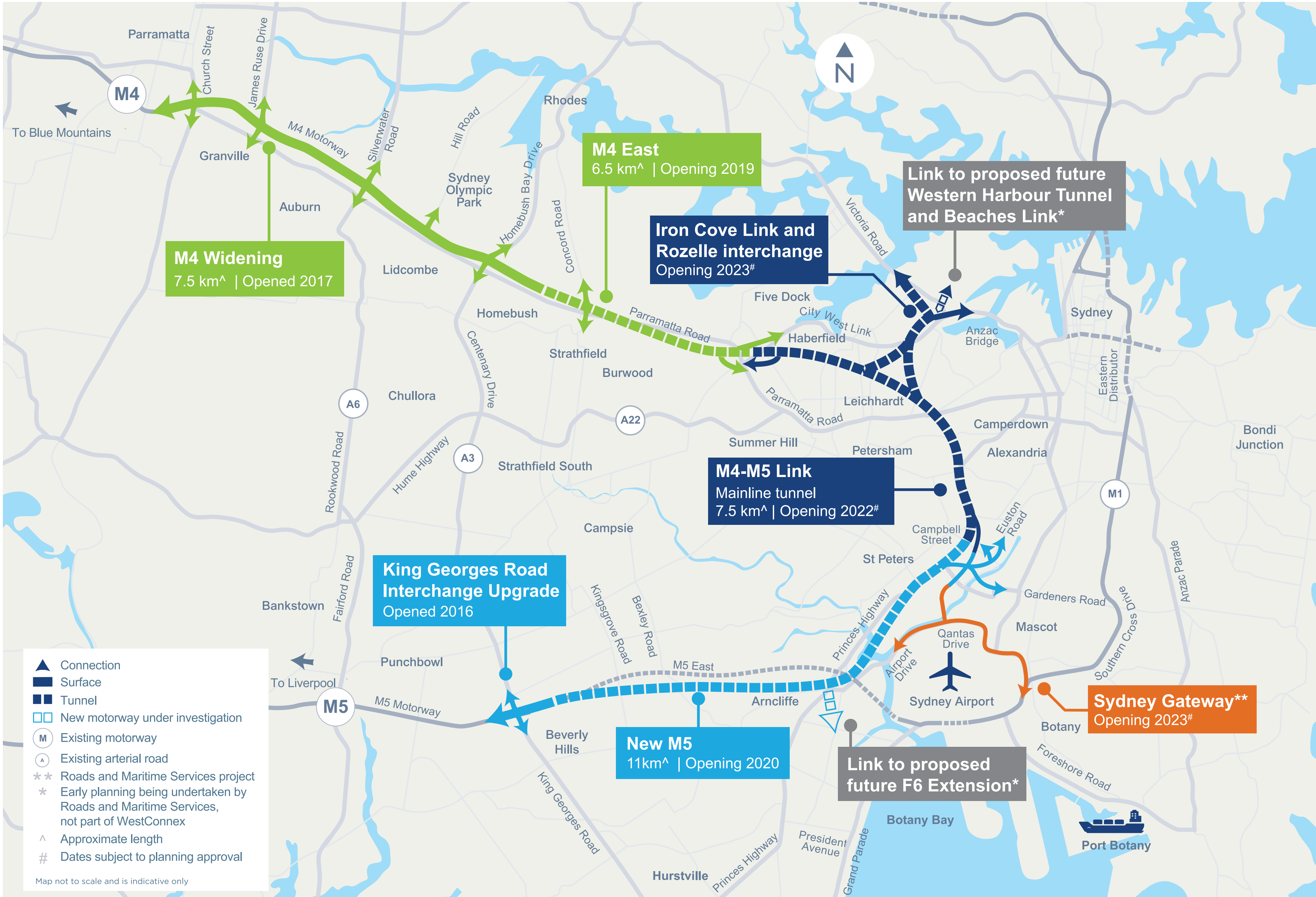

Figure 1-1 Overview of WestConnex and related projects

1.2 Purpose of this report

This report has been prepared to address the Secretary's Environmental Assessment Requirements (SEARs) in relation to hydrology, surface water quality and flooding, for the preparation of an EIS for the project. The report presents the state of the existing surface water and flooding environment as a baseline and then identifies the potential impacts that may arise from the construction and operation of the project and measures to manage the potential impacts.

1.3 SEARs and agency comments

Table 1-2 How SEARs have been addressed in this report

	Key issue SEARs	Section where addressed in this report
10. Water - Hydrology		
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).	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.	See **section 4.1** for the existing hydrological regime for surface water resource. Refer **Appendix T** (Technical working paper: Groundwater) of the EIS for discussion regarding 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.	See **sections 2.4.1, 5.2.1, 5.2.2** and **6.3** for surface water balance. Refer **Appendix T** (Technical working paper: Groundwater) of the EIS 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:	
	(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;	See **sections 4.1, 4.2, 4.6, 4.9, 5.2, 5.4** and **6.2.4** for surface water. Refer **Appendix T** (Technical working paper: Groundwater) of the EIS for groundwater hydrology. Refer **Appendix S** (Technical working paper: Biodiversity) of the EIS for impacts on aquatic habitat.

	Key issue SEARs	Section where addressed in this report
	(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 **Appendix T** (Technical working paper: Groundwater) of the EIS for impacts on groundwater and **Appendix S** (Technical working paper: Biodiversity) of the EIS for impacts on groundwater dependant ecosystems and species.
	(c) changes to environmental water availability and flows, both regulated/licensed and unregulated/rules-based sources;	See **sections 2.4.1, 5.1, 5.2.2** and **6.2.4**.
	(d) direct or indirect increases in erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses;	See **sections 4.2, 4.9**, **5.2.2**, **5.3.2**, **6.2.4**, **6.3.5**, **8** and **Appendix S** (Technical working paper: Biodiversity) of the EIS.
	(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	See **sections 4.2, 5.2.2** and **6.2.4** and **8**.
	(f) water take (direct or passive) from all surface and groundwater sources with estimates of annual volumes during construction and operation.	See **sections 2.4.1** , **5.1** and **6.1** for surface water. Refer to **Appendix T** (Technical working paper: Groundwater) of the EIS for groundwater.
	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 the urban waterways would be undertaken and with consideration to the artificial nature of the receiving waterways. Refer to **Appendix T** (Technical working paper: Groundwater) of the EIS.
	5. The assessment must include details of proposed surface and groundwater monitoring.	For proposed surface water monitoring, see **sections 4.5** and **8.2**. For proposed groundwater monitoring, refer to **Appendix T** (Technical working paper:

	Key issue SEARs	Section where addressed in this report
		Groundwater) of the EIS.
	6. The proposed tunnels should be designed to prevent drainage of alluvium in the palaeochannels.	Refer to **Appendix T** (Technical working paper: Groundwater) of the EIS.
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:	
	(a) state the ambient NSW Water Quality Objectives (NSW WQO) and environmental values for the receiving waters relevant to the project, including the indicators and associated trigger values or criteria for the identified environmental values;	**Section 3.2.2**.
	(b) identify and estimate the quality and quantity of all pollutants that may be introduced into the water cycle by source and discharge point and describe the nature and degree of impact that any discharge(s) may have on the receiving environment, including consideration of all pollutants that pose a risk of non-trivial harm to human health and the environment;	The quantity of stormwater pollutants has been assessed in **section 6.3**. Tunnel pollutant discharges are assessed in **section 6.3**. Other potential pollutants of concern have been listed. Refer to **sections 4.10, 5.3** and **6.3**. Residual impacts to water quality are discussed in **sections 8.2.2** and **8.2.4**.
	(c) identify the rainfall event that the water quality protection measures will be designed to cope with;	Operational measures are designed based on pollutant load reduction (rather than a rainfall event). Construction measures will be designed in accordance with the Blue Book. See **section 8.2**.
	(d) assess the significance of any identified impacts including consideration of the relevant ambient water quality outcomes;	**Sections 5.3, 6.3** and **8.2** Residual impacts to water quality are discussed in **sections 8.2.2** and **8.2.4**.
	(e) demonstrate how construction and operation of the project will, to the extent that the project can influence, ensure that:	
	- where the NSW WQOs for receiving waters are currently being met they will continue to be protected; and	**Sections 8.2.2** and **8.2.4**.
	- where the NSW WQOs are not currently being met, activities will not worsen water quality and, where reasonably practicable, work toward their achievement over time;	**Sections 8.2.2** and **8.2.4**.
	(f) justify, if required, why the WQOs cannot be maintained or achieved over time;	**Sections 8.2.2** and **8.2.4**.

	Key issue SEARs	Section where addressed in this report
	(g) demonstrate that all practical measures to avoid or minimise water pollution and protect human health and the environment from harm are investigated and implemented;	**Sections 2.4** and **8.2.** A review of tunnel treatment options is provided in **Annexure H**.
	(h) identify sensitive receiving environments (which may include estuarine and marine waters downstream) and develop a strategy to avoid or minimise impacts on these environments; and	**Sections 2.4, 4.1, 4.6** and **8**.
	(i) identify proposed monitoring locations, monitoring frequency and indicators of surface and groundwater quality.	**Sections 4.5** and **8.2**.
	2. The assessment should consider the results of any current water quality studies, as available, in the project catchment.	**Section 4.5**.
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:	**Sections 6.2.1, 6.2.2** and **Annexure C**.
	(a) how the tunnel entries and cut-and-cover sections of the tunnels would be protected from flooding during construction works;	**Sections 5.2, 6.2** and **8.1.2**.
	(b) any detrimental increases in the potential flood affectation of the project infrastructure and other properties, assets and infrastructure;	**Sections 5.2, 6.2** and **8.1.2**.
	(c) consistency (or inconsistency) with applicable Council floodplain risk management plans;	**Sections 3.2.9**, **4.4.1** and **6.2**.
	(d) compatibility with the flood hazard of the land;	**Sections 4.4.1, 6.2** and **8.1**.
	(e) compatibility with the hydraulic functions of flow conveyance in flood ways and storage areas of the land;	**Sections 4.4.1** and **6.2**.
	(f) whether there will be adverse effect to beneficial inundation of the floodplain environment, on, or adjacent to or downstream of the site;	**Sections 5.2** and **6.2**.
	(g) downstream velocity and scour potential;	**Section 6.2**.
	(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;	**Section 6.2** and **8.1.1**.

	Key issue SEARs	Section where addressed in this report
	(i) any impacts the development may have on the social and economic costs to the community as consequence of flooding;	See **section 6.2.1**
	(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; and	See **sections 4.2, 5.2.1, 5.2.2 6.2.4** and **6.3**.
	(k) any mitigation measures required to offset potential flood risks attributable to the project.	See **Sections 6.2** and **8.1**.
	2. The assessment should take into consideration any flood studies undertaken by local government councils, as available.	See **Sections 3.4** and **4.4.1**.
	Other issue SEARs	
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.	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.	Refer to **Appendix R** (Technical working paper: Contamination) of the EIS, **Appendix T** (Technical working paper: Groundwater) of the EIS and **sections 4.10, 5.3, 6.3** and **8**.
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.	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.	See **sections 5.3** and **6.3**. Refer to **Appendix I** (Technical working paper: Air quality) of the EIS and **Appendix J** (Technical working paper: Noise and vibration) of the EIS.

Table 1-3 How agency comments have been addressed in this report

Agency letters	
Inner West Council	
Requirement	**Section where addressed in EIS**
Reference should also be made to various water quality studies currently underway, most particularly studies being prepared by NSW Urban Growth.	**Section 4.5**.
As the project drains to two significant areas of Sydney Harbour (Iron Cove and White Bay/Blackwattle Bay) it is essential that attention be paid to all phases of the project (construction, early operation and continued operation) including emergency situations (eg spills in or adjacent to the site) and that the project should aim to both.	**Sections 2.4, 5.3, 6.3** and **8.2**.

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Reference should specifically be made to Council's recent Flood Study which provides detailed information on existing flood behaviour across the entire LGA. In addition, Council is currently preparing a Flood Risk Management Study and Plan for the entire LGA incorporating flood management and mitigation measures which may in some cases impact on or overlap with the proposed works.	**Section 4.4.1**.
Ashfield Council	
Requirement	**Section where addressed in EIS**
The SEARs should also specify a requirement for the EIS to address cumulative impacts of the proposal across all major issues – traffic, noise, vibration, social, health, visual, heritage, biodiversity, environmental, climate change, flooding and water quality.	**Section 7** for flooding and water quality cumulative impacts.
Department of Primary Industries (Water)	
Requirement	**Section where addressed in EIS**
The SSI report notes Johnstons Creek and Whites Creek traverse the project corridor (section 4.8.1, page 56) and palaeochannels are associated with these creeks (section 4.7.1, page 52). The proposed tunnels should be designed to prevent drainage of alluvium in the palaeochannels.	Refer to **Appendix T** (Technical working paper: Groundwater) of the EIS.
The SSI report notes construction of the project has the potential for disturbance of contaminated soils (section 4.7.2, page 55). The disturbance of contaminated groundwater is another potential soil, water and contamination-related impact that should be addressed.	Refer to EIS **Appendix R** (Technical working paper: Contamination) of the EIS and **Appendix T** (Technical working paper: Groundwater) of the EIS. **Sections 2.4, 5.3, 6.3** and **8.2**.
Water licensing requirements: The SSI report indicates water resources are required during construction, particularly during tunnelling and groundwater may also be used (see section 4.10.1, page 63). Under Schedule 5, Part 1, clause 2 of the Water Management (General) Regulation 2011, roads authorities are exempt from the requirement to hold a water access licence for water required for road construction and road maintenance. While Roads and Martime is currently exempt from requiring a licence for this water during construction, arrangements for the licensing requirements are currently being finalised between Roads and Martime and DPI Water. The proponent is requested to continue liaising with DPI Water to ensure that any licensing requirements are met.	Not relevant for assessment purposes. Refer **Appendix T** (Technical working paper: Groundwater) of the EIS.
Hawthorne Canal and Rozelle Bay are important key fish habitat within or adjacent to the project boundary. DPI Fisheries recommends that the project is designed to minimise the following potential impacts to these waterways: · Erosion and sedimentation impacts during construction · Operational water quality impacts · Direct impacts to aquatic habitats, such as saltmarsh are avoided or minimised.	**Sections 2.4** and **8.2**.
Marrickville Council	
Requirement	**Section where addressed in EIS**
Stormwater and groundwater treatments should be detailed in the context of both local biodiversity and water quality	**Sections 6.3** and **8.2**. Refer to **Appendix S** (Technical

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objectives. The impact of changes to the permeability of surfaces should also be detailed.	working paper: Biodiversity) of the EIS.
Council is working with a number of regional councils in improving the water quality and environmental health of the Cooks River and Parramatta River. A comprehensive assessment will be needed to evaluate the water quality issues and surface water contamination risks during construction and at operation stages.	**Sections 2.4, 5.3, 6.3** and **8.2**.
NSW OEH	
Requirement	**Section where addressed in EIS**
The EIS must assess the impacts of the proposed project on flood behaviour, including: · Any impacts the development may have on the social and economic costs to the community as a consequence of flooding · 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.	**Sections 4.2, 5.3, 6.2** and **8.2**.
The EIS should ensure the use of the latest data from Local Councils' relevant flood studies. It is prudent to consult with Ashfield, Leichhardt, Marrickville and City of Sydney Councils to ensure the latest flood data is used.	**Section 4.4.1**.
The EIS must map the following features relevant to flooding within the vicinity of the project, as described in the Floodplain Development Manual 2005 (NSW Government 2005) including: · Flood prone land · Flood planning area – the area below the flood planning level (ie the area below the 1 in 100 year flood level plus an identified freeboard) · Hydraulic categorisation (floodway and flood storage areas).	**Sections 4.4.1** and **6.2.1**.
The EIS must describe the flood assessment and modelling undertaken in determining the design flood levels for events, including as a minimum the 1 in 10 year, 1 in 100 year flood levels and the probable maximum flood (PMF), or an equivalent extreme event.	**Section 6.2.1** and **Annexure C.**
The EIS must model the effect of the proposed project (including earthworks) on the flood behaviour under the following scenarios: · Current flood behaviour for a range of design events as identified above. · The 1 in 200 and 1 in 500 year flood events as proxies for assessing sensitivity to an increase in rainfall intensity of flood producing rainfall events due to climate change.	**Section 6.2.1**. For climate change assessment see **section 6.2.2**.
The EIS should ensure that the tunnel entries and cut and cover sections of the tunnels would be protected from flooding during construction works, considering both mainstream flooding and local overland flow paths. The EIS should identify appropriate mitigation measures such as physical barriers for further assessment in the detailed design prior to construction.	**Section 8.1**.

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The EIS should ensure that in the operational stage the proposed tunnel's dive structure, dilation structures and systems, fire and safety systems, emergency evacuation and key extraction infrastructure would be protected up to the PMF level or the 100 year ARI flood level plus 0.5 metres freeboard, whichever is greater, considering both mainstream flooding and local overland flow paths.	**Section 6.2.1**.
Modelling in the EIS must consider and document: · The impact of the project on existing flood behaviour for a full range of flood events including up to the PMF · The impact of the project on flood behaviour resulting in detrimental changes in potential flood affection of other properties, assets or infrastructure. This may include redirection of flow, flow velocities, flood levels, hazards and hydraulic categories Impacts of earthworks and stockpiles within the flood prone land up to the PMF level · The assessment should be based on an understanding of cumulative flood impacts of construction and operational phase. Whether appropriate mitigation measures required to offset potential flood risk arise from the project. Proposed mitigation work should be modelled and assessed on the overall catchment basis in order to ensure it fits its purpose and meets the criteria of the relevant Council where it is located.	**Sections 5.2, 6.2.1, 7** and **8.1**.

1.4 Study area

The study area for the surface water and flooding assessment includes the project's surface footprint, as well as areas where potential surface water and flooding impacts could occur as a result of construction or operation of the project.

All project activities would lie within the following sub-catchments which form part of the larger Parramatta River and Cooks River catchments:

- Dobroyd Canal (Iron Cove Creek) – the section of the project within this catchment includes the Wattle Street interchange and construction ancillary facilities at Haberfield (Option A) and Ashfield and Haberfield (Option B)
- Hawthorne Canal – project surface features include the Darley Road civil and tunnel site, which remains as an access point to the tunnel
- Whites Creek – a portion of the Rozelle interchange and associated local roads
- Easton Park drain – project surface features include the Rozelle interchange and Rozelle civil and tunnel site
- Rozelle Bay – the Rozelle civil and tunnel site, Rozelle interchange and associated roads
- Whites Bay – a portion of the Victoria Road works are located in the Whites Bay catchment
- Iron Cove – the Iron Cove Link is located within an area that drains to Iron Cove
- Johnstons Creek – The Pyrmont Bridge Road tunnel site is located within the catchment of Johnstons Creek
- Alexandra Canal – St Peters interchange and the Campbell Road civil and tunnel site is located within its catchment.

The extent of the project activities within each of these catchments is discussed further in **section 4.1**.

1.5 Structure of this report

This technical working paper is structured as follows:

- Chapter 1 – Introduction – This chapter provides a brief overview of the outlines the project and presents the purpose of this report
- Chapter 2 – The project – This chapter provides an overview of the project
- Chapter 3 – Assessment methodology – This chapter describes the methodology employed for the Technical Working Paper – Surface water and flooding assessment
- Chapter 4 – Existing environment – This chapter describes the surface water study area and its existing surface water and flooding conditions
- Chapter 5 – Assessment of construction impacts – This chapter describes the potential impacts on surface water and flooding resulting from the project during construction
- Chapter 6 – Assessment of operational impacts – This chapter describes the potential impacts to surface water and flooding resulting from the project during operation
- Chapter 7 – Assessment of cumulative impacts – This chapter describes the potential cumulative impacts to surface water and flooding resulting from the project and other key developments
- Chapter 8 – Mitigation and management – This chapter provides a summary of environmental mitigation, management and monitoring responsibilities in relation surface water management and flooding mitigation for the project
- Chapter 9 – Conclusion
- Chapter 10 – References
- Annexure A – Photographs
- Annexure B – Water Quality Data Summary
- Annexure C – Flood Model Development
- Annexure D – Step by Step Flood Risk Assessment
- Annexure E – Water Quality Monitoring Program
- Annexure F – Stormwater Quality Modelling Catchments
- Annexure G – NSW Water Quality Objectives – Indicators and Criteria
- Annexure H – Tunnel water treatment plant options review.

2 The project

2.1 Project location

The project would be generally located within the City of Sydney and Inner West local government areas (LGAs). The project is located about two to seven kilometres south, southwest and west of the Sydney central business district (CBD) and would cross the suburbs of Ashfield, Haberfield, Leichhardt, Lilyfield, Rozelle, Annandale, Stanmore, Camperdown, Newtown and St Peters. The local context of the project is shown in **Figure 2-1**.

2.2 Overview of the project

Key components of the project are shown in **Figure 2-1** and would include:

- Twin mainline motorway tunnels between the M4 East at Haberfield and the New M5 at St Peters. Each tunnel would be around 7.5 kilometres long and would generally accommodate up to four lanes of traffic in each direction
- Connections of the mainline tunnels to the M4 East project, comprising:
  - A tunnel-to-tunnel connection to the M4 East mainline stub tunnels east of Parramatta Road near Alt Street at Haberfield
  - Entry and exit ramp connections between the mainline tunnels and the Wattle Street interchange at Haberfield (which is currently being constructed as part of the M4 East project)
  - Minor physical integration works with the surface road network at the Wattle Street interchange including road pavement and line marking
- Connections of the mainline tunnels to the New M5 project, comprising:
  - A tunnel-to-tunnel connection to the New M5 mainline stub tunnels north of the Princes Highway near the intersection of Mary Street and Bakers Lane at St Peters
  - Entry and exit ramp connections between the mainline tunnels and the St Peters interchange at St Peters (which is currently being constructed as part of the New M5 project)
  - Minor physical integration works with the surface road network at the St Peters interchange including road pavement and line marking
- An underground interchange at Leichhardt and Annandale (the Inner West subsurface interchange) that would link the mainline tunnels with the Rozelle interchange and the Iron Cove Link (see below)
- A new interchange at Lilyfield and Rozelle (the Rozelle interchange) that would connect the M4-M5 Link mainline tunnels with:
  - City West Link
  - Anzac Bridge
  - The Iron Cove Link (see below)
  - The proposed future Western Harbour Tunnel and Beaches Link
- Construction of connections to the proposed future Western Harbour Tunnel and Beaches Link project as part of the Rozelle interchange, including:
  - Tunnels that would allow for underground mainline 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)
  - A dive structure and tunnel portals within the Rozelle Rail Yards, north of the City West Link / The Crescent intersection
  - Entry and exit ramps that would extend north underground from the tunnel portals in the

  - Rozelle Rail Yards to join the mainline connections to the proposed future Western Harbour Tunnel and Beaches Link
  - A ventilation outlet and ancillary facilities as part of the Rozelle ventilation facility (see below)
- Twin tunnels that would connect Victoria Road near the eastern abutment of Iron Cove Bridge and Anzac Bridge (the Iron Cove Link). Underground entry and exit ramps would also provide a tunnel connection between the Iron Cove Link and the New M5 / St Peters interchange (via the M4-M5 Link mainline tunnels)
- The Rozelle surface works, including:
  - Realigning The Crescent at Annandale, including a new bridge over Whites Creek and modifications to the intersection with City West Link
  - A new intersection on City West Link around 300 metres west of the realigned position of The Crescent, which would provide a connection to and from the New M5/St Peters interchange (via the M4-M5 Link mainline tunnels)
  - Widening and improvement works to the channel and bank of Whites Creek between the light rail bridge and Rozelle Bay at Annandale, to manage flooding and drainage for the surface road network
  - Reconstructing the intersection of The Crescent and Victoria Road at Rozelle, including construction of a new bridge at Victoria Road
  - New and upgraded pedestrian and cyclist infrastructure
  - Landscaping, including the provision of new open space within the Rozelle Rail Yards
- The Iron Cove Link surface works, including:
  - Dive structures and tunnel portals between the westbound and eastbound Victoria Road carriageways, to connect Victoria Road east of Iron Cove Bridge with the Iron Cove Link
  - Realignment of the westbound (southern) carriageway of Victoria Road between Springside Street and the eastern abutment of Iron Cove Bridge
  - Modifications to the existing intersections between Victoria Road and Terry, Clubb, Toelle and Callan streets
  - Landscaping and the establishment of pedestrian and cycle infrastructure
- Five motorway operations complexes; one at Leichhardt (MOC1), three at Rozelle (Rozelle West (MOC2), Rozelle East (MOC3) and Iron Cove Link (MOC4)), and one at St Peters (MOC5). The types of facilities that would be contained within the motorway operations complexes would include substations, water treatment plants, ventilation facilities and outlets, offices, on-site storage and parking for employees
- Tunnel ventilation systems, including ventilation supply and exhaust facilities, axial fans, ventilation outlets and ventilation tunnels
- Three new ventilation facilities, including:
  - The Rozelle ventilation facility at Rozelle
  - The Iron Cove Link ventilation facility at Rozelle
  - The Campbell Road ventilation facility at St Peters
- Fitout (mechanical and electrical) of part of the Parramatta Road ventilation facility at Haberfield (which is currently being constructed as part of M4 East project) for use by the M4-M5 Link project
- Drainage infrastructure to collect surface and groundwater for treatment at dedicated facilities. Water treatment would occur at
  - Two operational water treatment facilities (at Leichhardt and Rozelle)
  - The constructed wetland within the Rozelle Rail Yards
  - A bioretention facility for stormwater runoff within the informal car park at King George Park at

Rozelle (adjacent to Manning Street). A section of the existing informal car park would also be upgraded, including sealing the car park surface and landscaping

- Treated water would flow back to existing watercourses via new, upgraded and existing infrastructure
- Ancillary infrastructure and operational facilities for electronic tolling and traffic control and signage (including electronic signage)
- Emergency access and evacuation facilities, including pedestrian and vehicular cross and long passages and fire and life safety systems
- Utility works, including protection and/or adjustment of existing utilities, removal of redundant utilities and installation of new utilities. A Utilities Management Strategy has been prepared for the project that identifies management options for utilities, including relocation or adjustment. Refer to **Appendix F** (Utilities Management Strategy) of the EIS.

The project does not include:

- Site management works at the Rozelle Rail Yards. These works were separately assessed and determined by Roads and Maritime through a Review of Environmental Factors under Part 5 of the EP&A Act (refer to **Chapter 2** (Assessment process) of the EIS)
- Ongoing motorway maintenance activities during operation
- Operation of the components of the Rozelle interchange which are the tunnels, ramps and associated infrastructure being constructed to provide connections to the proposed future Western Harbour Tunnel and Beaches Link project.

Temporary construction ancillary facilities and temporary works to facilitate the construction of the project would also be required.

2.2.1 Staged construction and opening of the project

It is anticipated the project would be constructed and opened to traffic in two stages (as shown in **Figure 2-1**).

Stage 1 would include:

- Construction of the mainline tunnels between the M4 East at Haberfield and the New M5 at St Peters, stub tunnels to the Rozelle interchange (at the Inner West subsurface interchange) and ancillary infrastructure at the Darley Road motorway operations complex (MOC1) and Campbell Road motorway operations complex (MOC5)
- These works are anticipated to commence in 2018 with the mainline tunnels open to traffic in 2022. At the completion of Stage 1, the mainline tunnels would operate with two traffic lanes in each direction. This would increase to generally four lanes at the completion of Stage 2, when the full project is operational.

Stage 2 would include:

- Construction of the Rozelle interchange and Iron Cove Link including:
  - Connections to the stub tunnels at the Inner West subsurface interchange (built during Stage 1)
  - Ancillary infrastructure at the Rozelle West motorway operations complex (MOC2), Rozelle East motorway operations complex (MOC3) and Iron Cove Link motorway operations complex (MOC4)
  - Connections to the surface road network at Lilyfield and Rozelle
  - Construction of tunnels, ramps and associated infrastructure as part of the Rozelle interchange to provide connections to the proposed future Western Harbour Tunnel and Beaches Link project
- Stage 2 works are expected to commence in 2019 with these components of the project open to traffic in 2023.

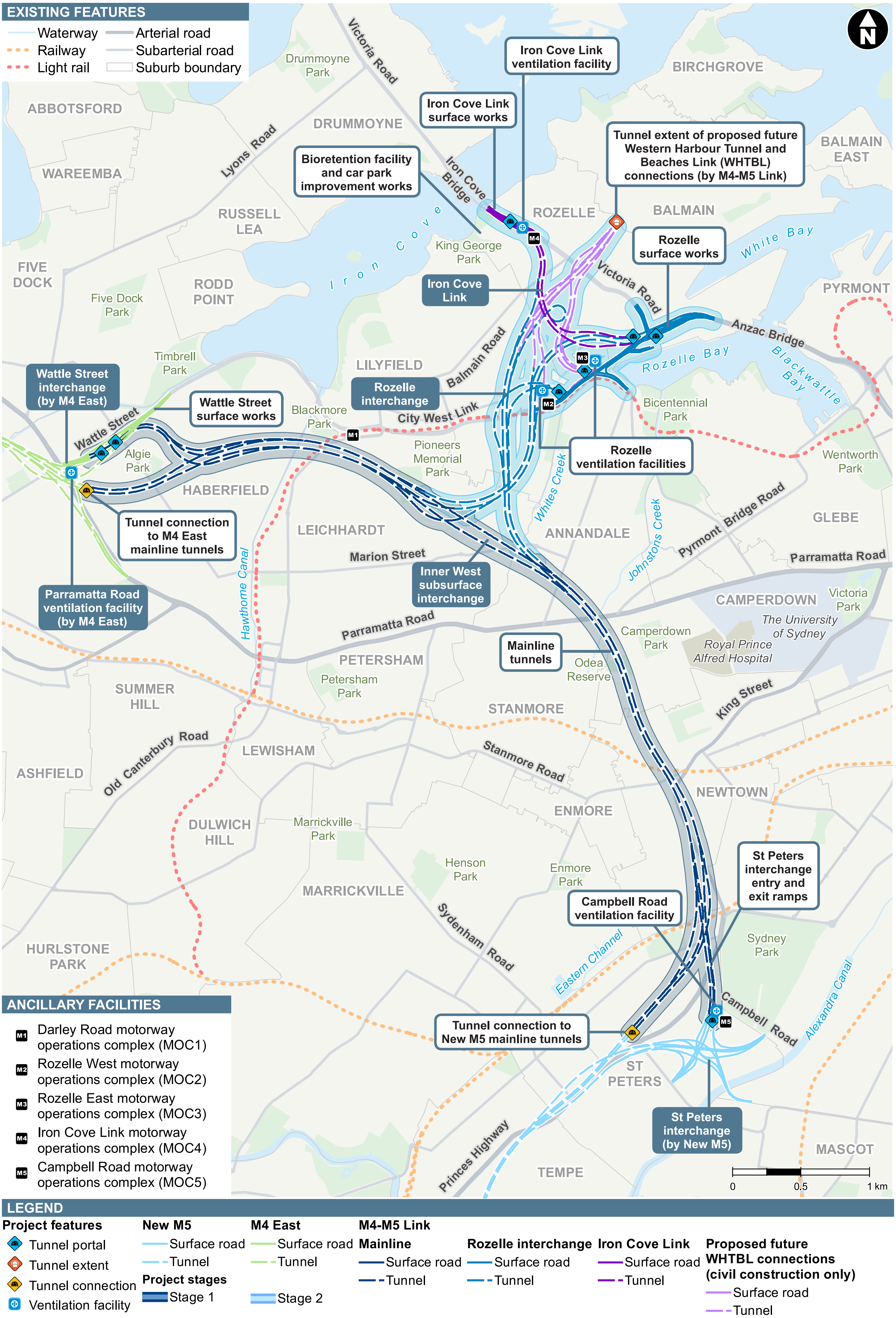


Figure 2-1 Overview of the project

2.3 Construction activities

An overview of the key construction features of the project is shown in **Figure 2-2** and would generally include:

- Enabling and temporary works, including provision of construction power and water supply, ancillary site establishment including establishment of acoustic sheds and construction hoarding, demolition works, property adjustments and public and active 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.

A more detailed overview of construction activities is provided in **Table 2-1**.

Table 2-1 Overview of construction activities

Component	Typical activities
Site establishment and enabling works	· Vegetation clearing and removal · Utility works · Traffic management measures · Install safety and environmental controls · Install site fencing and hoarding · Establish temporary noise attenuation measures · Demolish buildings and structures · Carry out site clearing · Heritage salvage or conservation works (if required) · Establish construction ancillary facilities and access · Establish acoustic sheds · Supply utilities (including construction power) to construction facilities · Establish temporary pedestrian and cyclist diversions
Tunnelling	· Construct temporary access tunnels · Excavation of mainline tunnels, entry and exit ramps and associated tunnelled infrastructure and install ground support · Spoil management and haulage · Finishing works in tunnel and provision of permanent tunnel services · Test plant and equipment
Surface earthworks and structures	· Vegetation clearing and removal · Topsoil stripping · Excavate new cut and fill areas · Construct dive and cut-and-cover tunnel structures · Install stabilisation and excavation support (retention systems) such as sheet pile walls, diaphragm walls and secant pile walls (where required) · Construct required retaining structures · Excavate new road levels
Bridge works	· Construct piers and abutments · Construct headstock · Construct bridge deck, slabs and girders · Demolish and remove redundant bridges
Drainage	· Construct new pits and pipes · Construct new groundwater drainage system

Component	Typical activities
	· Connect drainage to existing network · Construct sumps in tunnels as required · Construct water quality basins, constructed wetland and bioretention facility and basin · Construct drainage channels · Construct spill containment basin · Construct onsite detention tanks · Adjustments to existing drainage infrastructure where impacted · Carry out widening and naturalisation of a section of Whites Creek · Demolish and remove redundant drainage
Pavement	· Lay select layers and base · Lay road pavement surfacing · Construct pavement drainage
Operational ancillary facilities	· Install ventilation systems and facilities · Construct water treatment facilities · Construct fire pump rooms and install water tanks · Test and commission plant and equipment · Construct electrical substations to supply permanent power to the project
Finishing works	· Line mark to new road surfaces · Erect directional and other signage and other roadside furniture such as street lighting · Erect toll gantries and other control systems · Construct pedestrian and cycle paths · Carry out earthworks at disturbed areas to establish the finished landform · Carry out landscaping · Closure and backfill of temporary access tunnels (except where these are to be used for inspection and/or maintenance purposes) · Site demobilisation and preparation of the site for a future use

Twelve construction ancillary facilities are described in this EIS (as 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).

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 number, location and layout of construction ancillary facilities would be finalised as part of detailed construction planning during detailed design and would meet the environmental performance outcomes stated in the EIS and the Submissions and Preferred Infrastructure Report and satisfy criteria identified in any relevant conditions of approval.

The construction ancillary facilities would be used for a mix of civil surface works, tunnelling support, construction workforce parking and administrative purposes. Wherever possible, construction sites would be co-located with the operational footprint to minimise property acquisition and temporary disruption. The layout and access arrangements for the construction ancillary facilities are based on the concept design only and would be confirmed and refined in response to submissions received during the exhibition of the EIS and during detailed design.

2.3.1 Construction program

The total period of construction works for the project is expected to be around five years, with commissioning occurring concurrently with the final stages of construction. An indicative construction program is shown in **Table 2-2**.

Table 2-2 Indicative construction program

Construction activity	Indicative construction timeframe																							
	2018				2019				2020				2021				2022				2023			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Mainline tunnels																								
Site establishment and establishment of construction ancillary facilities			■	■	■	■	■	■	■	■														
Utility works and connections			■	■	■	■	■	■																
Tunnel construction				■	■	■	■	■	■	■	■	■	■											
Portal construction				■	■	■	■	■																
Construction of permanent operational facilities												■	■	■	■	■								
Mechanical and electrical fitout works														■	■	■								
Establishment of tolling facilities															■	■								
Site rehabilitation and landscaping																■	■	■	■					
Surface road works																	■	■	■					
Demobilisation and rehabilitation																			■	■				
Testing and commissioning																■	■	■	■	■				
Rozelle interchange and Iron Cove Link																								
Site establishment and establishment of construction ancillary facilities				■	■	■	■	■	■															

Construction activity	Indicative construction timeframe 2018				2019				2020				2021				2022				2023			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Utility works and connections and site remediation				■	■	■	■	■																
Tunnel construction									■	■	■	■	■	■	■	■	■							
Portal construction						■	■	■																
Construction of surface road works						■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■			
Construction of permanent operational facilities						■	■	■	■	■	■	■	■	■	■	■								
Mechanical and electrical fitout works													■	■	■	■	■	■	■	■				
Establishment of tolling facilities																		■	■					
Site rehabilitation and landscaping																			■	■	■			
Demobilisation and rehabilitation																						■	■	
Testing and commissioning																			■	■	■	■	■	

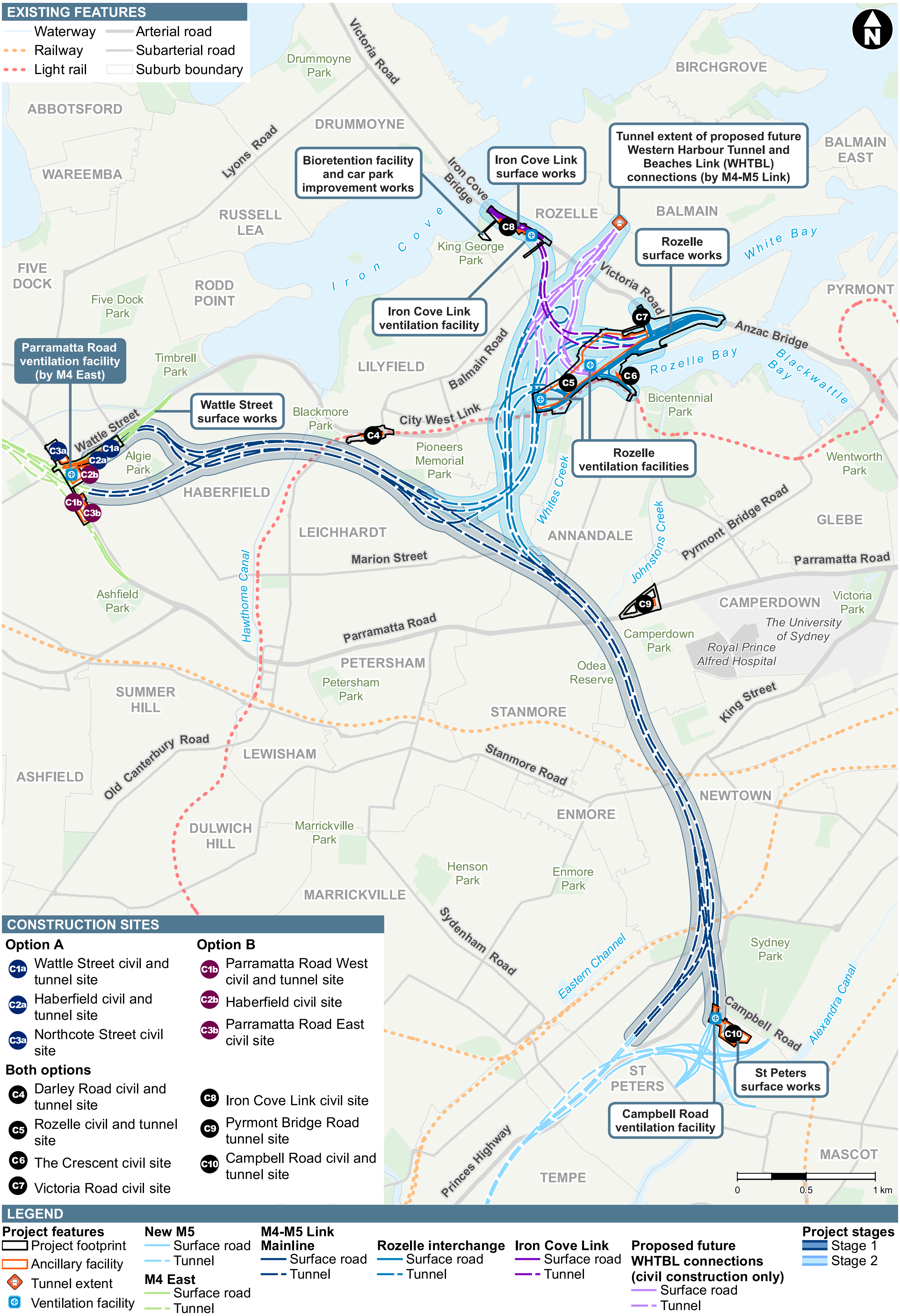


Figure 2-2 Overview of project footprint and ancillary facilities

2.4 Other project specific aspects

This section describes the specific aspects of the project related to surface water and flooding that are proposed in the current design. The potential impacts of the development during the construction and operational phases were considered during the design process and are described in detail in **section 5** and **section 5.4** of this report, additional mitigation measures as well as a recommended water quality monitoring programme to be considered and further developed during the detailed design of the project are described in **section 8**.

2.4.1 Construction

Water use

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.

An estimate of daily stormwater and treated tunnel groundwater usage is provided in **Table 2-3**.

Table 2-3 Indicative stormwater and groundwater daily construction use

Site	Rainwater / stormwater reuse		Treated Groundwater Use	
	Daily (kL/day)	Annual (kL/year)	Daily (kL/day)	Annual (kL/year)
C1a – Wattle Street civil and tunnel site	2	730	250	91250
C2a – Haberfield civil and tunnel site	1	365	0	0
C3a – Northcote Street civil site	0	0	0	0
C1b – Parramatta Road West civil and tunnel site	2	730	250	91250
C2b – Haberfield civil site	1	365	0	0
C3b – Parramatta Road East civil site	1	365	0	0
C4 – Darley Road civil and tunnel site	1	365	50	18250
C5 – Rozelle civil and tunnel site	3	1095	370	135050
C6 – The Crescent civil site	1	365	0	0
C7 – Victoria Road civil site	1	365	0	0
C8 – Iron Cove civil site	1	365	50	18250
C9 – Pyrmont Bridge Road tunnel site	1	730	25	9125
C10 – Campbell Road civil and tunnel site	1	365	100	36500

Construction wastewater management

Construction wastewater (including stormwater, groundwater and construction water) would be generated from all temporary construction ancillary facilities (see **section 2.4.1**) with the exception of the Northcote Street civil site which would be used for parking and construction support only.

Civil construction sites such as Victoria Road would incorporate contoured embankments and surface drains to channel water to sedimentation basins for treatment and reuse on site, for dust suppression and wheel washes, for example.

The total volume of wastewater generated during construction would vary according to construction activities taking place, the amount of groundwater infiltrating into the tunnel, and the length of the tunnel that has been excavated. Indicative daily volumes of wastewater at each site and associated indicative discharge points are shown in **Table 2-4**.

Table 2-4 Indicative construction wastewater volumes and discharge points

Site	Daily discharge (kL/day)	Discharge points
C1a – Wattle Street civil and tunnel site	Managed by Haberfield civil and tunnel site	Managed by Haberfield civil and tunnel site
C2a – Haberfield civil and tunnel site	1200	Discharging to a stormwater pipe under Parramatta Road that connects to Dobroyd Canal
C3a – Northcote Street civil site	Managed by Haberfield civil and tunnel site	Managed by Haberfield civil and tunnel site
C1b – Parramatta Road West civil and tunnel site	1200	Discharging to a stormwater pipe under Parramatta Road that connects to Dobroyd Canal
C2b – Haberfield civil site	Managed by Parramatta Road West civil and tunnel site	Discharging to a stormwater pipe under Parramatta Road that connects to Dobroyd Canal
C3b – Parramatta Road East civil site	Managed by Parramatta Road West civil and tunnel site	Discharging to a stormwater pipe under Parramatta Road that connects to Dobroyd Canal
C4 – Darley Road civil and tunnel site	700	Existing drainage system draining to Hawthorne Canal
C5 – Rozelle civil and tunnel site	2400	Existing drainage system at City West Link draining to Rozelle Bay Easton Park drain discharging to Rozelle Bay
C6 – The Crescent civil site	10	Existing drainage system at City West Link draining to Rozelle Bay
C7 – Victoria Road civil site	200	Existing drainage system at Victoria Road draining to White Bay
C8 – Iron Cove civil site	300	Existing drainage system at Victoria Road draining to Iron Cove
C9 – Pyrmont Bridge Road tunnel site	1200	Discharging to a stormwater pipe under Parramatta Road which discharges to Johnstons Creek
C10 – Campbell Road civil and tunnel site	1200	Discharging to a stormwater pipe that connects into Alexandra Canal

Spoil management

Spoil stockpiles would be contained by roller doors between the cut and cover ramps and tunnel section at Wattle Street, and within acoustic sheds at all other temporary construction ancillary facilities where spoil would be stockpiled (including Haberfield, Darley Road, Rozelle, Pyrmont Bridge Road and Campbell Road). The roller doors/acoustic sheds would minimise potential for transport of spoil sediments by both wind and rain.

Flood risk

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 set-back 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, where feasible.

2.4.2 Operation

Portal drainage

Tunnel portals would be designed to ensure immunity from the greater of the PMF or 100 year average recurrence interval (ARI) event plus 0.5 metres freeboard. Where the portals lie within the PMF extent, this would be achieved by appropriate flood protection measures.

Where open surface roadways grade toward portal openings, the pavement drainage system at tunnel entrances would be sized to capture and drain runoff generated by the local catchment in events up to the PMF.

Surface roadway drainage, gravity outfalls and treatment

Surface roads would be drained by gravity to appropriate discharge locations. This may be in the form of an outfall discharge or a connection to an existing drainage network. Some form of stormwater treatment would be provided prior to discharge/connection where feasible and practicable.

Due to the constrained or heavily urbanised nature of the interface between the project works and surrounding areas there may not be opportunity to install treatment devices within individual surface catchments. In these highly constrained areas good practice treatment techniques such as inline pollution control measures would be deployed where feasible and practical. However, consideration would also be given to other Water Sensitive Urban Design (WSUD) measures such as wetlands, swales and bioretention where feasible including the proposed constructed wetland and bioretention systems at Rozelle and the proposed bioretention basin located within King George Park. The design of such stormwater quality treatment measures would be undertaken and finalised during detailed design. The stormwater quality objectives are presented in **section 3.2.11** and a preliminary assessment of the types of stormwater treatment devices which could potentially be implemented and their performance is provided in **section 6.3**. The proposed drainage and treatment facilities are shown in **Figure 2-3** to **Figure 2-5**. Indicative operational stormwater discharge locations are provided in **Figure 2-6**.

Tunnel drainage and treatment

Tunnel drainage infrastructure would be designed to accommodate a combination of 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. During operation, the two tunnel drainage streams from the mainline would either be pumped via rising mains to a water treatment plant at Darley Road in Leichhardt with treated flows ultimately discharged to Hawthorne Canal.

During operation, tunnel drainage for Rozelle would be pumped to an operational water treatment plant at Rozelle interchange, with treated flows ultimately being discharged to Rozelle Bay.

Tunnel drainage from about one kilometre of the northbound and 600 metres 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.

The tunnels are designed to restrict groundwater inflow to below one litre per second per kilometre. Therefore, groundwater inflow is expected to be up to around 23 litres per second for the mainline tunnel and 22 litres per second for the Rozelle tunnels. The second drainage system would incorporate pumping infrastructure to pump out other potential water ingress sources as listed previously, via rising mains, at a rate of around five to 30 litres per second to enable sumps to be emptied in around one day.

The two tunnel drainage streams are expected to produce flows containing a variety of different pollutants that require some form of treatment before discharge. The level of treatment to be provided by each plant would need to reflect the groundwater conditions, which would be informed by knowledge of adjoining tunnel projects (M4 East and New M5) and the M4-M5 Link groundwater monitoring. Groundwater conditions are discussed in **section 4.11**. The proposed operational water treatment plant discharge criteria are provided in **section 8.2**. The design of the operational water treatment plant would be developed and finalised during detailed design. A review and multi-criteria analysis of the various treatment options is provided within **Annexure H**. The review indicates that when considering a range of factors, primary sedimentation is likely to be the most appropriate groundwater treatment process. This option reflects the accepted groundwater treatment process strategies for other transport and power tunnel infrastructure in Sydney.

Treated flows from the Rozelle water treatment plant would be discharged to a constructed wetland within the Rozelle Rail Yards. This would afford some ‘polishing’ of the effluent, helping to remove a proportion of the residual dissolved constituents such as nitrogen and phosphorus not removed by the operational water treatment plant. Indicative operational water treatment plant discharge points are provided in **Figure 2-6**.

Flood risk

The layout of the operational sites has taken into consideration the flood risk posed to the sites and how to manage these risks, as appropriate, in accordance with relevant standards and guidelines. This has meant that mitigation measures are already included as part of the project as a consequence of the evolution of the concept and reference design.

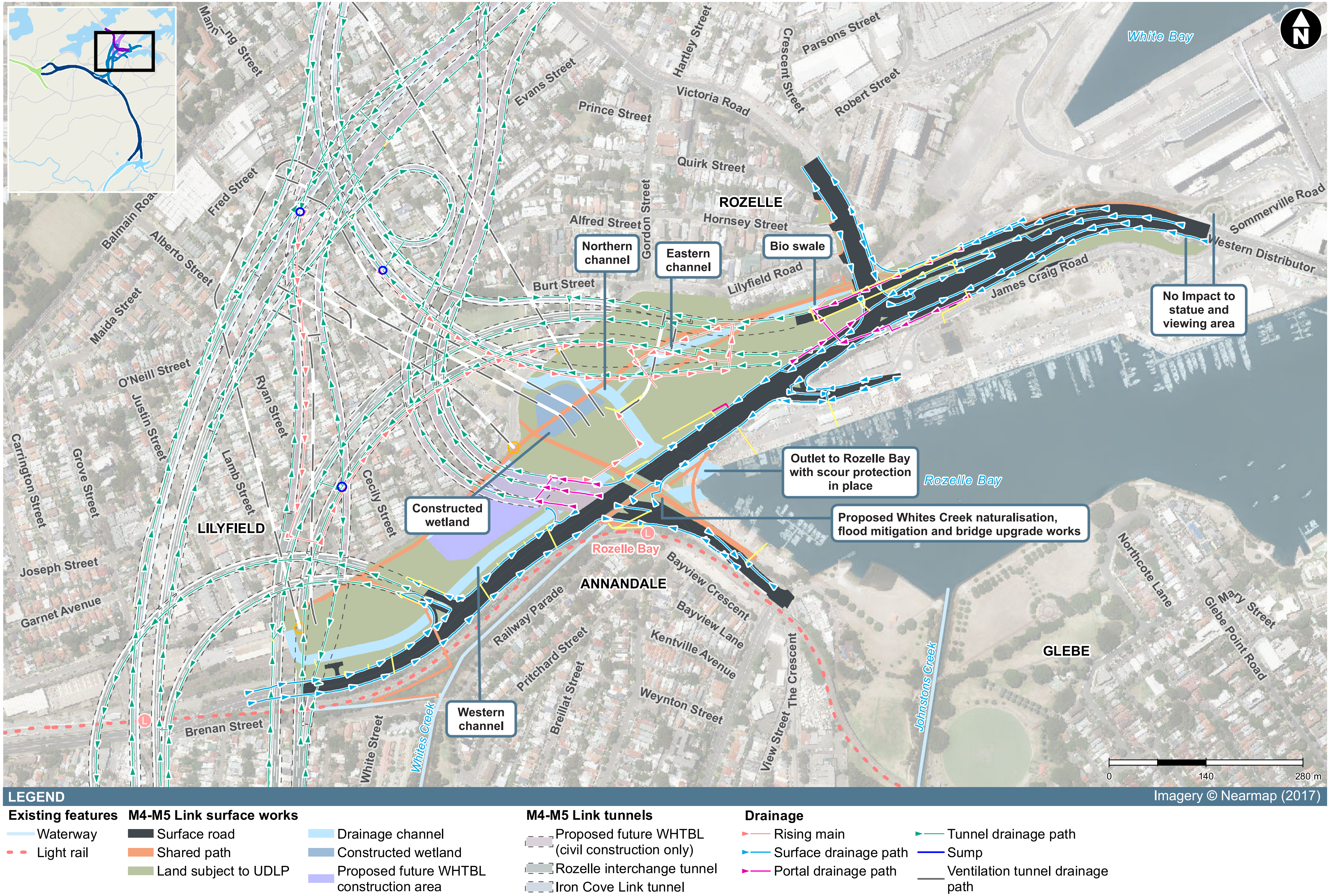


Figure 2-3 Rozelle Rail Yards drainage schematic

Figure 2-4 Iron Cove Link drainage schematic

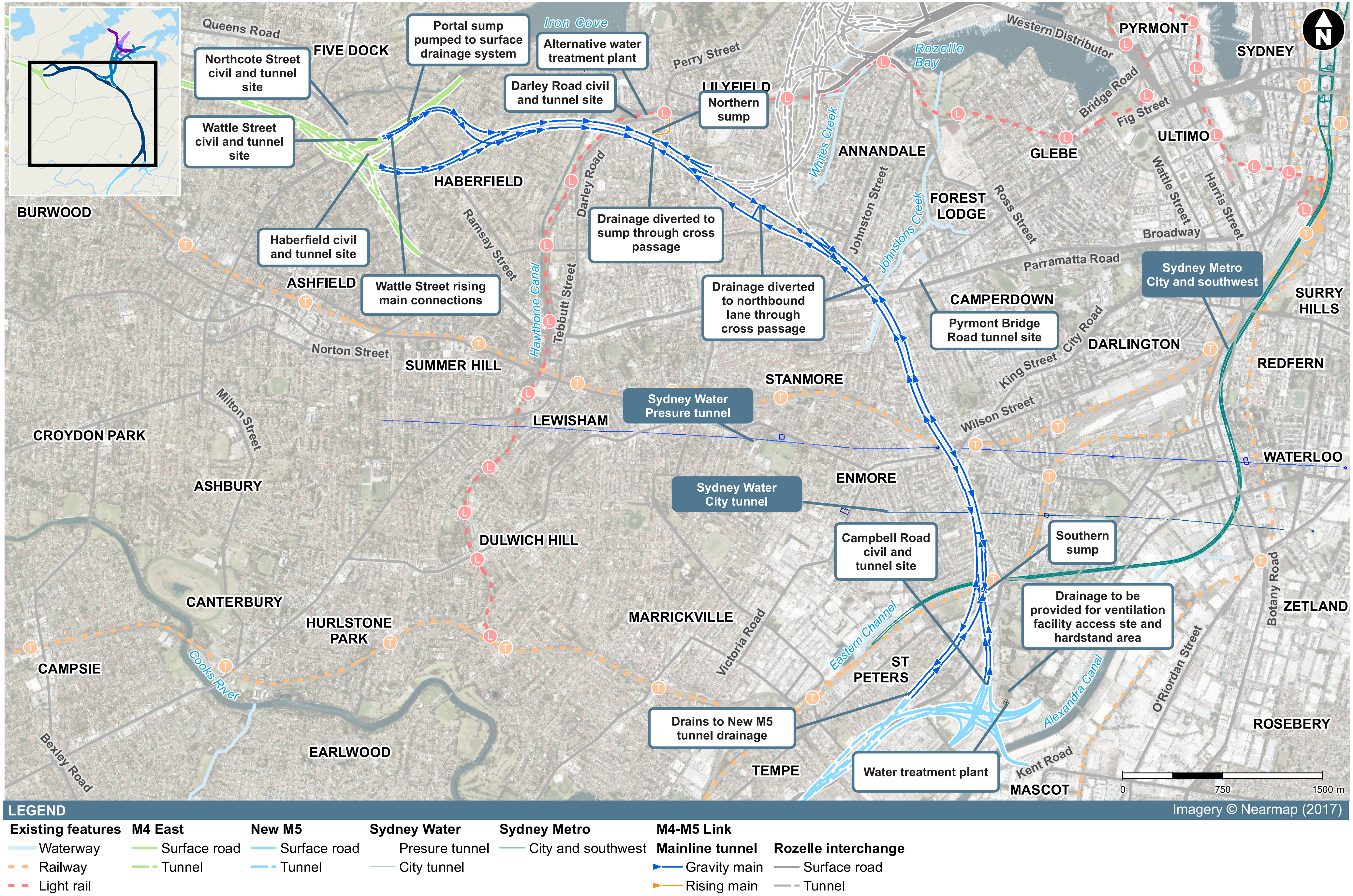


Figure 2-5 Mainline tunnel works drainage schematic

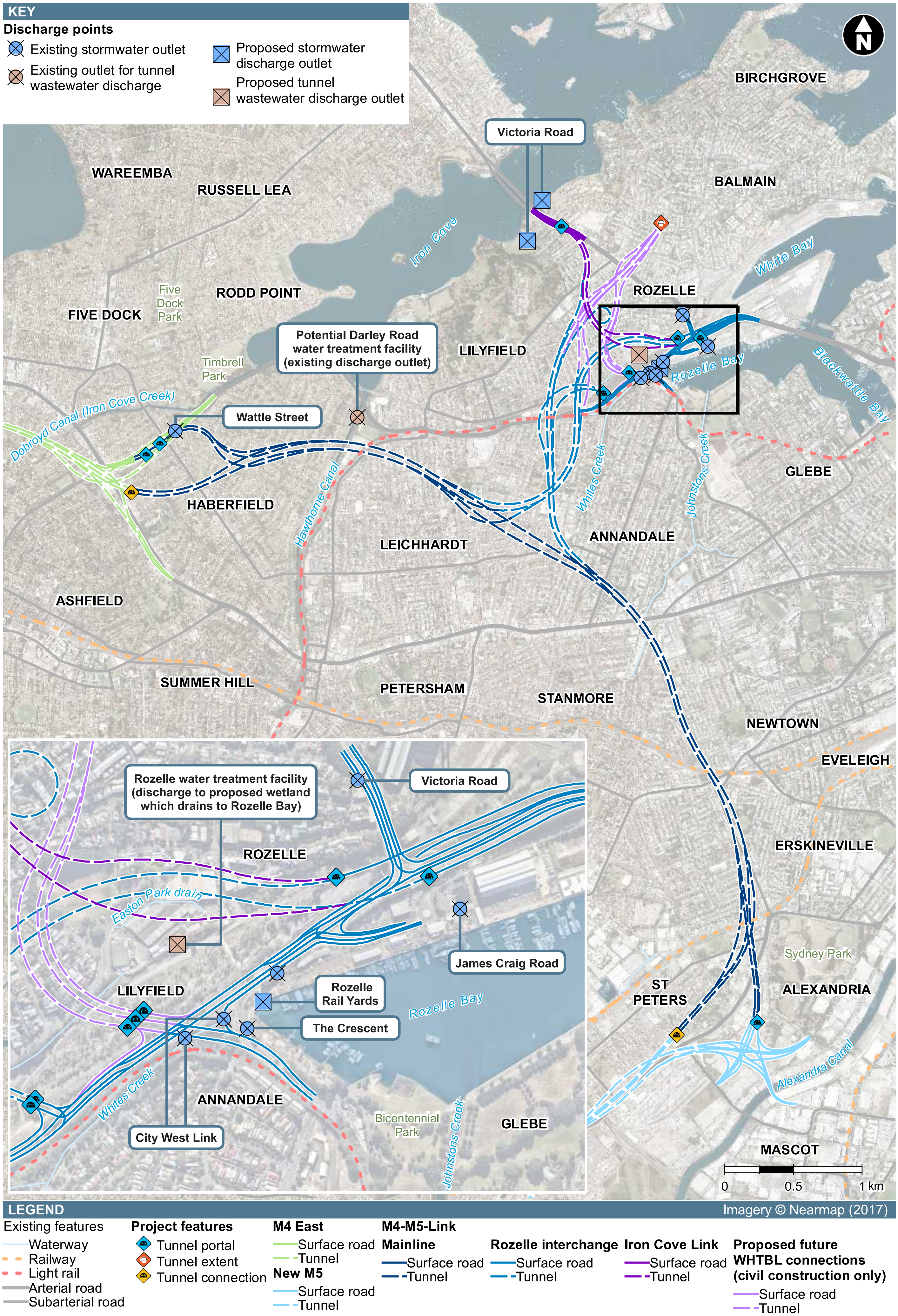


Figure 2-6 Indicative operational discharge points

3 Assessment methodology

3.1 Relevant legislation

3.1.1 Water Act 1912 (NSW) and Water Management Act 2000 (NSW)

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 capture and use. The *Water Act 1912* (NSW) is being progressively phased out and replaced by the WM Act but some provisions are still in force. The *Water Management Amendment Act 2014* (NSW) amends the WM Act in relation to planning, licensing and compliance aspects.

The objective of the WM Act is the sustainable and integrated management of the state's water for the benefit of both present and future generations. The WM Act 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 main tool the WM Act provides for managing the state's water resources are water sharing plans. These 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. See **section 4.1** for details of human and environmental values/uses of the waterways.

The project is located within an area covered by the *Water Sharing Plan for the Greater Metropolitan Region Unregulated River Water Sources*. This Plan includes rules for protecting the environment, extractions, managing licence holders' water accounts, and water trading in the plan area (DPI, 2016). Rules relevant for the waterways within the study area, which includes the hydrological catchment of Parramatta River up to the mangrove limit and hydrological catchment of the Cooks River and Botany Bay up to the mangrove limit are listed in **Table 3-1**.

Water access licences (WALs) entitle licence holders to specified shares in the available water within a particular water management area or water source and to take water at specified times, rates or circumstances from specified areas or locations. However, the project does not propose to extract any surface water from local urban waterways. Therefore, Water Sharing Plan rules as documented below do not apply.

In any case, under Schedule 5, Part 1, clause 2 of the Water Management (General) Regulation 2011 (NSW), roads authorities are exempt from the requirement to hold a water access licence to take water for road construction and road maintenance.

In response to the SEARs, DPI stated that *'while Roads and Maritime is currently exempt from requiring a licence for this water during construction, arrangements for the licensing requirements are currently being finalised between Roads and Maritime and DPI Water'*.

Table 3-1 Water Sharing Plan rules

Rules	Lower Parramatta River management zone[1]	Cooks River and Botany Bay management zone[2]
Access rules		
Environmental Flow Protection Rule	Pumping is not permitted when there is no visible flow at the pump site	Pumping is not permitted when there is no visible flow at the pump site
Trading rules		
INTO management zone	Trading into the zone is not permitted if the trade will increase the total licensed entitlement of the zone	Not permitted
WITHIN management zone	Permitted subject to assessment	Permitted subject to assessment
Conversion to High Flow Access licence	Not permitted	Not permitted

Notes:

[1] Includes the hydrological catchment of Parramatta River to the mangrove limit excluding the Upper Parramatta River Management Zone.

[2] Includes the hydrological catchment of Cooks River and Botany Bay up to the mangrove limit excluding the Georges River Management Zone.

3.1.2 Other legislation

Other legislation that applies to the project that is relevant to this report includes:

- EP&A Act
- *Protection of the Environment Operations Act 1997* (NSW) (POEO Act)
- *Fisheries Management Act 1994* (NSW) (FM Act)
- Sydney Regional Environmental Plan (Sydney Harbour Catchment) 2005.

3.2 Relevant guidelines and policies

3.2.1 Australian and New Zealand Guidelines for Fresh and Marine Water Quality

The *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC/ARMCANZ 2000), (commonly referred to as the 'ANZECC Water Quality Guidelines') form part of the National Water Quality Management Strategy and list a range of environmental values for water bodies. Different water quality criteria are set for the water bodies based on environmental values assigned to that water body. These values include consideration as to whether the water is to be used for drinking, recreation or according to ecological values. The ANZECC Water Quality Guidelines provide water quality criteria (scientifically-based benchmark values) for a wide range of parameters for each of these values. The ANZECC Water Quality Guidelines state that '*The Guidelines are not intended to be used as mandatory standards because there is significant uncertainty associated with the derivation and application of water quality guidelines*'. However, the guidelines provide a useful measure of risks to aquatic ecosystem health.

The ANZECC Water Quality Guidelines *'have not been designed for direct application in activities such as discharge consents, recycled water quality or stormwater quality, nor should they be used in this way. (The exception to this may be water quality in stormwater systems that are regarded as* *having some conservation value). They have been derived to apply to the ambient waters that receive effluent or stormwater discharges, and protect the environmental values they support'.*

The ANZECC Water Quality Guidelines are appropriate for the assessment of the existing ambient (baseflow) water quality of watercourses in proximity to the project as discussed in **section 4.1**.

3.2.2 NSW Water Quality and River Flow Objectives

The *NSW Water Quality and River Flow Objectives* (NSW Department of Environment, Climate Change and Water (DECCW) 2006) are consistent with the agreed national framework of the ANZECC Water Quality Guidelines and are '*primarily aimed at maintaining and improving water quality, for the purposes of supporting aquatic ecosystems, recreation and where applicable water supply and the production of aquatic foods suitable for consumption and aquaculture activities*' (DECCW 2006).

The NSW Water Quality and River Flow Objectives have been developed for the CRC and SHPRC. The receiving waterway classification for waterways in the study area in accordance with DECCW (2006) is provided in **Table 3-2**. The water quality and river flow objectives that were determined are shown in **Table 3-3**. The associated water quality indicators and criteria as detailed in DECCW (2006) are provided within **Annexure G**.

Table 3-2 Receiving waterway catchment and classification

Receiving waterway within study area	Catchment	Classification of waterway with respect to NSW Water Quality and River Flow Objectives
Dobroyd Canal	SHPRC	Waterways affected by urban development
Hawthorne Canal	SHPRC	Waterways affected by urban development
Whites Creek	SHPRC	Waterways affected by urban development
Easton Park drain	SHPRC	Waterways affected by urban development
Johnstons Creek	SHPRC	Waterways affected by urban development
Alexandra Canal	CRC	Partially Waterways affected by urban development and partially Estuaries
Rozelle Bay	SHPRC	Lower Estuary
Iron Cove	SHPRC	Upper Estuary

Table 3-3 NSW water quality and river flow objectives relevant to project

Objective	Applicable catchments / waterway	Where covered in this report
Water quality objectives		
Protect aquatic ecosystems	Waterways affected by urban development in SHPRC Upper estuary in SHPRC Lower estuary in SHPRC Estuaries in CRC	**Sections 2.4** and **8.2**.
Protect visual amenity	Waterways affected by urban development in SHPRC Upper estuary in SHPRC Lower estuary in SHPRC Estuaries in CRC	**Sections 2.4** and **8.2**
Protect secondary contact recreation	Waterways affected by urban development in SHPRC Upper estuary in SHPRC	**Sections 2.4** and **8.2**

Objective	Applicable catchments / waterway	Where covered in this report
	Lower estuary in SHPRC Estuaries in CRC – for achievement within 5 years	
Protect primary contact recreation	Waterways affected by urban development in SHPRC – for achievement in 10 years or more Upper estuary in SHPRC Lower estuary in SHPRC Estuaries in CRC – for achievement in 10 years or more	**Sections 2.4** and **8.2**
Aquatic foods (to be cooked before eating)	Upper estuary in SHPRC Lower estuary in SHPRC Estuaries in CRC – for achievement in 5 to 10 years	**Sections 2.4** and **8.2**.
River flow objectives		
Protect pools in dry times	Urban waterways in SHPRC	Not Applicable – limited application to catchment or hard lined waterways and no surface water extraction from waterways or natural wetlands is proposed. See **section 4.2** for details.
Protect natural low flows	Urban waterways in SHPRC	Not Applicable – all urban waterways in study area are hard lined with limited habitat. See **section 4.2** for details.
Protect important rises in water levels	Estuaries in CRC	See **sections 5.2, 6.2** and **8.1**.
Maintain wetland and floodplain inundation	Waterways affected by urban development in SHPRC Upper estuary in SHPRC Lower estuary in SHPRC	See **sections 5.2, 6.2** and **8.1**.
Mimic natural drying in temporary waterways	Waterways affected by urban development in SHPRC	Not Applicable - urban waterways in study area are hard lined with limited habitat. See **section 4.2** for details.
Maintain natural flow variability	Waterways affected by urban development in SHPRC Estuaries in CRC	**Sections 4.2** and **5.2.2**.
Maintain natural rates of change in water levels	Waterways affected by urban development in SHPRC Estuaries in CRC	**Sections 5.2, 6.2** and **sections 2.4** and **8.2**.
Manage groundwater for ecosystems	Upper estuary in SHPRC	Refer to **Appendix T** (Technical working paper: Groundwater) of the EIS.
Minimise effects of weirs and other structures	Waterways affected by urban development in SHPRC Upper estuary in SHPRC Lower estuary in SHPRC Estuaries in CRC	Not Applicable - no weirs or fish barriers are proposed as part of the project.
Maintain or	Upper estuary in SHPRC	**Section 8.2**.

Objective	Applicable catchments / waterway	Where covered in this report
rehabilitate estuarine processes and habitats	Lower estuary in SHPRC Estuaries in CRC	

3.2.3 Managing Urban Stormwater – Soils and Construction

The *Managing Urban Stormwater (MUS) – Soils and Construction* series of handbooks are an element of the NSW Government's urban stormwater program specifically applicable to the construction phase of developments. These are aimed at providing guidance for managing soils in a manner that protects the health, ecology and amenity of urban streams, rivers estuaries and beaches through better management of stormwater quality.

The MUS handbooks were produced to provide guidelines, principles, and recommended minimum design standards for good management practice in erosion and sediment control during the construction of roads. Of particular relevance to the project are Volume 1, 4th Edition (Landcom, 2004) (commonly known as The Blue Book 1) and Volume 2D, Main Road Construction (DECC, 2008) (commonly known as The Blue Book 2).

3.2.4 Sydney Harbour Water Quality Improvement Plan

The *Sydney Harbour Water Quality Improvement Plan* (Greater Sydney Local Land Services 2015) (SHWQIP) was developed by Greater Sydney Local Land Services, NSW OEH and Local Government in coordination with a range of stakeholders. The SHWQIP provides a coordinated management framework for the local councils, state government agencies and federal government agencies that have a stake in improving the future health of Sydney Harbour and its catchments. This plan applies to the greater portion of the study area which ultimately drains to Sydney Harbour.

The main objective of the SHWQIP '*is to identify threats to water quality in the Harbour and its tributaries and to set targets for pollutant load reductions (in terms of total nitrogen, total phosphorus, suspended sediment and pathogens) required to protect the condition and values of the Sydney Harbour, its tributaries, estuaries and waterways. The WQIP is designed to give focus and direction to water quality policy development and on-ground implementation throughout the Sydney Harbour catchment'.*

While the SHWQIP does not include pollutant reduction targets for individual developments, catchment load and estuary condition targets have been developed for sub-catchments and LGAs using feasible scenario options for both the management of stormwater and improvements in sewer outflow performance. These targets are based on the following scenario including assumptions of feasible change/actions:

- WSUD incorporated into 70 per cent of infill developments
- WSUD retrofitted into 10 per cent of existing urban areas
- Improving sewer overflow performance to limit overflows to no more than 40 events in 10 years.

The targets are designed to provide direction to change rather than being prescriptive of the exact management actions that should be undertaken to achieve these goals. It is acknowledged that different scenarios to that assumed above could also achieve the targets. The targets for the City of Sydney LGA and the former LGAs of Leichhardt, Ashfield and Marrickville are outlined in **Table 3-4**. Targets for some of the Sydney Harbour sub-catchments within the study area are provided in **Table 3-5**. No targets are available for Rozelle Bay.

Table 3-4 Load targets by LGA based on 70% WSUD to infill redevelopment, 10% retrofit to existing urban areas and capping sewer overflows to no more than 40 in 10 years

Stormwater pollutant	LGA reduction target			
	Leichhardt	Sydney	Ashfield	Marrickville
Total suspended solids (TSS)	21%	35%	24%	15%
Total phosphorus (TP)	17%	28%	20%	13%
Total Nitrogen (TN)	12%	19%	13%	9%
Enterococci	18%	30%	21%	14%
Faecal coliforms	20%	34%	23%	15%

Table 3-5 Load targets by sub-catchment based on 70% WSUD to infill redevelopment, 10% retrofit to existing urban areas and capping sewer overflows to no more than 40 in 10 years

Stormwater pollutant	LGA reduction target				
	Dobroyd Canal	Hawthorne Canal	Whites Creek	Johnstons Creek	Iron Cove
Total suspended solids (TSS)	26%	22%	29%	14%	11%
Total phosphorus (TP)	21%	18%	24%	12%	9%
Total Nitrogen (TN)	15%	12%	16%	8%	6%
Enterococci	24%	20%	26%	12%	10%
Faecal coliforms	25%	21%	27%	13%	11%

As the targets are based on LGA or sub-catchment scale management actions, they are not considered appropriate for use in terms of the project's stormwater treatment design. However, the proposed incorporation of stormwater treatment measures within the project's drainage network is considered to be consistent with the principles of the SHWQIP (ie implementing WSUD / stormwater treatment measures within infill development/existing urban areas).

3.2.5 Botany Bay and Catchment Water Quality Improvement Plan

Sydney Metropolitan Catchment Management Authority's (SMCMA) *Botany Bay and Catchment Water Quality Improvement Plan* (SMCMA 2011) is a contemporary plan designed specifically for the catchment of Botany Bay. The CRC is a sub-catchment of the larger Botany Bay catchment hence this plan applies to parts of the study area near to the St Peters interchange that are within the Alexandra Canal catchment and drain to the Cooks River.

The main objective of the *Botany Bay and Catchment Water Quality Improvement Plan* (BBWQIP) was to set targets for pollutant load reductions (in terms of total nitrogen, total phosphorus and suspended sediment) required to protect the condition of Botany Bay, its estuaries and waterways. The plan is an agreed water quality improvement plan that builds on research and engagement undertaken as part of the BBWQIP, to provide direction for future land use and water quality management decisions in the Botany Bay catchment.

The plan is aimed at Local, State and Federal Government agencies. A primary objective of the BBWQIP is to establish stormwater pollution reduction targets for all new development and re-development within the Botany Bay catchment to protect the condition of the bay, its estuaries and waterways. These pollutant reduction targets are shown in **Table 3-6**.

Table 3-6 Stormwater reduction targets recommended for urban development in the Botany Bay catchments

Stormwater pollutant	Reduction target	
	Greenfield developments Large re-developments	Multi-unit dwellings, commercial and industrial developments, small re-developments
Gross pollutants	90%	90%
TSS	85%	80%
TP	60%	55%
TN	45%	40%

3.2.6 Floodplain Development Manual

The *Floodplain Development Manual* (NSW Government 2005) incorporates the NSW Government's Flood Prone Land Policy, the primary objectives of which are to reduce the impact of flooding and flood liability on owners and occupiers of flood prone property. Additionally, it is also intended to reduce public and private losses resulting from floods, whilst also recognising the benefits of use, occupation and development of flood prone land.

The *Floodplain Development Manual* forms the NSW Government's primary technical guidance for the development of sustainable strategies to support human occupation and use of the floodplain. It also promotes strategic consideration of key issues including safety to people, management of potential damage to property and infrastructure, and management of cumulative development impacts. Importantly, the *Floodplain Development Manual* promotes the concept that proposed developments be treated on their merit rather than through the imposition of rigid and prescriptive criteria. This means that each project needs to be assessed on a case by case basis and that there is no single solution or standard that should be applied to all projects. The overall benefits and impacts of a project should be taken into consideration when development is proposed in flood affected areas.

3.2.7 Planning directions and guidelines on flooding

In January 2007 the NSW Department of Planning issued Planning circular PS 07-003 *New guideline and changes to section 117 direction and Environmental Planning and Assessment Regulation on flood prone land*. This provided an overview of its new guideline to the *Floodplain Development Manual* and provided advice on a package of changes concerning flood-related development controls for residential development on land above the 100 year ARI flood and up to the PMF.

The *Guideline on Development Controls on Low Flood Risk Areas* confirmed that unless there are exceptional circumstances, councils should adopt the 100 year ARI flood as the basis for deriving the Flood Planning Level (FPL) for residential development. In proposing a case for exceptional circumstances, a council would need to demonstrate that a different flood planning levels was required for the management of residential development due to local flood behaviour, flood history, associated flood hazards or a particular historic flood. The guideline also notes that, unless there are exceptional circumstances, councils should not impose flood related development controls on residential development on land above the residential FPL (low flood risk areas). However, the guideline does acknowledge that controls may need to apply to critical infrastructure and consideration be given to evacuation routes and vulnerable developments in areas above the 100 year ARI flood. This has been taken into consideration when setting the hydrologic standards for various items of the project infrastructure as set out in **section 3.4.4**.

In July 2007 the NSW Minister for Planning issued a list of directions to local councils under section 117(2) of the EP&A Act Direction 4.3 – Flood Prone Land applies to all councils that contain flood prone land within their LGA.

The assessment of the potential impacts that the project would have on existing flood risk and also the future development potential of flood affected land outside the project footprint is shown in **sections 5.2** and **6.2**. The assessment includes the impacts of storms with ARI's up to

100 years in the case of residential type development (and by default commercial and industrial type development) and storm ARI's greater than 100 years in the case of critical infrastructure (such as hospitals) and vulnerable developments (such as aged care facilities).

3.2.8 Floodplain Risk Management Guideline – Practical Considerations of Climate Change

The *Floodplain Risk Management Guideline – Practical Consideration of Climate Change* (DECC 2007) was prepared to assist Councils in the preparation and implementation of their Floodplain Risk Management (FRM) plans.

The 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; and increasing those rainfalls by 30 per cent would produce about a 500 year ARI flood. On current projections, the increase in rainfall within the design life of the project is likely to be around 10 per cent, with the higher value of 30 per cent representing an upper limit. Given that finished road levels for the project generally lie above the upper envelope of 100 year ARI flooding, the impact on flood behaviour of a 10 per cent increase in 100 year ARI design rainfall intensities was assessed as part of this investigation.

Many of the watercourses within the study area are tidally influenced, therefore climate change in terms of potential sea level rise is a relevant consideration. Climate change is expected to impact sea levels and rainfall intensities, both of which may have significant influence on flood behaviour at specific locations. DECC 2007 states that the Intergovernmental Panel on Climate Change (IPCC) 2007 trends indicate that average global sea level rise (not including ice flow melt) may be between 0.18 to 0.59 metres by between 2090 and 2100. Adding to this, the ice flow melt uncertainty of up to 0.2 metres gives an adjusted global range of 0.18 to 0.79 metres. IPCC 2007 and recent CSIRO modelling indicate that mean sea levels along the NSW coast are expected to rise by more than the global mean. Combining the relevant global and local information indicates that sea level rise on the NSW coast is expected to be in the range of 0.18 to 0.91 metres by between 2090 and 2100 (DECC 2007).

In 2009 the NSW Government released its *Sea Level Rise Policy Statement* (NSW Government, 2009) which supported adaptation to projected sea level rise impacts. The policy statement included sea level rise planning benchmarks for use in assessing potential impacts of projected sea level rise in coastal areas, including flood risk and coastal hazard assessment. These benchmarks were a projected rise in sea level (relative to 1990 mean sea level) of 0.4 metres by 2050 and 0.9 metres by 2100, based on work carried out by the Intergovernmental Panel on Climate Change and CSIRO. In its *Flood Risk Management Guide: Incorporating Sea Level Rise Benchmarks in Flood Risk Assessments* (DECCW 2010), the NSW Government recommended that these benchmark rises should be used to assess the sensitivity of flood behaviour to future sea level rise.

In 2012 the NSW Government announced its Stage 1 Coastal Management Reforms (NSW Government 2012). As part of these reforms, the NSW Government no longer recommends state-wide sea level rise benchmarks, with local councils now having the flexibility to consider local conditions when determining local future hazards.

In the absence of a formal State Government policy on sea level rise benchmarks, the previously recommended rises in sea level of 0.4 metres by 2050 and 0.9 metres by 2100 have been adopted for assessing the impact future climate change could have on flooding conditions in the vicinity of the project. The key findings of the assessment are set out in **section 6.2**.

3.2.9 Local council requirements for flooding

The majority of the project and its surface operational features are located in the Inner West Council LGA (formerly Ashfield, Leichhardt and Marrickville Councils) with a small length of sub-surface tunnel encroaching into the City of Sydney LGA.

The Local Environment Plans for each of the Councils state that the FPL for residential development is in all cases equal to the peak 100 year ARI flood level plus 0.5 metres freeboard for properties subject to mainstream flooding. The approach is consistent with the NSW Government's Guideline on Development Controls on Low Flood Risk Areas.

The Development Control Plans that support the Local Environment Plans identify that some of the surface features of the project are located within areas designated as Flood Control Lots, which are areas that have been identified as having the potential to be flood affected. The Rozelle interchange, Darley Road civil and tunnel site and Pyrmont Bridge tunnel site are identified as Flood Control Lots.

The Inner West Council is currently working toward formation of a Floodplain Risk Management Committee for the new Council. This would address management of the hazards associated with flooding and mitigation of the amount of flooding at or through properties. The Plan would address flood management issues within the former Leichhardt LGA as identified in the *Leichhardt Flood Study* (Cardno 2014). In the absence of a floodplain risk management plan, the assessment of flood behaviour (existing and future) has therefore been based on the flood study.

3.2.10 Other policies and guidelines

Other polices and guidelines that apply to the project include:

- *NSW State Rivers and Estuaries Policy* (NSW Water Resources Council1993)
- *National Water Quality Management Strategy* (ANZECC 2000)
- *Guidelines for Design of Fish and Fauna Friendly Waterway Crossings* (Fairfull and Witheridge, 2003)
- Fish Passage Requirements for Waterway Crossings (Fairfull and Witheridge 2003)
- *Controlled Activities – Guidelines for Riparian Corridors* (NSW Office of Water 2011)
- *Controlled Activities – Guidelines for Watercourse Crossings* (NSW Office of Water 2010)
- *Controlled Activities – Guidelines for In-stream Works* (NSW Office of Water 2010)
- *Controlled Activities – Guidelines for Laying Pipes and Cables in Watercourses* (NSW Office of Water 2011)
- *Controlled Activities – Guidelines for Outlet Structures* (NSW Office of Water 2010)
- Managing Urban Stormwater: Council Handbook, Draft (NSW EPA 1981)
- Australian Rainfall and Runoff (Institute of Engineers Australia 2001; AR&R)
- Australian Runoff Quality (Institute of Engineers Australia 2006; ARQ)
- *Guideline on Development Controls on Low Flood Risk Areas* (NSW Government 2007)
- The Estimation of Probable Maximum Precipitation in Australia: Generalised Short- Duration Method (Bureau of Meteorology (BoM 2003)
- Derivation of the NSW Government's Sea Level Rise Planning Benchmarks. Technical Note (DECCW 2009)
- *Coastal Planning Guideline – Adapting to Sea Level Rise* (NSW Department of Planning 2010)
- *Coastal Risk Management Guideline – Incorporating Sea Level Rise Benchmarks in Coastal Risk Assessments* (NSW Department of Planning 2010)
- *Flood Risk Management Guide: Incorporating Sea Level Rise Benchmarks in Flood Risk Assessments* (DECCW 2010).

Relevant policies and guidelines of Roads and Maritime that also apply to the project include:

- *Water Policy (*NSW Roads and Traffic Authority (RTA) 1997)
- Roads and Maritime Services Code of Practice for Water Management (Roads and Maritime 1999)
- Stockpile Site Management Procedures (RTA 2001)

- Procedures for Selecting Treatment Strategies to Control Road Runoff (RTA 2003)
- Roads and Maritime Services Erosion and Sediment Management Procedure (Roads and Maritime 2008)
- *Roads and Maritime Services Technical Guideline: Temporary Stormwater Drainage for Road Construction* (Roads and Maritime 2011)
- *Roads and Maritime Technical Guideline Environmental Management of Construction Site Dewatering* (RTA 2011)
- *Draft Technical Guide for Climate Change Adaptation for the State Road Network* (Roads and Maritime 2016).

Relevant Austroads guidelines that apply to the project include:

- *AP-R180 Road Runoff and Drainage: Environmental Impacts and Management Options* (Austroads 2011)
- *AP-R232 Guidelines for Treatment of Stormwater Runoff from the Road Infrastructure* (Austroads 2003)
- *Guide to Road Design, Part 5: Drainage Design* (Austroads 2013).

3.2.11 Project stormwater quality objectives

The stormwater treatment design will be developed with consideration to the SHPRC water quality objectives (DECCW 2006) which are primarily aimed at maintaining or improving water quality within Sydney Harbour and the Parramatta River estuary. There are no M4-M5 Link treatment facilities proposed within catchments draining to the Cooks River.

To facilitate this objective, the stormwater treatment design for the project is will adopt the following mean annual pollutant load reduction targets where practical and space is available:

- 85 per cent reduction in the mean annual load of Total Suspended Solids (TSS)
- 65 per cent reduction in the mean annual load of Total Phosphorous (TP)
- 45 per cent reduction in the mean annual load of Total Nitrogen (TN)
- 90 per cent reduction in the mean annual load of Gross Pollutants >5 millimetres (GP).

In some instances, due to the highly constrained urban environment, there may not be opportunity to install treatment devices within individual surface catchments and achieve the pollutant load reduction targets. In these highly constrained areas good practice treatment techniques would be deployed where feasible and practical.

3.3 Key assumptions

The overall surface water assessment was undertaken based on the following key assumptions:

- In order to undertake stormwater quality Model for Urban Stormwater Improvement Conceptualisation (MUSIC) modelling, assumptions were made with regards to the size of catchments and the size, type and location of permanent water quality treatment devices as detailed in **section 3.4.3**
- Groundwater inflows to the tunnel drainage system were assumed to be similar quality to that previously documented within the New M5 and M4 East EIS documents due to the similar geology and land use traversed by the project. Where elevated levels of other parameters have been identified in the groundwater sampling program undertaken to date for the project, these have also been considered in the assessment.

3.4 Methodology

This section details the methodology adopted for this assessment, which has included:

- Undertaking a desktop review and analysis of existing information to determine potential receptors, characterise the existing environment 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 related to flooding, drainage, hydrology, geomorphology, water supply and water quality
- Identifying appropriate measures to mitigate potential impacts.

3.4.1 Desktop analysis

The existing surface water environment within the study area has been characterised and potential impacts have been identified through an initial desktop analysis of available information. The desktop analysis has included consideration of:

- Information and previous studies pertaining to surface water within the study area. This included previous flooding and surface water studies that have been used to inform the EIS undertaken for the M4 East and New M5 projects
- Other Technical Working Papers included in this EIS, including those relating to groundwater, contamination and biodiversity.

Data collection

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

- Inner West Council (formerly Leichhardt, Ashfield, Marrickville) and City of Sydney Council
- Roads and Maritime, SMC, UrbanGrowth NSW, Sydney Water Corporation and Transport for NSW (CBD and South East Light Rail).

Review of previous studies

A number of previous studies into various aspects of surface water and flooding in the study area have been reviewed as listed in **Table 3-7**.

Table 3-7 Previous studies

Relevance	Reference
Surface water, flooding and drainage	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 2014, Cardno)
	Alexandra Canal Catchment Flood Study (City of Sydney Council 2014, Cardno)
	M4 East EIS, Appendix Q, Surface Water: Flooding and Drainage (Lyall and Associates 2015a)
	New M5 Environmental Impact Statement, Appendix P, Technical Working paper: Flooding (Lyall and Associates 2015b)
	St Peters Interchange and Local Road Upgrades Flood Modelling, Hydrology Model Development Report, Substantial Detailed Design, Rev D, Doc No. M5N-AJV-TER-100-114-HY-1499, 24/06/2016 (CPB Contractors, Dragados, Samsung Joint Venture (CDS) 2016a)
	St Peters Interchange and Local Road Upgrades Drainage Drawings set, M5N-AJV-DWG-900-300-DR Final Design, M5N-AJV-DWG-700-300-DR (FD) (CDS 2016b)
	M4 East - Design and Construct, Technical Report – Hydrology and Flooding, Project Wide, Final Design, Doc No. M4E-AEH-TR-00-120-053001_D_00, 15/09/2016 (CPB Contractors, Samsung, John Holland Joint Venture (CSJ) 2016a)
	M4 East - Design and Construct, Technical Report – Flood Mitigation Strategy, Project Wide – Permanent Works, Final Design, Doc No. M4E-AEH-TR-00-120-100001_D_00, 23/06/2016 (CSJ 2016b)
Water quality	Source of heavy metals in sediments of the Port Jackson estuary, Australia (Birch and Taylor 1999)
	Catchment condition as a major control on the quality of receiving basin sediments (Sydney Harbour, Australia) (Birch and McCready 2008)
	Leichhardt State of the Environment Report, 2009-2010
	Assessment of water quality and treatment options in Johnstons Creek, Whites Creek, Hawthorne Canal and Balmain catchments. (Beck 2010)
	Field and modelling investigations of fresh-water plume behaviour in response to infrequent high-precipitation events, Sydney Estuary, Australia. (Lee, Birch and Lemckert 2010)
	Metals, nutrients and total suspended solids discharged during different flow conditions in highly urbanised catchments (Beck and

Relevance	Reference
	Birch, 2010)
	Pollution in Sydney Harbour: sewage, toxic chemicals and microplastics. Briefing Paper No 03/2015 (Montoya, 2015)
	M4 East Environmental Impact Statement, Appendix O, Technical Working paper: Soil and water quality assessment (GHD, 2015)
	Baseline assessment of ecological structure and environmental condition at the Bays Precinct (Bugnot, A.B., Mayer-Pinto, M., Johnston, E.L., Coleman, R.A., Morris, R. L., and Dafforn, K.A. 2016)
Waterways	Sydney Light Rail Extension – Stage 1 – Inner West Extension Environmental Assessment (Parsons Brinckerhoff 2010)
	Sydney Water heritage search tool www.sydneywater.com.au

Review of baseline data

A number of sources provided data for the purpose of this assessment. These include:

- Details of trunk drainage assets operated by Sydney Water
- Details of pit and pipe stormwater drainage provided by Inner West Council and City of Sydney Council. Data included locations of pits and pipes
- Light Detection and Ranging (LIDAR) topographic survey
- Survey of Rozelle Rail Yards
- Aerial imagery
- Water quality monitoring data provided by SMC from the New M5 and M4 East projects and by UrbanGrowth NSW for The Bays Precinct project.

3.4.2 Field assessment

The purpose of the site visits was to visually assess the locations of the proposed surface elements of the project and the current state of surface water receptors and potential pathways to the receptors. Field inspections were made on three separate occasions, as shown in **Table 3-8**.

Table 3-8 Summary of site visits

Date	Area visited	Waterbodies visited	Outcomes
18 May 2016	St Peters, Rozelle Rail Yards, Wattle Street, Darley Street, Pyrmont Bridge Road	Dobroyd Canal, Hawthorne Canal, Easton Park drain, Whites Creek, Rozelle Bay, Johnstons Creek, Alexandra Canal	Inspection of waterways
12 July 2016	Rozelle Rail Yards	Whites Creek, Easton Park drain, Rozelle Bay	Inspection of waterways and drainage infrastructure
5 September 2016	Rozelle Rail Yards and Victoria Road	Whites Creek, Easton Park drain, Rozelle Bay, Iron Cove	Inspection of waterways and drainage infrastructure

3.4.3 Assessment of potential impacts

Water quality during construction

The assessment of surface water quality impacts during proposed construction works involved:

- Assessment of potential construction activities that could mobilise sediments and other pollutants into the surface water environment
- Review of existing policies and guidelines applicable to the management of water quality during construction
- Assessment of the potential impacts of the quality and volume of proposed discharges of treated construction water on the receiving environment.

Water quality during operation

MUSIC modelling of the existing and proposed conditions was undertaken to assess potential impacts on receiving waters associated with pollutant loads generated from pavement runoff and the performance of the proposed treatment system.

The MUSIC model was developed by the Cooperative Research Centre for Catchment Hydrology (now eWater CRC) as a decision support system for the design of stormwater treatment devices, and is now considered the standard method for determining compliance with water quality targets within the stormwater industry. The MUSIC model used was based on the NSW MUSIC modelling guidelines for the meteorological template and pollutant generation parameters.

The performance of the types of treatment devices likely to be used for stormwater quality treatment has been modelled and the results are presented in **section 6.3.2**. The type and design of specific stormwater treatment measures across the project would be further refined as part of detailed design. Modelling undertaken for this assessment has required assumptions to be made regarding the size of catchments as well as the type, size and design of stormwater quality improvement devices. The results of the modelling should therefore be considered as estimates of the likely treatment performance that can be expected. Modelling would need to be revised during detailed design and this would be accompanied by a description of the treatment devices and any accompanying calculations including the assumptions.

The following assumptions were made for the purposes of developing the pre-construction MUSIC model scenario:

- Hydrological and pollutant parameters were selected in accordance with the NSW MUSIC modelling guidelines (Sydney Metropolitan Catchment Management Authority 2010)
- Climate data for Sydney Meteorological Office weather station for the period 1962 to 1966 was selected as recommended in the NSW MUSIC modelling guidelines (Sydney Metropolitan Catchment Management Authority 2010)
- A catchment area equivalent to the proposed development pavement drainage catchment was modelled, using separate sub-catchments for each existing land use type
- Gross Pollutant Traps (GPTs) were assumed to be installed upstream of Iron Cove on Victoria Road heading south and northbound. The GPTs were modelled in accordance with the NSW MUSIC modelling guidelines with a high flow bypass equivalent to the three month ARI for the pavement catchment being assessed.

The following assumptions were made for the purposes of developing the post-construction MUSIC model scenario:

- Hydrological and pollutant parameters were selected in accordance with the NSW MUSIC modelling guidelines
- Surface runoff from the road surfaces of Victoria Road to Anzac Bridge east bound ramps, a portion of City West Link, a portion of Victoria Road, portals for the future proposed Western Harbour Tunnel ramp and M4 ramps to Anzac Bridge, and the Rozelle ancillary infrastructure facilities were assumed to be treated by either the constructed wetland or one of the proposed bioretention systems at Rozelle
- Surface runoff from a portion of Iron Cove Link including a portion of the Victoria road northbound, the Victoria Road southbound, and the Victoria Road portals were assumed to be treated by the bioretention basin within King George Park
- Other areas including The Crescent bridge, a portion of City West Link east bound and west bound, James Craig Road, the proposed New M5 ramps, a portion of the upgraded section of Victoria Road at Rozelle, a portion of the upgraded section of Victoria Road at Iron Cove Link and portals at Wattle Street were assumed to be constrained and treated by proprietary devices including a GPT and a hydrodynamic separator. The GPTs were modelled as per the existing conditions modelling approach. Hydrodynamic separators were modelled conservatively assuming a 33 per cent reduction in performance to a proprietary hydrodynamic separator MUSIC node
- The constructed wetland was modelled as an ephemeral wetland with no permanent pool to account for the groundwater flows (associated with tunnel ingress) which would be passing through the wetland permanent pool
- Assumed pervious public open space areas and indicative shared pathways within these areas were not incorporated within the model.

Annexure F provides full details of the catchments modelling in MUSIC.

Proposed discharges of treated tunnel water were qualitatively assessed for potential impacts on Hawthorne Canal, Whites Creek and Rozelle Bay associated with the quality of water discharge. This considered groundwater inflow quality at other tunnel water treatment plants in Sydney, groundwater quality data collected for the project and the characteristics of the two tunnel drainage streams (groundwater being a continuous flow and the other water ingress events being discontinuous flows), (see **section 2.4.2**). The finalisation of the design of the treatment plant and discharge quality criteria will be undertaken during detailed design and will be informed by ongoing groundwater quality monitoring.

Flooding

A staged approach was undertaken to determine the level of assessment required to establish:

- The flood risk posed to the surface features of the M4-M5 Link
- The potential impact of the development on surrounding properties
- Mitigation measures required to protect sensitive infrastructure.

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 as a consequence of the following considerations:

- Existing flood risk information
- Identifying risk to the sites and mechanisms of flooding
- Determining flood risk to the project and potential impacts of the development to surrounding areas.

Where sites were identified as being at high risk of flooding, the process followed enabled consideration of flood risk in the design of the layout of the interchanges and construction sites.

This included identifying opportunities to:

- Provide easements from areas identified at risk of flooding in order to maintain existing flowpaths
- Locate land uses across the study area based on the 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 was determined by following the steps in **Figure 3-1**. All surface features within the study area associated with the proposed M4-M5 Link project (interchanges and construction sites) were assessed through this process. For details of the step by step process see **Annexure D**. A summary of this assessment is provided in **sections 5.2** and **6.2**.

It is noted that SEARs 12.1 (f) refers to ‘adverse effect on beneficial inundation’. Beneficial inundation is considered to be more applicable to a rural agricultural environment. Therefore, in the context of this EIS, 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 was undertaken:

- Development of new hydrologic and hydraulic flood models
- Running the flood models identifying flood behaviour under present day (pre-project) conditions for the 10 year and 100 year ARI events, as well as the PMF
- Assessment of the potential impact the project would have on flooding characteristics during construction and operation

- Assessment of the impact a partial blockage of major hydraulic structures due to floating debris 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). Further detail on the methodology adopted for locations that required a quantitative assessment is provided in **Annexure C**.

Process for establishing flood risk and the level of assessment required

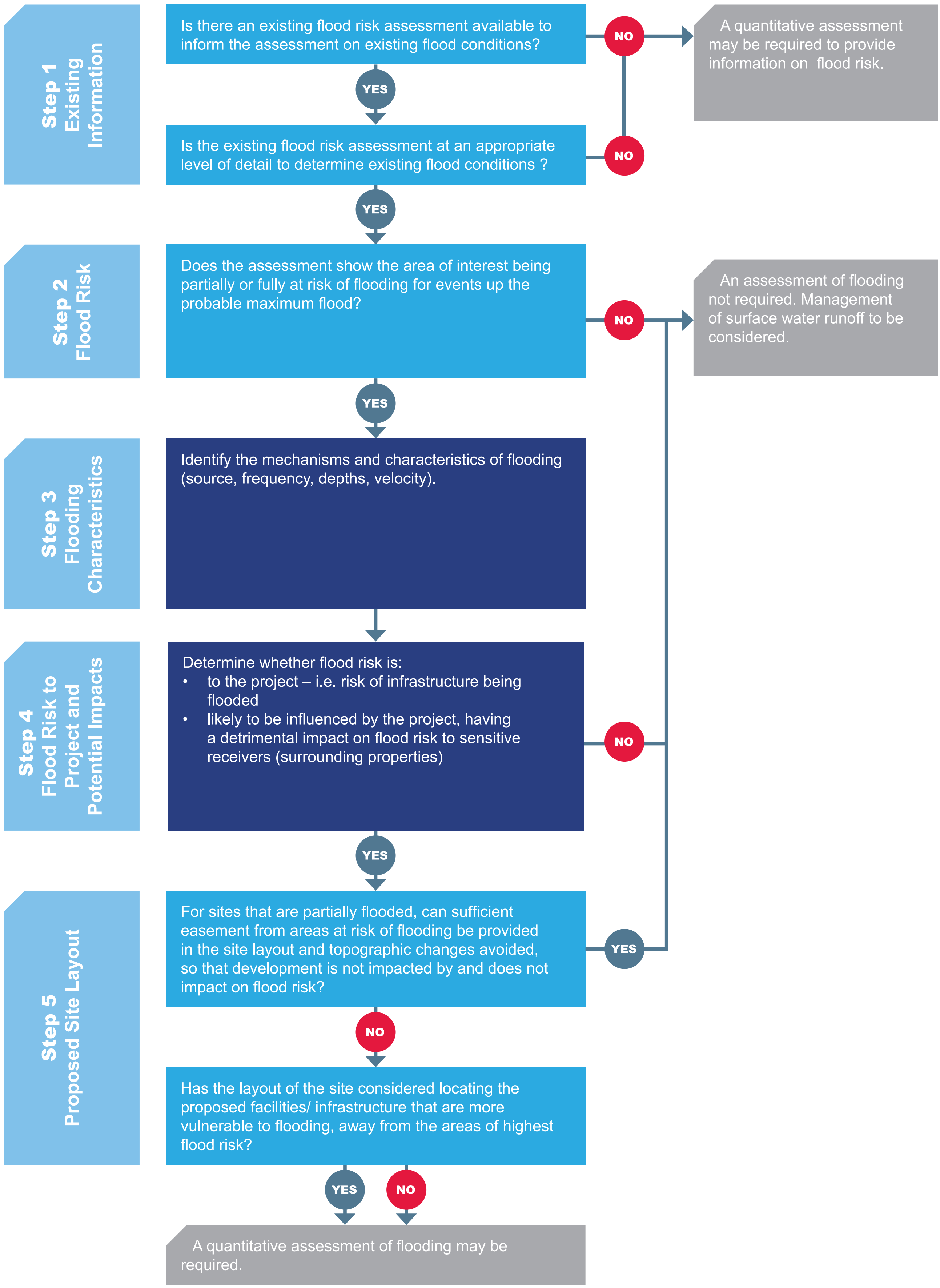


Figure 3-1 Flood risk assessment decision process (AECOM 2017)

3.4.4 Hydrologic standards

The standards adopted in the assessment of transverse drainage and flood mitigation measures were established in accordance with the *Floodplain Development Manual* 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 and are outlined in **Table 3-9**.

Table 3-9 Hydrologic standards

Project infrastructure	Standards
Tunnel portals and ancillary facilities (ventilation facility, water treatment plants)	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 will maintain the existing level of flood immunity where feasible, taking the duration of the construction stages into consideration.
Impacts on existing development	**Standards**
Operational	100 year ARI flood standard is to be adopted in the assessment of measures which are required to mitigate any adverse flooding impacts attributable to the project. Changes in flood behaviour under PMF conditions would also be assessed in order 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 in order to set requirements that are commensurate to the period of time that the risk exposure occurs. To this end, this report identifies the risks and potential impacts associated with construction activities and the site so that informed decisions on the flood criteria to be set as part of the flood risk management plan for the construction of the project can be made.

4 Existing environment

4.1 Catchments and watercourses

The project footprint is located within the SHPRC and the CRC. The majority of the study area is located within the Sydney Harbour catchment, which covers an area of around 484 square kilometres including its main tributary the Parramatta River. The southern portion of the project footprint, within proximity to the St Peters interchange is located within the CRC. The CRC covers an area of around 100 km^2 in southern Sydney and discharges to Botany Bay at Mascot.

The predominant waterways within the SHPRC traversed or affected by the project footprint include Hawthorne Canal, Whites Creek, Johnstons Creek as well as Dobroyd Canal (also known as Iron Cove Creek) and Easton Park drain. Dobroyd Canal and Hawthorne Canal discharge to Iron Cove while Whites Creek, Johnstons Creek and Easton Park drain discharge to Rozelle Bay.

The channels of Dobroyd Canal, Hawthorne Canal, Whites Creek and Johnstons Creek are considered to be of historical significance as they are four of a group of similar channels which were the earliest purpose built stormwater drains to be constructed in Sydney (Sydney Water 2014).

Alexandra Canal is the main waterway downstream of the project footprint within the CRC. Alexandra Canal is one of only two navigable canals built in NSW and is characterised by its controlled route, defined edges and sandstone embankment walls. The canal is considered to be of high historic, aesthetic and technical/research significance (Sydney Water 2014).

Rozelle Bay, Iron Cove, White Bay, Alexandra Canal and downstream portions of Dobroyd Canal and Hawthorne Canal have been mapped as Key Fish Habitat, as defined in the *Fisheries Policy and Guidelines for Fish Habitat Conservation and Management* (update 2013) (Fairfull 2013). The project's receiving waters are marine environments which include the intertidal and subtidal ecosystem of the harbour and its estuarine tributaries. Further details of the aquatic habitat and species present within the waterways are provided within **Appendix S** (Technical working paper: Biodiversity) of the EIS.

The stream order, based on the Strahler System for each waterway is provided in the following sections. The stream order was assessed based on the Framework for Biodiversity Assessment (FBA).

Uses of the waterways within the study area include recreational users (including swimming, boating and aesthetics), commercial activities (commercial shipping and tourism) and as an ecological resource. Commercial fishing in Sydney Harbour, Parramatta River and other connected tidal waterways has been banned since 2006 as a precautionary measure due to elevated levels of dioxins in some fish and seafood. Recreational fishing is still allowed but fishers are urged to follow dietary advice on the consumption of seafood. There is very limited extraction of fresh water, or reuse of stormwater within the SHPRC (DECCW 2006) and no known freshwater extractions occur downstream of the construction and operational surface water discharge points.

Figure 4-1 shows the waterways and associated catchments within the study area, which are traversed or downstream of the project footprint. Photographs of the key waterways are shown in **Annexure A**. The locations of the photographs are shown in **Figure 4-2**.

4.1.1 Dobroyd Canal

Dobroyd Canal 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 Dobroyd Canal catchment is fully urbanised with an area of around 800 hectares. The canal comprises an open channel between Iron Cove and the intersection of Carshalton and Norton Streets with underground branches extending upstream (**Annexure A** – Photo 1). Dobroyd Canal is a first order stream and is mapped as Key Fish Habitat downstream of Ramsay Street, Haberfield.

This waterway runs parallel to the Wattle Street interchange and the proposed tunnel portal of the M4-M5 Link. The 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) are located within the Dobroyd Canal catchment (see **Figure 4-1**). The Wattle Street interchange will drain to Dobroyd Canal during operation.

4.1.2 Hawthorne Canal

Hawthorne Canal starts in Lewisham and flows into Iron Cove at Dobroyd Point. The canal's catchment is around 670 hectares and is heavily urbanised (PB 2010). Sydney Water Corporation owns the canal. It was originally a natural waterway known as Long Cove Creek but has since been straightened and given artificial banks. The channel 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 around two metres in upper areas to 22 metres at its confluence with Iron Cove (WMAwater 2013). Hawthorne Canal is a first order stream and is mapped as Key Fish Habitat downstream of approximately Marion Street, Leichhardt.

The proposed M4-M5 Link tunnel alignment crosses beneath Hawthorne Canal adjacent to Hawthorne Parade, around 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.

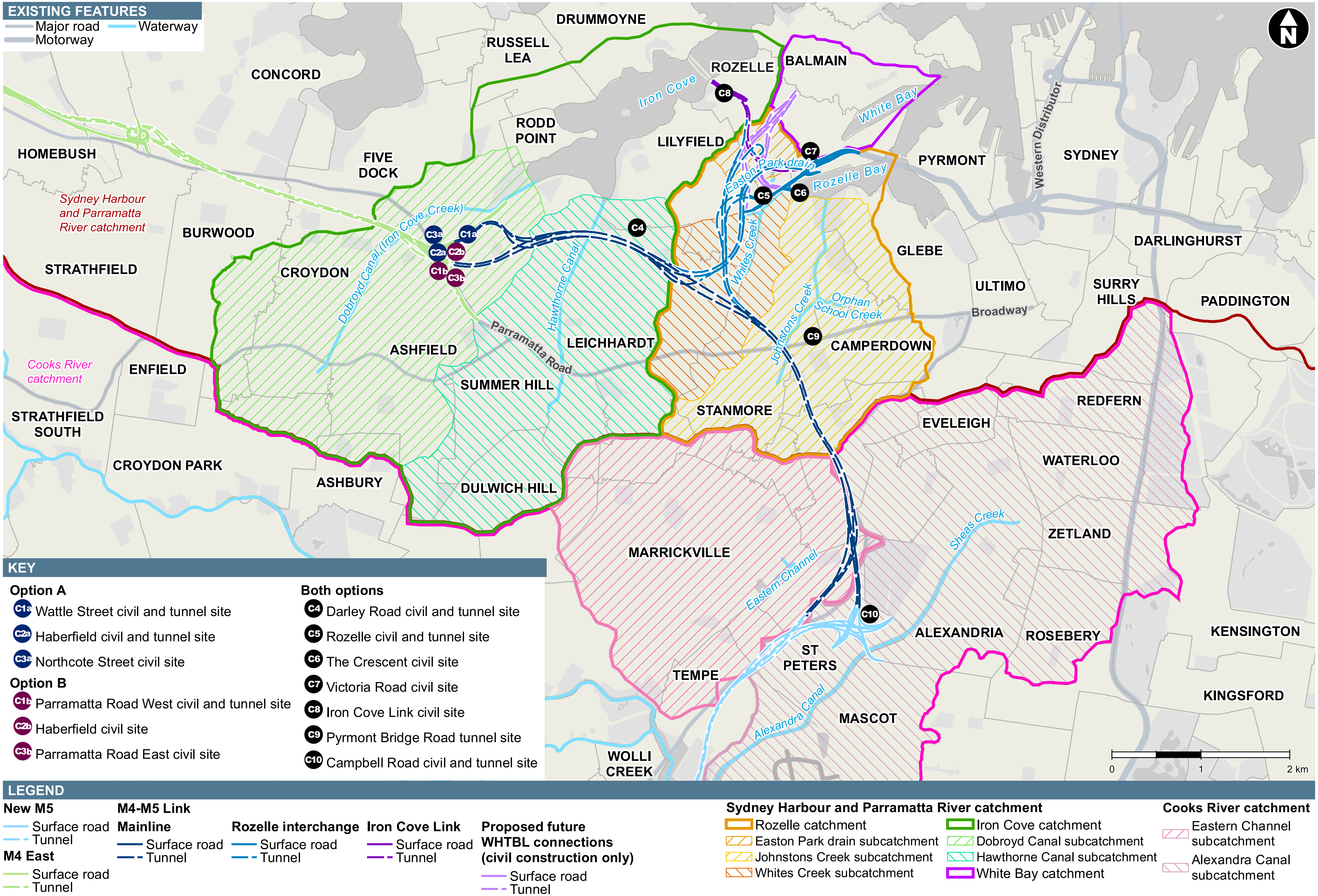


Figure 4-1 Catchments and waterways within study area

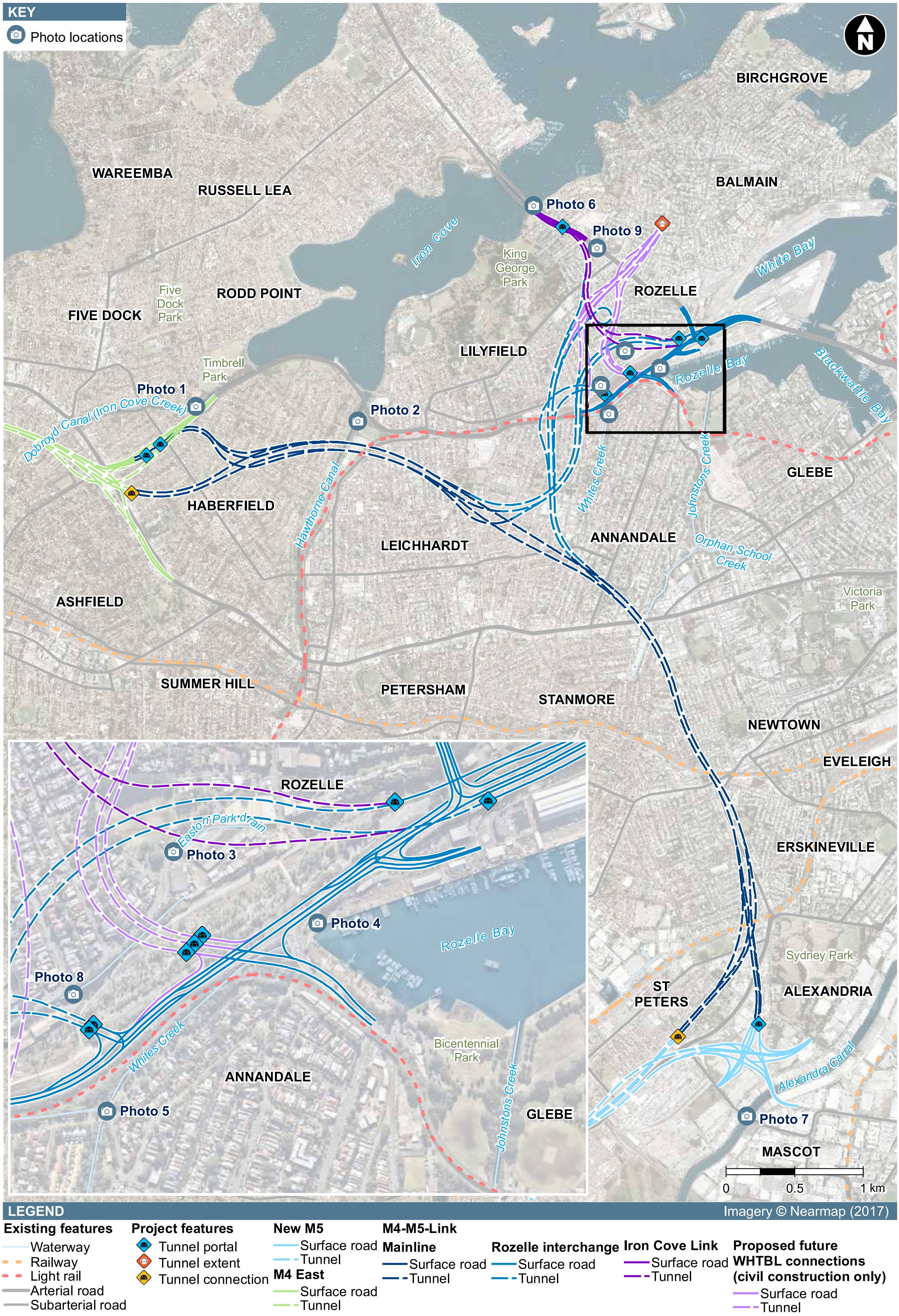


Figure 4-2 Location of photographs

4.1.3 Whites Creek

Whites Creek is a brick and concrete-lined channel that flows through the suburbs of Leichhardt and Marrickville, discharging to Rozelle Bay (**Annexure A** – Photo 5). The Whites Creek catchment is heavily urbanised and comprises an area of around 262 hectares. Originally a natural watercourse, the Whites Creek stormwater channel was constructed progressively during the period 1898 to 1938. The channel 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, raising the level of sections of these roads, the construction of new culverts into Rozelle Bay, in addition to upgrade and widening of the existing bridge structure that crosses Whites Creek at The Crescent. Whites Creek is a first order stream. The Crescent civil site (C6) is located at the confluence between Whites Creek and Rozelle Bay.

4.1.4 Easton Park drain

Easton Park drain, running between Denison Street adjacent to Easton Park and Rozelle Bay, conveys runoff from a heavily urbanised catchment of around 55 hectares within the suburb of Rozelle. The drain originates from a series of stormwater networks that discharge into a brick-lined, open channel south of Lilyfield Road (**Annexure A** – Photo 3). The open channel section passing through the industrial area between Lilyfield Road and the Rozelle Rail Yards is around 175 metres long. It discharges into a culvert that runs underneath the Rozelle Rail Yards and outlets into Rozelle Bay, to the east of the intersection of City West Link and The Crescent (**Annexure A** – Photo 3). Observations of the outfall suggest that discharges from the culvert are influenced by tidal fluctuations in Rozelle Bay (**Annexure A** – Photo 4).

Easton Park drain passes through the proposed Rozelle interchange, from Lilyfield Road in the north to Rozelle Bay in the south. Easton Park drain is a first order stream. 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.

4.1.5 Johnstons Creek

The Johnstons Creek catchment is heavily urbanised being situated within the suburbs of Glebe, Annandale, Petersham and Newtown, immediately west of Sydney CBD and comprises a total area of around 460 hectares (WMAwater 2014). Originally a natural watercourse discharging to Rozelle Bay, Johnstons Creek was converted into a stormwater channel in the 1890s. The channel consists of a wide open concrete section at the Rozelle Bay end and brick walls further upstream.

The proposed M4-M5 Link mainline tunnel traverses beneath Johnstons Creek adjacent to Bridge Road, Stanmore, south of Parramatta Road. At this point, Johnstons Creek is a first order stream. The Pyrmont Bridge Road tunnel site (C9) is located within the Johnstons Creek catchment.

4.1.6 Rozelle Bay

The Rozelle Bay catchment is highly urbanised and comprises a total area of around 857 hectares. Rozelle Bay is located between the suburbs of Glebe, Annandale, Lilyfield and Rozelle with flow inputs from Whites Creek, Johnstons Creek and Easton Park drain. The foreshore is actively used for recreational fishing and the bay houses private recreation craft, 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 in the Sydney Regional Environmental Plan (Sydney Harbour Catchment) (NSW Government 2005). Rozelle Bay is mapped as Key Fish Habitat and is an estuarine environment.

Rozelle Bay is 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 flows from the Rozelle interchange. The Rozelle civil and tunnel site (C5) is located within the Rozelle Bay catchment. The Victoria Road civil site (C7) is located on the boundary of the Rozelle Bay and White Bay catchments.

4.1.7 Iron Cove

The Iron Cove catchment, a bay within the Parramatta River estuary, is highly urbanised and comprises a total area of around 2,011 hectares (**Annexure A**– Photo 6). Dobroyd Canal (Iron Cove Creek) and Hawthorne Canal discharge into Iron Cove.

Iron Cove is classified as W5 Water Recreation in the Sydney Regional Environmental Plan (Sydney Harbour Catchment) (NSW Government 2005). The Sydney Regional Environmental Plan also identifies some waters adjacent to the Iron Cove foreshore as Wetlands Protection Area. Iron Cove has been mapped as Key Fish Habitat.

A portion of the proposed road upgrades (ie the widening of a section of Victoria Road) associated with Iron Cove Link will drain into Iron Cove, either utilising existing outlets or a new direct drainage outlet. Iron Cove is a second order stream. The Iron Cove civil site (C8) and proposed bioretention basin and car park improvement works in Manning Street within King George Park are located within the Iron Cove catchment.

4.1.8 White Bay

The White Bay catchment is highly urbanised and comprises a total area of around 163 hectares. White Bay 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 wharf is one of only two deep-water wharves west of the Sydney Harbour Bridge. It is used for a variety of port uses, including bulk vessel loading and vessel repairs. The White Bay Cruise Terminal is Sydney's second cruise terminal to the Overseas Passenger Terminal at Circular Quay. The former White Bay power station is located around 260 metres west of White Bay. Glebe Island is a strategic deep-water port actively used for deep-water wharfage, including bulk vessel and unloading.

White Bay is classified as W1 Maritime Waters in the Sydney Regional Environmental Plan (Sydney Harbour Catchment) (NSW Government 2005). White Bay is mapped as Key Fish Habitat and is an estuarine environment.

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 could potentially drain via an existing or new connection to White Bay.

4.1.9 Alexandra Canal

The Alexandra Canal catchment (including Sheas Creek) has an area of around 23 square kilometres and takes in 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.

Alexandra Canal is a constructed canal, originally a natural watercourse named Sheas Creek. It flows into the Cooks River near the north-western corner of Sydney Airport. Dredging and canalisation of Sheas Creek started in the 1880s to make the creek navigable in order to attract industries to the area. By 1896 the creek was excavated by about three metres and spoil was used to fill banks by up to 1.8 m to reclaim the low lying wetland areas surrounding the creek. The canal was substantially complete by 1900. 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 area draining to it. Due to its size, in relation to its inflows as well as tidal action, the canal accumulates sediment. Dredging to remove sediment build up was regularly undertaken up to the 1950's. By that time, road and rail had made boat navigation in the canal superfluous for goods transportation. The last major works on the canal, including backfilling and dredging, were carried out in the 1970's when the north-south runway for Sydney Airport was built (DPWS 2004). The contaminated sediments within the canal have been declared a remediation site by the NSW EPA.

The proposed M4-M5 Link underground connection to the St Peters interchange and ventilation facility are located in the catchment of Alexandra Canal. The Campbell Road civil and tunnel site (C10) is located within the Alexandra Canal catchment. Alexandra Canal is a second order stream within the vicinity of St Peters interchange (**Annexure A**– Photo 7).

4.1.10 Eastern Channel

The Eastern Channel catchment includes the suburbs of Tempe, Sydenham, Enmore and Newtown and is around 776 hectares in area. The catchment is heavily urbanised and altered by a relatively even mix of commercial and residential property. The catchment has a very small proportion of open space in the form of recreational parklands.

The Eastern Channel runs along the Sydenham to Tempe railway line, discharging into the Cooks River. The channel conveys stormwater as a concrete-lined trapezoidal-shaped open channel. The main open section is around 2.3 kilometres in length from near Murray Street, Marrickville to its confluence with the Cooks River adjacent to Tempe Station. Part of the channel is tidal due to its connectivity with the Cooks River.

The proposed M4-M5 Link mainline tunnel runs through the Eastern Channel catchment. However, no surface works or discharges, surface operational facilities or surface carriageways are proposed within the catchment, and as such the project is not expected to impact the channel. No further assessment of the Eastern Channel in relation to surface water and flooding impacts has been undertaken.

4.2 Geomorphology

The urban waterways within the study area are all artificial, hard lined (e.g. concrete channel, piped channel, brick channel, underground concrete channel) stormwater channels, with the exception of Alexandra Canal which has an unlined base and hard lined banks. The characteristics of the watercourses in the study area are outlined in **section 4.1**. The geomorphic characteristics of the watercourses reflect their urban and anthropogenic nature. Sea walls have been constructed around Rozelle Bay and White Bay where development occurs up to the shoreline, with boat vessel moorings also occurring within the bays. The Iron Cove shoreline comprises a mixture of sea wall and vegetated zones with parkland and residential development occurring adjacent to the shoreline.

Given the characteristics of the majority of watercourses and subsequent lack of potential for lateral or vertical adjustment, further detailed assessment of potential geomorphological impacts on the urban waterways associated with the project is not considered necessary. This includes assessment of erosion and creek health impacts due to increased runoff volumes, frequency and flow rates associated with an increase in impervious area. Potential for scour and sediment loading at discharge points within the receiving bays has been considered in **sections 5.2.1** and **6.3**. The potential for an increase in discharge volume to increase the disturbance of contaminated sediments in Alexandra Canal is discussed in **section 6.3**. Potential impacts to Whites Creek as a result of the construction of the proposed bridge are discussed in **sections 5.2** and **5.3.2**.

4.2.1 Creek renewal/naturalisation works

Sydney Water is currently investigating potential opportunities for naturalisation within a section of Johnstons Creek and Whites Creek in Annandale. A concept design has been developed for the Whites Creek naturalisation project. Naturalisation at Whites Creek includes the replacement of deteriorating concrete banks and low flow channel with a combination of rocks, native plants and sandstone blocks or concrete. No concept design is currently available for Johnstons Creek.

The Sydney Water naturalisation works on Whites Creek would be located adjacent to Railway Parade and Hutchinson to the south of the Rozelle interchange, and are scheduled for construction in the 2017 financial year. The project would similarly incorporate channel naturalisation works extending from The Crescent back to Railway Parade, adopting a similar philosophy regarding surface treatments to integrate with Sydney Water's naturalisation works.

The potential works on Johnstons Creek proposed by Sydney Water extend from Rozelle Bay to 20 metres south of The Crescent. The construction schedule for the works on Johnstons Creek is currently not known.

4.3 Drainage

Due to the extensive urban nature of the study area, there is a dense network of stormwater drainage which conveys stormwater flows for the smaller storm events. This network manages stormwater flows predominantly from the roads and impervious areas of the catchments before discharging into the local waterways and canals. Dobroyd Canal, Hawthorne Canal, Easton Park drain, Whites Creek, Johnstons Creek and Alexandra Canal all receive inputs from the stormwater network. In larger storm events when the capacity of the existing drainage system is exceeded, runoff follows overland paths to these waterways and canals.

The 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 Rozelle Rail Yards is likely to be of relatively poor condition as a consequence of age and a lack of maintenance since the site ceased as an active rail facility in the late 1990s. The Easton Park drain is the only known discharge point from the northern section of the site. From the limited drainage information available, 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 by SMC personnel on site following rainfall has been 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 in the vicinity of the Rozelle Rail Yards, some of which connect into the Easton Park drain system. The catchment to the northwest of the proposed Rozelle interchange is connected to Whites Creek via a brick arch culvert which passes underneath the CBD and South East Light Rail site and the 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 300 millimetre to 450 millimetre diameter pipes.

To the south of the Darley Road site, an Inner West Council stormwater drainage system serves the road network. The drainage network on Darley Road is reported as 2.4 metre diameter pipes receiving surface water inputs from drainage to the east and to the south.

It is expected that the age or quality of some of these existing stormwater drainage assets is commensurate with the age of the buildings and houses in the area and 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 Inner West and City of Sydney councils.

There are numerous drainage networks to be crossed by the proposed road alignment. This is of particular relevance for those areas of the project footprint 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.

4.4 Hydrology and flooding

As discussed in **section 4.1**, the project footprint is located within a number of catchments including Dobroyd Canal, Hawthorne Canal, Whites Creek, Johnsons Creek and Alexandra Canal.

Land within the study area (see **section 1.4**) is predominantly of urbanised nature with small pockets of open space frequently located along some of the watercourses. Development within the study area is typically well established with a high proportion of residential and commercial land use.

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 flowpaths or in localised topographic depressions and encroaching into floodplains, reducing storage capacity

- Culverting and channelisation of watercourses increasing the speed of water travelling through the system
- Increases in the area of 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.

4.4.1 Existing flood behaviour

A summary of the existing flood conditions at the surface features during the operational phase of the M4-M5 Link project is presented in **Table 4-1**. 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 development. Flood risk associated with the construction ancillary facilities is discussed in **section 5.2**.

Wattle Street interchange

The Wattle Street interchange (M4 East project) is located in the catchment of Dobroyd Canal. Due to the interface of the M4-M5 Link project with the M4 East project and timing for completion of construction of these projects, the 'existing' flood conditions at the Wattle Street interchange has been taken to be represented by the post-construction situation for the M4 East project. This is because the existing flooding conditions at this location, which will incorporate flood mitigation measures that also afford protection to the M4-M5 Link project, will change post-development of the M4 East project.

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 flowpath have been implemented in the M4 East project design 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 will be diverted around the western tunnel portal towards Parramatta Road. The eastern end of the interchange is affected by flooding from Dobroyd Canal. 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 preceding construction of the M4 East project means that the risk of flooding to the M4-M5 Link project from a PMF is considered to be low. As the design surface layout or levels of the interchange will not change as a consequence of the M4-M5 Link project, the impact of the development 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 (New M5 project) is located in the catchment of Alexandra Canal. Due to the interface of the M4-M5 Link project with the New M5 project, and timing for completion of construction of this project, the 'existing' flood conditions at the St Peters interchange has been taken to be represented by the post-construction situation for the New M5 project. This is because the existing flooding conditions at this location will change post-development of 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 is generally located above 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 construction site within the St Peters interchange, including provision of flood mitigation measures. For the St Peters interchange the mitigation measures provided by the preceding construction of the New M5 project means that the risk of flooding to the M4-M5 Link project from a PMF is considered to be low. Therefore, the impact of the project on flood risk is considered to be negligible and no additional mitigation measures are necessary for the M4-M5 Link at this location. Therefore a quantitative assessment of impacts at this location is not required.

Rozelle interchange

The Rozelle interchange is 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 around two metres AHD (Australian Height Datum) to seven metres 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 (see **Annexure A** – Photo 8). Sub-catchments draining to Rozelle civil and tunnel site are shown in **Figure 4-2**.

Two watercourses are located within this section of the study area:

- Easton Park drain
- 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 a distance of around 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 in water level in 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 approximately 1.9 kilometre 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 in Annandale. Downstream near the Rozelle interchange, Whites Creek is a brick and concrete lined open channel approximately nine metres wide which is spanned by a number of road and rail crossings in proximity to the Rozelle Rail Yards. The creek discharges into Rozelle Bay immediately east of The Crescent and is also tidally influenced.

The flood study undertaken by Leichhardt Council (Cardno 2014) suggests that the existing drainage system surcharges in the five year ARI storm event and that overland flooding occurs along the line of Whites Creek as well as the connecting ‘tributaries’.

Although the existence of a direct surface water connection between the Rozelle Rail Yards and Whites Creek has not been established, there are potential indirect surface pathways. This includes the adjacent CBD and South East Light Rail Rozelle maintenance depot to the west of the Rozelle Rail Yards, which includes the Inner West Light Rail line. The CBD and South East Light Rail line passes underneath City West Link roadway and may present a pathway for surface water to exchange between the Rozelle Rail Yards area and a drain that discharges into Whites Creek. Another pathway relates to 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 a harbour embayment located approximately 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* (Cardno 2014), commissioned by the former Leichhardt Council, suggests that a significant area of the Rozelle Rail Yards 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. Flooding along Whites Creek is fairly confined to the main channel, but there are breakout areas mainly along the right 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 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 2013 (DCP 2013 Part E, Leichhardt Municipal Council). As the site is below the FPL and located in 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.

The results of the flood modelling of existing conditions shows that the Rozelle Rail Yards 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 **Annexure C**.

As the Rozelle Rail Yards 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 existing 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 flood flow or a significant increase in flood levels.

The Rozelle Rail Yards has minimal known formal flow conveyance other than through the Easton Park drain. The main surface outlet from the site is at a low point on City West Link, where excess floodwater spills over the road and discharges into Rozelle Bay. However, the overtopping of City West Link currently only 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 4-4, Figure 4-5** and **Figure 4-6**. The figures highlight the Rozelle Rail Yards currently providing a large area of surface water storage during these events. Modelled flood depths for the 10 and 100 year ARI design events are generally less than one metre across the site. 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 majority of the site, and typically less than 0.2 metres per second (see **Figure 4-7**). Zones of faster moving floodwaters up to approximately 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 4-8** 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 Yard is generally a low flood hazard area, with the exception of a small area near Victoria Road.

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

Iron Cove Link

The proposed Iron Cove Link is located on Victoria Road within the catchment of Iron Cove. The area slopes from the southeast (around 24 metres AHD) to the northwest (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 interchange. Sub-catchments draining to the Iron Cove Link civil site are shown in **Figure 4-9**.

The existing flood conditions for the 10 and 100 year ARI design events and PMF are shown in **Figure 4-10, Figure 4-11** and **Figure 4-12**. Maximum water depths of less than 0.25 metres are found on Victoria Road in the area of 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 **(Figure 4-13**). 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 4-14**. 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 (2014). 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 (see **Annexure A** – Photo 9).

Darley Road

The Darley Road civil and tunnel site (C4), where the operational water treatment plant (WTP) for the M4-M5 Link may be located, is situated south of City West Link in the catchment of Hawthorne Canal. The site is situated in an area covered by two flood studies, the *Hawthorne Canal Flood Study* (WMAwater 2013) commissioned by Ashfield and Marrickville councils (now Inner West Council), and the *Leichhardt Flood Study*. The site slopes east to west with ground levels dropping from around 12 to four metres AHD. The eastern side of the Darley Road site sits higher than the CBD and Inner West Light Rail line to the north, with levels dropping by approximately eight metres in its western extent and sitting lower than the rail line. Sub-catchments draining to Darley Road civil and tunnel site are shown in **Figure 4-15**.

The existing flood conditions for the 10 and 100 year ARI design events and PMF are shown in **Figure 4-16** and **Figure 4-17**. The *Hawthorne Canal Flood Study* shows that the Darley Road site is located on the fringe of the 100 year ARI flood extent. However, the majority 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 north east section of the site is subject to flooding as a consequence of water spilling onto the site from the Light Rail Station 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 around 0.8 metres for the PMF event (see **Figure 4-18**).

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 (see **Figure 4-19**).

Flood hazards in the vicinity of the site are generally low, but medium to high hazards are estimated along the north-eastern boundary with the light rail line (see **Figure 4-20**).

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 building development means that all runoff is channelled along Bignell Lane. Water ponds at the low point on Bignell Lane, where 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 in the 100 year ARI event and up to one metre at the low point on Bignell Lane. Given the small catchment size, the relatively high flood depths are a result of the confined overland flowpath.

During construction, the existing buildings on the site will be demolished and replaced with facilities of a smaller footprint, which would allow for less concentrated overland flows paths 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, 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.

Table 4-1 M4-M5 Link operational surface features and existing flood risk

Project surface feature	Catchment(s)	Existing flood risk assessment	Existing flood risk review	Further assessment required
Wattle Street interchange	Dobroyd Canal	M4 East EIS (Roads and Maritime 2015a) M4 East Final Design (CSJ 2016a, b)	· M4-M5 Link portals and cut and cover sections of the tunnel have been constructed as part of the M4 East project · M4 East project 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 M4-M5 Link project will not change the M4 East design surface layout or levels; therefore, it is considered that the: - Risk of flooding to the M4-M5 Link tunnel structure in a PMF event is low - M4-M5 Link project will not have an impact on flood risk to surrounding properties at this location · Therefore, no further mitigation measures are considered to be required beyond that provided by the M4 East project.	No
Rozelle interchange	Easton Park drain, Rozelle Bay, Whites Creek	Leichhardt Flood Study (Cardno 2014a)	· The Rozelle Rail Yards is subject to extensive flooding in the 5 year ARI event · Limited information available from the Leichhardt study on flood depths at the Rozelle Rail Yards and the potential risk to 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 interchange motorway operations complexes (MOC2 and MOC3) and tunnel ventilation facility are located at the Rozelle Rail Yards.	Yes
Iron Cove Link	Iron Cove	Leichhardt Flood Study (Cardno 2014a)	· An overland flowpath is present on Victoria Road for the 5 year ARI event · Floodwater depths of up to 0.3 metres for the PMF and peak flow velocities between 2-3 metres per second for PMF	Yes

Project surface feature	Catchment(s)	Existing flood risk assessment	Existing flood risk review	Further assessment required
			· 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.	
St Peters interchange	Alexandra Canal	M5 EIS (Roads and Maritime 2015b) New M5, Substantial Detailed Design report, Rev D, (CDS 2016a)	· The tunnel stubs for the M4-M5 Link and New M5 project have been 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 M4-M5 Link portals would be at low risk of flooding as they are protected from the PMF by the measures provided by the New M5 project · The New M5 tunnel ventilation facility (St Peters ventilation facility) has been designed to be above the PMF event · The M4-M5 Link tunnel ventilation facility (Campbell Road motorway operations complex (MOC5)) is proposed to be located above the tunnel portal and would therefore also be flood protected up to the PMF event · The M4-M5 Link project would not change surface levels or layout outside of the perimeter flood bund and therefore will not have a detrimental impact on flood risk to surrounding properties at this location · No further mitigation is required in addition to that provided as part of the New M5 project at this location.	No
Darley Road	Hawthorne Canal	Hawthorne Canal Flood Study (WMAwater 2013), 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 at this location.	Yes

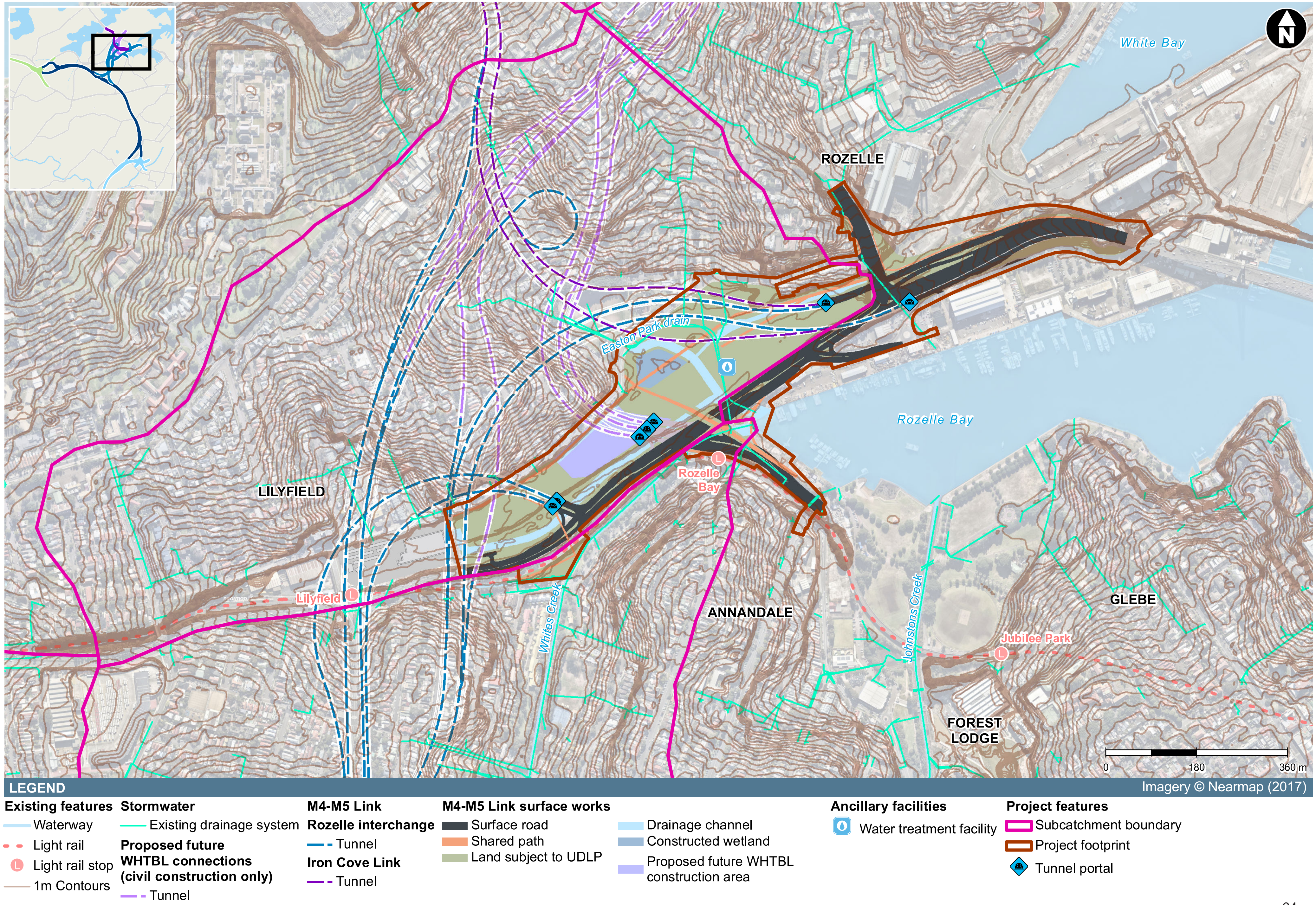


Figure 4-3 Subcatchment draining to Rozelle civil and tunnel site

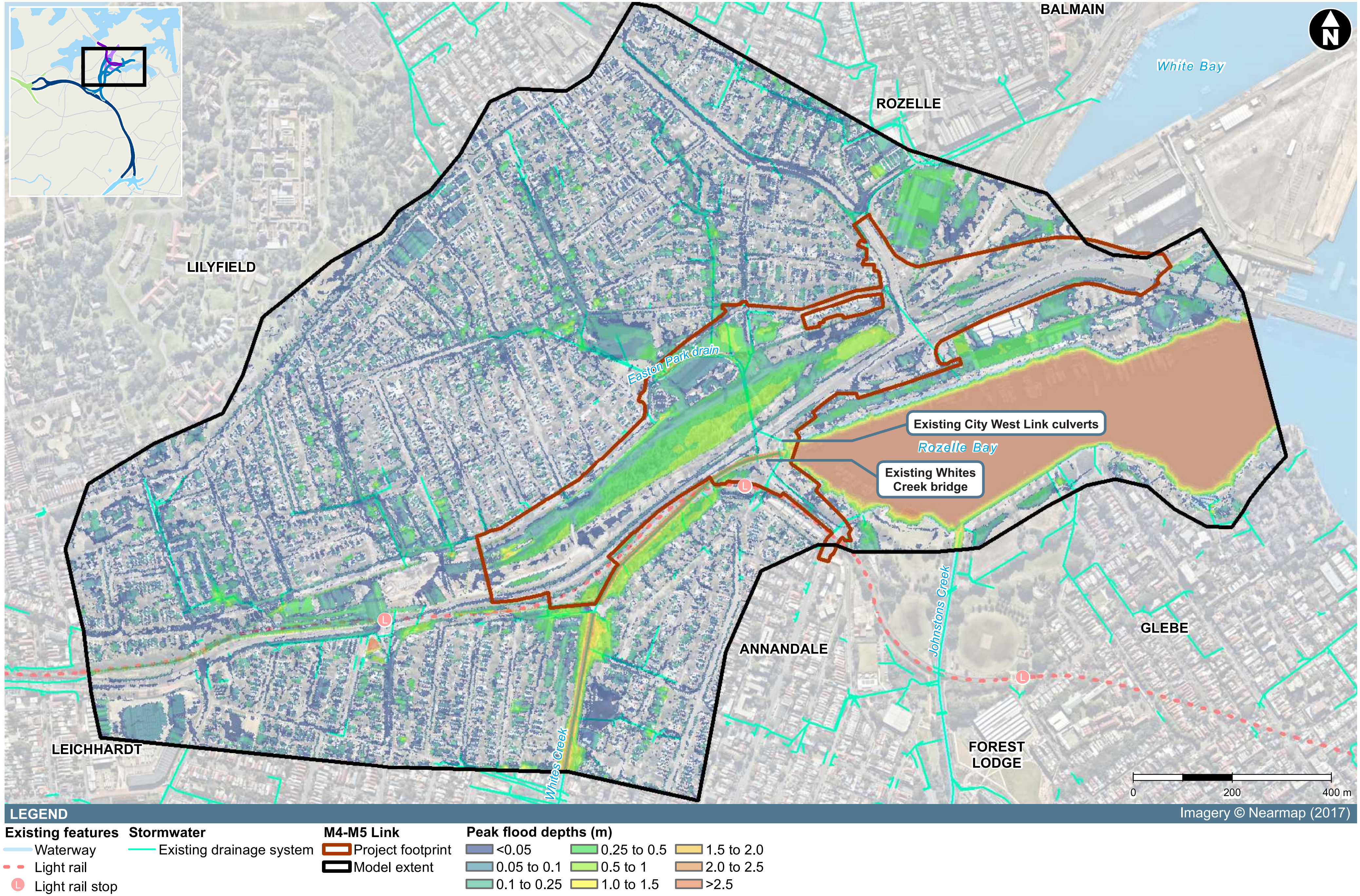


Figure 4-4 Present day flood behaviour – Rozelle interchange - peak flood depths (10 year ARI)

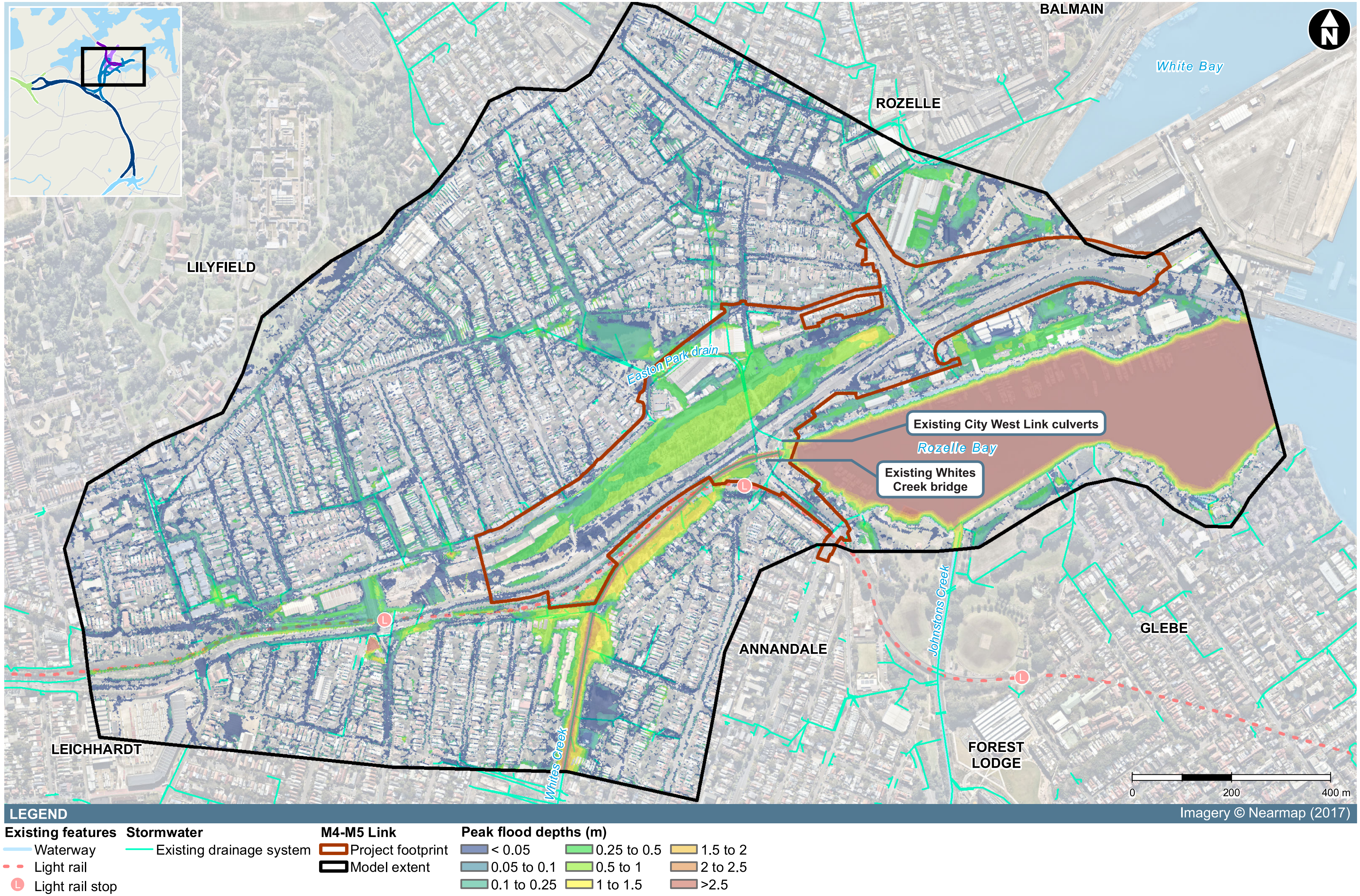


Figure 4-5 Present day flood behaviour – Rozelle interchange - peak flood depths (100 year ARI)

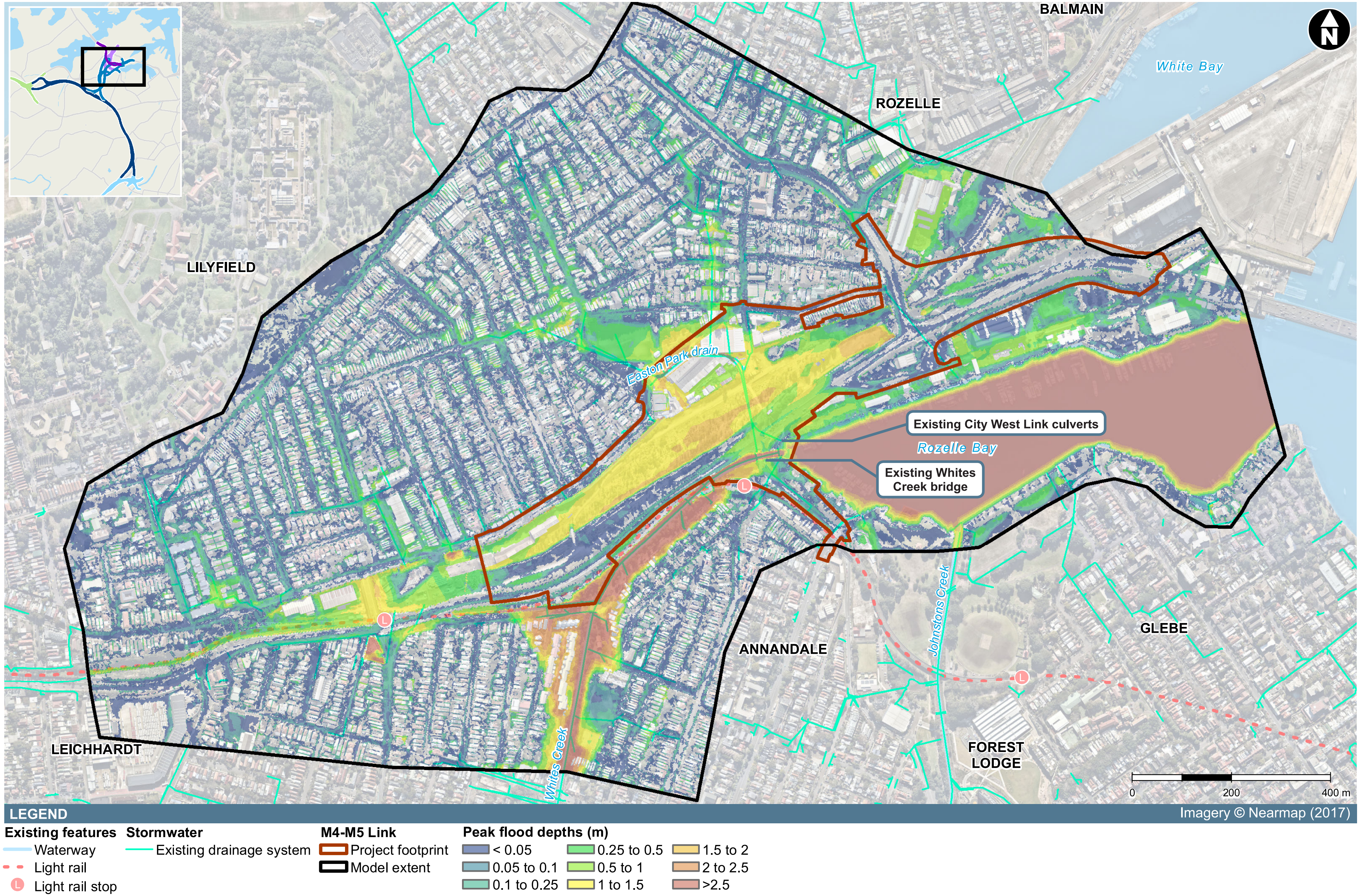


Figure 4-6 Present day flood behaviour – Rozelle interchange - peak flood depths (PMF)

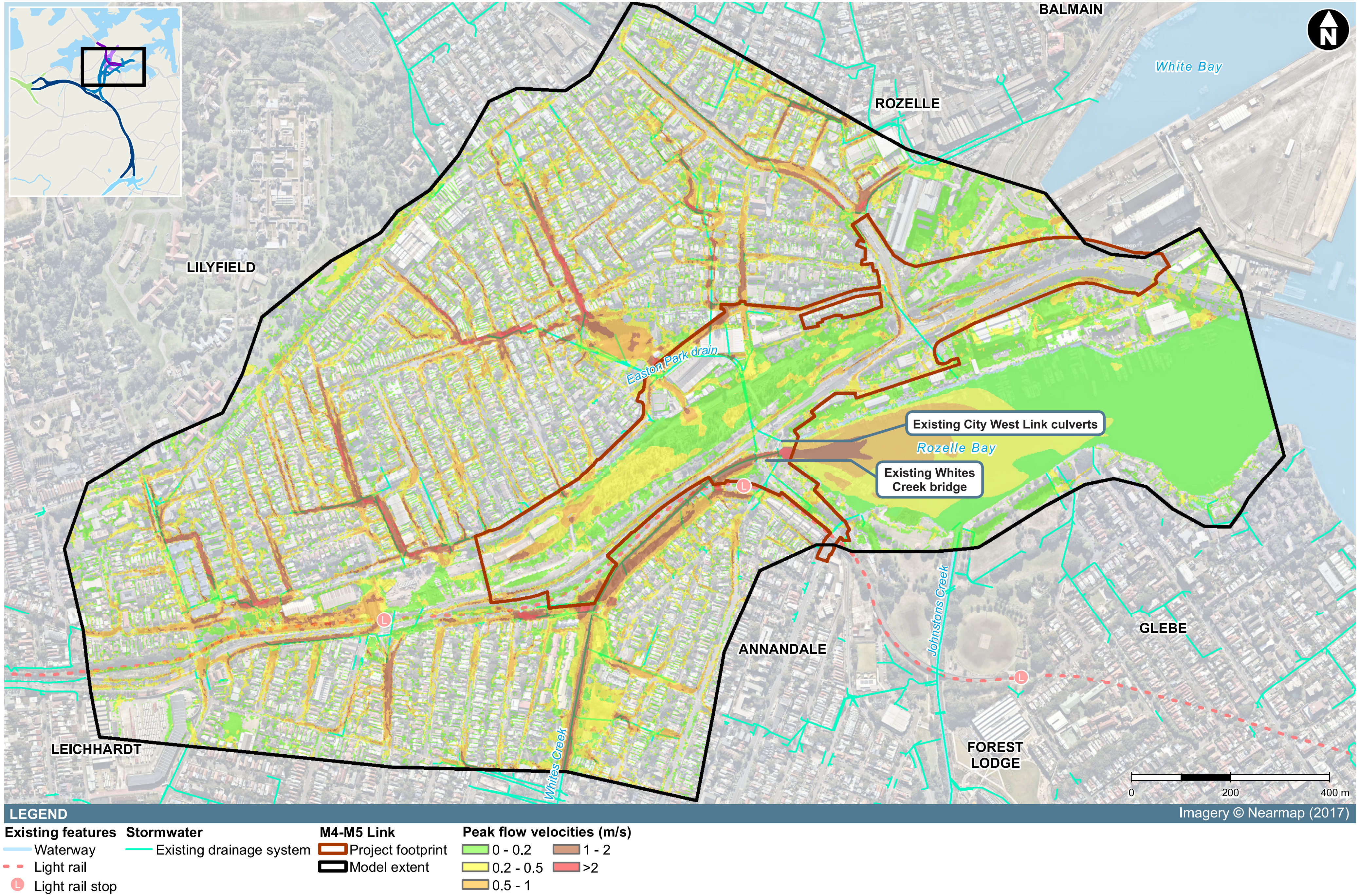


Figure 4-7 Present day flood behaviour – Rozelle interchange - peak flow velocities (100 year ARI)

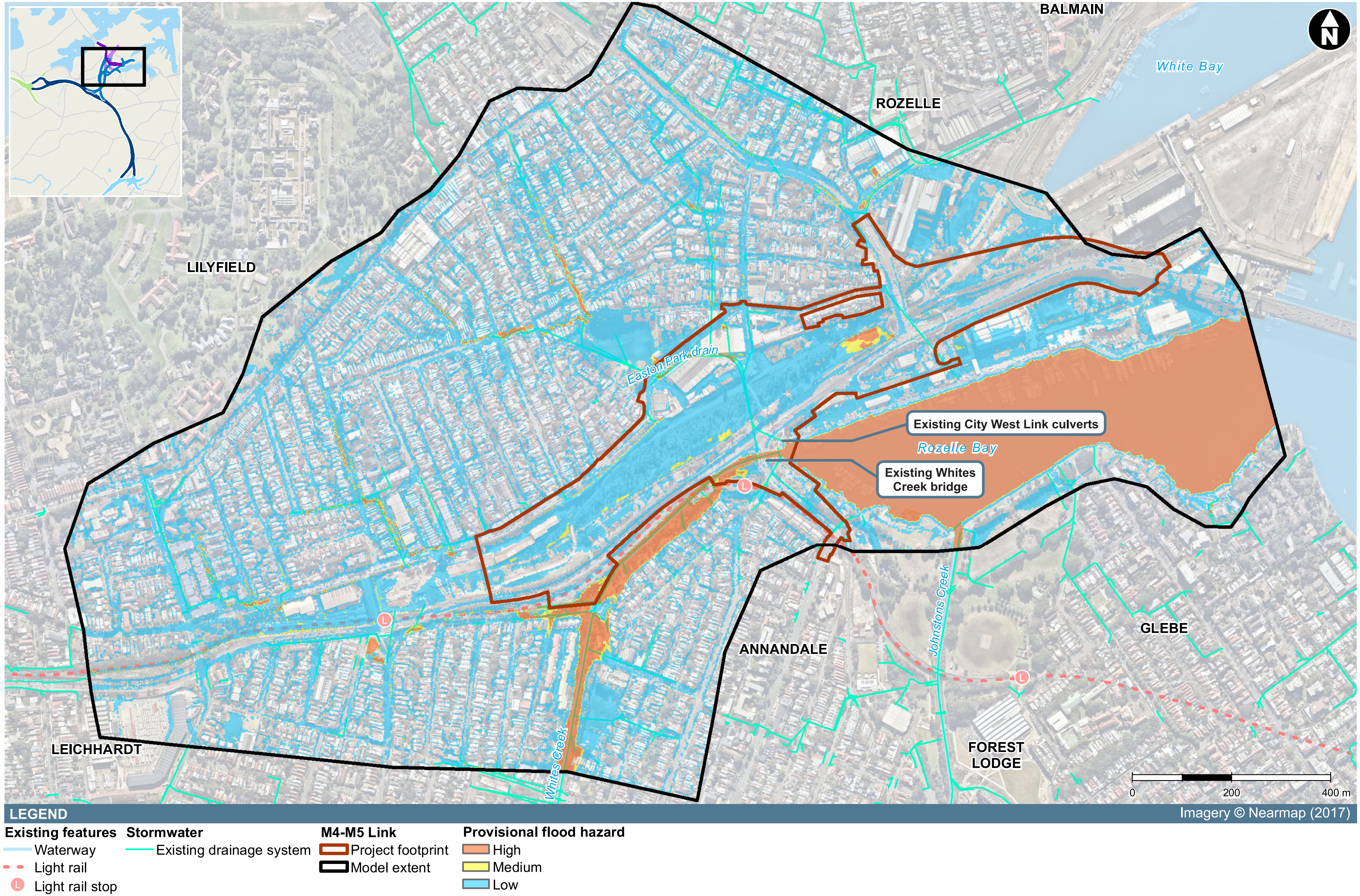


Figure 4-8 Present day flood behaviour – Rozelle interchange - provisional flood hazard (100 year ARI)

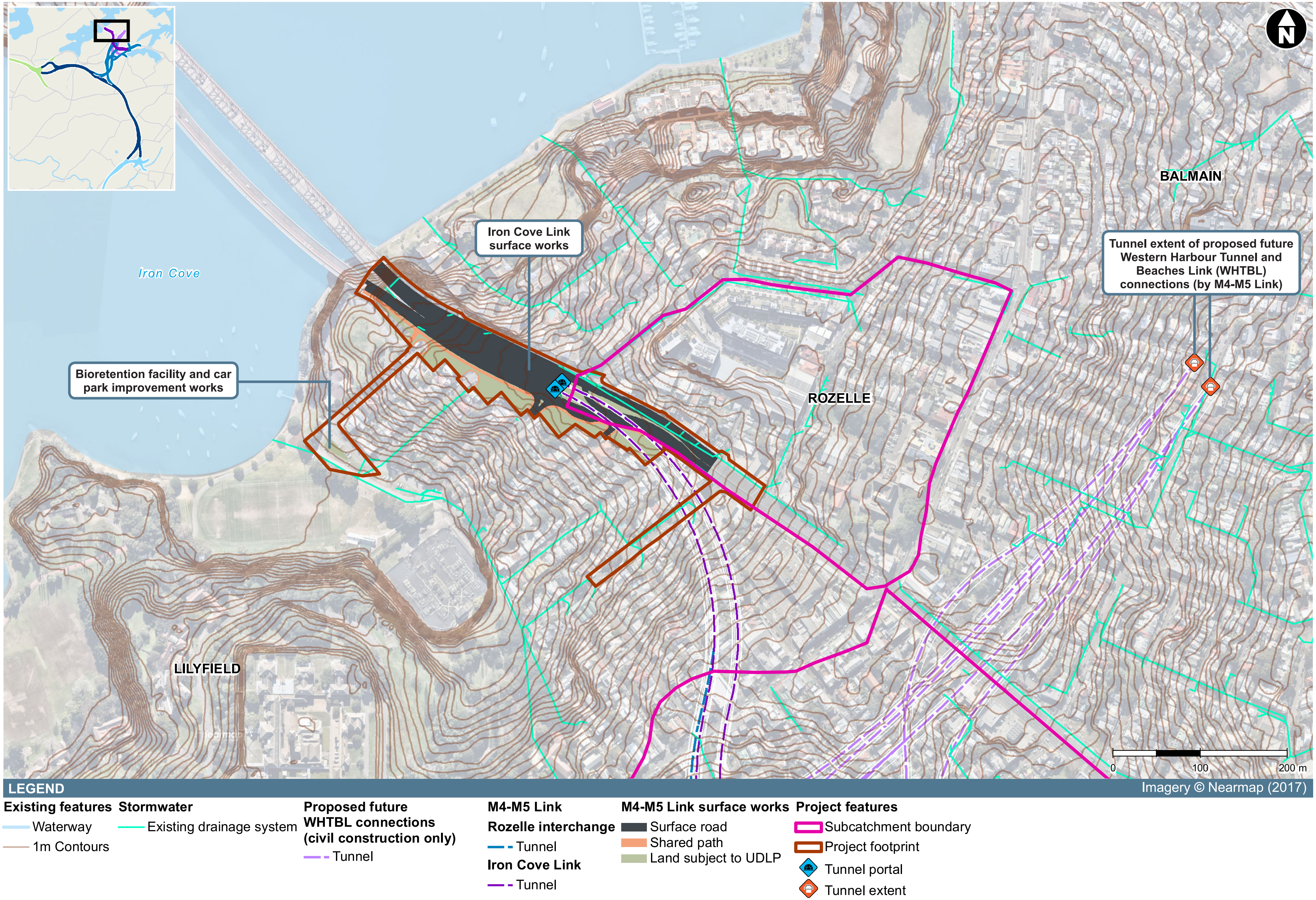


Figure 4-9 Subcatchment draining to Iron Cove Link civil site

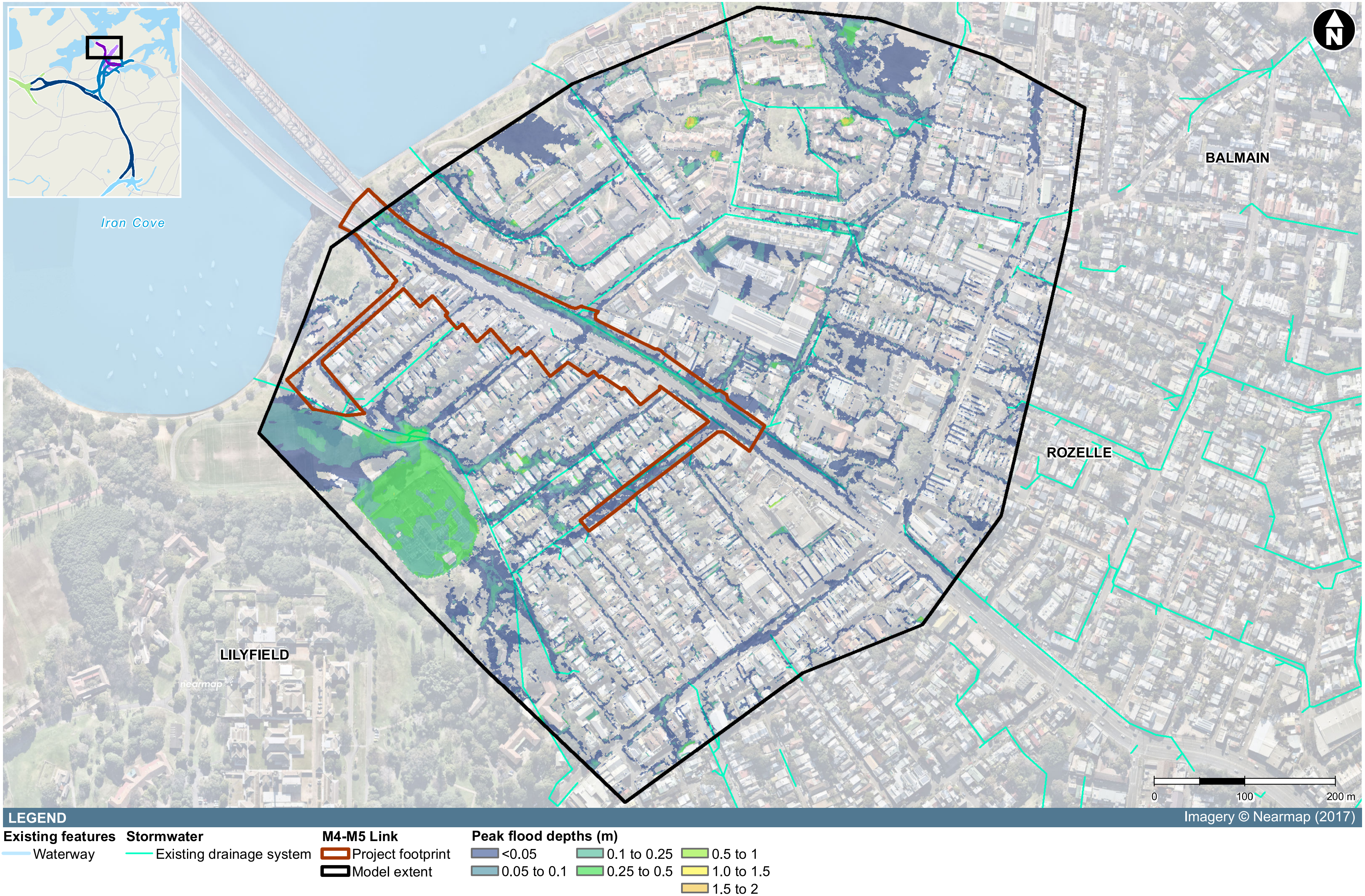


Figure 4-10 Present day flood behaviour – Iron Cove Link - peak flood depths (10 year ARI)

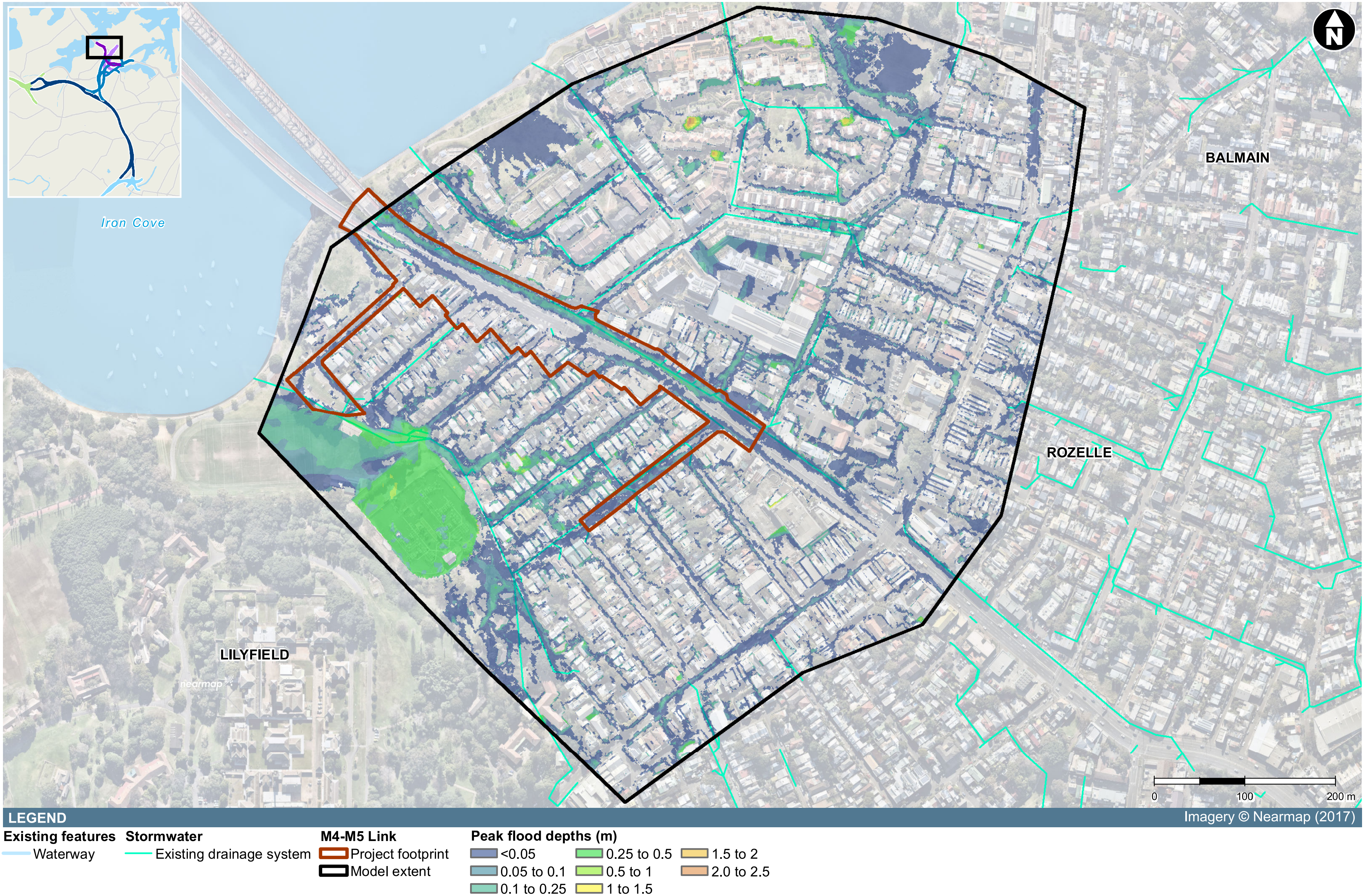


Figure 4-11 Present day flood behaviour – Iron Cove Link - peak flood depths (100 year ARI)

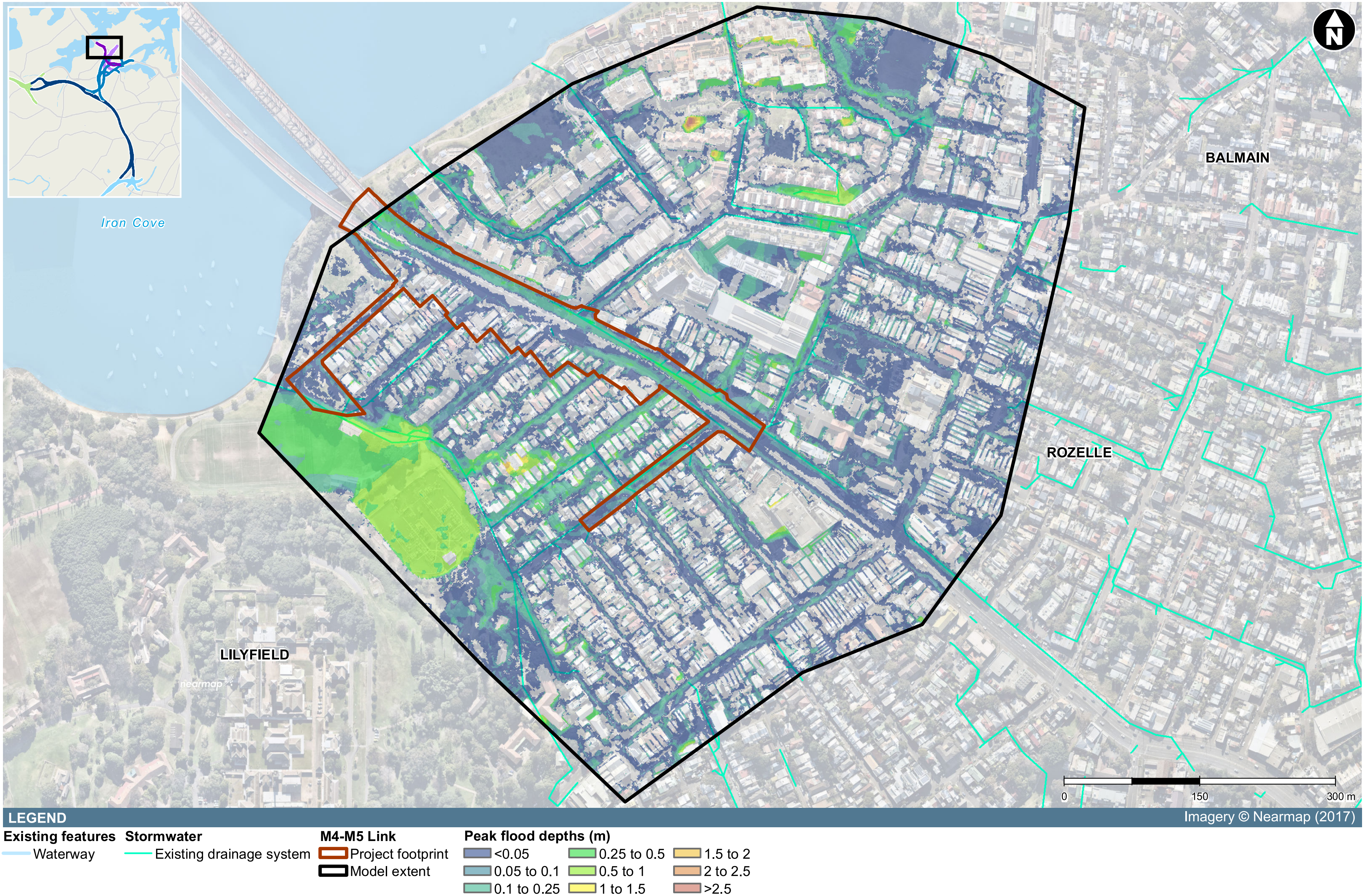


Figure 4-12 Present day flood behaviour – Iron Cove Link - peak flood depths (PMF)

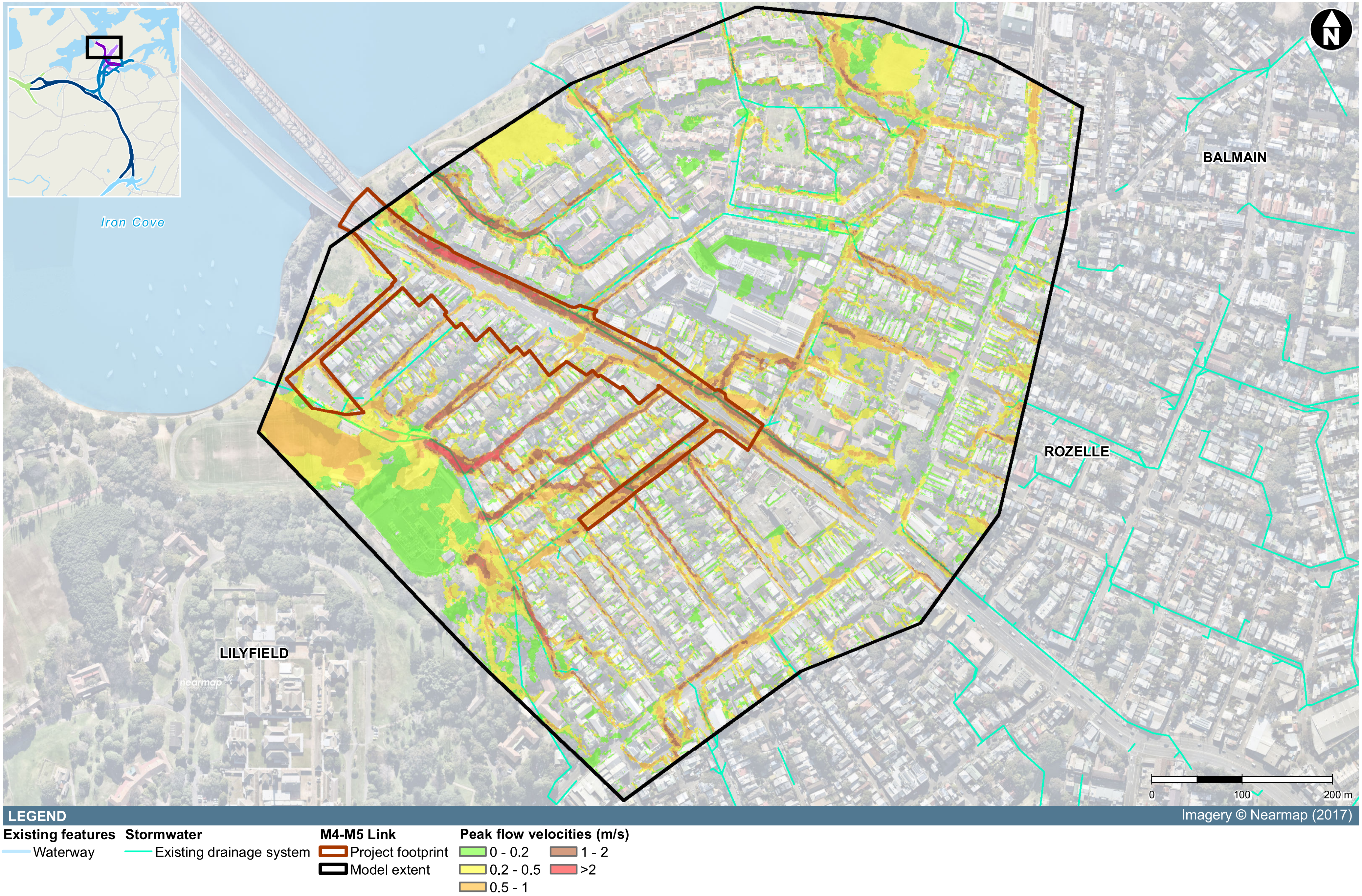


Figure 4-13 Present day flood behaviour – Iron Cove Link - peak flow velocities (100 year ARI)

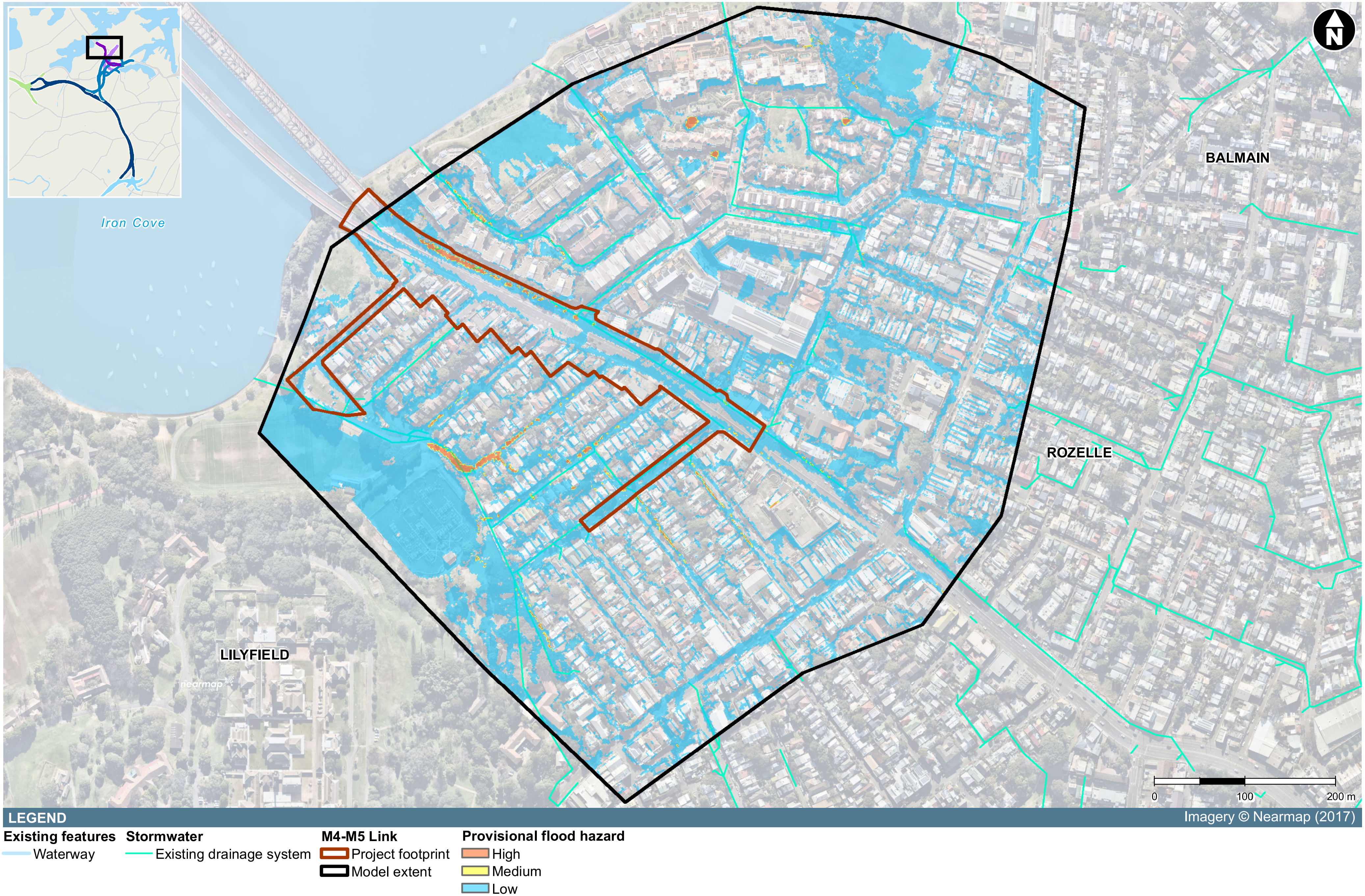
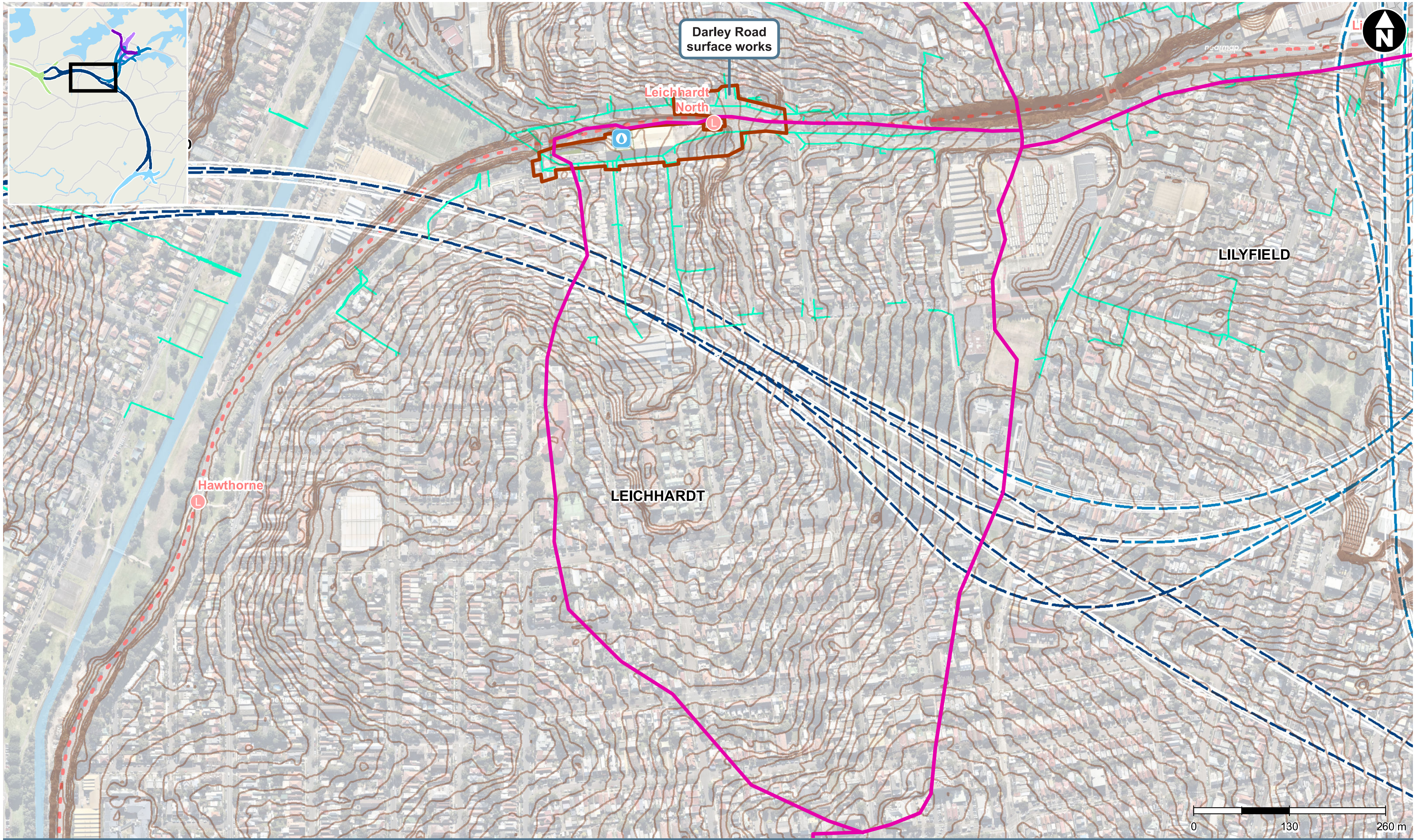


Figure 4-14 Present day flood behaviour – Iron Cove Link - provisional flood hazard (100 year ARI)



LEGEND

Imagery © Nearmap (2017)

Existing features
- Waterway
- Light rail
- Light rail stop
- 1m Contours

Stormwater
- Existing drainage system

M4-M5 Link

Mainline tunnel
- Tunnel

Rozelle interchange
- Tunnel

M4-M5 Link surface works
- Land subject to UDLP

Ancillary facilities
- Water treatment facility

Project features
- Subcatchment boundary
- Project footprint

Figure 4-15 Subcatchment draining to Darley Road civil and tunnel site

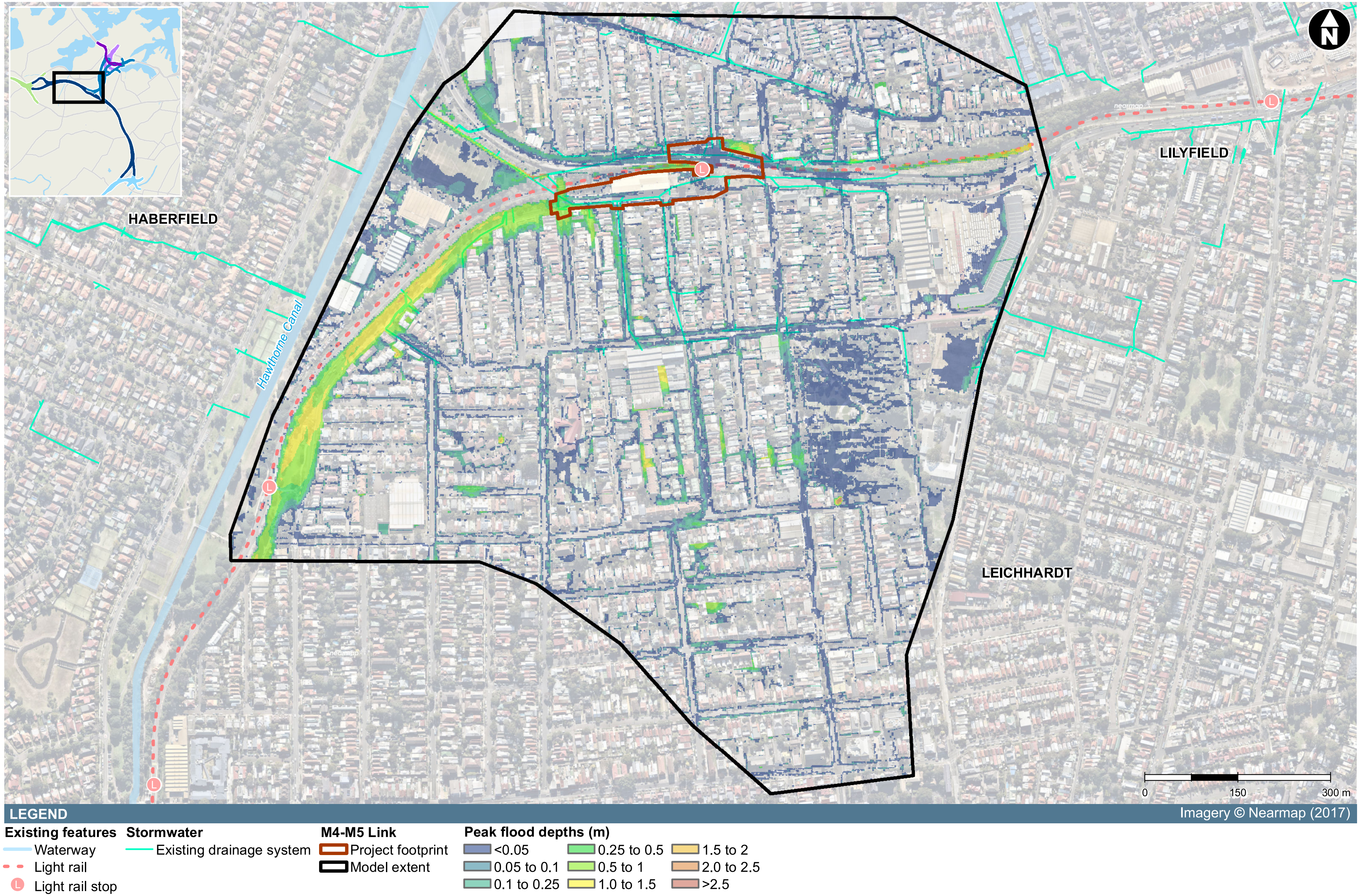


Figure 4-16 Present day flood behaviour – Darley Road - 10 year ARI maximum depths

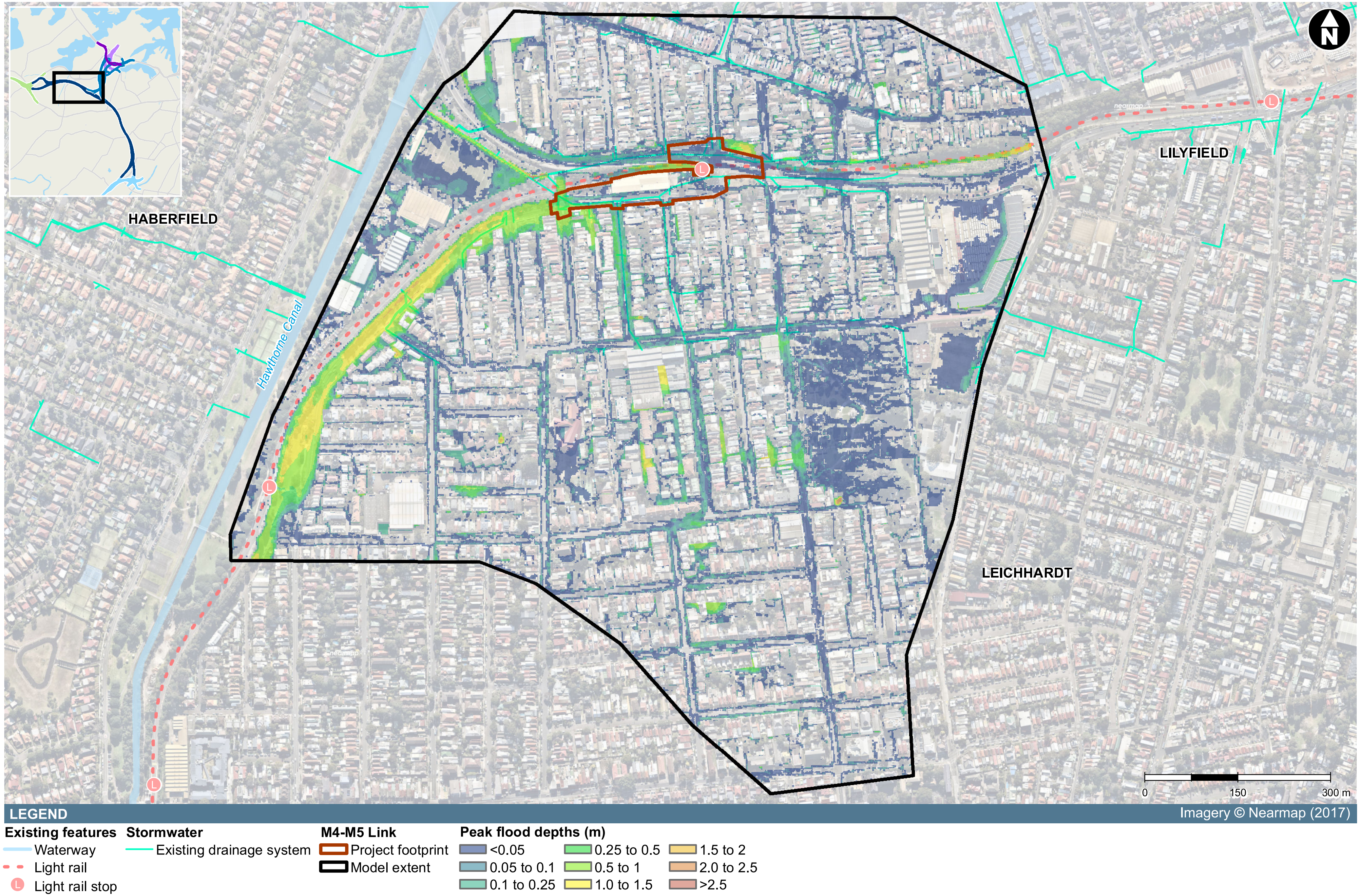


Figure 4-17 Present day flood behaviour – Darley Road - 100 year ARI maximum depths

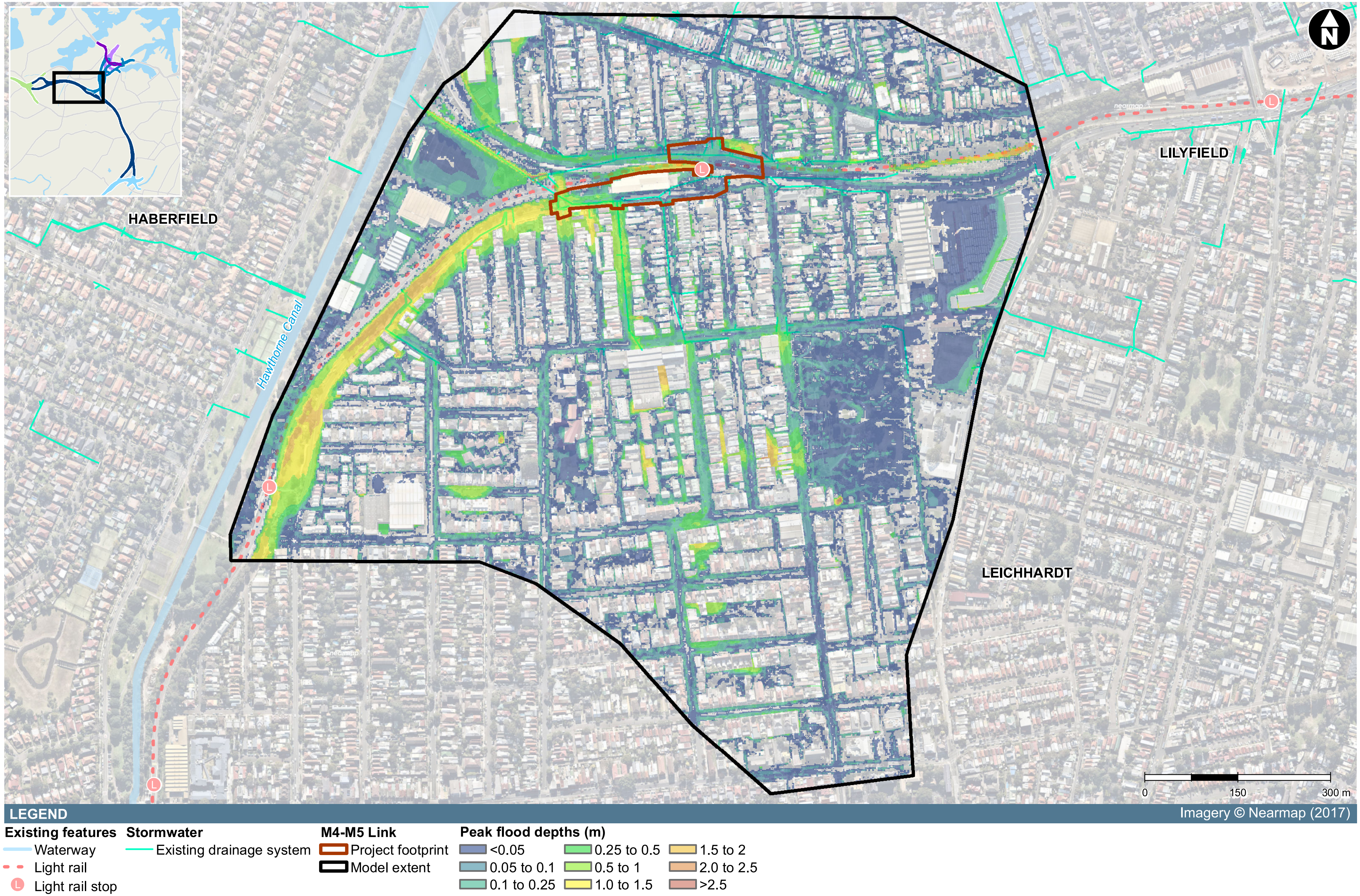


Figure 4-18 Present day flood behaviour – Darley Road - peak flood depths (PMF)

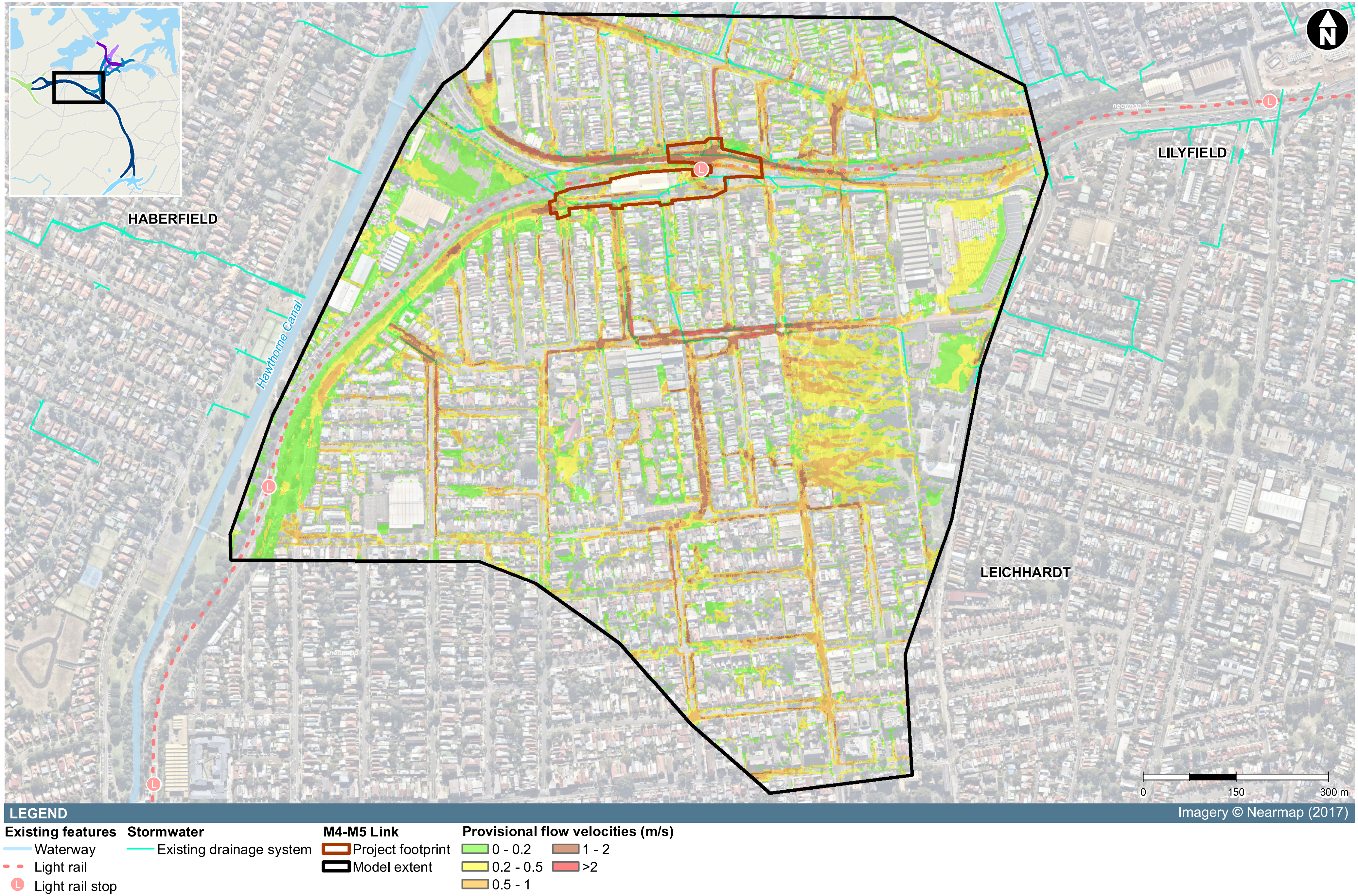


Figure 4-19 Present day flood behaviour – Darley Road - peak flow velocities (100 year ARI)

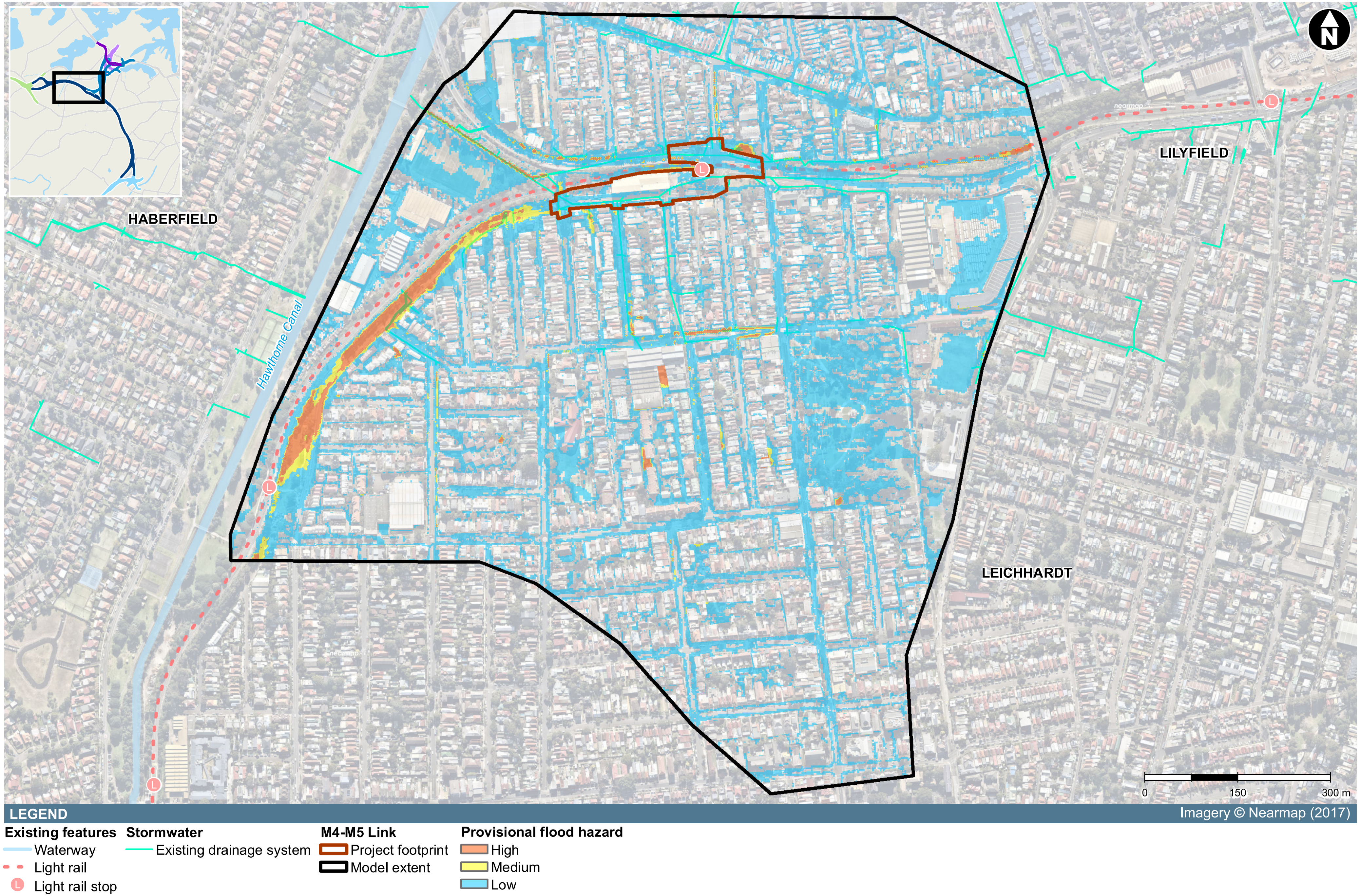


Figure 4-20 Present day flood behaviour – Darley Road - provisional flood hazard (100 year ARI)

4.5 Surface water quality

Surface water quality within the receiving urban waterways and bays are currently affected by a range of point and diffuse sources of pollutants which has led to contamination of sediments. Key existing water quality issues include:

- Primary contemporary sources of pollution to the waters and sediments of Sydney Harbour are stormwater, sewage overflows and leachate from contaminated reclaimed land (Montoya 2015)
- The urbanisation of the catchments and subsequent reduction in pervious area reduces the likelihood of pollutants and sediments, transported in stormwater runoff to settle or deposit out before entry into the estuary or contributing waterways
- The artificial channelisation and hard (typically concrete) lining of waterways mitigates against erosive processes in the channels, reducing the ability for sediments to be deposited from upstream catchments prior to discharge to the estuary
- Stormwater discharged via large canals with extensive catchments is a major point source of contaminants to Parramatta River estuary and Sydney Harbour (Birch and Taylor 1999)
- Stormwater discharged from highly urbanised catchments on the southern shore of the Parramatta River estuary and Sydney Harbour has been identified as the primary source of contaminants responsible for ecological degradation and reduction in recreational value of these waters (Beck and Birch 2010)
- A study conducted by Beck and Birch (2010) in Johnstons Creek, Whites Creek and Hawthorne Canal found that the majority (>90 per cent) of metal (copper, lead and zinc) and total suspended solid annual loads were contributed during high flow conditions (>50 mm rainfall day), whereas ≤55 per cent of total nitrogen and ≤21 per cent of total phosphorus were contributed to annual loading by dry weather base flow conditions by the three catchments
- Contaminants associated with illegal dumping or sewage overflows may also be important in contamination of Parramatta River estuary and Sydney Harbour (Beck and Birch 2010)
- Harbour sediments contain a variety of contaminants including dioxins, heavy metals and organochlorine pesticides with Iron Cove, Rozelle Bay and Blackwattle Bay some of the worst affected
- The NSW EPA declared the bed sediments of Alexandra Canal between Huntley Street, Alexandria and the junction of Alexandra Canal with the Cooks River at Mascot as a remediation site in August 2000 under Section 23 of the *Contaminated Land Management Act 1997* (NSW). The bed sediments have been found to be contaminated with chlorinated hydrocarbons including organochlorine pesticides, polychlorinated biphenyls and metals. Contamination levels are considered by the NSW EPA to present a significant risk of harm to human health and the environment
- Nutrients and heavy metals supplied by stormwater canals draining highly urbanised catchments have accumulated in bottom sediments in concentrations up to 50 times greater than pre-anthropogenic levels (Birch and Taylor 1999). Estuarine sediments adjacent to these canals contain the highest concentrations of heavy metals. Atmospheric contributions may also be an important diffuse source of heavy metals to the estuary but sewage overflows and stormwater drains with small catchments are not considered to be important point sources of heavy metals (Birch and Taylor, 1999)
- Typically, the Parramatta River estuary is well-mixed and contaminants associated with base-flow stormwater runoff deposit close to discharge points becoming permanently trapped in estuary embayments. Catchment runoff increases rapidly during high precipitation events (rainfall >50 millimetres per day) and upon reaching the waterbody forms a buoyant layer above saline estuarine waters. Under these conditions, contaminants associated with stormwater runoff may migrate beyond off-channel embayments and depending on the intensity of the storm, the plume may reach the main estuary channel even exiting the Parramatta River estuary mouth into Sydney Harbour (Lee, Birch and Lemckert 2010). A study conducted in the Parramatta River estuary on freshwater plume behaviour following high-precipitation events (Lee, Birch and Lemckert 2010) found that the fresh-water plume broke down within the estuary, therefore

contaminants associated with stormwater runoff due to high-precipitation events were retained within the system for a longer period than was previously recognised

- Elevated levels of heavy metals, pH, turbidity and nutrients were frequently recorded during water quality sampling conducted in the waterways within the study area. The monitoring results were representative of waterways within a highly urbanised catchment.

It is noted that disturbance of contaminated sediments can cause impacts on surface water quality.

A baseline surface water monitoring program was undertaken as part of the M4-M5 Link project to:

- Evaluate the existing surface water quality at predetermined locations located within the vicinity of the project
- Inform the EIS
- Monitor and assess the surface water quality over a 12 month monitoring program and form a baseline of environmental conditions against which compliance can be measured during the construction and operation of the project.

The monitoring program includes a minimum of 12 months of baseline monitoring conducted at tidal and non-tidal locations with samples collected up to twice monthly including one monthly dry weather sampling event in the same week of each month and one wet weather sampling event following rainfall events (> 15 millimetres over a 24 hour period) when they occur.

A review of available M4-M5 Link project water quality monitoring data and other known water quality monitoring data carried out by others was undertaken to establish water quality conditions within the waterways in the study area. A summary of the results is presented in **Annexure B**. The monitoring results were compared with relevant ANZECC (2000) guideline trigger values (ie estuarine / marine trigger values). Existing water quality conditions within the key receiving waterways and bays potentially affected by the project are discussed in the following sections. The monitoring locations are shown in **Figure 4-21**.

4.5.1 Dobroyd Canal

A review of known water quality data was undertaken to gain an appreciation of water quality conditions within the canal including:

- Samples collected by AECOM at two tidally influenced locations (SW8 and SW9), the pedestrian bridge at Reg Coady Reserve and west of Ramsey Street bridge between July 2016 and May 2017, as part of the M4-M5 Link baseline surface water sampling
- Samples collected by GHD at one non-tidal (DB01) location from a footbridge connecting Gregory and Hedge Avenues and one tidally influenced (DB02) location from a footbridge connecting Timbrell Park and Reg Coady Reserve between June 2015 and May 2016, as part of the M4 East project.

Elevated levels of heavy metals (copper, chromium, lead, nickel and zinc) and nutrients (phosphorus, nitrogen and nitrate) were recorded in tidal and non-tidal zones. The pH was also outside guideline levels and the turbidity exceeded guideline levels on some occasions. High electrical conductivity indicated brackish conditions on occasion in the assumed non-tidal sampling location, indicating this location may be tidally influenced. Total recoverable hydrocarbons were also detected.

4.5.2 Hawthorne Canal

A review of known water quality data was undertaken to gain an appreciation of water quality conditions within the canal including:

- Samples collected by AECOM at two tidally influenced locations in Hawthorne Canal (SW5 and SW6) at Hawthorne Canal Reserve kiosk (tidal) and its discharge point to Iron Cove (tidal) between July 2016 and May 2017, as part of the M4-M5 Link baseline surface water sampling
- Samples collected by GHD at a tidally influenced location (DSW) from a footbridge connecting Hawthorne Parade and Lords Road between June 2015 and May 2016, as part of the M4 East project.

Elevated levels of heavy metals (chromium, copper, lead and zinc) and nutrients (phosphorus, nitrogen and nitrate) were recorded. On some occasions the pH was also outside guideline levels and the turbidity exceeded guideline levels.

4.5.3 Whites Creek

A review of known water quality data was undertaken to gain an appreciation of water quality conditions within Whites Creek including samples collected by AECOM at a tidally influenced location in Whites Creek (SW2) at Whites Creek Valley Park between July 2016 and May 2017, as part of the M4-M5 Link baseline surface water sampling, and samples collected by Sydney University on behalf of UrbanGrowth NSW within a tidally influenced location (SW2) as part of The Bays project between June and September 2016.

Elevated levels of heavy metals (chromium, copper, lead and zinc), phosphorus, nitrogen, nitrate, oxides of nitrogen and were recorded. On some occasions the pH was also outside guideline levels and the turbidity exceeded guideline levels.

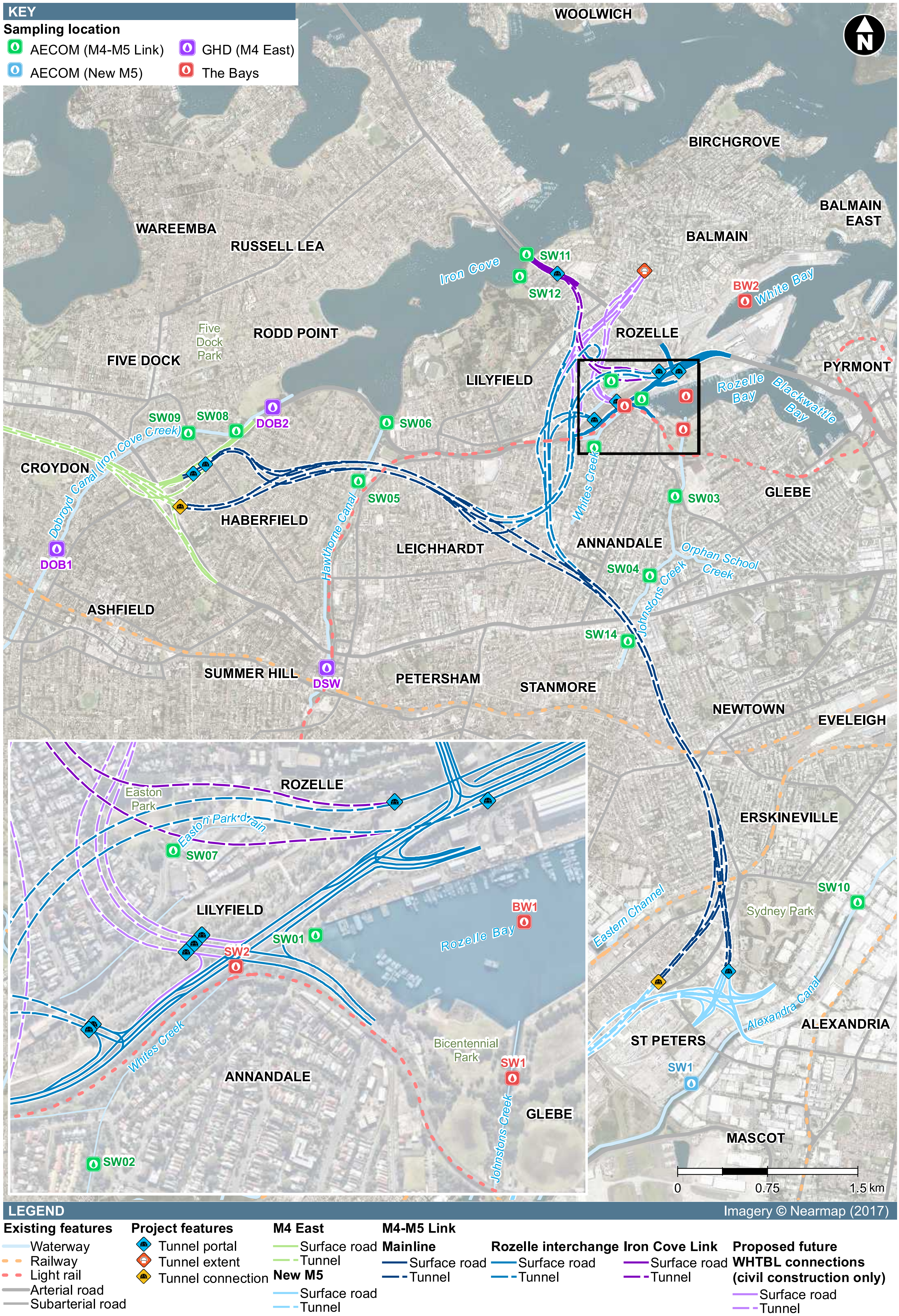


Figure 4-21 Locations of water quality data

4.5.4 Easton Park drain

A review of known water quality data was undertaken to gain an appreciation of water quality conditions within Johnstons Creek including samples collected by AECOM at a tidally influenced location (SW7) at Lilyfield Road opposite Easton Park during July 2016 and May 2017, as part of the M4-M5 Link baseline surface water sampling.

Elevated levels metals (copper, lead, and zinc) and nutrients (nitrogen, phosphorus and nitrate) were recorded. On some occasions the pH was also outside guideline levels and the turbidity exceeded guideline levels.

4.5.5 Johnstons Creek

A review of known water quality data was undertaken to gain an appreciation of water quality conditions within Johnstons Creek, including samples collected by AECOM at a tidally influenced (SW3) and two non-tidal locations (SW4 and SW14) at Smith Park pedestrian bridge, Chester Street and Cruikshank Street, Camperdown respectively between July 2016 and May 2017, as part of the M4-M5baseline surface water sampling, and samples collected by the University of Sydney on behalf of UrbanGrowth NSW within a tidally influenced location (SW1) as part of The Bays project between June and September 2016.

Elevated levels of heavy metals (cadmium, copper, chromium, lead, nickel and zinc), phosphorus, nitrogen and nitrate were recorded. On some occasions the pH was also outside guideline levels and the turbidity exceeded guideline levels. The electrical conductivity indicated brackish conditions on occasion in the assumed non-tidal sampling location which indicate this location may be tidally influenced. Total recoverable hydrocarbons were also detected in the non-tidal sampling location (SW4).

4.5.6 Rozelle Bay

Rozelle Bay is historically affected by industrial activities which have led to the contamination of its sediments. Research completed at Sydney University in 2014 assessed the condition of Sydney Harbour and its sub-catchments and sub-estuaries. Each sub-catchment/sub-estuary was graded on three indicators – catchment pressures, water quality and sediment quality. These grades were combined into an overall grade. Blackwattle/Rozelle Bay has been graded as D+ with a recommendation that high priority management was required (Montoya 2015).

Rozelle Bay sediments are contaminated with heavy metals and dioxins, with research indicating that the sediments are highly toxic (Montoya 2015). Discharge points are the worst affected by dioxins and metal concentrations in surficial sediments have generally declined over the past few decades (Montoya 2015). A recent assessment of environmental conditions in Rozelle Bay by the University of New South Wales (Bugnot *et al* 2016) found evidence of severe degradation in Rozelle Bay but the degradation appeared to be fairly localised. Sediments had concentrations of copper, lead, zinc and arsenic above recommended sediment quality guideline values.

A review of known water quality data was undertaken to establish water quality conditions within the bay. This included samples collected by AECOM at one location (SW1) within Rozelle Bay at the Whites Creek outlet between July 2016 and May 2017 as part of the M4-M5 Link baseline surface water sampling and one location within the centre of the bay (BW1) collected by Sydney University on behalf of UrbanGrowth NSW as part of The Bays project between July and September 2016. Elevated levels of heavy metals (copper, chromium, lead and zinc), nitrogen, phosphorus, nitrate, oxides of nitrogen, ammonia and chlorophyll a were recorded. On some occasions the pH was also outside guideline levels and the turbidity exceeded guideline levels. Enteroccoci was recorded on occasions.

4.5.7 Iron Cove

Iron Cove is historically affected by industrial activities which have led to the contamination of its sediments. Iron Cove sediments are contaminated with heavy metals and dioxins, with research indicating the sediments to be moderately toxic (Montoya 2015). However, metal concentrations in surficial sediments have generally declined over the past few decades (Montoya 2015).

Sydney University assessed Iron Cove to be graded C with a recommendation that high priority management was required (Montoya 2015). Montoya (2015) reported that water quality samples collected from Iron Cove exceeded ANZECC (2000) guideline criteria for nitrogen phosphorus, chlorophyll-a and enterococci.

A review of known water quality data was undertaken to establish water quality conditions within the bay. This included samples collected by AECOM at two locations (SW11 and SW12) within Iron Cove as part of the M4-M5 Link baseline surface water sampling between November 2016 and May 2017. Elevated levels of metals (chromium, copper, lead, mercury and zinc), nitrogen, nitrate and phosphorus were recorded. The turbidity also exceeded guideline levels and the pH was outside guideline levels on occasions.

4.5.8 White Bay

White Bay is historically affected by waterfront industry including abattoirs on Glebe Island which discharged polluted effluent into the surrounding waters until the abattoirs were moved to Homebush in 1916 (Montoya 2015).

A review of known water quality data was undertaken to establish water quality conditions within the bay. This included samples collected on behalf of UrbanGrowth NSW within the centre of the bay (BW2) as part of The Bays Precinct project between July and September 2016.

Elevated levels of metals (copper and zinc), nitrogen, nitrate and phosphorus, were recorded. The turbidity also exceeded guideline levels on occasions.

4.5.9 Alexandra Canal

A review of known water quality data was undertaken to gain an appreciation of water quality conditions within Alexandra Canal, including samples collected by AECOM at a non-tidally influenced location (SW10) on the canal’s upstream tributary, Sheas Creek, at the south side of Huntley Street Bridge between July and May 2017, as part of the M4-M5 Link baseline surface water sampling. Samples were also taken at a tidally influenced location (SW1) on Alexandra Canal at Coward Street as part of the New M5 project surface water sampling conducted between June 2015 and November 2015.

Elevated levels of metals (copper, lead, chromium (III+VI), nickel, manganese and zinc) and nutrients (nitrogen, nitrate and phosphorus) and turbidity were recorded. The pH was also outside guideline levels on occasions.

4.6 Sensitive receiving environments

The project has the potential to interact with a number of sensitive receiving environments, namely:

- Protected wetlands in Iron Cove
- Iron Cove (classified as a water recreation zone)
- Johnstons Creek constructed wetland in Federal Park
- Whites Creek constructed wetland in Whites Creek Valley Park
- Mapped Key Fish Habitat in Rozelle Bay, Iron Cove, White Bay, Alexandra Canal and downstream portions of Dobroyd Canal and Hawthorne Canal
- The Cooks River
- Seagrass in Botany Bay.

4.7 Aquatic habitat and groundwater dependant ecosystems

An assessment of groundwater dependent ecosystems (GDE) and other sites of ecological significance are provided in **Appendix S** (Technical working paper: Biodiversity) and **Appendix T** (Technical working paper: Groundwater) of the EIS.

Appendix S (Technical working paper: Biodiversity) of the EIS states that waterways in or adjacent to the proposed works are not suitable habitat for threatened fish species and there are no SEPP 14 wetlands in the study area. It is also unlikely that there is valuable or specific aquatic habitat for threatened aquatic/estuarine species, populations or communities listed under the FM Act, *Threatened Species Conservation Act 1995* (NSW) or *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth) present within the project footprint. It is possible some species may opportunistically pass through the estuarine bays within the study area (Whites Bay, Rozelle Bay and Iron Cove) given the connectivity to the broader harbour and coastal habitats, but the species are unlikely to depend on the habitat within the study area (**Appendix S** of the EIS (Technical working paper: Biodiversity)).

A search of the GDE Atlas (BoM, accessed 27 September 2016) and review of the *Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2011* for high priority GDEs was undertaken as part of the Biodiversity Assessment (**Appendix S** of the EIS). The search indicated that there are no ecosystems within the study area that are likely to be dependent on groundwater. Although not mapped as being groundwater dependent, Johnstons Creek and Whites Creek are associated with palaeochannels. In low lying areas such as these, the project is not expected to change availability of water for plants due to the low permeability of the clayey soils in combination with frequent rainfall events and higher recharge than elevated sites.

4.8 Existing water quality treatment measures

Water quality improvement devices have been incorporated into the existing stormwater system at a number of locations within the study area. Known water quality treatment measures within the Johnstons Creek, Hawthorne Canal and Whites Creek catchments, as obtained from Beck 2010, are listed in **Table 4-2**.

Table 4-2 Known existing water quality improvement devices

Catchment	Device type	Location
Johnstons Creek	Gross Pollutant Trap (GPT)	Federal Park
	Wetland	Federal Park
	GPT Rocla basket trap	Creek Street and Wigram Road
	GPT	Gadigal Avenue, Victoria Park
	GPT	Larkin Street Road
	GPT Rocla Continuous Deflection Separation (CDS) Unit	Larkin Street Park
	GPT	Corner of Australia Square, Enmore and King Street, Newtown
	Biofiltration	Corner of Federal and Church Street
Hawthorne Canal	Litter Boom	Canal Mouth
	GPT	Francis Street
	GPT	Dept. of Defence, Hawthorne Parade
Whites Creek	CDS GPT	Thorby Avenue
	GPT Rocola basket trap	North Avenue and White Creek Lane
	Wetland	Wisdom Street
	Infiltration Basin	Gillies Street

The constructed wetland (owned by Inner West Council) located within Whites Creek Valley Park adjacent to Wisdom Street, Annandale receives low flows from Whites Creek. It is understood that a sewage overflow in 2009 caused the death of most of the fauna in the Whites Creek wetland (Leichhardt Council 2010). A constructed wetland receiving low flows from Johnstons Creek is also located in Federal Park, Annandale.

Sydney Park has four wetland areas which are an important part of the parks ecosystem as well as providing a flood mitigation role. A City of Sydney Council water reuse project at Sydney Park was completed in October 2015. Stormwater is diverted from the stormwater channel near the corner of Euston and Sydney Park Roads for treatment within a series of bioretention beds prior to being reused to top up the wetlands, irrigate the park and supply the neighbouring Council depot. The stormwater harvesting system is the largest water harvesting system in Sydney (City of Sydney Council 2016).

4.9 Riparian corridors

EIS **Appendix S** (Technical working paper: Biodiversity) indicates that the riparian buffer of Whites Creek and Rozelle Bay are located within the construction footprint at Rozelle and a small portion of the riparian buffer of Iron Cove touches the western edge of the construction footprint at Iron Cove. No other construction sites or operational areas of the project are within riparian corridors.

4.10 Contamination and acid sulfate soils

Potential contamination within the project footprint and its associated management has been assessed in **Appendix R** (Technical working paper: Contamination) of the EIS. Contaminants of potential concern within the project footprint as identified within **Appendix R** (Technical working paper: Contamination) of the EIS are provided in **Table 4-3**. These include contaminants which could potentially be present within soil, sediments and groundwater, based on a desktop review of relevant historical reports, land titles, council and government documentation and records, historical photographs, historical land use and activities, existing soil, sediment and groundwater data and site inspections.

Based on the NSW Department of Planning and Environment (DP&E) acid sulfate soil risk maps (Acid Sulfate Data Source Accessed 03/06/2015: NSW Crown Copyright - Planning and Environment Creative Commons 3.0 Commonwealth of Australia), acid sulfate soil classes were mapped as shown in **Table 4-3** for each of the construction sites. The classification scheme for acid sulfate soils is provided in **Table 4-4**.

Table 4-3 Contaminants of Potential Concern and acid sulfate soil class

Construction Site	Contaminants of Potential Concern (CoPC)	Acid sulfate soil classes
C1a Wattle Street civil and tunnel site	Lead, asbestos, metals, Polycyclic Aromatic Hydrocarbons (PAHs), and hydrocarbons	Class 5
C2a Haberfield civil and tunnel site	Lead, asbestos, Total Recoverable Hydrocarbons (TRH), Benzene, Toluene, Ethylbenzene, Xylenes (BTEX), PAHs, Volatile Organic Compound (VOCs), Volatile Halogenated Compounds (VHCs)	Class 5
C3a Northcote Street civil site	Lead, asbestos, TRH, BTEX, PAH, VOCs	Class 5
C1b Parramatta Road West civil and tunnel site	PAHs, metals, TRH, BTEX, PAHs, VOCs, lead, asbestos, Polychlorinated Biphenyls, PCBs, Phenols, Organochlorine Pesticides (OCPs), Organophosphorus Pesticides (OPPs)	Class 5
C2b Haberfield civil site	Lead, asbestos, Total Recoverable Hydrocarbons (TRH), Benzene, Toluene, Ethylbenzene, Xylenes (BTEX), PAHs, Volatile Organic Compound (VOCs), Volatile Halogenated Compounds (VHCs)	Class 5
C3b Parramatta Road East civil site	Metals, TRH, BTEX, PAHs, VOCs, PCBs, lead, asbestos, chlorinated hydrocarbons, OCPs, OPPs, phenols	Class 5
C4 Darley Road civil and tunnel site	Heavy metals, acid sulfate soils, PAHs, TRH, asbestos, VOCs, SVOCs	Class 2 and 5
C5 Rozelle civil and tunnel	Metals, TRH, PAHs, OCPs, asbestos, acid	Class 1, 3 and 5

Construction Site	Contaminants of Potential Concern (CoPC)	Acid sulfate soil classes
site	sulfate soils, SVOCs, VOCs, TBT	
C6 Crescent civil site	Lead, PAHs, Tributyltin, asbestos, PFAS-PFOS and PFHxS, metals, SVOCs, VOCs, TRH, BTEX Contaminants of potential concern for the sediments in Rozelle Bay include asbestos, Perfluroalkylated Substances (PFAS): PFAS compounds Perfluorooctanesulfonic acid (PFOS) and Perfluorohexane sulfonate (PFHxS), heavy metals, PAHs and Phathalates.	Class 5 (soils) Acid sulfate soils were detected in sediment samples collected from Rozelle Bay by AECOM in 2017
C7 Victoria Road civil site	TRH, BTEXN, PAHs, lead and asbestos.	Class 5
C8 Iron Cove civil site	Metals, TRH, VOCs, SVOCs, asbestos, acid sulfate soils, BTEX, PAHs, OCPs, Polychlorinated Biphenyls (PCBs), lead. Metals, OCPs, PAHs and asbestos also CoPCs for the proposed water quality treatment facility within the car park	Class 2 and 5
C9 Pyrmont Bridge Road tunnel site	Metals, TRH, BTEXN, PAHs, VOCs, lead, asbestos, PCBs, cyanide, SVOCs	Class 5
C10 Campbell Road civil and tunnel site	Landfill gases (methane, hydrogen sulphide, carbon dioxide and carbon monoxide), leachate (particularly ammonia), acid sulfate soils, heavy metals, PAHS, asbestos, SVOCs, VOCs, TRH, lead, BTEXN	Class 2 and 3

Table 4-4 Classification scheme in the acid sulfate soils planning maps

Class of land	Works which present an acid sulfate soil risk
1	Any works
2	Works below natural ground surface Works by which the watertable is likely to be lowered
3	Works beyond 1 metre below natural ground surface Works by which the watertable is likely to be lowered beyond 1 metre below natural ground surface
4	Works beyond 2 metres below natural ground surface Works by which the watertable is likely to be lowered beyond 2 metres below natural ground surface
5	Works within 500 metres of adjacent Class 1, 2, 3 or 4 land which are likely to be lower the watertable below 1 metre AHD on adjacent Class 1, 2, 3 or 4 land

4.11 Groundwater quality

As groundwater seepage to the tunnels will be captured, treated and ultimately discharged to Hawthorne Canal and Rozelle Bay, a review of groundwater quality data collected to inform **Appendix T** (Technical working paper: Groundwater) was undertaken of the EIS. At the time of reporting, 58 monitoring wells had been installed, with groundwater quality monitoring data collected from 47 wells to date. Sampling is conducted on a monthly basis and commenced in June 2016 for the earliest wells.

The sampling data has the following limitations:

· Sampling data provides an indication of groundwater at the monitoring well location at the time of sampling only. The yield of groundwater which would seep into the tunnels is assumed to be one litre per second per kilometre however the proportion of water from each aquifer zone (of varying water quality) is unknown. The respective composite quality of water seeping into the tunnel is therefore unknown

- No distinction between target lithology or depth has been made when analysing the data but samples collected from alluvium were discounted from the analysis as tunnels and cut and cover sections would be constructed as undrained through palaeochannels to prevent groundwater ingress in these areas (refer to **Appendix T** (Technical working paper: Groundwater) of the EIS)
- Sampling data relevant to the mainline tunnel included that collected from monitoring wells within the vicinity of St Peters and Haberfield and along the mainline alignment. See **Figure 4-22** for further details of the wells and well locations.
- Sampling data assumed to be relevant to the Rozelle tunnels included samples from monitoring wells at Rozelle, The Crescent, Iron Cove and Easton Park (see **Figure 4-22**).

A summary of the data is presented in **Table 4-5** and **Table 4-6** for monitoring wells relevant to the mainline tunnel and Rozelle tunnels respectively. The ANZECC (2000) marine 95 per cent protection level, freshwater 95 per cent protection level (or default trigger levels for physical and chemical stressors where appropriate) and recreational water quality guideline levels (consistent with the SHPRC water quality objectives) are shown for comparison as well as an indication of water quality within the receiving waters.

The mainline tunnel monitoring wells recorded:

- Consistently elevated concentrations of manganese and iron
- Consistently elevated concentrations of ammonia, total nitrogen and total phosphorus
- pH consistently outside the guideline levels
- Elevated concentrations of chromium, copper, lead, nickel, zinc, nitrite, nitrate and filterable reactive phosphorus on some occasions.

The Rozelle tunnel monitoring wells recorded:

- Consistently elevated concentrations of manganese and iron
- Consistently elevated concentrations of ammonia, total nitrogen and total phosphorus
- pH consistently outside the guideline levels
- Concentrations of chromium, copper, lead, nickel, zinc, nitrate, filterable reactive phosphorus on some occasions.

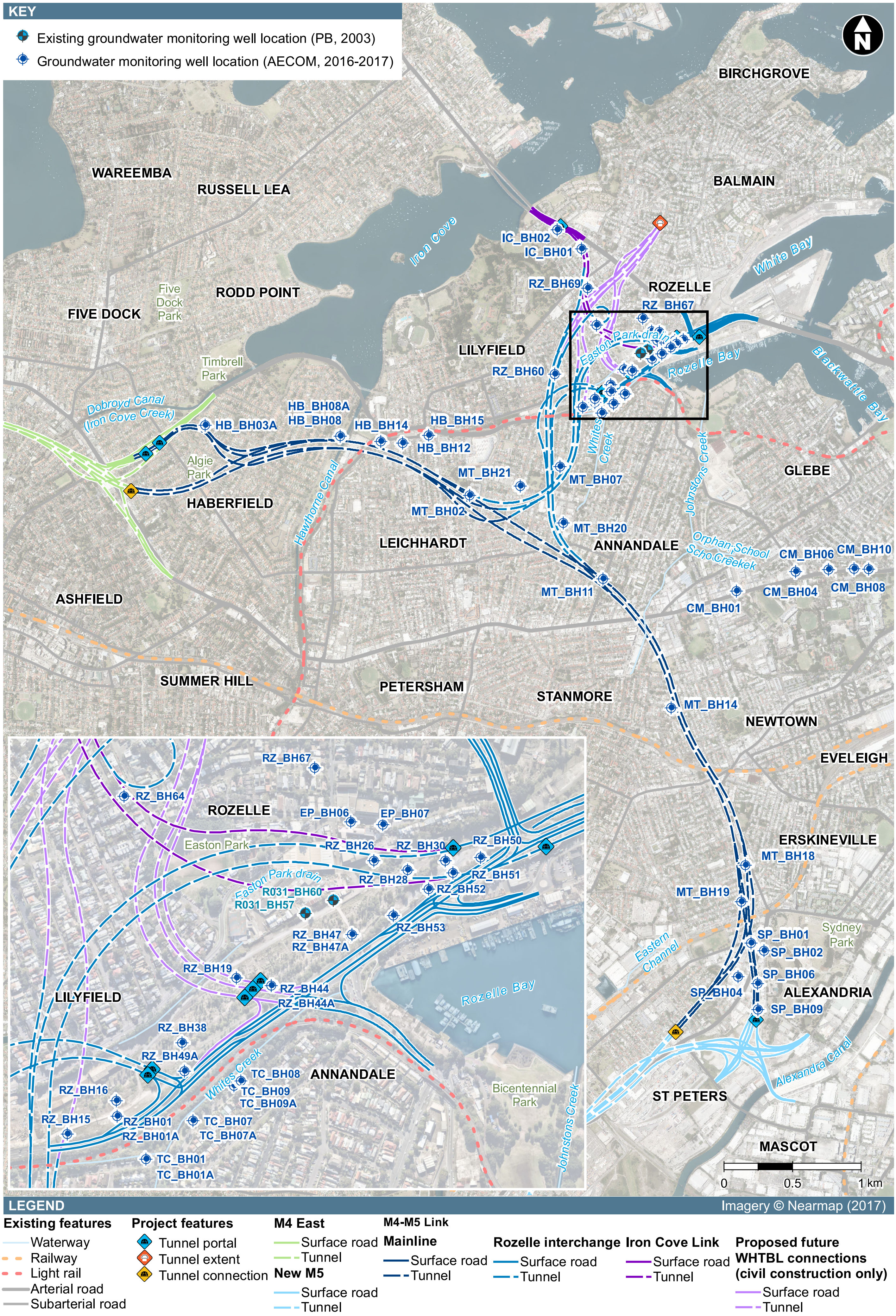


Figure 4-22 Groundwater monitoring well locations

Table 4-5 Groundwater monitoring - summary of samples relevant to mainline tunnel

Analyte	Units	95% marine protection level	95% freshwater protection level	Recreational water quality guideline level	Hawthorne Canal median[1]	Hawthorne Canal mean[1]	Number of wells data collected from	Number of Samples	Minimum	Maximum	Median	Mean[2]	Percentage of samples exceeding a guideline level[3]
Temperature	°C	-	-	-	21.2	24.4	15	64	17	26.1	21	21.1	-
pH	-	7- 8.5[4]	6.5 – 8.0[4]	6.5 – 8.5	7.6	7.4	15	64	5.51	12.69	7.52	8.40	72%
Conductivity	uS/cm	-	125 - 2000[4]	-	42334	36041	15	64	16.8	16300	2356	3139	61%
Arsenic	mg/L	-	-	0.05	<0.01	0.0042	15	64	<0.001	0.006	0.005	0.004	0%
Chromium	mg/L	-	-	0.05	<0.01	0.0034	15	64	<0.001	0.157	<0.001	0.0056	4%
Copper	mg/L	0.0013	0.0014	1	<0.01	0.0092	15	64	<0.001	0.029	<0.001	0.0013	15%
Iron	mg/L	-	-	0.3	0.34	0.77	15	64	0.05	458	10.8	41.9	97%
Lead	mg/L	0.0044	0.0034	0.05	<0.01	0.01	15	64	<0.001	0.004	<0.001	0.0005	1%
Manganese	mg/L	-	1.9	0.1	0.018	0.021	15	64	0.008	25.1	0.30	1.12	88%
Nickel	mg/L	0.07	0.011	0.1	0.004	0.0031	15	64	<0.001	0.15	0.002	0.009	19%
Zinc	mg/L	0.015	0.008	5	0.026	0.043	15	64	<0.005	0.126	<0.005	0.011	29%
Nitrite	mg/L	-	-	1	<0.01	0.01	15	66	<0.01	1.18	<0.01	0.054	1%
Nitrate	mg/L	-	0.7	10	0.09	0.36	15	66	<0.01	1.31	0.02	0.09	4%
Ammonia	mg/L	0.91	0.9	0.01	-	-	15	23	0.02	3.41	0.53	0.79	83%
Total Nitrogen	mg/L	0.3[4]	0.5[4]	-	0.25	0.82	15	24	0.3	158	1.4	2.1	90%
Filterable Reactive Phosphorus	mg/L	0.005	0.02	-	0.03	0.034	15	66	<0.01	0.13	<0.01	0.011	21%
Total Phosphorus	mg/L	0.03[4]	0.05[4]	-	0.07	0.29	15	16	0.01	236	0.15	1.16	88%

Exceeds 95% marine protection level
Exceeds 95% freshwater protection level
Exceeds recreational water quality guideline level

Notes:

[1]Based on M4-M5 Link surface water quality monitoring (see **Annexure B**)

[2]Results below the limit of reporting were assumed to be half the limit of reporting when calculating the mean

[3] Trigger values for toxicants have been obtained from ANZECC (2000) and are for reference only. Adjustments in trigger level for hardness (copper, nickel, lead, zinc) or pH (ammonia) has not been undertaken for receiving environment when determining trigger level exceedances.

[4] Default trigger values for physical and chemical stressors in south-east Australia (ANZECC, 2000)

[5] Excludes anomalous results for TP (236mg/L) and TN (158mg/L) collected on 8/6/2016

Table 4-6 Groundwater monitoring - summary of samples relevant to Rozelle tunnels

Analyte	Units	95% Marine Protection Level	95% Freshwater Protection Level	Recreational Water Quality Guideline level	Rozelle Bay Median[1]	Rozelle Bay Mean[1]	Number of wells data collected from	Number of Samples	Minimum	Maximum	Median	Mean[2]	Percentage of Samples exceeding guideline level [3]
Temperature	°C	-	-	-	21.2	20.9	31	237	16.72	26.5	20.9	20.92	-
pH	-	7- 8.5[4]	6.5 – 8.0[4]	6.5 – 8.5	7.61	7.39	31	237	4.48	12.37	7.05	7.57	70%
Conductivity	uS/cm	-	125 - 2000[4]	-	46630	41014	31	239	159.6	13552	1261	2076	23%
Arsenic	mg/L	-	-	0.05	<0.01	0.004	31	244	<0.001	0.019	<0.001	0.0010	0%
Chromium	mg/L	-	-	0.05	<0.01	0.003	31	245	<0.001	0.064	<0.001	0.0019	0%
Copper	mg/L	0.0013	0.0014	1	<0.01	0.006	31	245	<0.001	0.056	<0.001	0.0031	24%
Iron	mg/L	-	-	0.3	0.23	0.21	31	245	0.025	237	14.9	23.2	98%
Lead	mg/L	0.0044	0.0034	0.05	<0.01	0.005	31	245	<0.001	0.035	<0.001	0.0012	6%
Manganese	mg/L	-	1.9	0.1	0.006	0.014	31	245	0.007	5.62	0.469	0.623	90%
Nickel	mg/L	0.07	0.011	0.1	<0.01	0.0032	31	245	<0.001	0.159	0.004	0.007	13%
Zinc	mg/L	0.015	0.008	5	0.042	0.1	31	245	<0.005	0.229	<0.005	0.013	29%
Nitrite	mg/L	-	-	1	<0.01	0.01	31	234	<0.01	0.92	<0.01	0.020	0%
Nitrate	mg/L	-	0.7	10	0.09	0.19	31	234	<0.01	1.47	0.03	0.13	5%
Ammonia	mg/L	0.91	0.9	0.01	0.042	0.049	31	96	0.02	2.73	0.16	0.37	70%
Total Nitrogen	mg/L	0.3[4]	0.5[4]	-	0.25	0.49	31	122	0.2	13.4	0.9	1.25	87%
Filterable Reactive Phosphorus	mg/L	0.005	0.02	-	0.02	0.023	31	235	<0.01	0.16	<0.01	0.009	15%
Total Phosphorus	mg/L	0.03[4]	0.05[4]	-	0.025	0.27	31	50	0.01	0.99	0.15	0.22	86%

Exceeds 95% marine protection level
Exceeds 95% freshwater protection level
Exceeds recreational water quality guideline level

Notes:

[1]Based on M4-M5 Link surface water quality monitoring (see **Annexure B**)

[2]Results below the limit of reporting were assumed to be half the limit of reporting when calculating the mean

[3] Trigger values for toxicants have been obtained from ANZECC (2000) and are for reference only. Adjustments in trigger level for hardness (copper, nickel, lead, zinc) or pH (ammonia) has not been undertaken for receiving environment when determining trigger level exceedances.

[4] Default trigger values for physical and chemical stressors in south-east Australia (ANZECC 2000)

5 Assessment of construction impacts

Construction of the project would involve a range of activities at sites of both permanent and temporary occupancy. Construction activities are described in **section 2.3**. A list of construction ancillary facilities is provided in **section 2.3**.

An assessment of construction impacts associated with water extraction, flooding and drainage and water quality is provided in **sections 5.1, 5.2** and **5.2.1** respectively.

5.1 Water use

As detailed in **section 2.4.1**, the project would require water for various tunnelling and surface works activities. There would be a temporary increase in potable water demand as a result of the project during the construction phase. Potable water would be obtained from the Sydney Water potable supply network, subject to agreement with Sydney Water.

The use of alternative sources for non-potable water, as detailed in **section 2.4.1**, would reduce the increased demand on the Sydney Water potable supply network. The use of non-potable water would likely be considered for construction water requirements and environmental controls on the proviso that suitable treatment and management measures are implemented.

The water usage and associated source and volume of water supplied during construction will vary depending on the proposed construction method. Indicative volumes of water use for construction are provided in **section 2.4.1**.

5.2 Flooding and drainage

Flooding during construction of the project could potentially impact areas within and near to the construction sites. The construction footprint is shown in **Figure 2-2**. 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 (resulting in displacement of water) or impacts on the conveyance of floodwaters.

The likelihood of flooding and a summary of the potential impacts of construction sites and associated construction activities on flood risk is provided in **Table 5-1**. These are based on preliminary construction plans and indicative layouts, which would be refined in future as the detailed design and site construction planning is further developed.

The project proposes permanent tunnel portals at Wattle Street (C1a), Darley Road (C4), Rozelle (C5), Iron Cove (C8) and Campbell Road (C10). These are proposed to be created using cut and cover techniques. Tunnelling would also occur through temporary shafts at the Pyrmont Bridge Road tunnel site (C9), Parramatta Road West (C1b, if Option B is selected) and Darley Road (C4).

Ingress of floodwater into the shafts or cut and cover excavations during construction would pose significant risk to personal safety for those working in the tunnel. Where these facilities occur within the floodplain, such as at Darley Road and Rozelle, protection measures such as bunding or floodwater barriers would need to 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 generally minor in nature. These are readily mitigated by adjusting specific aspects of the construction ancillary facility designs and site planning in a way that recognises the identified flood conditions in order to minimise the potential for off-site flood impacts. The indicative layout of the construction ancillary facilities has been developed with information on existing flood risk and identifying opportunities to provide setback from high risk areas to minimise impacts on existing flowpaths, where feasible.

Typical mitigation measures that would be employed are outlined in **section 8** and a summary of locational criteria for ancillary facilities are listed below:

- Tunnels dives and shafts should be located outside flood affected areas. Where this is not possible, bunding or flood control barriers are required
- Stockpiles should be located outside the 20 year ARI flood extent
- Chemicals should be stored and substations located outside or above flood affected areas
- Site facilities, construction roads, and car parks should be located in low hazard areas.

As part of the works around the Rozelle interchange, the existing bridge structure over Whites Creek at The Crescent would be replaced. This is to satisfy road/geometric requirements as well as to address the durability of the existing structure, which is not considered sufficient to match that required for the project. The existing bridge over Whites Creek is a single span approximately nine metres long and 47 metres wide, and would be replaced with a new bridge. The new bridge is proposed to consist of two 16 metre spans (total length 32 metres) with an overall width of 88 metres. Along the right bank of the creek a new landscaped flow path will be constructed. The new bridge piers are proposed to be located along the flow path and outside the main channel so as to minimise flood impacts and low flow patterns.

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, it is noted that the longer spans have been designed to likely mitigate the potential impact this would have had 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 additional temporary structures associated with an alternative cast in situ type approach. A pre-cast approach would also result in a comparatively shorter timeframe for installation of the bridge and potential associated obstruction.

Table 5-1 Construction ancillary facilities and flooding

Construction ancillary facilities	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 catchment · Western side of the site inundated by PMF overland flowpath · 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 (2015), M4 East Detailed Design (CSJ 2016)	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 M4 East ventilation facility (Parramatta Road ventilation facility) · Office, storage and laydown area · Substation · Parking · Stockpiling underground	· Dobroyd Canal catchment · Outside of PMF flood extent for mainstream flooding and overland flowpath · M4 East EIS (2015), M4 East Detailed Design (CSJ 2016)	None anticipated – area outside of PMF flood extent.
C3a Northcote Street civil site (part of M4 East project footprint)	· Parking · Laydown area	· Dobroyd Canal catchment · Outside of PMF flood extent for mainstream flooding and overland flowpath · M4 East EIS (2015), M4 East Detailed Design (CSJ 2016)	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 catchment · Outside of 100 year ARI flood extent for mainstream flooding · Overland flowpaths 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 flowpaths will be maintained.

Construction ancillary facilities	Facilities	Existing flood risk (source, mechanisms)	Potential impacts
C2b Haberfield civil site (part of M4 East project footprint)	· Mechanical and electrical fitout of M4 East ventilation facility (Parramatta Road ventilation facility)	· Dobroyd Canal catchment · Outside of PMF flood extent for mainstream flooding and overland flowpaths · M4 East EIS (2015), M4 East Detailed Design (CSJ 2016)	None anticipated – area outside of PMF flood extent.
C3b Parramatta Road East civil site	· Parking · Buildings and laydown area	· Dobroyd Canal 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 substation	· Hawthorne Canal catchment · Localised shallow flooding from 10 year ARI and 100 year ARI flowpath from light rail line · Majority of the site may be inundated in a PMF with depths up to 0.5 metres at the western end of the site · Hawthorne Canal Flood Study (2013), Leichhardt Flood Study (2014), 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 flowpaths · 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.
C6 The Crescent civil site	· Construction of Whites Creek bridge · Widening and improvement works to Whites Creek · Construction of culverts from Rozelle Rail Yards	· 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.

Construction ancillary facilities	Facilities	Existing flood risk (source, mechanisms)	Potential impacts
	· Buildings and laydown area · Parking		
C7 Victoria Road civil site	· Buildings · Parking	· Rozelle Bay catchment · Outside of PMF flood extent · Leichhardt Flood Study (2014)	None anticipated – area outside of PMF flood extent.
C8 Iron Cove civil site	· Dive structure into Iron Cove Link tunnel · Buildings · Temporary water treatment plant · Workshop and storage	· Iron Cove catchment · Overland flowpaths on Victoria Road for 10 year ARI event · Leichhardt Flood Study (2014), 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 substation	· Johnsons Creek catchment · Overland flow in 10 year ARI event, depths of over 1m limited to Bignell Lane · Johnstons Creek Catchment Flood Study (2014), Leichhardt Flood Study (2014)	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.
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.

5.2.1 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 mechanisms, both of constructed drainage systems or those of overland flow paths, could occur as a consequence of the various construction activities and facilities. Specific causes of these impacts could include:

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

These are typical impacts faced on most construction projects and can 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 8**.

5.2.2 Discharge volume

The discharge of treated construction water would have a minor increase in base flow rates of receiving waterways. Discharges are likely to be continuous. Daily discharge rates are provided in **section 2.4.1**. The locations of discharge points into Dobroyd Canal, Hawthorne Canal, Easton Park drain and Alexandra Canal, all artificial waterways, are reaches that are tidally influenced. As the flow variability within the study area is dominated by tides and given the urban setting and artificial nature of the waterways, it is not considered likely that project discharges during construction would significantly impact on the natural flow variability or environmental water availability at these locations.

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 natural flow variability or environmental water availability.

Discharge from the Rozelle civil and tunnel site to Easton Park drain may initially be to the existing brick-lined open channel. During the course of the construction activities, the Easton Park drain would be re-aligned to enable construction progression through the site and construction of the ultimate alignment of the drain. It is unlikely that the treated water discharge would significantly impact on the natural flow variability or environmental water availability in the drain prior to its re-alignment.

5.3 Water quality

Sections 5.3.1 and **5.3.2** summarise potential project impacts on surface water quality during tunnelling works and surface works respectively. Further details of potential impacts and the receptors at risk are provided in **Table 5-2**.

5.3.1 Tunnelling activities

The project proposes twin tunnels and ramp tunnels which provide surface connections from the mainline tunnels to the St Peters interchange, Rozelle interchange, Iron Cove Link and the M4 East interface at Wattle Street. During construction, tunnelling works would result in large volumes of wastewater being generated from the following sources:

- Groundwater ingress
- Rainfall runoff in tunnel portals and ventilation outlets
- Heat and dust suppression water
- Wash down runoff.

A high proportion of the water generated from tunnelling would be collected from groundwater seepage. Natural groundwater quality along the alignment is variable, with the Ashfield Shale typically being more saline than the Hawkesbury Sandstone. Alluvial groundwater tends to become more saline down gradient due to increased tidal influences but in low lying areas may also be acidic due to the presence of potential acid sulphate soils (PASS). Previous and current land-use practices may have impacted groundwater quality at some locations by the introduction of contaminants such as hydrocarbons or heavy metals from light industrial activities.

The use of chemicals in the treatment and curing process of concrete as well as the concrete dust itself could result in construction water having an increased alkalinity. During construction, the wastewater generated in the tunnel would be captured, tested and treated at a construction water treatment plant (if required) prior to reuse or discharge, or disposal offsite if required (see **section 2.4.1**).

Information and knowledge from adjoining projects (M4 East and New M5) indicates that the water treatment plants will likely be required to include pH correction as well as the ability to remove iron, manganese, suspended solids, hydrocarbons and other settleable compounds. A review of groundwater quality data collected as part of the M4-M5 Link project is provided in **section 4.11**. The results indicate 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 were also recorded at elevated levels on a limited number of occasions.

Tunnel wastewater, if discharged untreated or poorly treated, has the potential to impact the receiving waterways by introducing increased nutrient loading and result in algal growth with increased risk to human health. There is also potential for reduction in visual amenity and impacts to aquatic species as a result of heavy metal or other toxicants.

Construction treatment and plant locations, discharge points and expected discharge volumes are described in **section 2.4.1**. The type, arrangement and performance of construction water treatment facilities will be developed and finalised during detailed design.

Provided appropriate treatment is achieved, tunnel wastewater discharges during construction would pose a negligible impact on receiving water quality. Further details of treatment requirements are provided in **section 8.2**. Impacts associated with the increased discharge volumes are discussed in **section 5.2.2**.

5.3.2 Surface activities

Surface activities would be required to support tunnelling and to construct surface infrastructure such as roadways, bridges, interchanges, tunnel portals, ventilation facilities, ancillary operations buildings and facilities. The highest risk of impacts on water quality during construction of surface works would be associated with:

- Exposure of soils during earthworks (including vegetation clearance, stripping of topsoil, removal of existing pavement, excavation, stockpiling and materials transport), may result in soil erosion and off-site movement of eroded sediments by wind and/or stormwater to receiving waterways. This could adversely impact water quality through increased turbidity, lowered dissolved oxygen levels, and increased nutrients (nitrogen, phosphorus) as well as any contaminants contained within the soils
- Demolition works, predominantly associated with the removal of buildings and residential dwellings. Sources of pollutants during demolition works that could affect water quality include asbestos and other building materials, toxic or pollutant laden soils, heavy metals, chemicals including hydrocarbons or fluids associated with demolition processes and machinery as well as dust and airborne pollutants. The typical impacts on surface water quality from the demolition in these areas would be through mobilised dust, litter and other building materials being deposited and picked up by stormwater runoff and conveyed to downstream waterways via drainage infrastructure
- Disturbance of contaminated land, which may result in soil and contaminants (see **section 4.10**) attached or mixed with the particles mobilised by stormwater runoff through the disturbed area. Soils and sediments containing contaminants transported by stormwater runoff and/or tidal influences to downstream waterways could potentially increase contaminant concentrations in the receiving environment. Refer to **Appendix R** of the EIS (Technical working paper: Contamination) for further details of the management of soil contamination during construction

- Exposure of potential acid sulfate soils (see **section 4.10**) as a result of earthworks or dewatering, which may result in generation of sulfuric acid and subsequent acidification of waterways and mobilisation of heavy metals into the environment if poorly managed. Refer to **Appendix R** (Technical working paper: Contamination) of the EIS to for further details of the management of acid sulfate soils during construction
- Rinse water from plant washing and concrete slurries may contain polluting contaminants which if discharged offsite could impact on surface water quality
- Potential spills or leaks of fuels and / or oils from maintenance or re-fuelling of construction plant and equipment or vehicle / truck incidents could potentially be conveyed to downstream waterways via drainage infrastructure
- Disturbance of Whites Creek and Rozelle Bay due to construction of the proposed new road and pedestrian bridges as part of the realigning of The Crescent and associated Whites Creek channel widening and naturalisation works. This may lead to disturbance of contaminated sediments and potentially erosion of exposed banks once the existing channel concrete lining has been removed and prior to construction of naturalised channel treatments. This could result in temporary impacts to water quality within Whites Creek and Rozelle Bay during construction. Impacts are likely to be temporary until settling occurs and would be managed in accordance with DPI guidelines
- The project includes widening and improvement works to the channel and bank at Whites Creek Annandale to manage flooding and drainage. The channel form would be naturalised with works extending back to the railway bridge, adopting a similar philosophy regarding surface treatments to integrate with Sydney Water's proposed channel naturalisation works (see **section 4.2.1**). The naturalisation works would be finalised during detailed design but are likely to incorporate features such as sandstone blocks and vegetated benches to provide ecological benefits to the channel. The proposed channel bed and bank treatments would be hard lined therefore impacts to channel form and geomorphology are unlikely to occur once the works are complete. Any vegetated zones (eg benches) would be susceptible to erosion and should be protected during the vegetation establishment period
- Upgrades to drainage infrastructure and the major diversion of Easton Park drain would involve removal and upgrade of some existing drainage infrastructure, during which time the exposed, potentially contaminated soils and sediments may be highly susceptible to erosion and flow paths may be interrupted or diverted
- Relocation of utilities would involve earthworks to remove existing services and construct new service routes, during which time exposed soils may be susceptible to erosion. Further details of the proposed utility adjustments are provided within the **Appendix F** (Utilities Management Strategy)
- Construction of new stormwater outlets to receiving bays (Rozelle and Iron Cove), which would potentially cause localised mobilisation of sediments that might be contaminated. Disturbance of sediments could temporarily impact on water quality within proximity to new stormwater discharge points until settling occurs. Where new discharge points are utilised during construction, there is potential for bed scouring and mobilisation of sediments to occur during stormwater discharges. Impacts on water quality are likely to be localised for short periods during and after storm events until settling occurs.
- Construction of the project would result in construction wastewater discharges from Campbell Road tunnel site, draining via an existing outlet to Alexandra Canal. Due to the extra sensitivity of Alexandra Canal bed sediments (see **section 4.1.9**) a quantitative assessment was undertaken to assess the impact of the additional flows. Wastewater would discharge at a flow rate of approximately 1200 kilolitres per day (13 litres per second) (see **section 2.4.1**). This is slightly higher than the estimated 7 litres per second of treated water indicated in the New M5 EIS Technical working paper: Surface water (New M5 EIS Appendix N) to be discharging at the Ricketty Street bridge for that project via the existing drainage system. Existing scour protection and/or energy dissipation measures would minimise localised disturbance of contaminated sediments near to the outlet. The 13 litres per day would contribute an increase of 0.015 per cent (0.024 per cent increase when combined with the estimated New M5 flows) to the one year ARI flow of 83.9 cubic metres per second at Alexandra Canal's confluence with the Cooks River (PB-

MWH 2009). Given the proposed wastewater discharge rate is negligible in relation to existing flows within the canal, impacts on levels and velocities in the canal would also be negligible, hence disturbance of contaminated sediments is not expected to occur.

Management and mitigation measures (see **sections 2.4.1** and **8.2.1**) would be required to reduce the potential for surface water quality impacts arising during construction of surface works. Provided appropriate measures are implemented during construction, short term impacts are expected to be manageable with no material impact on receiving water quality.

Table 5-2 Construction water quality impact summary

Location/construction component	Potentially impacting construction activities	Potential surface water quality impact	Waterways potentially affected
Civil and tunnel sites (excluding Rozelle and The Crescent) inclusive of their adjacent construction footprint including: · C1a Wattle Street · C2a Haberfield · C3a Northcote Street · C1b Parramatta Road West · C2b Haberfield · C3b Parramatta Road East · C4 Darley Road · C7 Victoria Road · C8 Iron Cove · C9 Pyrmont Bridge · C10 Campbell Road	· Vegetation clearance and topsoil stripping · Demolition works · Establish construction facilities, access and utility supply · Excavations · Concrete works · Stockpiling of spoil, construction materials and demolition materials · Relocation of utilities · Access and egress of vehicles to the site and public roads · Accidental spills / material drops during transportation of building waste from demolition sites with pollutants mobilised into waterways · Chemicals / fuel stored onsite · Operation of construction water treatment plant · Activities associated with construction for permanent works	· Erosion and mobilisation of exposed soils, open cuts and stockpiles by stormwater runoff and wind leading to sedimentation of waterways · Exposure of acid sulfate soils or contaminated soils which if mobilised via stormwater runoff could acidify or pollute waterways · Dust, litter and pollutants associated with building materials and demolition waste being mobilised by wind and stormwater runoff into waterways. · Leakage / spills of hydrocarbons or other chemicals from machinery with pollutants conveyed by stormwater runoff into waterways · Increased alkalinity due to transport of chemicals used in treatment and curing of concrete and concrete dust to waterways by stormwater or wind · Vehicles transferring soil to adjacent roads and stormwater runoff conveying soil and pollutants into waterways · Poorly treated water from construction water treatment plant being discharged into stormwater network	· C1a, C2a, C3a and C1b, C2b and C3b drain to Dobroyd Canal · C4 drains to Hawthorne Canal · C7 drains White Bay · C8 drains to Iron Cove · C9 drains to Johnstons Creek · C10 drains to Alexandra Canal
Construction works at Rozelle including the Rozelle civil and tunnel site (C5), The Crescent civil site (C6) and wider Rozelle interchange construction footprint	· Vegetation clearance and topsoil stripping · Demolition works · Establish construction facilities, access and utility supply · Excavations · Concrete works · Stockpiling of spoil, construction materials and demolition materials · Relocation of utilities	· Erosion and mobilisation of exposed soils and open cuts by stormwater runoff and wind leading to sedimentation of waterways · Scour of exposed channel bank material during Whites Creek naturalisation works and subsequent soil mobilisation and sedimentation. · Exposure of acid sulfate soils or contaminated soils which if mobilised via stormwater runoff could acidify or pollute waterways	· Rozelle Bay · Easton Park drain · White Bay · Whites Creek

Location/construction component	Potentially impacting construction activities	Potential surface water quality impact	Waterways potentially affected
	· Access and egress of vehicles to the site and public roads · Accidental spills / material drops during transportation of building waste from demolition sites with pollutants mobilised into waterways · Chemicals / fuel stored onsite · Operation of machinery · Operation of construction water treatment plant (C6 only) · Activities associated with construction for permanent works · Bridgeworks associated with new road and pedestrian bridges across and adjacent to Whites Creek · Whites Creek naturalisation works	· Dust, litter and other building materials being mobilised by wind and stormwater runoff into waterways. · Leakage / spills of hydrocarbons or other chemicals from machinery with pollutants conveyed by stormwater runoff into waterways · Increased alkalinity due to transport of chemicals used in treatment and curing of concrete and concrete dust to waterways by stormwater or wind · Vehicles transferring soil to adjacent roads and stormwater runoff conveying soil and pollutants into waterways · Poorly treated water from construction water treatment plant being discharged into stormwater network (C6 only)	
Potential new permanent drainage outlets to Rozelle Bay, Iron Cove and Whites Creek	· Construction of the outlets · Discharges from the outlets during construction	· Mobilisation of sediments and contaminants within the sediments at outlet locations · Scouring of sediments at outlet locations	· Rozelle Bay · Iron Cove · Whites Creek
Drainage infrastructure adjustments and upgrades	· Earthworks during drainage upgrades · Earthworks and construction of the Easton Park drain diversion	· Mobilisation of exposed soils by stormwater runoff leading to sedimentation of waterways · Exposure of acid sulfate soils or contaminated soils which if mobilised via stormwater runoff could acidify or pollute waterways · Increased alkalinity due to curing of concrete	· Iron Cove · Whites Creek · Easton Park drain · Rozelle Bay
Construction of new stormwater quality treatment facilities	· Vegetation removal · Earthworks to facilitate construction of the devices · Access and egress of vehicles to the site and public roads · Activities associated with construction for permanent works · Operation of machinery	· Erosion and mobilisation of exposed soils and open cuts by stormwater runoff and wind leading to sedimentation of waterways · Exposure of acid sulfate soils or contaminated soils which if mobilised via stormwater runoff could acidify or pollute waterways · Leakage / spills of hydrocarbons or other chemicals from machinery with pollutants	· Iron Cove · Rozelle Bay

Location/construction component	Potentially impacting construction activities	Potential surface water quality impact	Waterways potentially affected
		conveyed by stormwater runoff into waterways · Vehicles transferring soil to adjacent roads and stormwater runoff conveying soil and pollutants into waterways.	

5.4 Riparian vegetation

Appendix S (Technical working paper: Biodiversity) of the EIS indicates the works may require removal of planted native and exotic riparian vegetation for the upgrade of the intersection of The Crescent and City West Link. Water temperature is unlikely to be affected by the removal of riparian vegetation due to the shading provided by the proposed road and tidal influence. As Whites Creek is a concrete channel, the removal of vegetation would not impact on bank stability. New riparian vegetation would be established during the Whites Creek naturalisation works.

No direct impacts will occur to riparian vegetation at Dobroyd Canal, Hawthorne Canal, Iron Cove, Rozelle Bay, Johnstons Creek and Alexandra Canal as the construction footprint either lies outside of the riparian buffer or is on developed land.

6 Assessment of operational impacts

6.1 Water use

Surface water would not be extracted from any waterways for operation of the project. Opportunities for the reuse of treated stormwater or tunnel water would be considered for non-potable water uses in preference to discharge to the stormwater system or receiving waterbodies. This could include irrigation of landscaped areas by others within the Rozelle interchange and opportunities outside the project footprint such as Blackmore Park, Leichhardt.

6.2 Flooding and drainage

6.2.1 Operational related flood risk

The Rozelle interchange, Iron Cove Link and Darley Road site are partially located within the PMF flood extent, which has the potential to impact on the interchange and tunnel portals. The design standard is to 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). Therefore an exclusion strategy is required to prevent any floodwater ingress.

A water exclusion strategy has the potential to displace floodwaters where the interchange blocks existing flow paths, or reduces available floodplain storage, and thereby could impact surrounding properties. This is particularly the case at Rozelle Rail Yards as this area currently functions as a floodway and provides a significant amount of storage of floodwater in larger events such as the 100 year ARI and PMF.

Council emergency management and response procedures 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 currently working toward formation of a Floodplain Risk Management Committee for the new Council. There are no local NSW State Emergency Service (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. 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, once the design is more formalised, all relevant flooding information would be provided to council and SES and feed into the Floodplain Risk Management process. The process would also take into consideration safe entry to and egress and evacuation routes from the tunnels during floods.

The social and economic impacts from flooding during construction and operation may include damage to property and infrastructure and changes to mobility and access. However, the design of construction ancillary facilities and permanent operational infrastructure has been developed to avoid or minimise changes to flood behaviour in and around the project footprint. Potential damage to property and critical infrastructure would be assessed further using the detailed design, and if required, further refinements would be made to the temporary or permanent designs as required to minimise impacts. The social and economic impacts associated with flooding events during construction and operation are therefore forecast to be minor, localised, and likely constrained to short-term changes to access, mobility and potential disruption to services such as power and water supply.

Rozelle interchange

The proposed Rozelle interchange would provide connections between the M4-M5 Link mainline tunnels, City West Link, Victoria Road/Anzac Bridge and the Iron Cove Link. Below ground stub tunnels and entry and exit ramps at the surface would also be built to enable connections to the proposed future Western Harbour Tunnel and Beaches Link.

Due to the high risk of flooding posed to the Rozelle interchange, the design of the proposed layout and evolution of the road design was directly influenced by flood risk and drainage considerations.

An assessment of potential flood impacts at the Rozelle interchange was undertaken by modelling the installation of bunds/walls set at or above the PMF flood level (or 100 year ARI plus 0.5 metres, whichever is the greater) around the perimeter of three different portals/ ramps associated with the interchange to prevent floodwater ingress into the tunnel. Generally at the Rozelle interchange tunnel portals the PMF flood levels are greater than the 100 year ARI plus 0.5 metres levels.

No external flows would therefore enter the tunnels, but rainfall falling over the open tunnel dives would be captured by the tunnel drainage system. The tunnel drainage system would be designed to not only provide the required level of service during the operational phase of the project, but also the safety of people both within the tunnel and at the portals during floods.

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 flood levels are expected to reduce following construction of the project due to the installation of more efficient drainage channels. In the remainder of the Rozelle Rail Yards site flood levels are generally estimated to be higher than existing due to the proposed new buildings and other infrastructure that are raised above ground for flood protection.

The proposed tunnel ventilation facilities, substation and water treatment plant would be located adjacent to the new western and northern channels and would be set above PMF flood level (or 100 year ARI plus 0.5 metres whichever is the greater).

Raising surface levels along the 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 obstruction of 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, and had the potential to impact surrounding properties, in particular along Railway Parade. In order to retain the existing function of the site as a flood storage area and to minimise impacts in the 100 year ARI event (as per the design requirements), design changes were made to manage adverse impacts to an acceptable level.

In order to mitigate the potential increase in flood risk for surrounding properties due to the proposed Rozelle interchange, a number of measures have been incorporated into the development of the design, including:

- Provision of 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
- Increase of 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 2 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 will cross under the proposed M5 to City West Link ramps and Western Harbour Tunnel ramps (within the Rozelle Rail Yards) before combining with the northern channel to then pass under City West Link to discharge into Rozelle Bay. The channels would range in width from around two metres to six metres and the overbank flow path from approximately nine metres to 18 metres through the Rozelle interchange. A typical cross section is shown in **Annexure C**. 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 channel, should manage potential impacts to an acceptable level, ie no adverse flood impacts to adjoining properties for the 100 year ARI event (see **Table 6-1**). Peak flood depths for the 10 year and 100 year ARI event and PMF under proposed design conditions are shown in **Figure 6-1** to **Figure 6-3**.

The proposed interchange limits raising of road levels for City West Link and The Crescent. Road crest levels have generally been kept to within 0.3 metres of existing levels to minimise flood impacts. 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 significant 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. 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 estimated in events up to the 100 year ARI (see **Figure 6-4**). The Crescent would be realigned to the west from its current alignment, roughly following the light rail corridor before crossing over Whites Creek. The new bridge has been designed for a 100 year ARI flood immunity. The skewed angle of the realigned The Crescent and additional lanes result in a wider bridge structure than under existing conditions. In order to achieve increased hydraulic conveyance to compensate for the wider bridge, the length of the new bridge is proposed to be increased to two 16 metres spans (total length of 32 metres). It is proposed that the topography of the land between the new bridge and Rozelle Bay (immediately to the south of Whites Creek on the right overbank) is 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 and 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 6-4). This is a result of 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. These changes in flood behaviour under PMF conditions would be investigated further during detailed design to confirm potential impacts on critical infrastructure and address changes in flood hazard as a result of the project.

Peak flow velocities outside Whites Creek and the new drainage channels will generally remain below 0.5 metres per second in the 100 year ARI (see **Figure 6-5**), similar to existing conditions discussed in **section 4.4.1**. At the new bridge over Whites Creek at The Crescent, peak flow velocities entering the 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. Appropriate scour protection of the new overland flow path and stabilisation of all the outlets to the bay would be required, including the upgraded outlet from the rail yards. This would be undertaken to prevent scour of potentially contaminated sediments in Rozelle Bay at the upgraded outlets. Peak flow velocities in the new drainage channels through the rail yards would generally be less than 1.5 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.

The flood hazard for the land in the vicinity of the interchange would not change substantially from existing conditions (see **Figure 6-5**). The new drainage channels through the Rozelle Rail Yards would be high hazard areas as they are formal conveyance systems similar to the Easton Park drain and Whites Creek. The overland flow paths through the 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 of the rail yards.

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 in the vicinity of the interchange. Flood conditions along City West Link would be improved in events greater than the 100 year ARI and up to the PMF as a result of the project. 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 much reduced at only 0.5 metres.

The flood modelling undertaken suggests that the mitigation measures will minimise impacts on surrounding properties for the 100 year ARI event and therefore satisfy the required design standards. Refinements to the flood model will be required to inform the detailed design of the proposed interchange.

Iron Cove Link

The proposed Iron Cove Link includes:

- Two portals providing a connection to Rozelle interchange, west of the junction of Victoria Road and Terry Street
- Widening of Victoria Road to the south, between the eastern abutment of Iron Cove Bridge and Springside Street, in order to accommodate the project entry and exit portals
- Re-grading of road surface levels and removing some of the existing intersections with local roads
- Inclusion of a ventilation outlet and building.

Peak flood depths for the 10 year ARI, 100 year ARI event and PMF under proposed design conditions are shown in **Figure 6-7** to **Figure 6-9**. 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 (see **Figure 6-11**).

There would be some localised flood impacts along the northern (eastbound) carriageway heading to the city. The catchment at Iron Cove Link generally drains from the north-east towards Iron Cove Link. Changes in road levels along the main alignment, in particular at the intersections with existing local roads could lead to localised flood impacts along the northern carriageway. These impacts would be managed through limiting the raising of road levels and through upgrading the road drainage system to manage changed overland flowpaths.

There is also a risk of flood impacts on adjoining properties at the edge of Iron Cove to the east of the alignment (see **Figure 6-11**). 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 a major overland flowpath 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 flowpath width.

In order 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 need 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 also at Terry Street. The water would then be diverted into a new drainage network and discharged into Iron Cove (see **Figure 2-4**). Barriers or flood bunds would be set at or above the PMF flood level (or 100 year ARI plus 0.5 m whichever is the greater) to provide protection to the exposed sections of the portal from runoff from the adjacent roads. In order to minimise the potential impact on surrounding properties, the road would be graded and kerb lines used to keep runoff away from the portals but within the road reserve and directed towards a discharge point into Iron Cove. Where possible the road runoff would be directed to the proposed new bioretention facility at Manning Street, within King George Park prior to discharge to Iron Cove.

Critical 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. The sites would be protected from local stormwater runoff flooding the site through the provision of bunds around these sites or raising floor levels to the PMF (or 100 year ARI plus 0.5 metres whichever is the 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 up to 2.2 metres per second in the 100 year ARI, similar to existing conditions described in **section 4.4.1** (see **Figure 6-13**). The flood hazard for the land in the vicinity of Iron Cove Link also does not change substantially from existing conditions (see **Figure 6-14**).

Darley Road

The proposed Darley Road operational facilities would house 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 the majority 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) would 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, 100 year ARI event and PMF under proposed design conditions are shown in **Figure 6-14** to **Figure 6-17**.

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 light rail corridor (see **Figure 6-17** and **Figure 6-19**). 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 light rail corridor would need to be managed in consultation with Transport for NSW by either providing a managed flowpath through the site, whilst still protecting vulnerable infrastructure, and/or by providing additional piped drainage systems.

Peak flow velocities along Darley Road would be similar as under existing conditions at 1.5 metres per second (see **Figure 6-20**). Provisional flood hazards would also be similar to existing conditions (see **Figure 6-21)**.

Table 6-1 shows peak design flood depths for selected locations at the Rozelle interchange, Iron Cove Link and Darley Road for the 100 year ARI event.

Table 6-1 Peak design flood levels at selected sites - 100 year ARI (m AHD)

Location	Pre-construction	Post-construction*
Rozelle interchange		
The Crescent bridge at Whites Creek	3.00	2.75 (-0.25)
Culvert at City West Link	3.00	2.09 (-0.91)
Western channel upstream of tunnel portal bridge	3.00	2.33 (-0.67)
Iron Cove Link		
Victoria Road near Iron Cove Bridge	17.86	17.86 (+0.0)
Victoria Road near Crystal Street	25.56	25.72 (+0.16)
Manning Street	3.62	3.61 (-0.01)
Victoria Road near Callan Street	23.51	23.72 (+0.21)
King George Park	3.16	3.15 (-0.01)
Darley Road		
SLR stop	8.11	8.20 (+0.09)
Darley Road near Charles Street	3.29	3.29 (+0.0)
Darley Road near James Street	14.59	14.59 (+0.0)

Note: *: Values in brackets indicate change in peak design flood level compared to pre-construction conditions

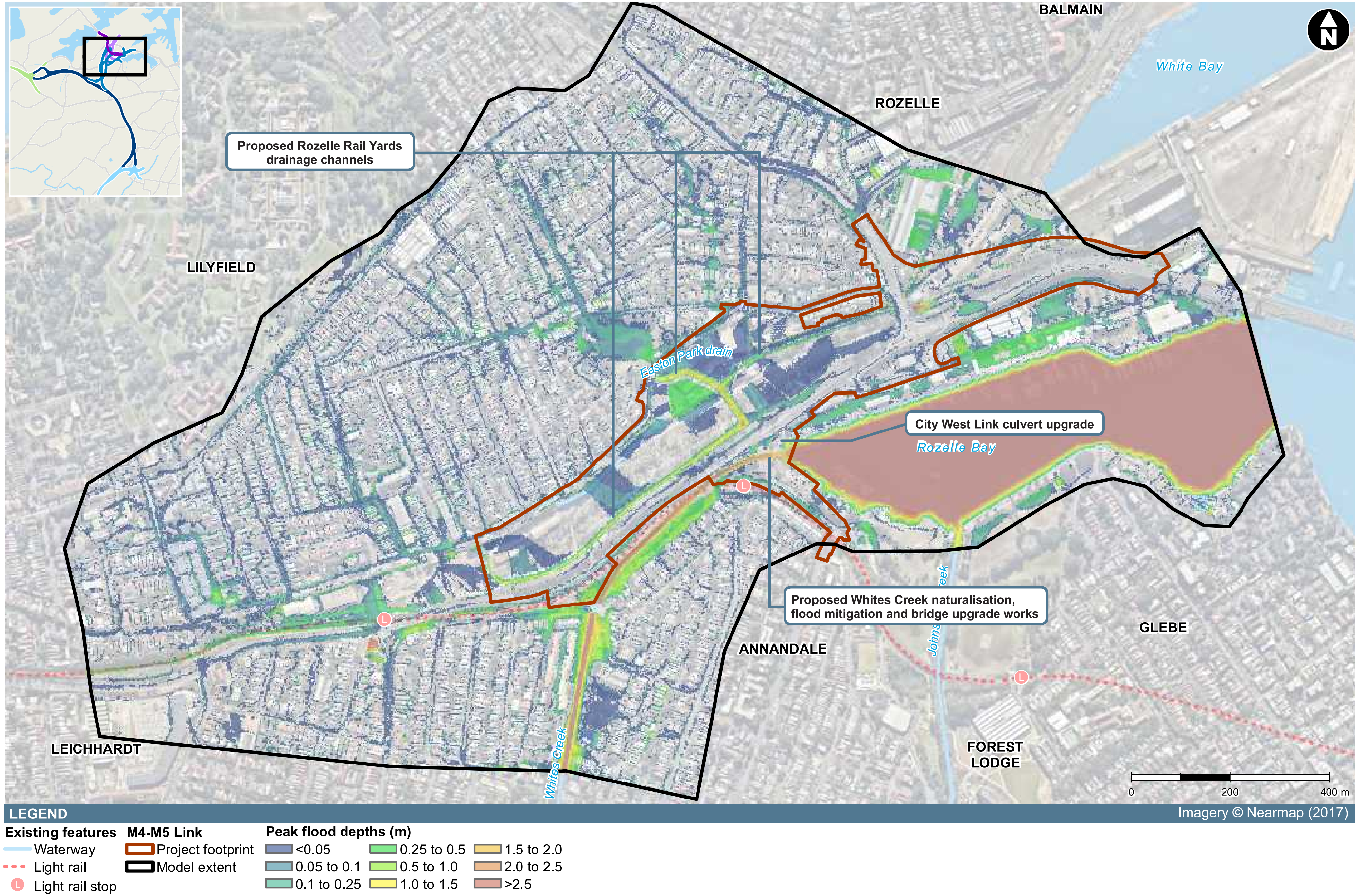
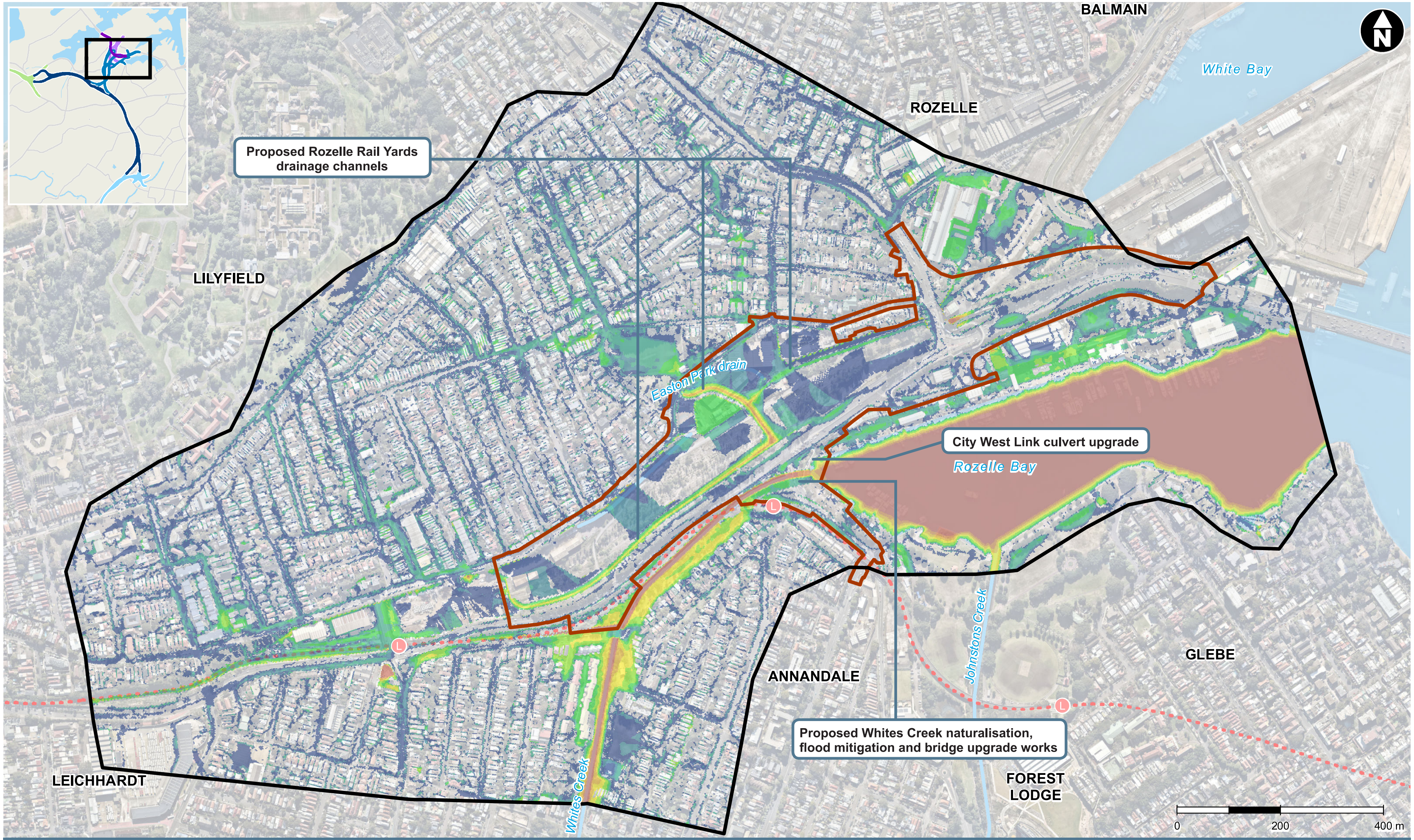


Figure 6-1 Proposed design conditions flood behaviour – Rozelle interchange - peak flood depths (10 year ARI)



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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 6-2 Proposed design conditions flood behaviour – Rozelle interchange - peak flood depths (100 year ARI)

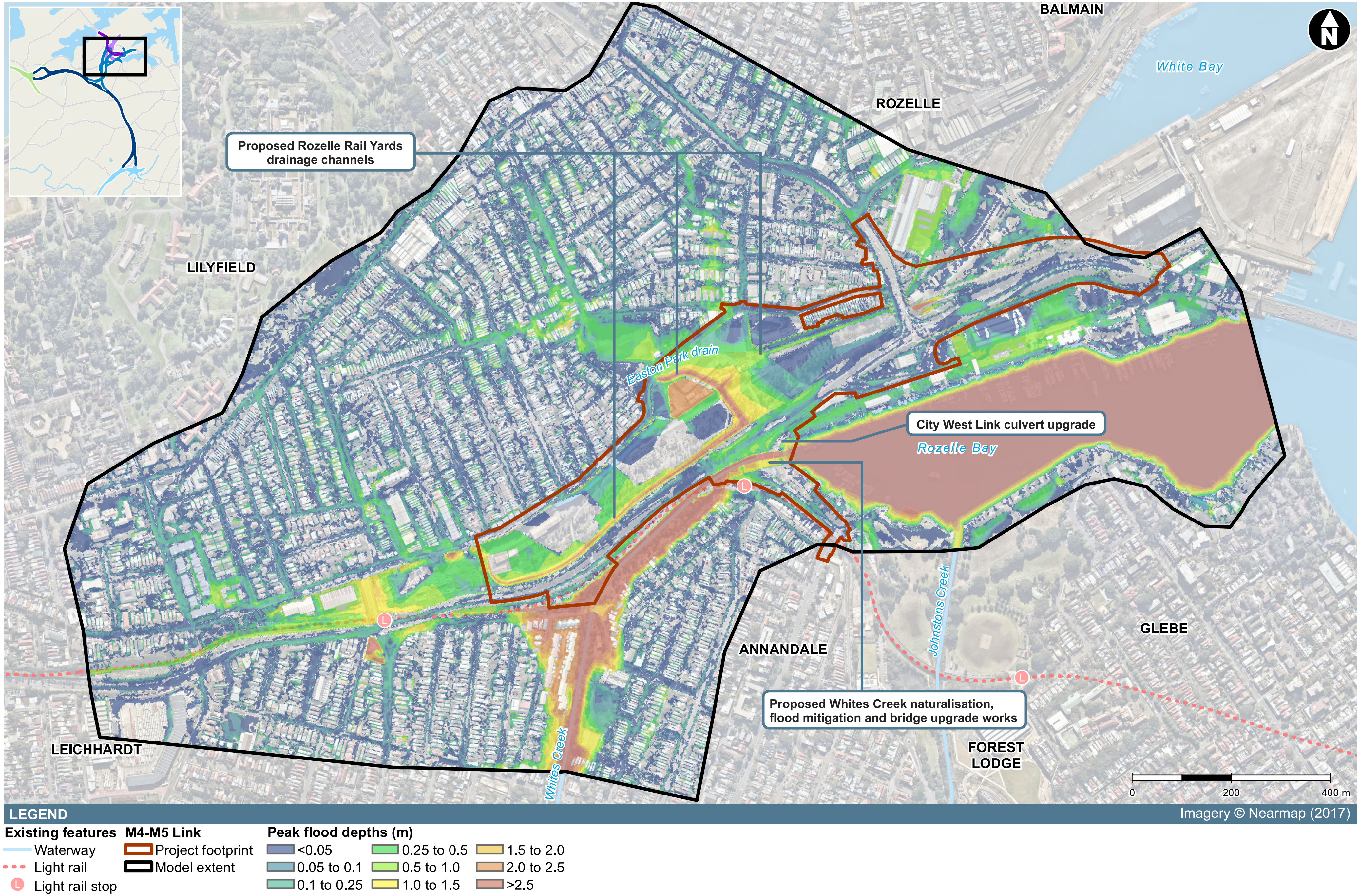

Figure 6-3 Proposed design conditions flood behaviour – Rozelle interchange - peak flood depths (PMF)

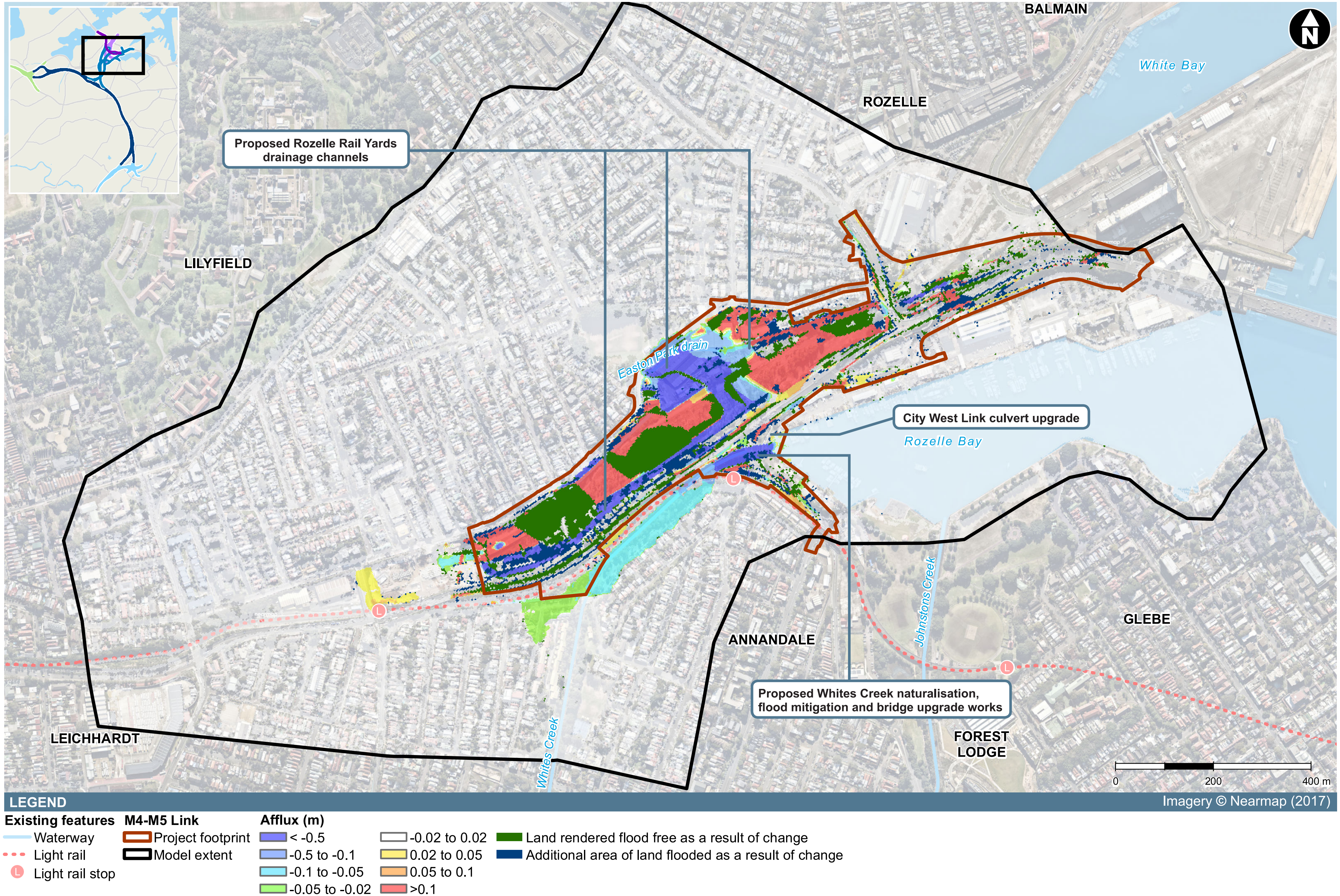

Figure 6-4 Proposed design conditions flood behaviour – Rozelle interchange - relative flood impact (100 year ARI)

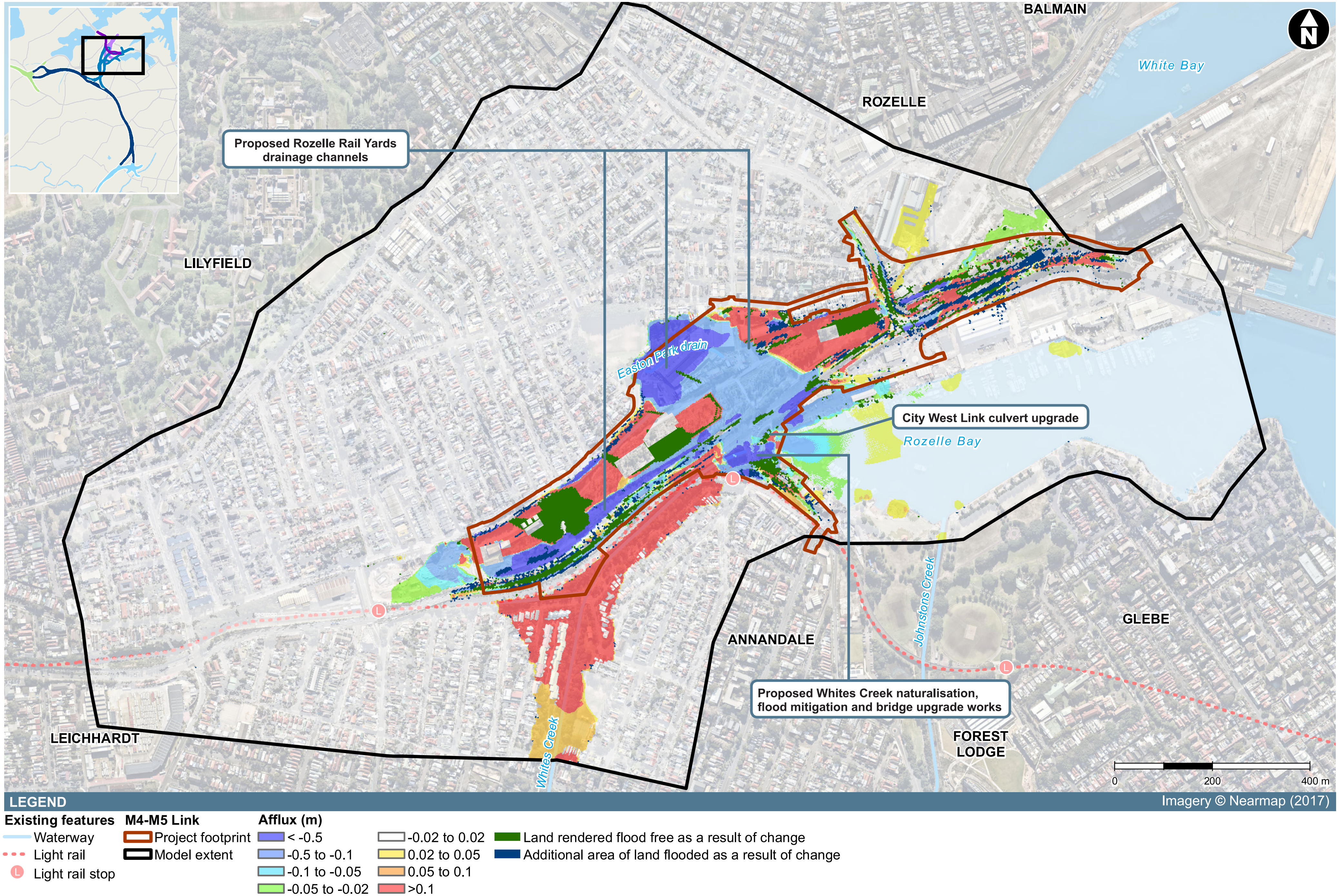

Figure 6-5 Proposed design conditions flood behaviour – Rozelle interchange - relative flood impact (PMF)

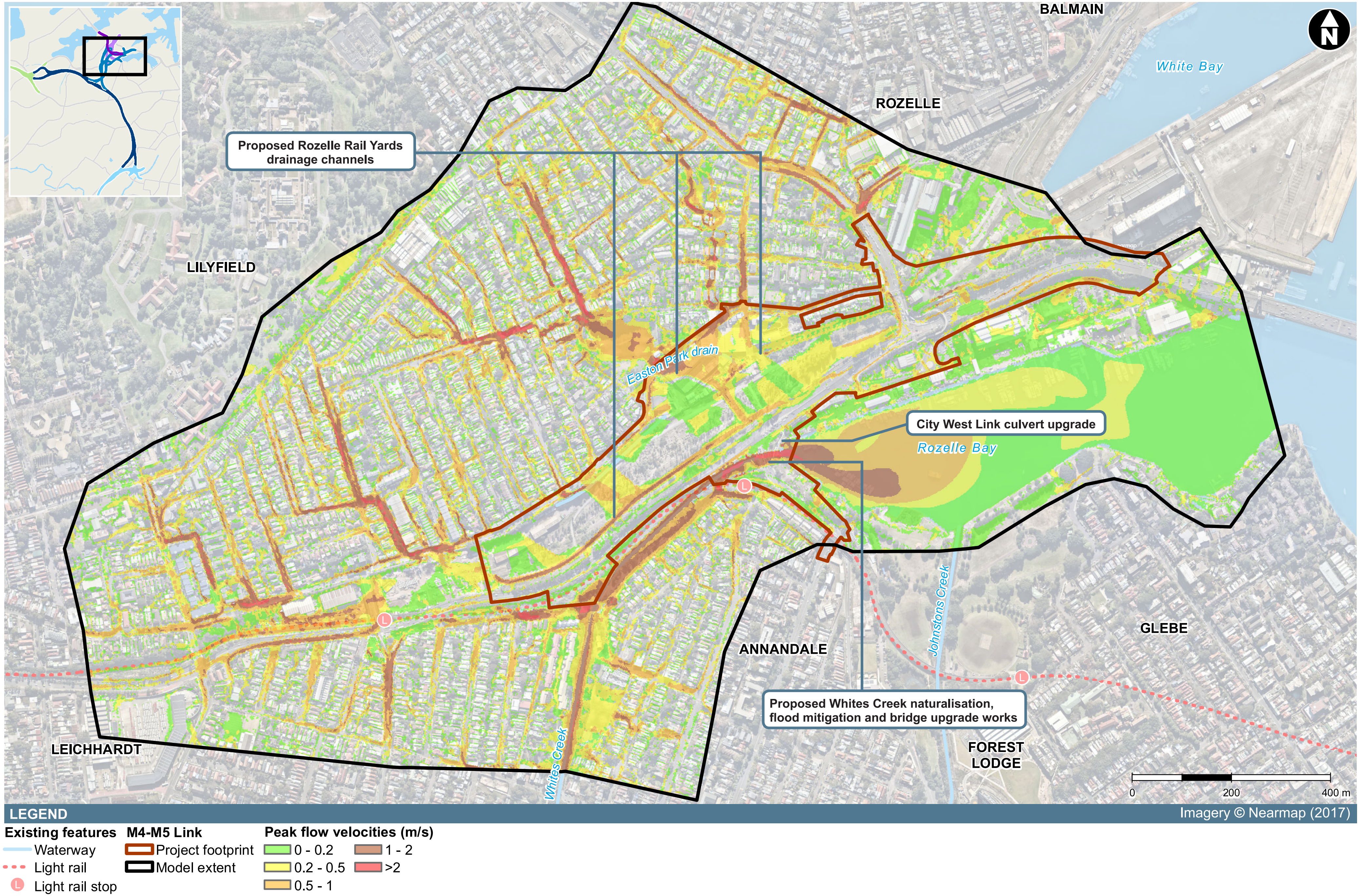

Figure 6-6 Proposed design conditions flood behaviour – Rozelle interchange - peak flow velocities (100 year ARI)

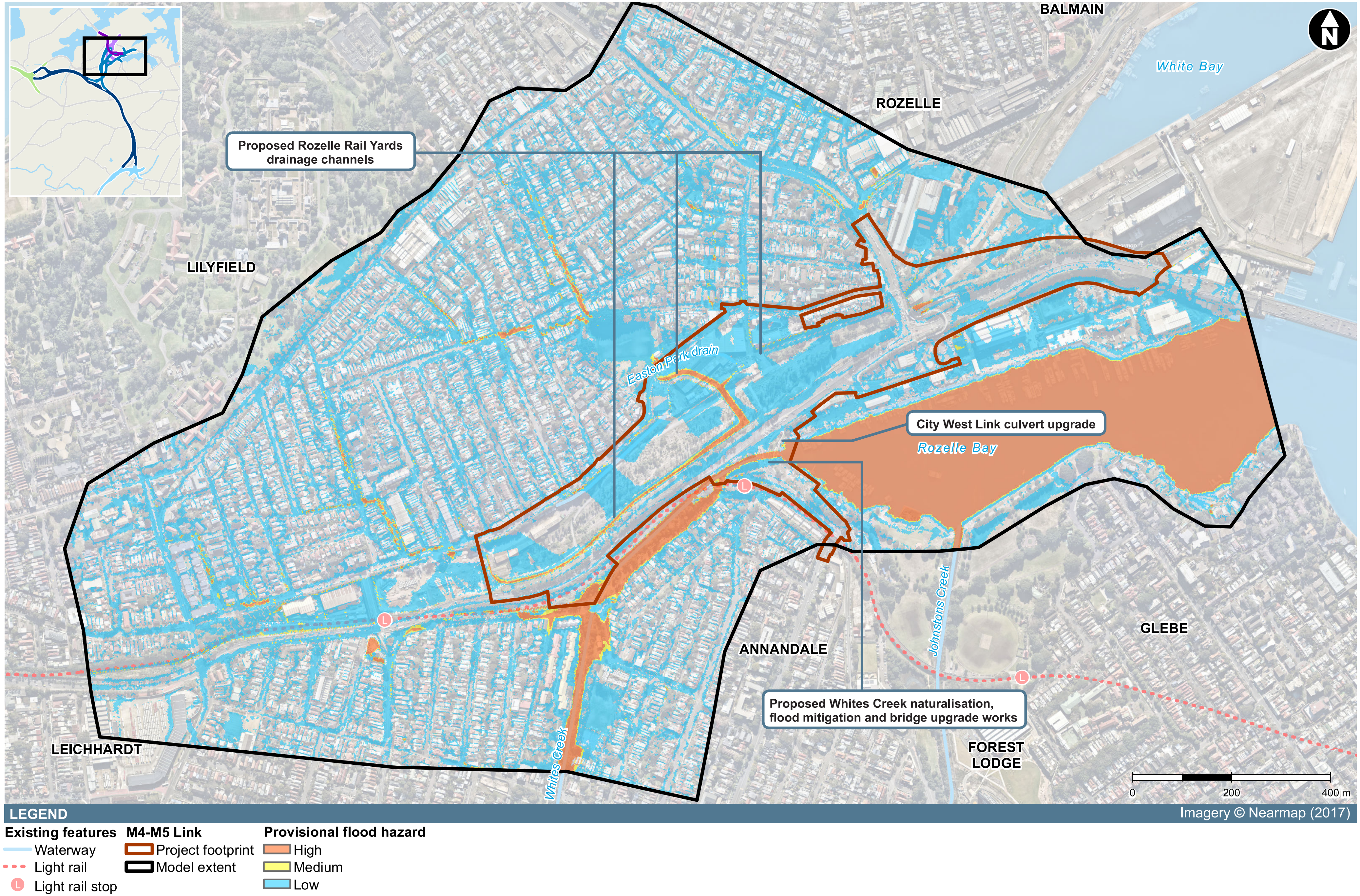

Figure 6-7 Proposed design conditions flood behaviour – Rozelle interchange - provisional flood hazard (100 year ARI)

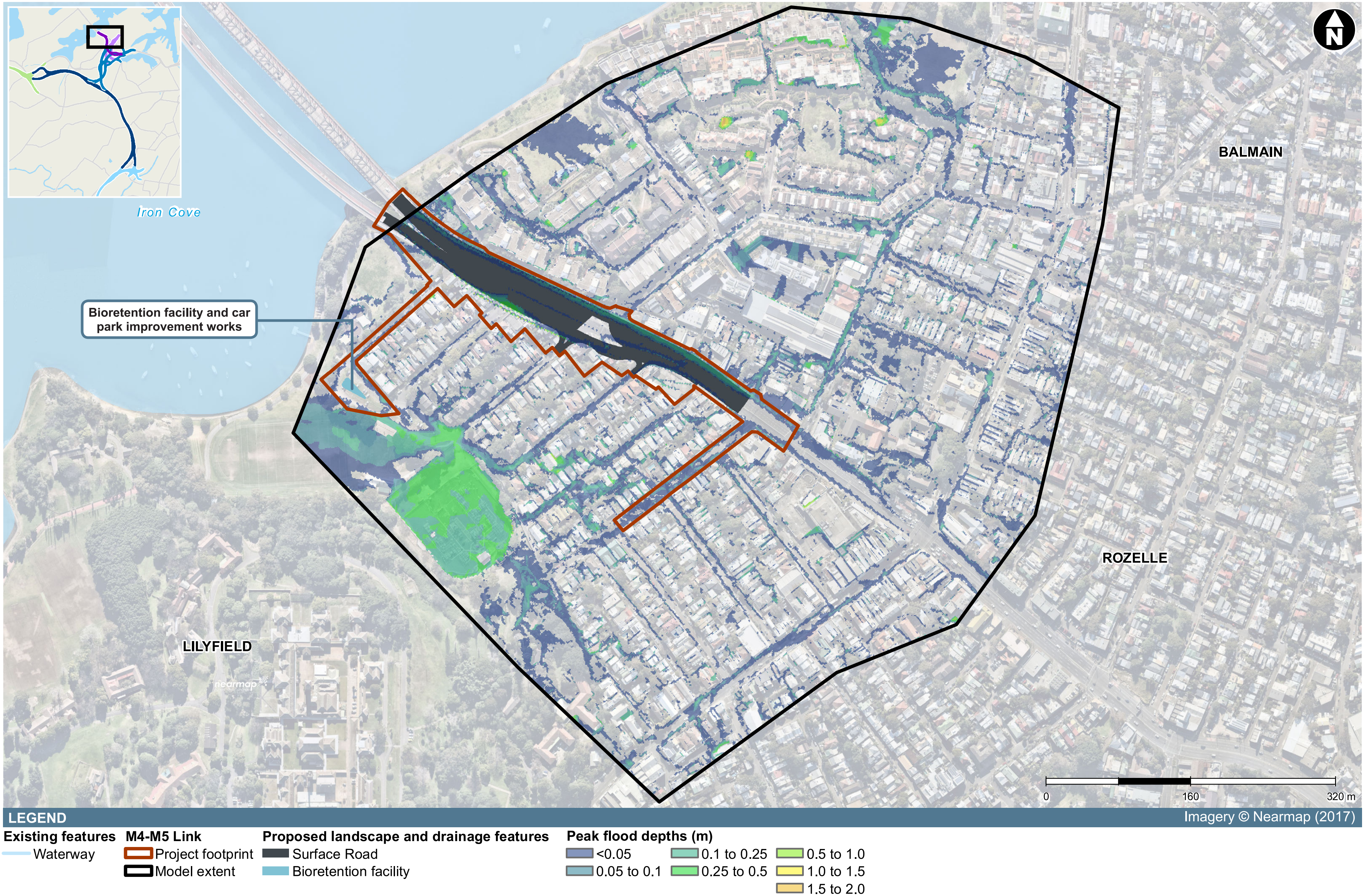

Figure 6-8 Proposed design conditions flood behaviour – Iron Cove Link - peak flood depths (10 year ARI)

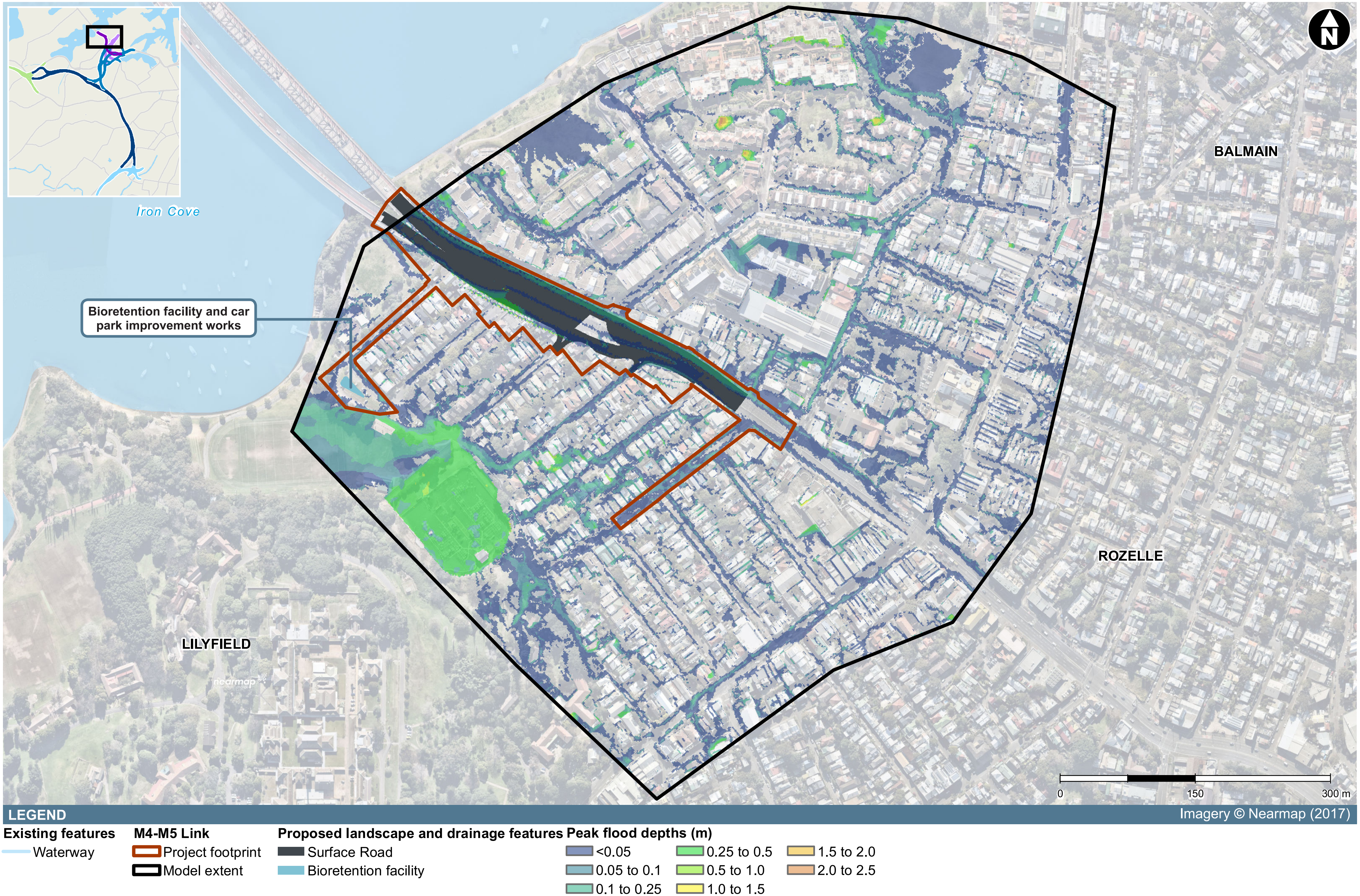

Figure 6-9 Proposed design conditions flood behaviour – Iron Cove Link - peak flood depths (100 year ARI)

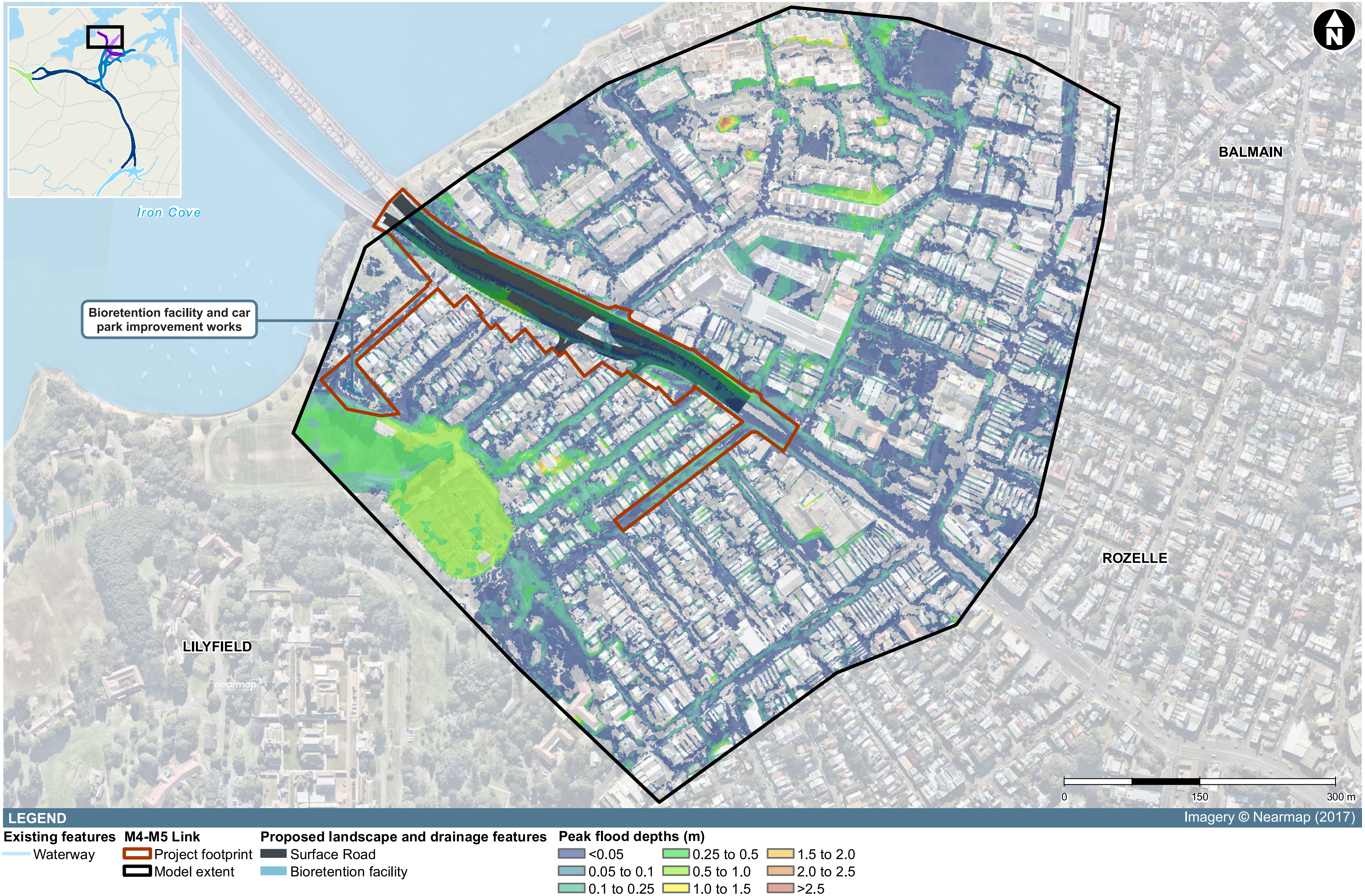

Figure 6-10 Proposed design conditions flood behaviour – Iron Cove Link - peak flood depths (PMF)

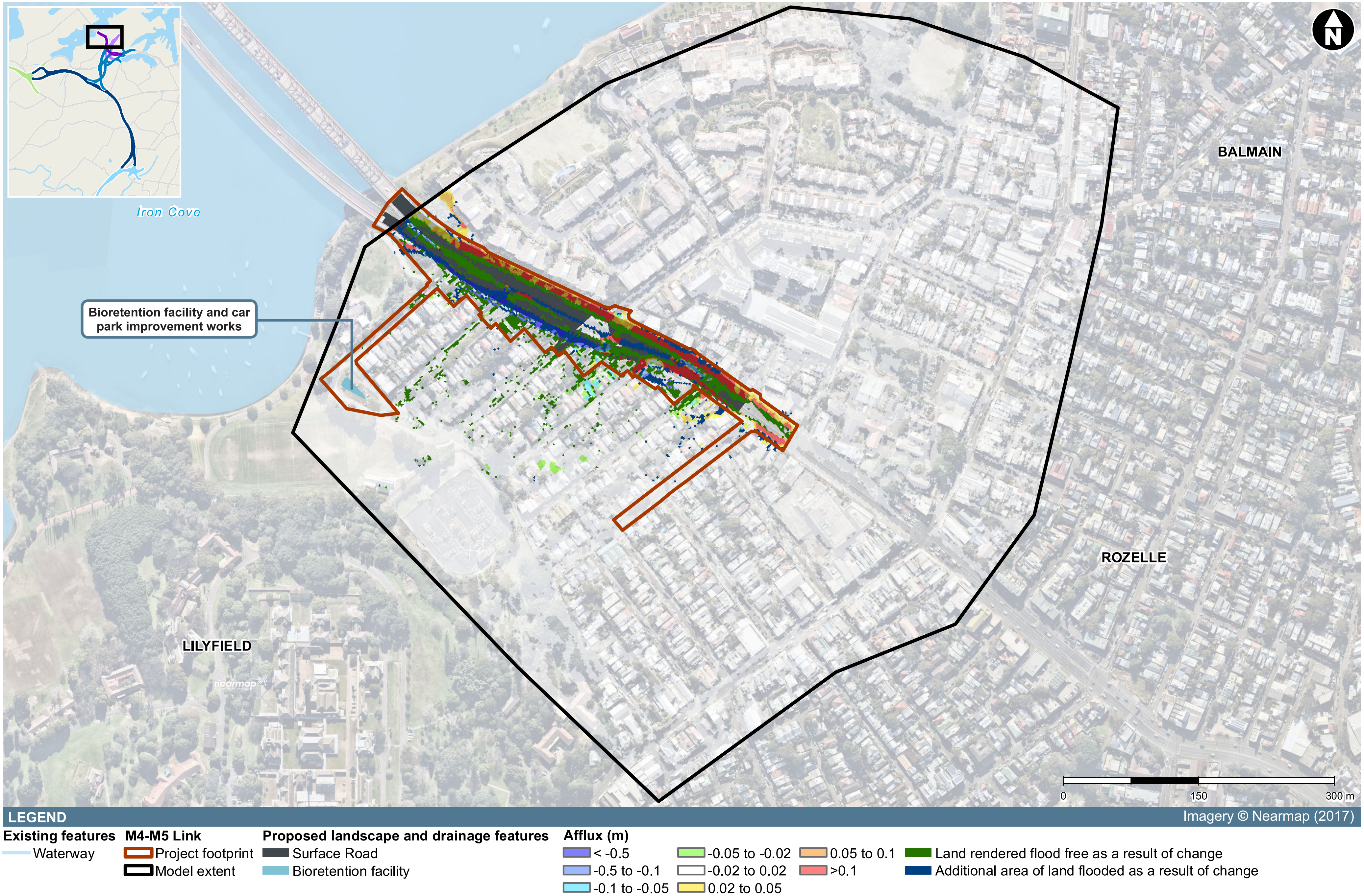

Figure 6-11 Proposed design conditions flood behaviour – Iron Cove Link - relative flood impact (100 year ARI)

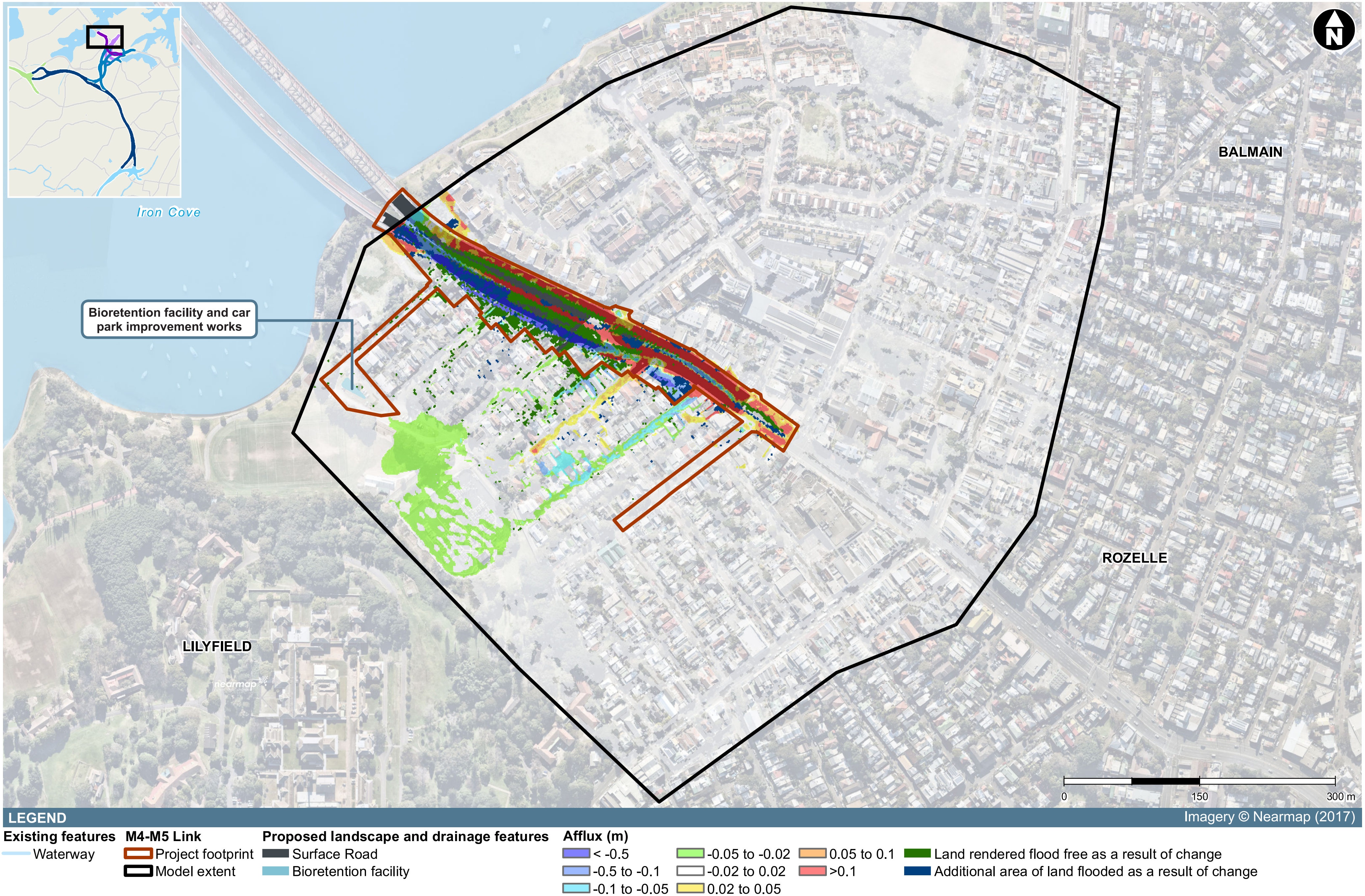

Figure 6-12 Proposed design conditions flood behaviour – Iron Cove Link - relative flood impact (PMF)

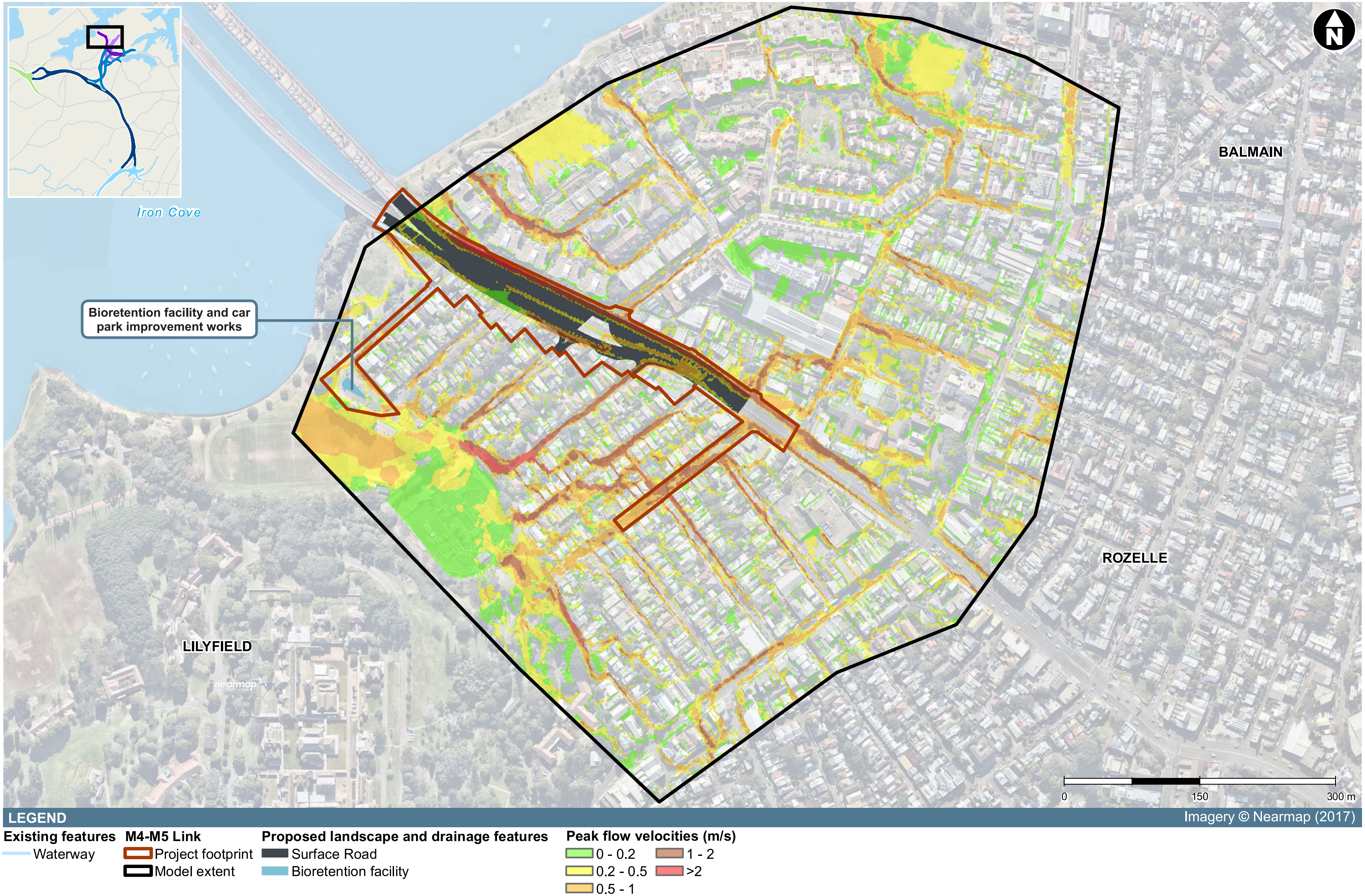

Figure 6-13 Proposed design conditions flood behaviour – Iron Cove Link - peak flow velocities (100 year ARI)

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Existing features
- Waterway

M4-M5 Link
- Project footprint
- Model extent

Proposed landscape and drainage features
- Surface Road
- Bioretention facility

Provisional flood hazard
- High
- Medium
- Low

Figure 6-14 Proposed design conditions flood behaviour – Iron Cove Link - provisional flood hazard (100 year ARI)

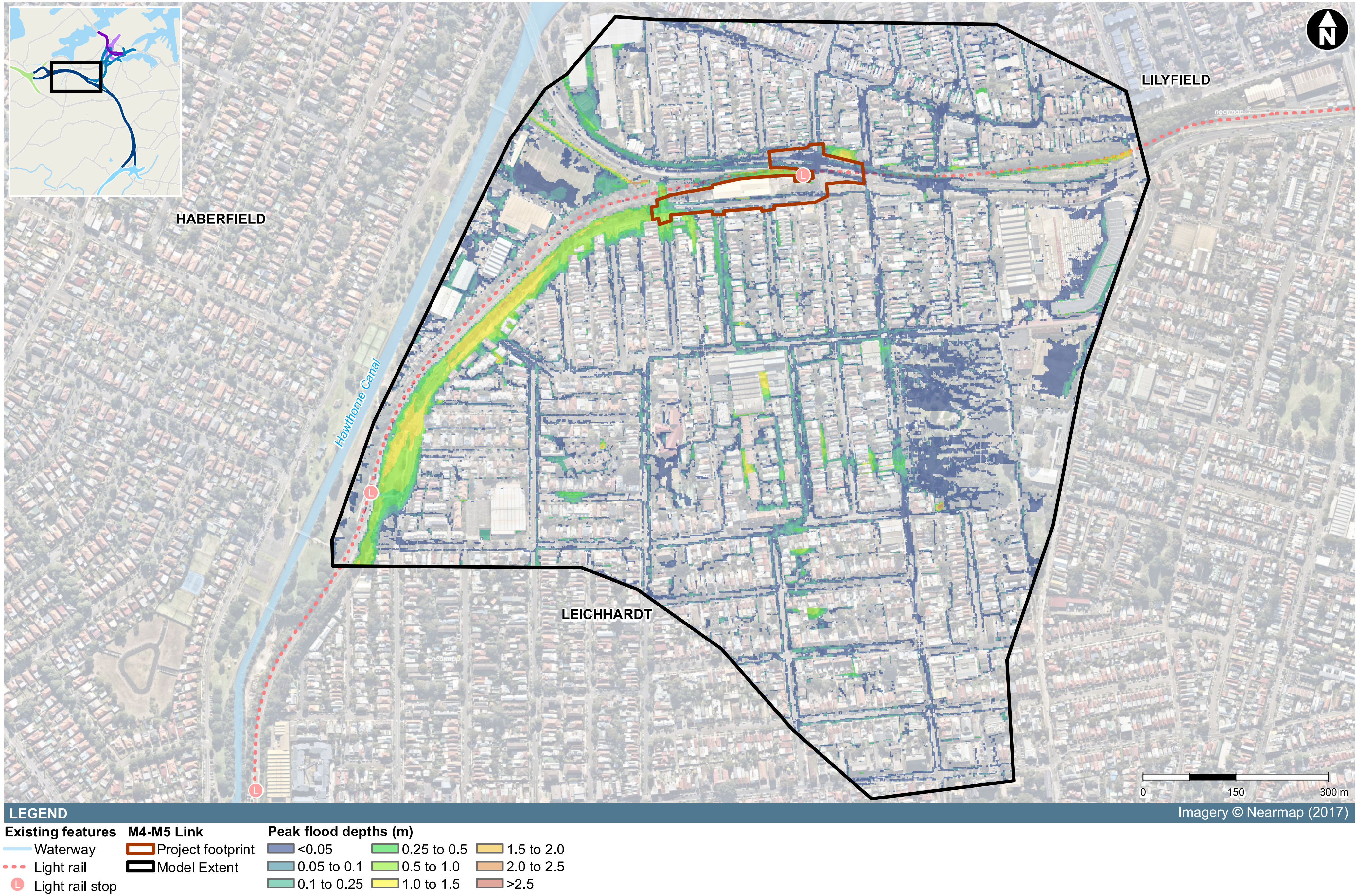


Figure 6-15 Proposed design conditions flood behaviour – Darley Road - peak flood depths (10 year ARI)

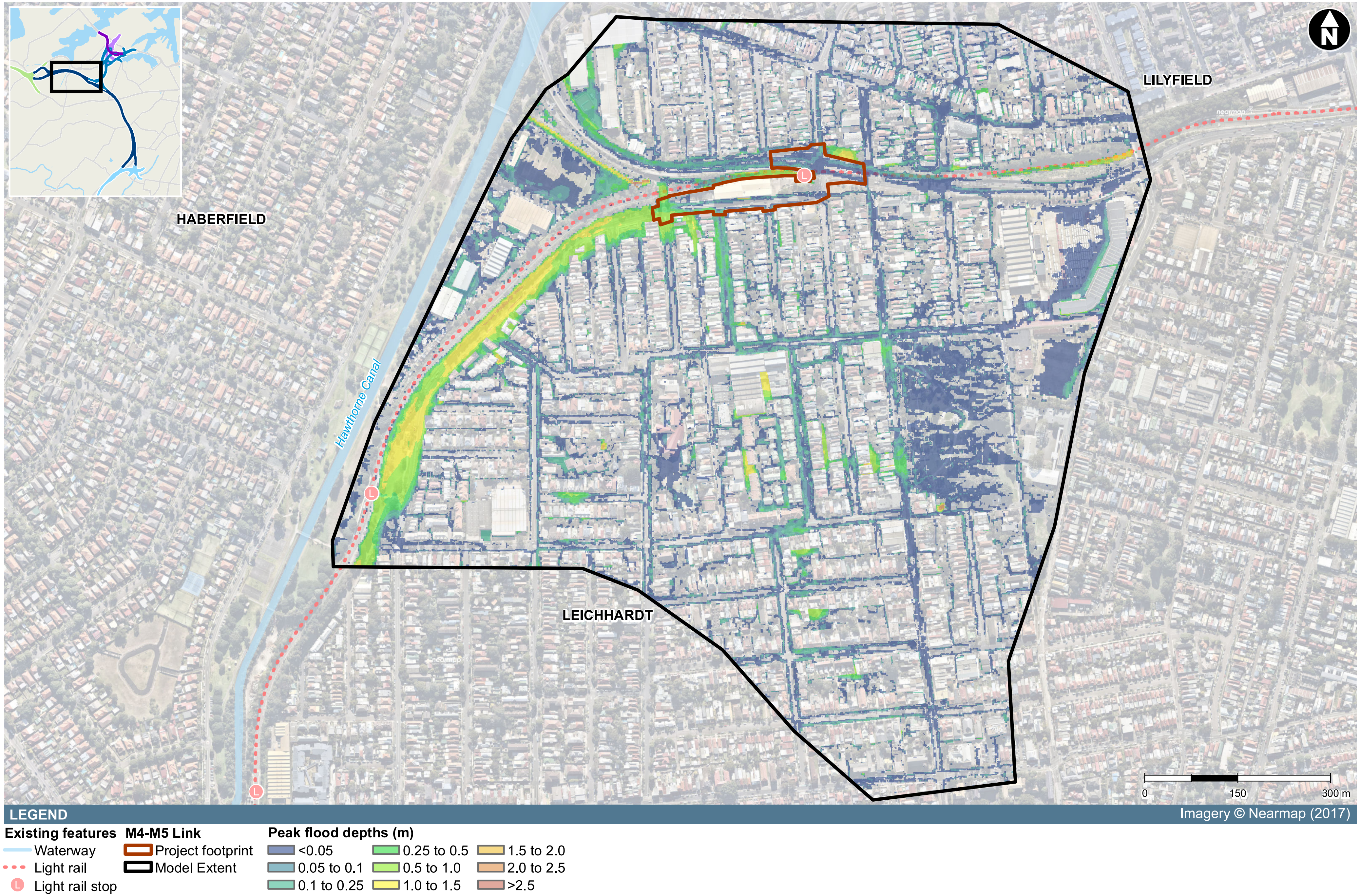
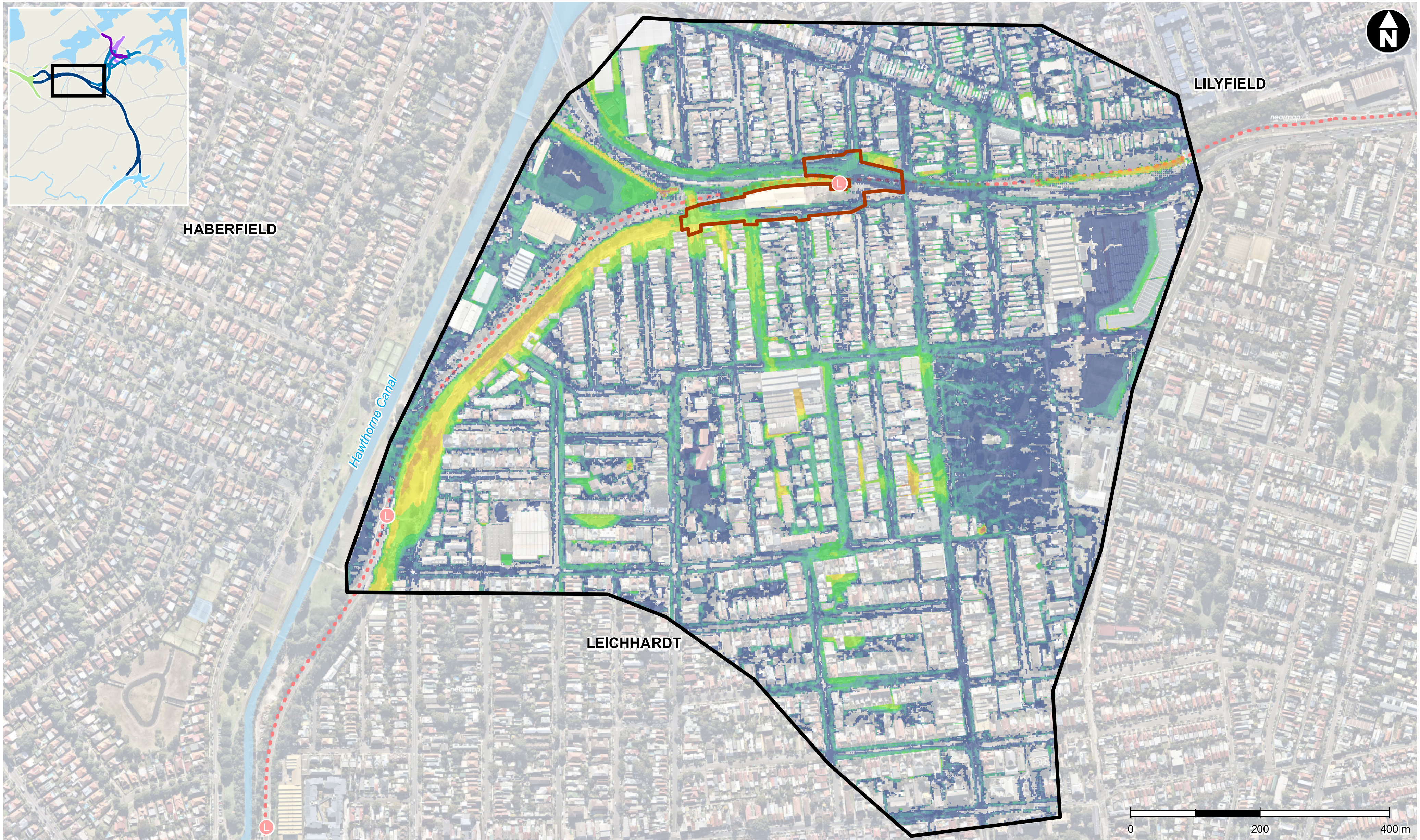


Figure 6-16 Proposed design conditions flood behaviour – Darley Road - peak flood depths (100 year ARI)



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 6-17 Proposed design conditions flood behaviour – Darley Road - peak flood depths (PMF)

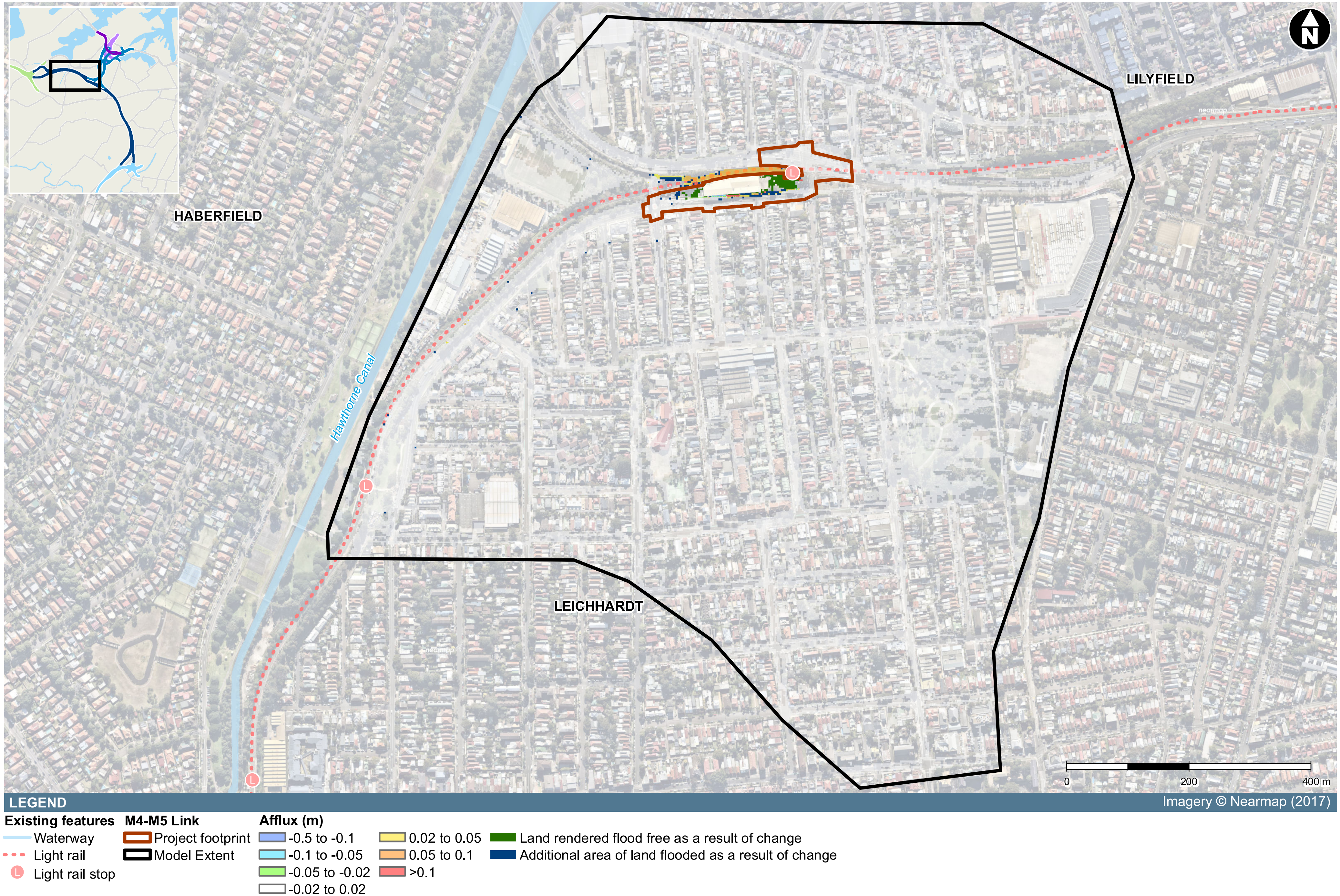
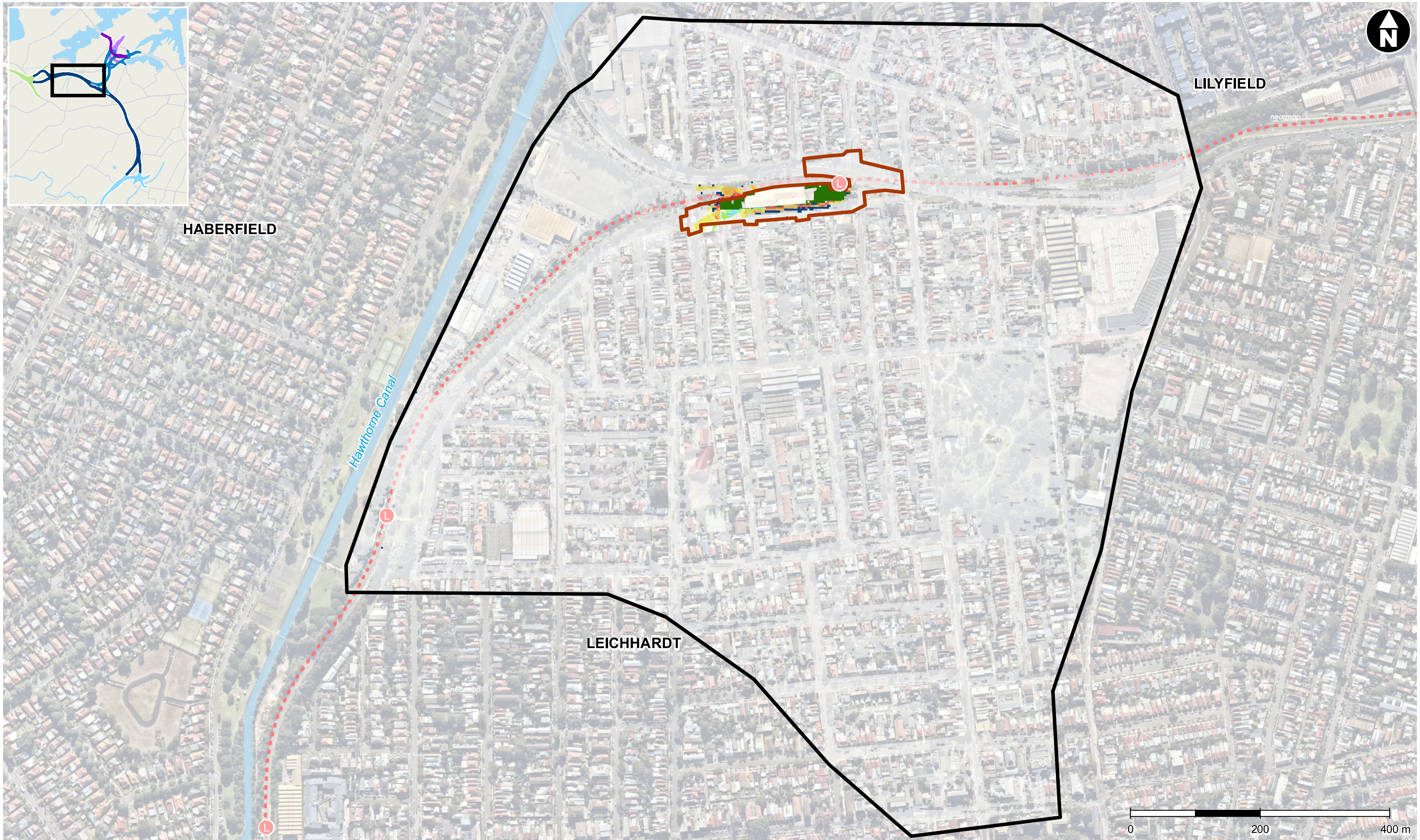


Figure 6-18 Proposed design conditions flood behaviour – Darley Road - relative flood impact (100 year ARI)



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Imagery © Nearmap (2017)

Existing features	M4-M5 Link	Afflux (m)		
Waterway	Project footprint	-0.5 to -0.1	0.02 to 0.05	Land rendered flood free as a result of change
Light rail	Model Extent	-0.1 to -0.05	0.05 to 0.1	Additional area of land flooded as a result of change
Light rail stop		-0.05 to -0.02	>0.1	
		-0.02 to 0.02		

Figure 6-19 Proposed design conditions flood behaviour – Darley Road - relative flood impact (PMF)

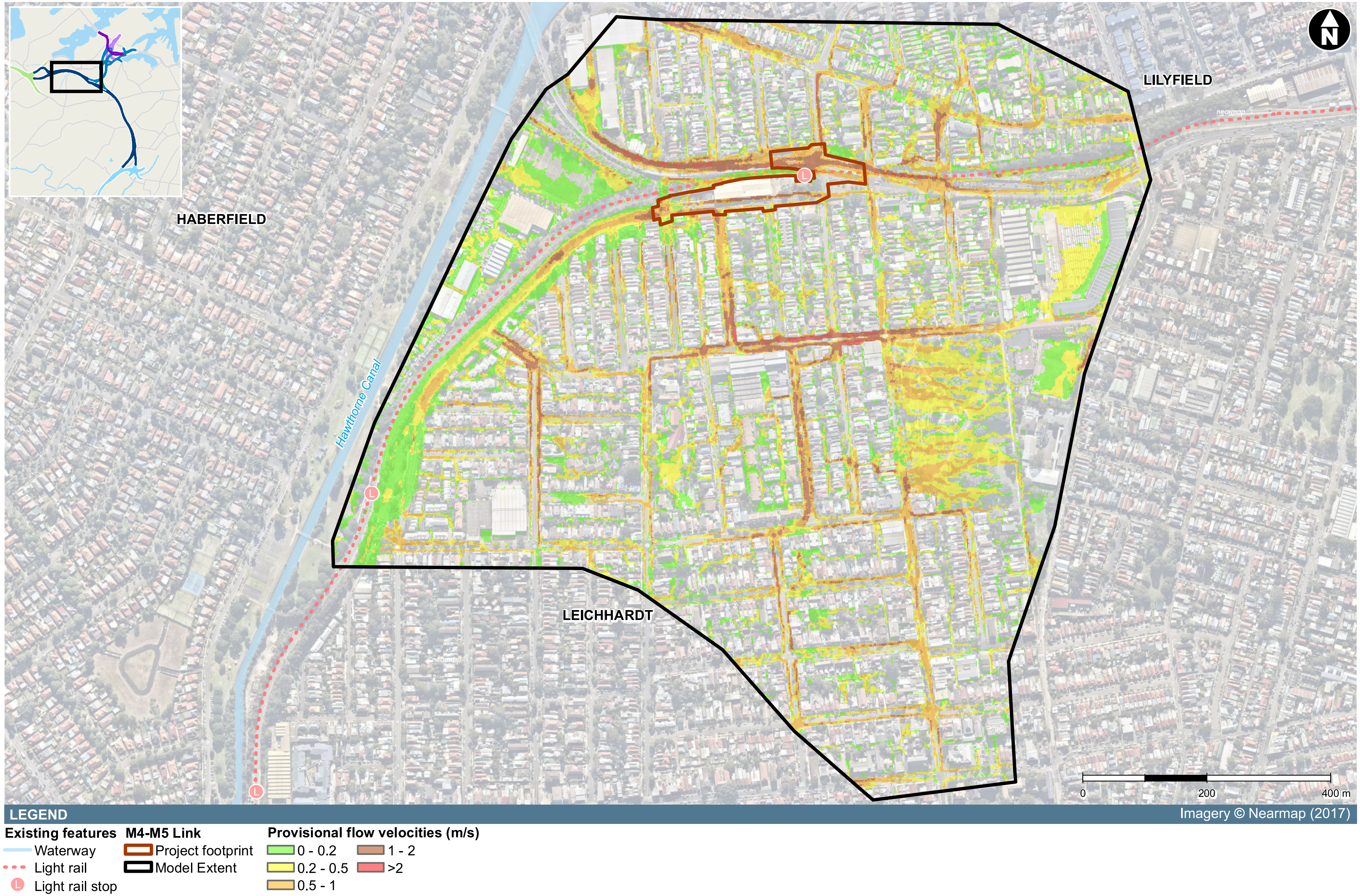

Figure 6-20 Proposed design conditions flood behaviour – Darley Road - peak flow velocities (100 year ARI)

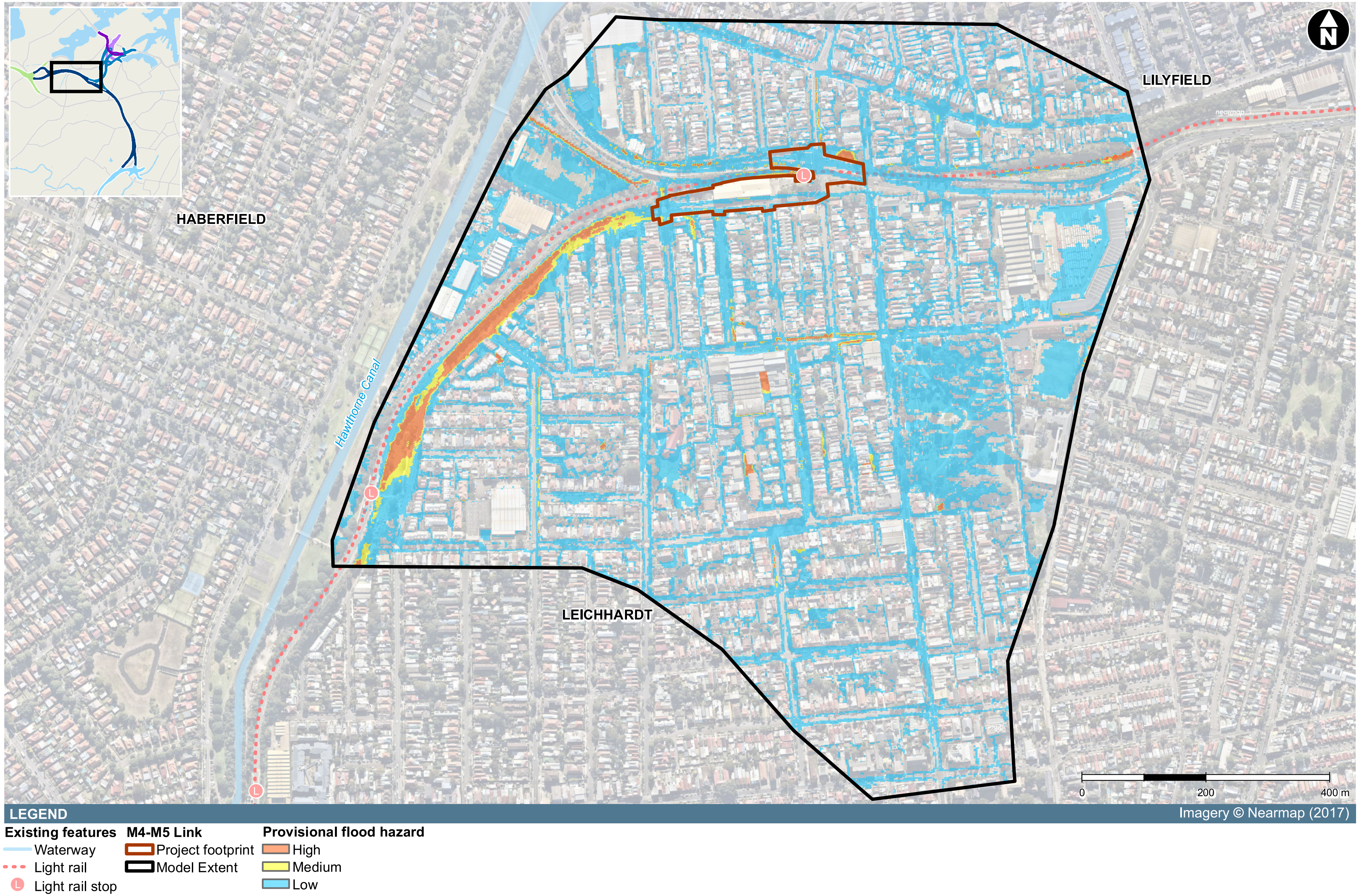

Figure 6-21 Proposed design conditions flood behaviour – Darley Road - provisional flood hazard (100 year ARI)

6.2.2 Potential impacts of future climate change

Future climate change could lead to sea level rise and potential increase in rainfall intensity and frequency. This could affect flood behaviour over the life of the project. An assessment of the potential impact of climate change on flood behaviour in the vicinity of the M4-M5 Link has therefore been undertaken and is discussed below:

- 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 (see **section 3.4.1**). Therefore no additional assessments with regards to climate change are required for these areas
- The Rozelle interchange is located in close proximity to Rozelle Bay and both sea level rise and potential increases in rainfall intensity could affect the flooding in the vicinity of the interchange
- Iron Cove Link is situated at a level that is well above the influence of any sea level rise associated with climate change. Therefore, only the influence of increases in rainfall intensities was considered
- Darley Road is located in proximity to Hawthorne Canal, which will be influenced by sea level rise as well as increased rainfall intensities and frequencies.

Rozelle interchange

Based on the guidelines set out in **section 3.2.8**, 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 **Table 6-2** 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.

Table 6-2 Design flood scenario for assessment of climate change impacts at Rozelle interchange

Scenario	Local catchment flood	Tailwater boundary condition
R1	200 year ARI	2016 High High Water Solstice Springs (HHWSS) peak tide level plus 0.4 m (1.4 m AHD)
R2	500 year ARI	2016 HHWSS peak tide level plus 0.9 m (1.9 m AHD)
R3	500 year ARI	2016 Extreme tide peak storm tide level plus 0.9 m (2.8 m AHD)
R4	PMF(1)	2016 HHWSS peak tide level plus 0.4 m (1.4 m AHD)
R5	PMF(1)	2016 SS peak tide level plus 0.9 m (1.9 m AHD)

Notes:

[1]There are currently no guidelines which quantify the likely increase in probable maximum precipitation (PMP) associated with future climate change. By its definition, the PMP is the result of the optimum combination of the available moisture in the atmosphere and the efficiency of the storm mechanism in regards to rainfall production. On this basis no adjustment has been made to the PMP rainfall intensities for future climate change.

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 **Table 6-3**. Potential impacts are as follows:

- Potential increases in rainfall intensities by up to 10 per cent would lead to flood level increases of approximately 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

- 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, in particular 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 **Figure 6-22** and **Figure 6-23**.

Table 6-3 Summary of peak flood levels – 2016 and future climate change conditions for the Rozelle interchange

Location	100 year ARI							PMF				
	2016 Conditions	Scenario R1		Scenario R2		Scenario R3		2016 Conditions	Scenario R4		Scenario R5	
	Level (m AHD)	Level (m AHD)	Change (m)	Level (m AHD)	Change (m)	Level (m AHD)	Change (m)	Level (m AHD)	Level (m AHD)	Change (m)	Level (m AHD)	Change (m)
The Crescent bridge at Whites Creek	2.75	2.90	+0.16	3.10	+0.35	3.40	+0.66	5.07	5.07	+0.0	5.08	+0.10
Western channel	2.33	2.41	+0.08	3.53	+0.19	3.04	+0.71	3.33	3.64	+0.03	3.67	+0.06
New culverts at City West Link	2.09	2.20	+0.11	2.36	+0.27	3.00	+0.91	3.61	3.36	+0.04	3.41	+0.08
CBD and South East Light Rail site	5.91	5.91	+0.0	5.91	+0.01	5.91	+0.01	6.09	6.09	0.00	6.09	0.00

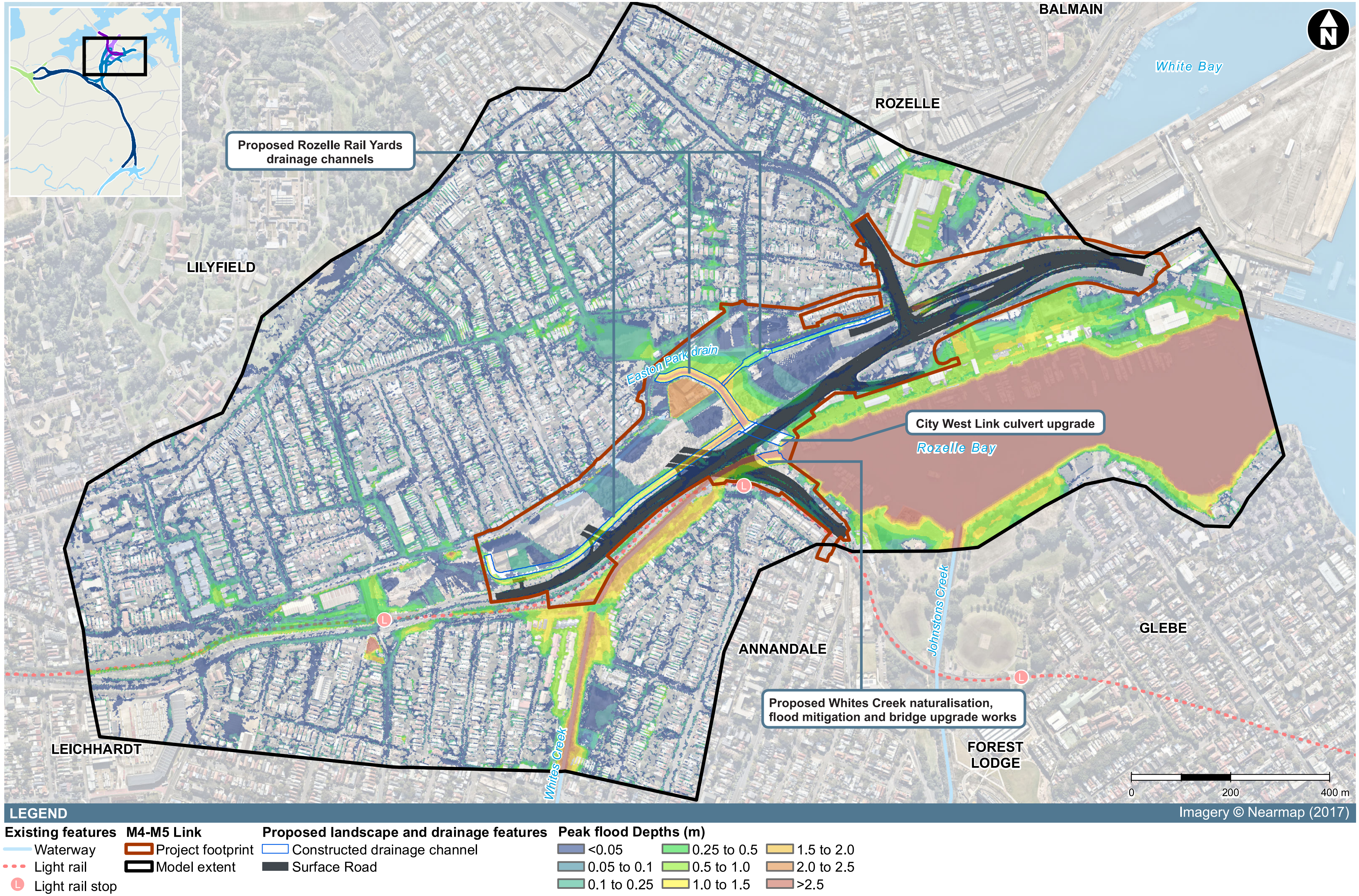

Figure 6-22 Potential climate change impact – Rozelle interchange - peak flood depths (100 year ARI)

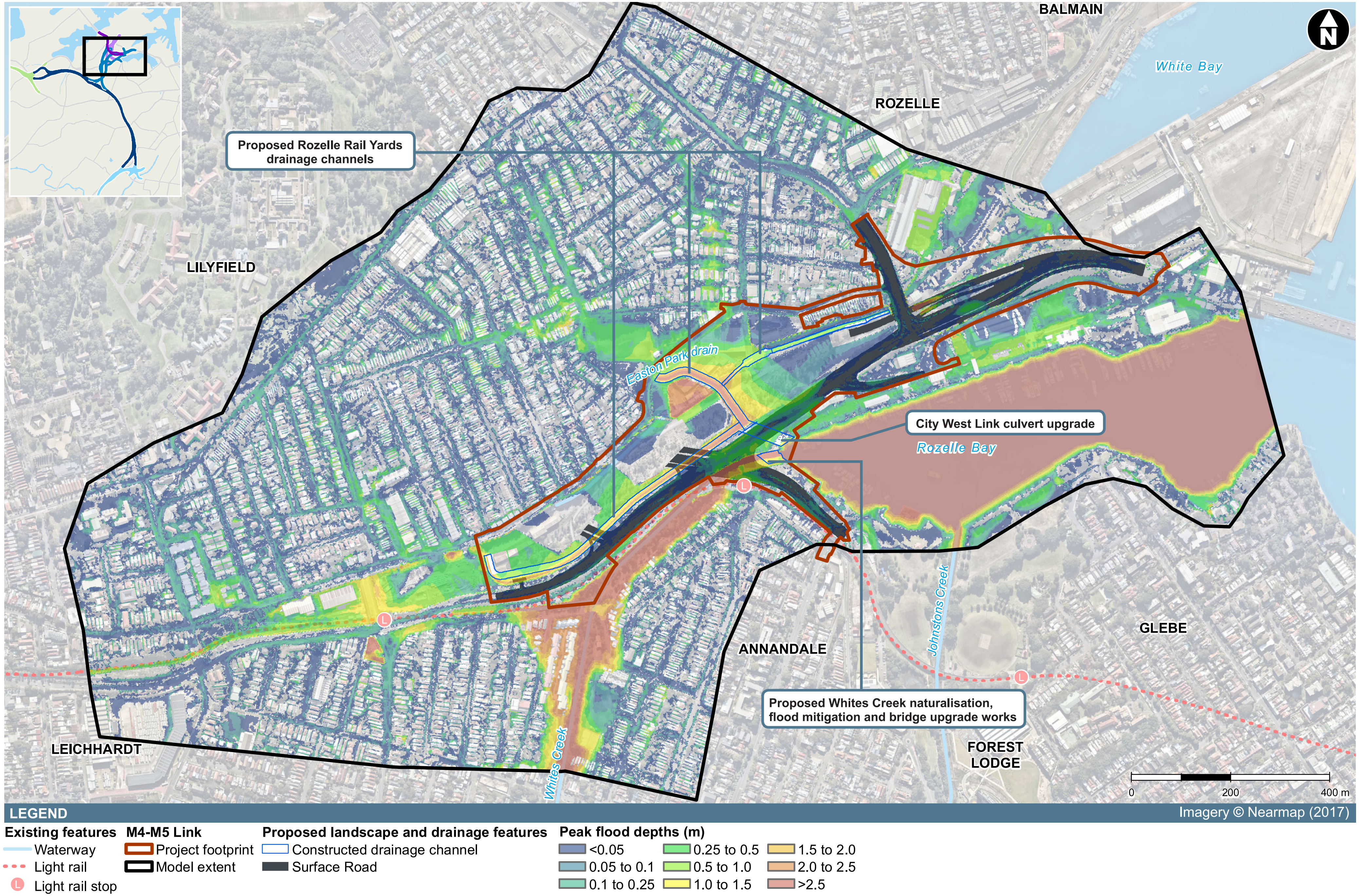

Figure 6-23 Potential climate change impact – Rozelle interchange - peak flood depths (PMF)

Iron Cove Link

The climate change assessment at Iron Cove involved determining the potential influence on flood levels as a consequence of higher rainfall intensity. 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 (see **Table 6-4**). Along roads and other areas with reasonable hydraulic gradients and shallow depths the increase in flood level would only be between 0.01 and 0.05 metres.

Flood behaviour with potential increases in rainfall intensities and sea level rise in a 100 year ARI and PMF events are shown in **Figure 6-24** and **Figure 6-25**.

Table 6-4 Summary of peak flood levels – 2016 and future climate change conditions at Iron Cove Link

Location	100 year ARI	200 year ARI		500 year ARI	
	Level (m AHD)	Level (m AHD)	Difference (m)	Level (m AHD)	Difference (m)
Victoria Road near Iron Cove Bridge	17.86	17.89	+0.03	17.90	+0.04
Victoria Road near Crystal Street	25.72	25.73	+0.01	25.74	+0.02
Manning Street	3.61	3.63	+0.02	3.66	+0.05
Victoria Road near Callan Street	23.72	23.73	+0.01	23.75	+0.03
King George Park	3.15	3.17	+0.02	3.19	+0.04

Darley Road

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 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 (see **Table 6-5**). Along roads and other areas with reasonable hydraulic gradients and shallow depths the increase in flood level would only be between 0.01 and 0.05 metres. In ponding areas flood levels could rise up to 0.16 metres under future climate conditions.

Flood behaviour with potential increases in rainfall intensities and sea level rise in a 100 year ARI and PMF events are shown in **Figure 6-26** and **Figure 6-27**.

Table 6-5 Summary of peak flood levels – 2016 and future climate change conditions at Darley Road

Location	100 year ARI	200 year ARI		500 year ARI	
	Level (m AHD)	Level (m AHD)	Difference (m)	Level (m AHD)	Difference (m)
Leichhardt North light rail stop	8.20	8.22	+0.02	8.25	+0.05
Darley Road near Charles Street	3.29	3.32	+0.03	3.45	+0.16
Darley Road near James Street	14.59	14.59	+0.0	14.59	+0.0

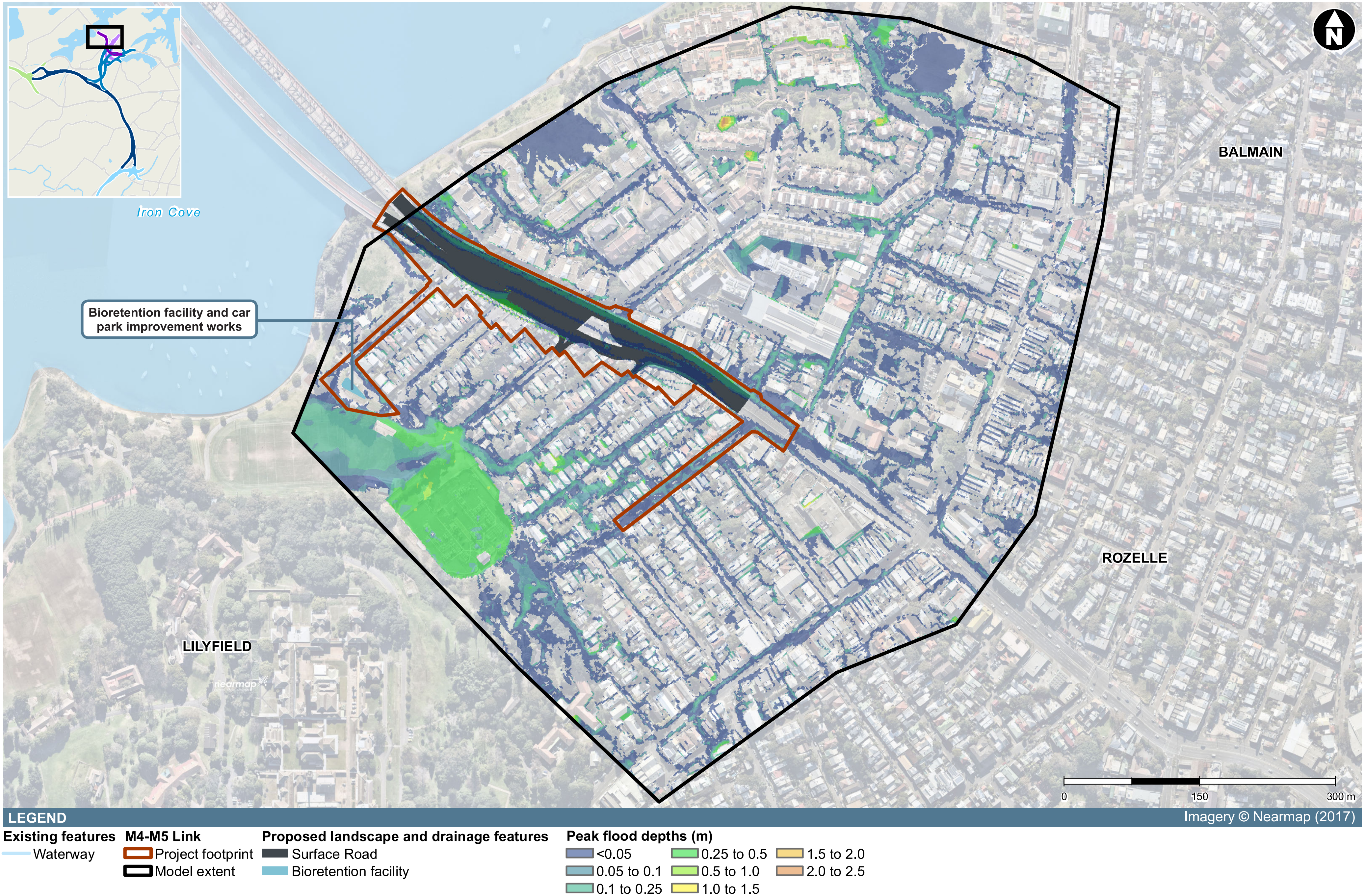

Figure 6-24 Potential climate change impact – Iron Cove Link - peak flood depths (100 year ARI)

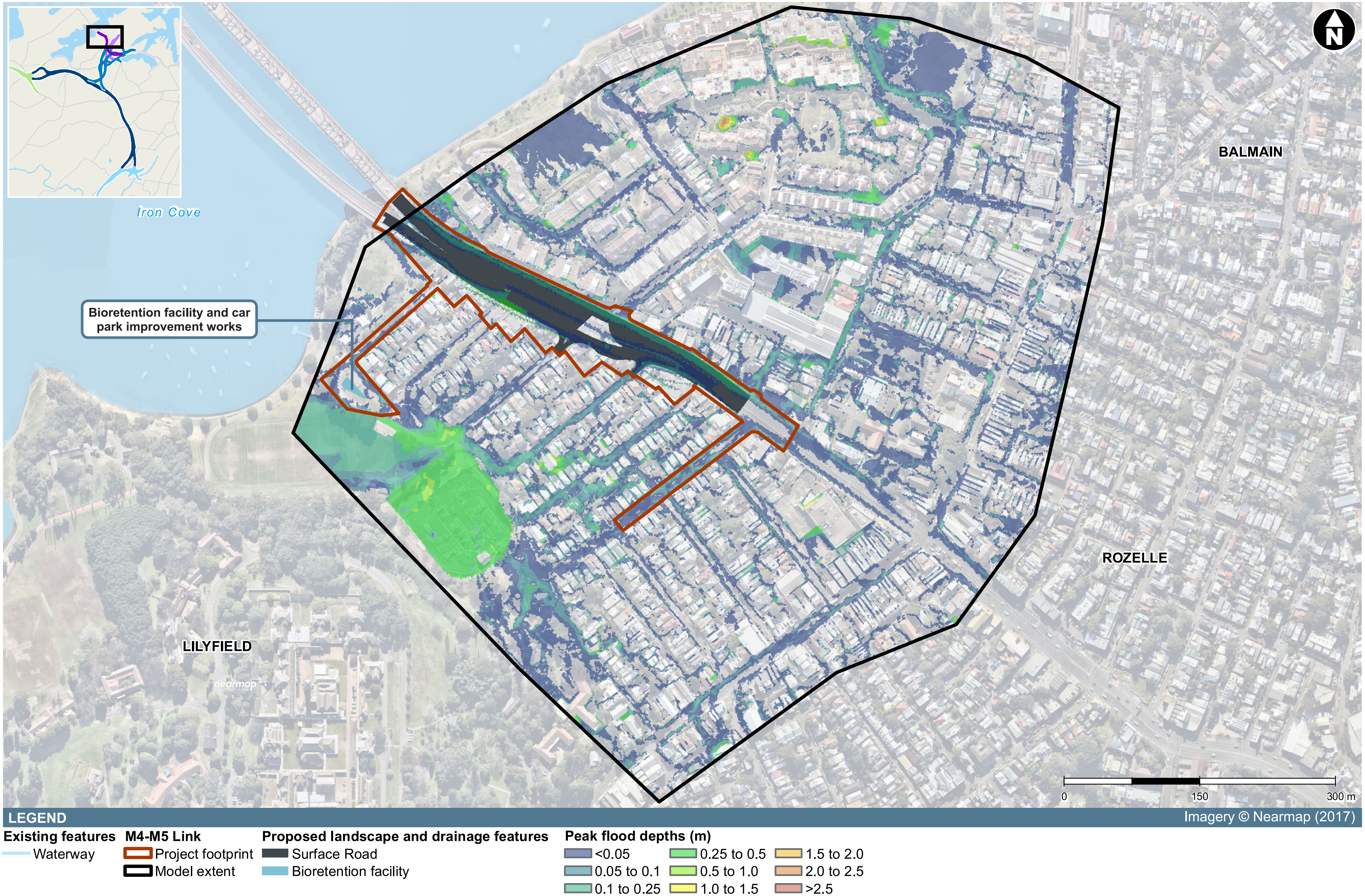

Figure 6-25 Potential climate change impact – Iron Cove Link - peak flood depths (PMF)

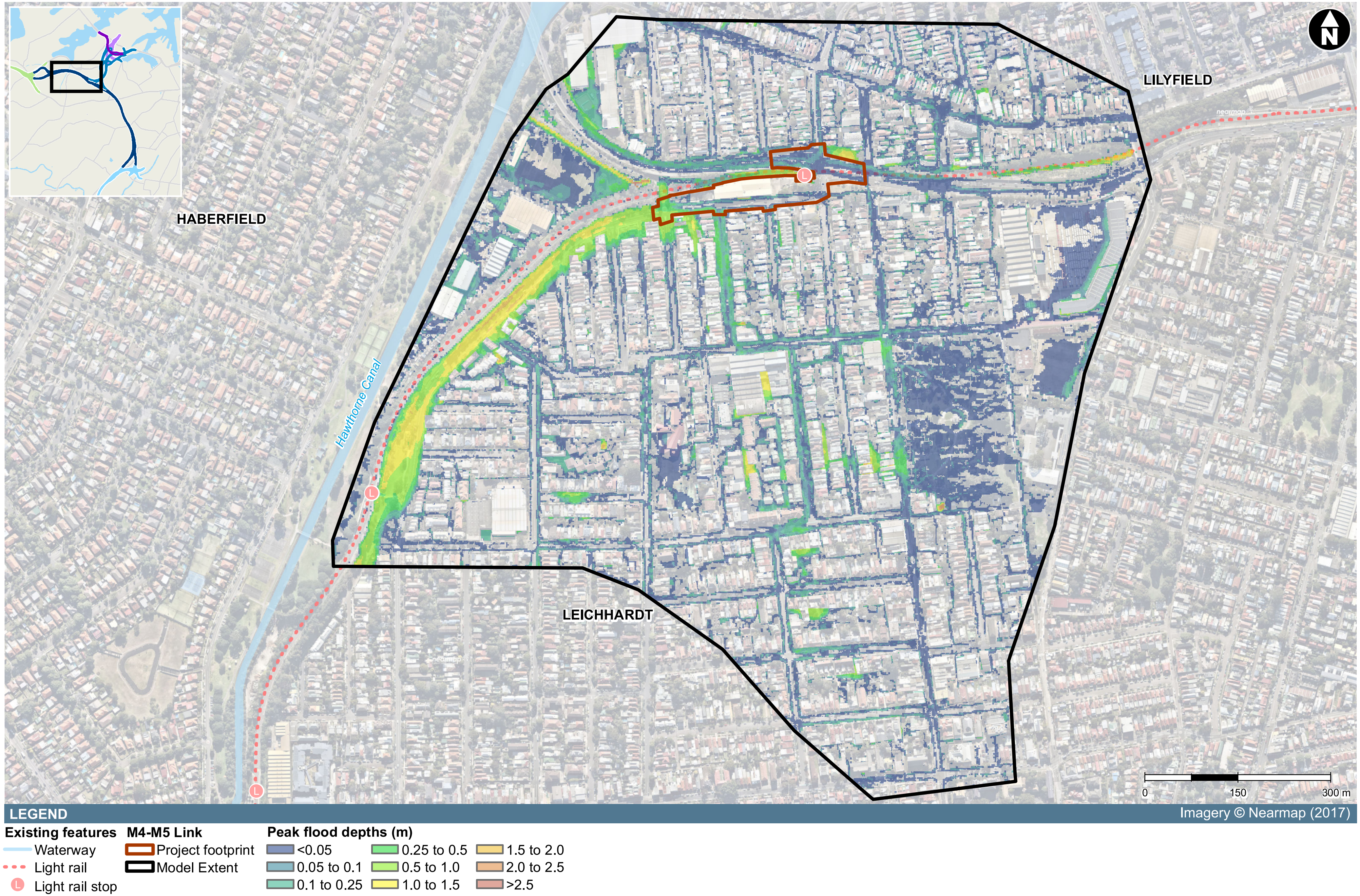

Figure 6-26 Potential climate change impact – Darley Road - peak flood depths (100 year ARI)

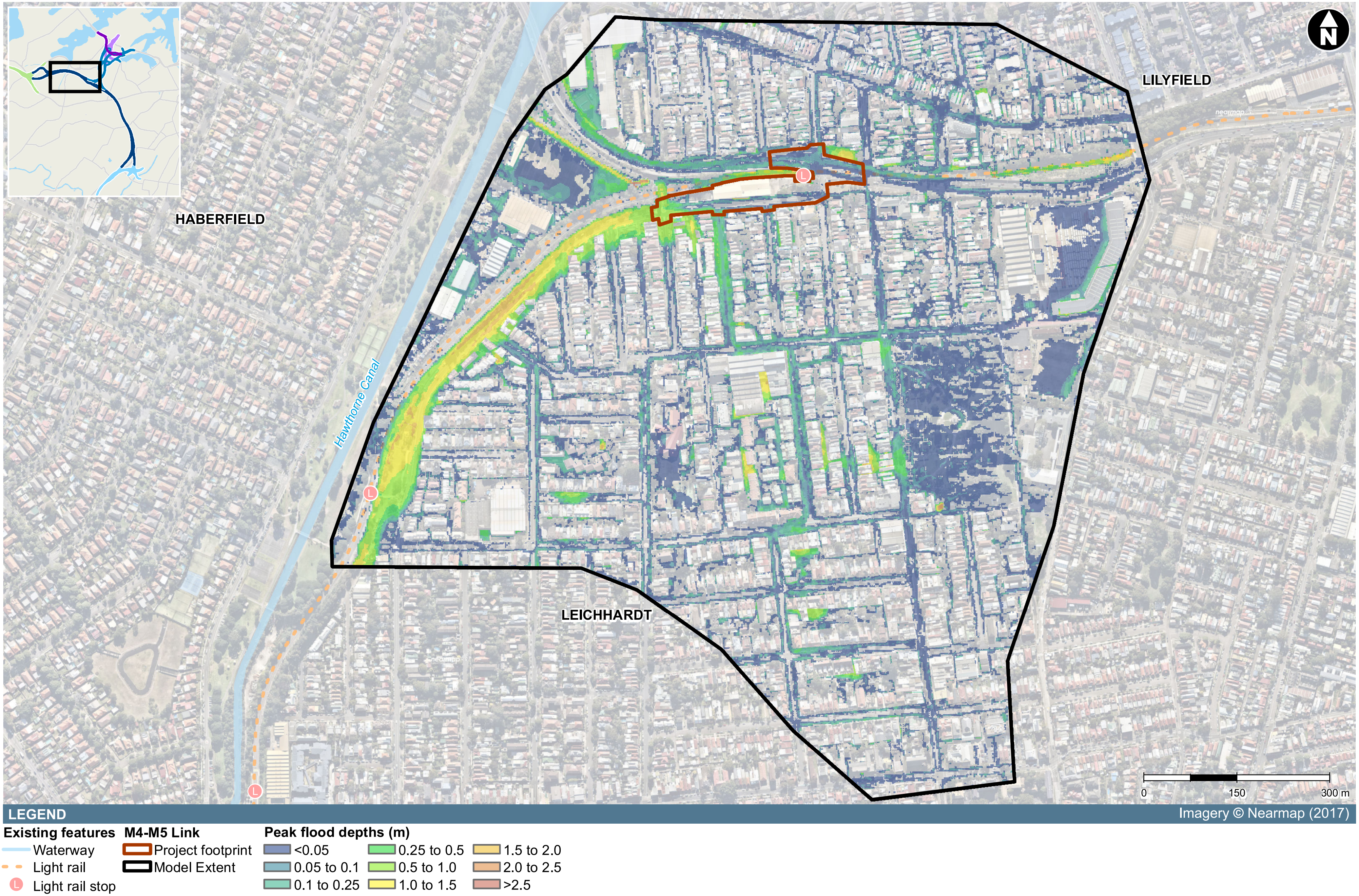

Figure 6-27 Potential climate change impact – Darley Road - peak flood depths (PMF)

6.2.3 Impact on existing drainage infrastructure

There is limited existing drainage infrastructure at many of the sites associated with the M4-M5 Link project 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 into 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.

6.2.4 Surface water balance

Stormwater runoff volumes generated within the project footprint would be increased as a result of an increase in impervious surfaces associated with surface road widenings, ramps and ancillary surface infrastructure. The change in effective impervious area, (see **section 3.4.3**) is provided in **Table 6-6**. The footprint included within the modelling is shown in **Annexure C**.

MUSIC modelling was undertaken to estimate changes in annual stormwater runoff volume to receiving waterways as a result of the project. The MUSIC modelling methodology is described in **section 3.4.3** (note that proposed public open space areas were not included within the modelling) and the impacts on annual runoff volume are provided in **Table 6-7**. A comparison of the stormwater discharges for the existing and post development scenarios is provided for each waterway in **Figure 6-28** to **Figure 6-32**.

The results indicate that annual runoff volumes would be increased as a result of the project with increases occurring to Rozelle Bay, Dobroyd Canal, White Bay and Whites Creek. A slight decrease in runoff volume would occur to Iron Cove as a result of the additional losses at the bioretention basin.

Design refinements made at The Crescent after MUSIC modelling was completed for this assessment would slightly increase the impervious area of the project. This very small increase would not significantly change the effective impervious area or water balance calculated for the project.

Table 6-6 MUSIC modelling - change in effective impervious area

Catchment	Total catchment area (ha)	Existing effective impervious area (ha)	Proposed effective impervious area (ha)	Increase (ha)
Total Project	11.2	8.4	11.2	2.8
Rozelle Bay	8.1	6.0	8.1	2.1
Iron Cove	1.9	1.8	1.9	0.1
White Bay	0.3	0.1	0.2	0.2
Whites Creek	0.5	0.2	0.3	0.3
Dobroyd Canal	0.4	0.3	0.1	0.1

Table 6-7 Mean annual runoff volume

Catchment	Existing conditions flow (ML/year)	Proposed conditions flow (ML/year)	Change (ML/year)
Total Project	125	145	20
Rozelle Bay	91.8	111	19.2
Iron Cove	20.8	20.7	-0.1
White Bay	3	3.2	0.2
Whites Creek	5.0	5.3	0.3
Dobroyd Canal	3.9	4.6	0.8

Treated tunnel water flows from the operational water treatment plants at Darley Road and at Rozelle would ultimately discharge to Hawthorne Canal and Rozelle Bay respectively, leading to an increase in base flow rate to those waterways. Indicative flow rates are provided in **section 2.4.2** for the respective tunnel waste water streams. Up to around 725 megalitres per year and 693 megalitres per year of treated groundwater would be discharged to Hawthorne Canal and Rozelle Bay respectively. Up to around 50 megalitres per year of tunnel drainage from approximately one kilometre of the northbound and 600 metres 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 based on the MUSIC modelling and incorporating treated tunnel water discharges is provided in **Table 6-8**.

The project would result in a negligible impact on the frequency and duration of stormwater discharges to Iron Cove, White Bay, Whites Creek and Dobroyd Canal. Discharges from the project footprint would be continuous to Rozelle Bay and Hawthorne Canal as a result of the treated tunnel water discharges.

The flow variability within the receiving waterways is dominated by tides at the discharge locations. Therefore the minor increases in storm flow within Rozelle Bay and White Bay and increase in base flow to Hawthorne Canal and Rozelle Bay would pose a negligible impact on the natural flow variability, environmental water availability or natural processes of the waterways. As detailed in **section 4.2**, given the waterways are hard lined, increased discharge volumes would not impact on bank stability of the waterways. Potential bed scour impacts are discussed in **section 6.3.4**.

The impacts associated with discharges from the Arncliffe operational water treatment plant were assessed as part of the New M5 EIS. The additional tunnel drainage flow (around 1.6 litres per second) associated with the M4-M5 Link would be negligible compared to flows within the Cooks River therefore 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.

Table 6-8 Surface water balance – post development

Catchment	Rainfall (ML / year)	Evapotranspiration (ML / year)	Infiltration (ML / year)	Water use (ML / year)	Stormwater discharge (ML / year)	Treated tunnel water discharge (ML / year)	Total discharge volume (ML / year)
Total Project	171.4	26.4	0	0	145	0	145
Rozelle Bay	132.2	21.2	0	0	111	725	836
Iron Cove	24.3	3.6	0	0	20.7	0	20.7
White Bay	3.7	0.5	0	0	3.2	0	3.2
Whites Creek	6.0	0.7	0	0	5.3	0	5.3
Dobroyd Canal	5.2	0.6	0	0	4.6	0	4.6
Hawthorne Canal	0	0	0	0	0	693	693

Note: See **section 3.4.3** for MUSIC modelling assumptions. It is noted that proposed public open space areas at Rozelle were not included within the MUSIC modelling

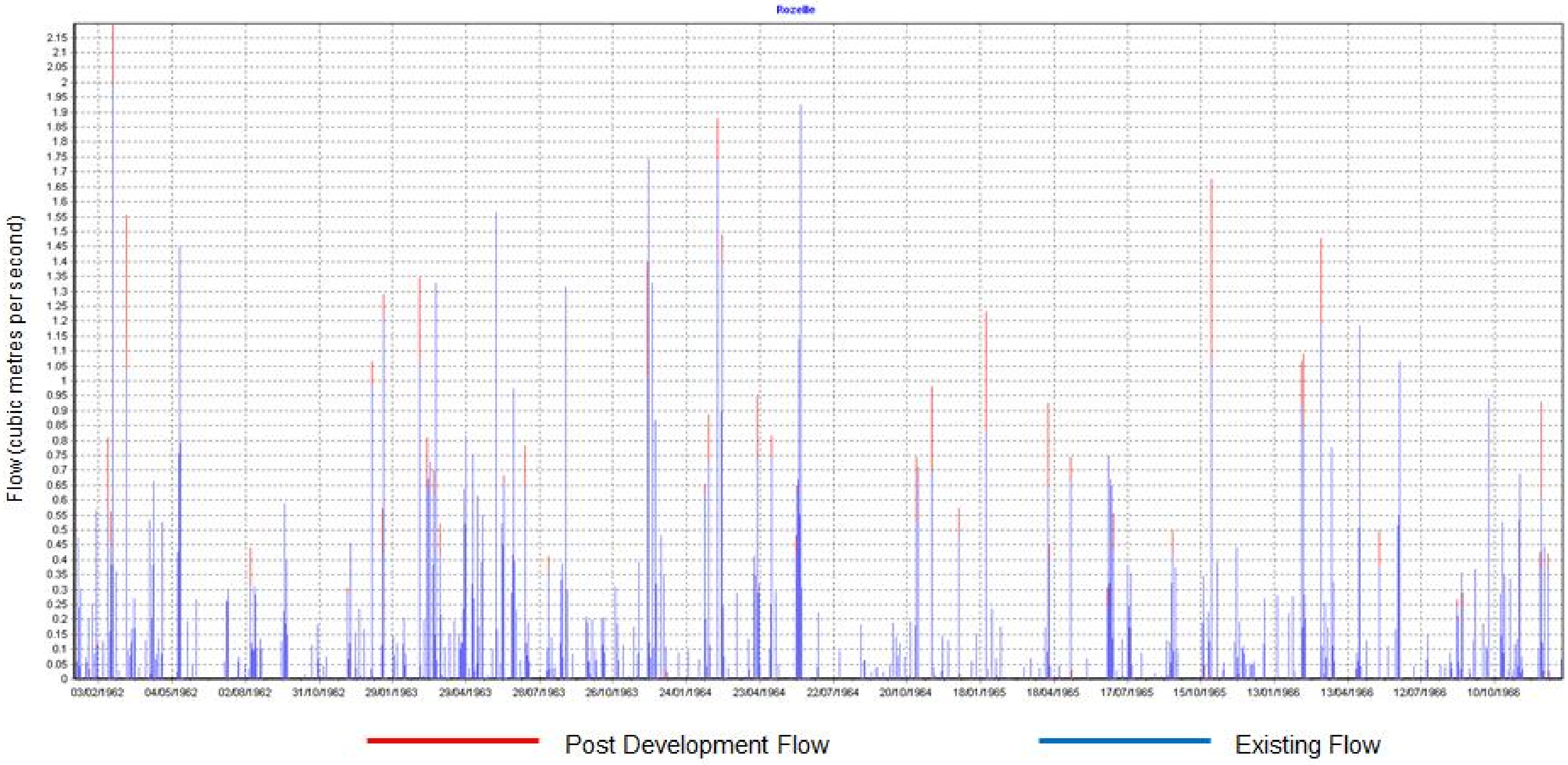

Figure 6-28 Stormwater discharges to Rozelle Bay

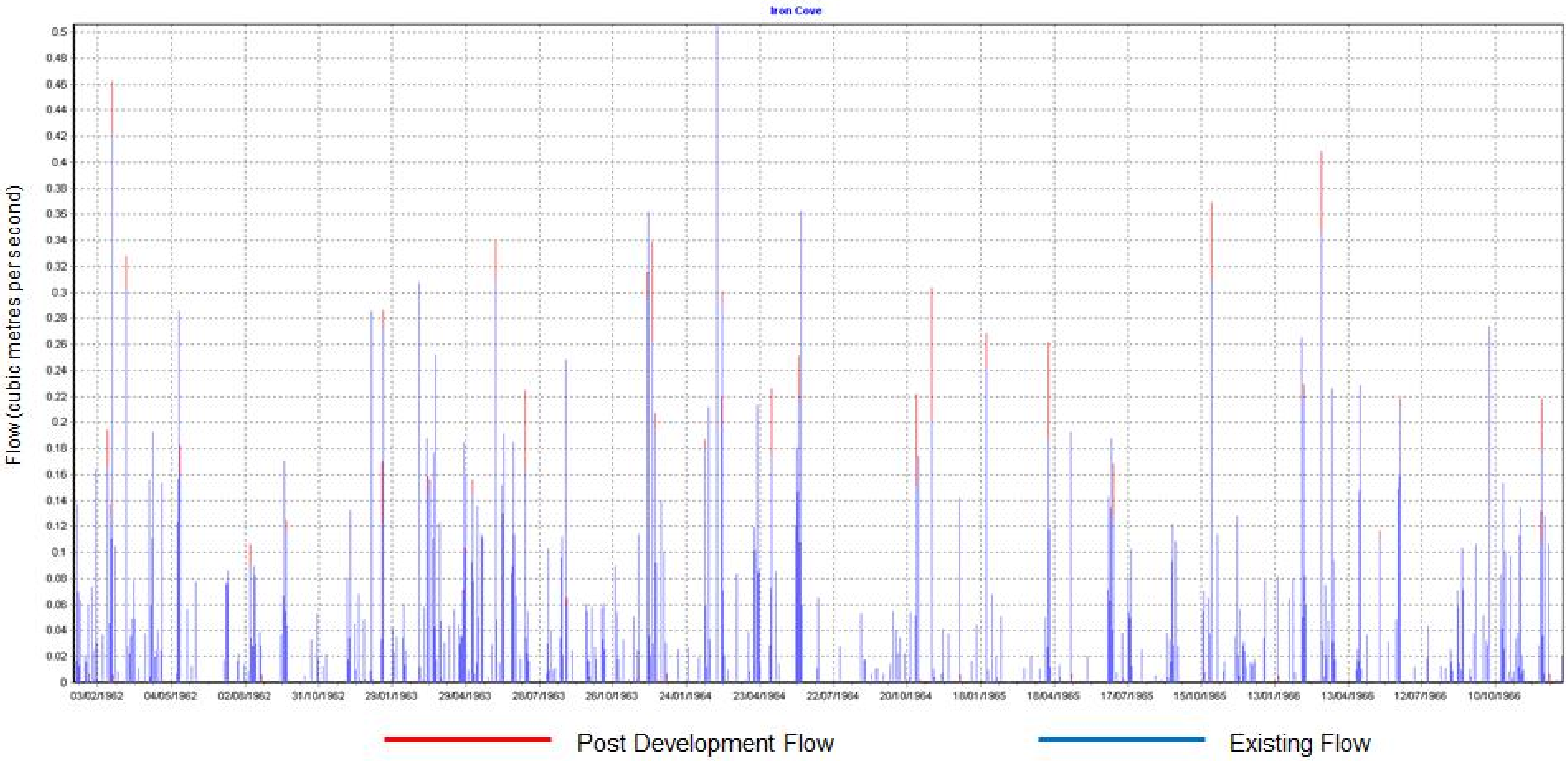

Figure 6-29 Stormwater discharges to Iron Cove

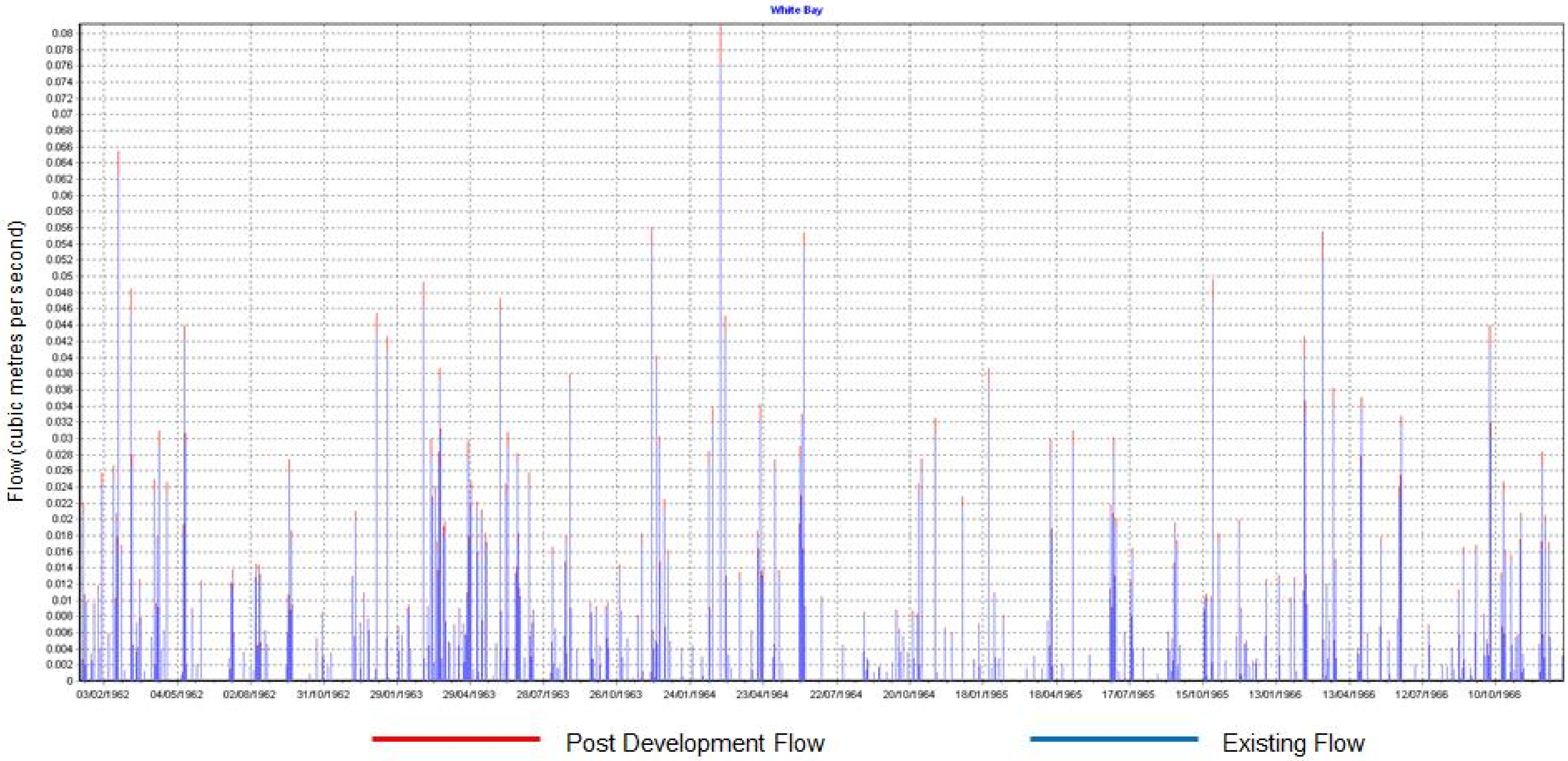

Figure 6-30 Stormwater discharges to White Bay

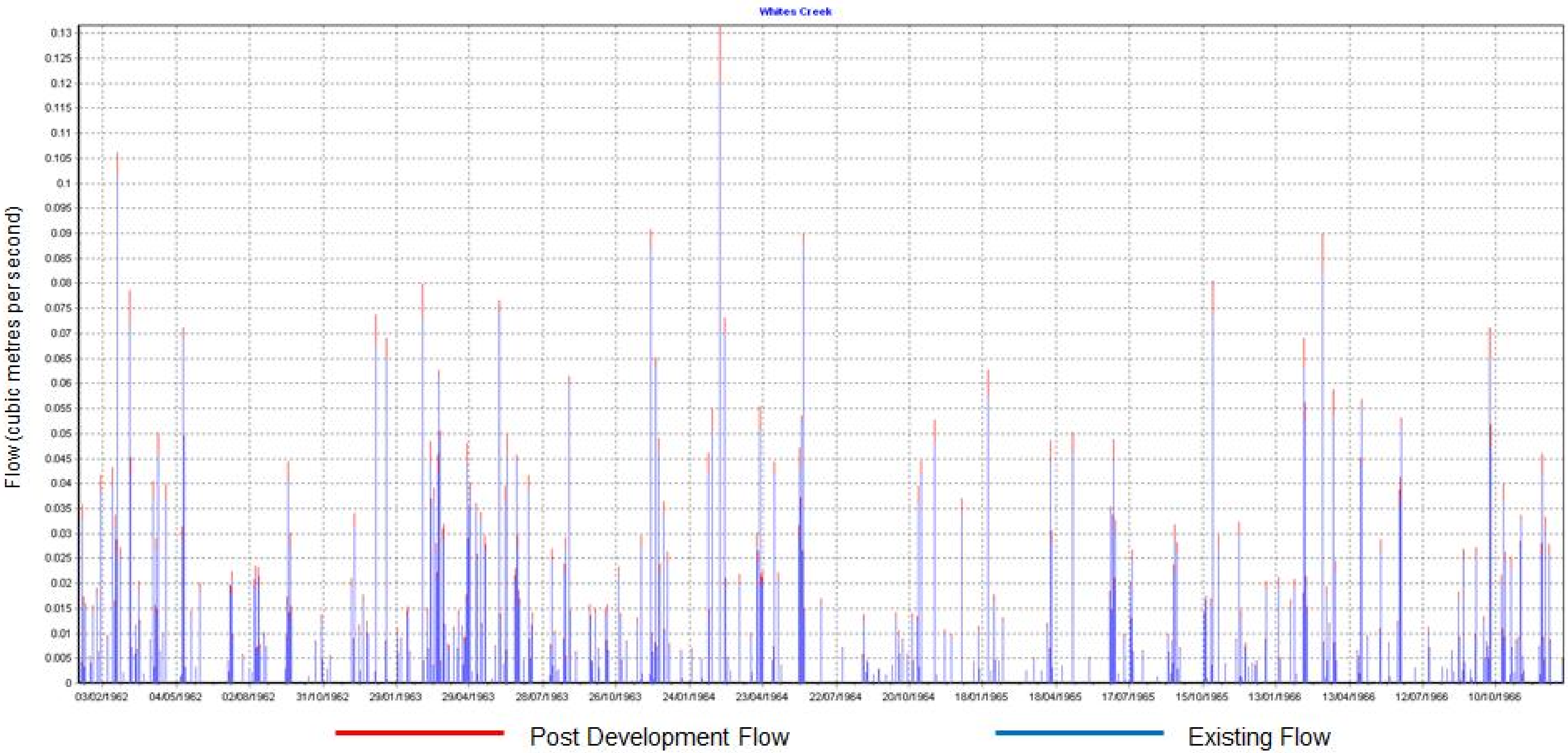

Figure 6-31 Stormwater discharges to Whites Creek

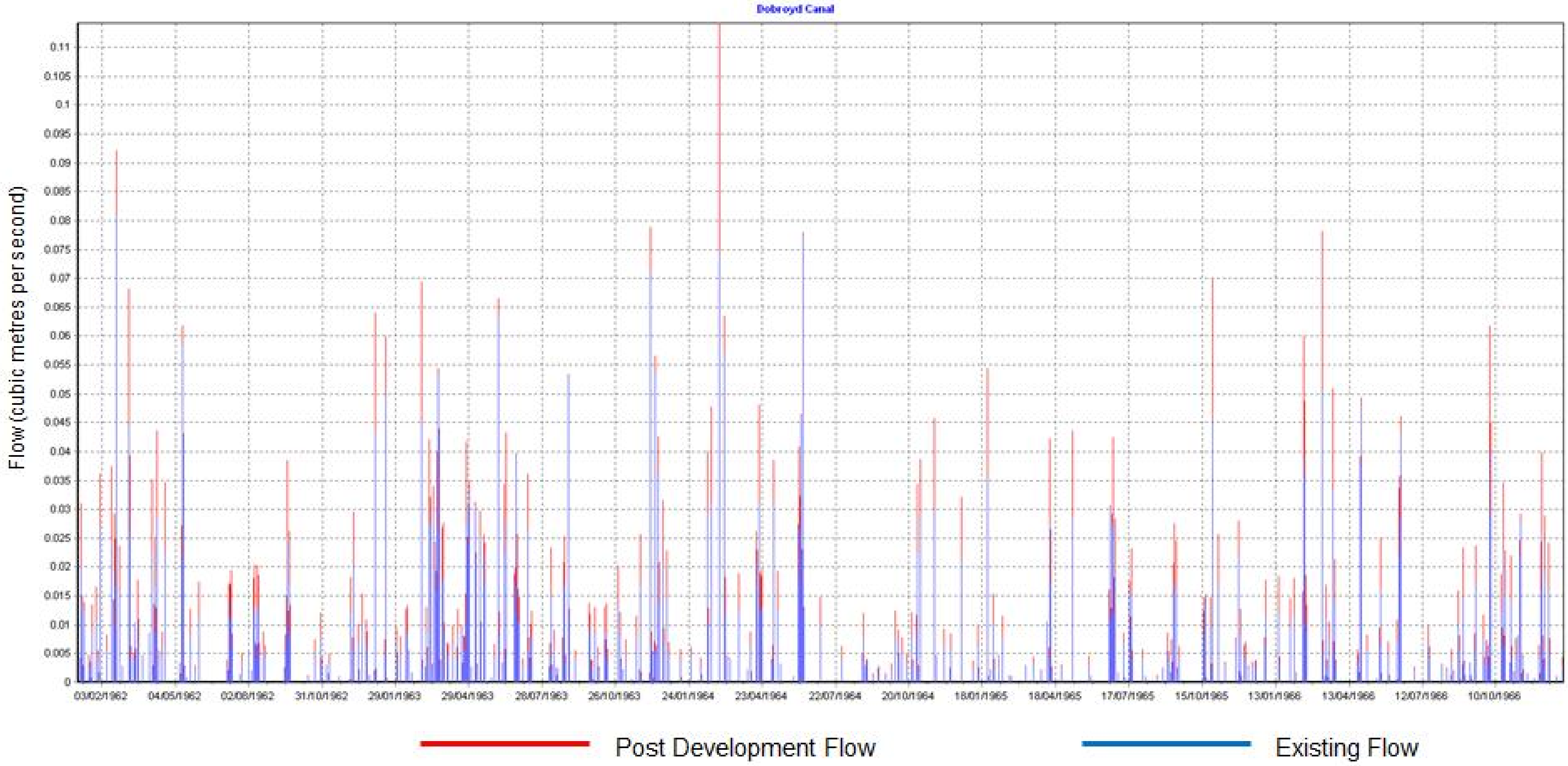

Figure 6-32 Stormwater discharges to Dobroyd Canal

6.3 Water quality

6.3.1 Potential operational impacts

The highest risk of impacts on water quality during operation of the project would be associated with:

- Increased stormwater runoff and associated increases in pollutant loading from roads
- Poor maintenance of stormwater quality treatment devices
- Spills or leaks of fuels and / or oils from vehicle accidents or from operational plant and equipment
- Discharges of poorly treated tunnel wastewater (eg groundwater ingress, stormwater ingress, tunnel wash-down water)
- Erosion of soft landscaped areas during the vegetation establishment period
- Scour / mobilisation of contaminated sediments at potential new outlet locations (i.e. Rozelle Bay and Iron Cove) and increased flow to existing locations (ie Alexandra Canal).

Discussion of the potential impacts on water quality associated with the operation of the project is provided in the following sections.

6.3.2 Stormwater discharge quality

The project is split into sections of above ground roadway, including interchanges with existing surface roads, and subsurface road through tunnels. New surface roadway, exposed to direct rainfall, is proposed at Rozelle interchange and Iron Cove Link. The Wattle Street ramps will also generate a minor amount of surface runoff. The project does not include any new surface roadways at St Peters interchange.

Increases in impervious area, such as road pavement, exposed to direct rainfall will contribute to an increase in runoff volume and associated increase in pollutant mobilisation. Runoff from road pavement would typically contain pollutants such as sediments, nutrients, oils and greases, petrochemicals and heavy metals, which result from atmospheric deposition, vehicle leaks, operational wear, road wear or spills of materials on the road. These pollutants could potentially impact on water quality when discharged to receiving waterways.

Pollutants from road surfaces (within above ground areas) are typically generated at a rate of about:

- TSS: 4,000 kilograms per year per hectare
- TP: Seven kilograms per year per hectare
- TN: 28 kilograms per year per hectare.

These rates were estimated from MUSIC stormwater quality modelling for a 100 per cent impervious catchment in Sydney. Stormwater pollutant loads generated by the project would be controlled by a stormwater quality treatment system designed in accordance with the project stormwater quality objectives (see **section 3.2.11**).

The proposed drainage system is indicatively shown in **Figure 2-3** to **Figure 2-5** and is described below. Indicative operational discharge points are shown in **Figure 2-6**. The assumed treatment for various catchments, as described below, is shown in **Annexure F**.

Subject to detailed design, a new discharge outlet would be constructed to Rozelle Bay to serve the majority of the Rozelle interchange. Portions of The Crescent, James Craig Road and City West Link unable to be drained to the Rozelle Rail Yards would likely drain via existing drainage connections to Rozelle Bay. Victoria Road northbound and southbound would likely drain to two separate outlets to Iron Cove. Either an upgraded existing discharge outlet or a new discharge outlet would be provided. Drainage from the Wattle Street ramps will discharge via a gross pollutant trap to sumps in the tunnel before being pumped to the surface, discharging to the surface drainage network, ultimately draining to Dobroyd Canal. City West Link adjacent to Whites Creek would utilise existing discharge outlets or a new discharge outlet would be provided. The portion of Victoria Road potentially draining to White Bay would drain via the existing surface drainage network. As detailed in **section 2.4.2**, operational stormwater quality treatment measures are proposed within the vicinity of Rozelle interchange and Iron Cove Link to treat stormwater prior to discharge.

MUSIC modelling was undertaken to assess the impact of the project and performance of the stormwater quality treatment measures with consideration to the SHPRC water quality objectives and the project pollutant load reduction targets as detailed in **section 3.2.11**. The modelling methodology is described in **section 3.4.3**. As discussed in **section 3.4.3**, the treatment strategy and associated modelling results are preliminary only and subject to detailed design.

The modelling results are summarised in **Table 6-9** for the main locations where stormwater will be discharged (Rozelle, Iron Cove, White Bay and Whites Creek) and for the project as a whole.

The modelling results indicate that:

- The project as a whole will generally reduce the mean annual stormwater pollutant loads being discharged to the Sydney Harbour and the Parramatta River estuary when compared to the existing conditions
- The project will generally reduce the mean annual stormwater pollutant load being discharged to the five receiving waterways when compared to the existing conditions, with the exception of total phosphorus loading to Dobroyd Canal which was slightly higher than the existing loading
- The stormwater mean annual pollutant load reduction targets (see **section 3.2.11**) were not quite achieved for the project or the individual catchments based on the treatment train measures that could practically or readily be implemented.

By decreasing the mean annual stormwater pollutant load when compared to existing conditions, the project would provide a beneficial effect in terms of reducing stormwater pollutant loads to the SHPRC. Further discussion on the projects overall impact on ambient water quality and the SHPRC water quality objectives, including other aspects of the project such as tunnel wastewater, is provided in **section 8.2.3**.

The pollutant load reduction targets were not achievable due to the modelling assumption that primary and secondary treatment proprietary devices would be utilised within highly constrained zones (see **section 3.4.3**) where implementation of vegetated WSUD or tertiary treatment devices is not considered feasible and/or reasonable. Oversizing other treatment measures to offset the reduced treatment within all the constrained zones was assessed and is not considered to be feasible and/or reasonable given that improvements in treatment performance diminish significantly with increasing footprint of the treatment devices.

Treatment performance could potentially diminish over time if the stormwater quality treatment devices (both vegetated WSUD and proprietary devices) are not adequately maintained during the operational phase. A maintenance plan would be developed during detailed design.

Table 6-9 MUSIC modelling results – water quality

Parameter	M4-M5 Link operation source load	M4-M5 Link operation residual load (following treatment)	% Reduction	Existing residual load	Impact compared to existing conditions
TOTAL PROJECT					
Total suspended solids (kg/year)	48600	8450	83%	33900	-25450
Total Phosphorus (kg/year)	81	39	52%	58	-19
Total Nitrogen (kg/year)	353	209	41%	271	-62
Gross pollutants (kg/year)	3520	242	93%	2530	-2288
ROZELLE BAY					
Total suspended solids (kg/year)	36500	5300	86%	24500	-19200
Total Phosphorus (kg/year)	61	28	55%	42	-15
Total Nitrogen (kg/year)	271	156	43%	202	-46
Gross pollutants (kg/year)	2710	108	96%	1860	-1752
IRON COVE					
Total suspended solids (kg/year)	7470	2170	71%	6680	-4510
Total Phosphorus (kg/year)	13	6	56%	11	-6
Total Nitrogen (kg/year)	51	31	39%	49	-18
Gross pollutants (kg/year)	501	103	80%	488	-385
WHITE BAY					
Total suspended solids (kg/year)	1130	240	79%	1080	-840
Total Phosphorus (kg/year)	2	1	27%	2	-0.4
Total Nitrogen (kg/year)	8	5	30%	7	-2
Gross pollutants (kg/year)	76	8	90%	72	-65
WHITES CREEK					
Total suspended solids (kg/year)	1850	395	79%	1650	-1255

Parameter	M4-M5 Link operation source load	M4-M5 Link operation residual load (following treatment)	% Reduction	Existing residual load	Impact compared to existing conditions
Total Phosphorus (kg/year)	3	2	27%	3	-1
Total Nitrogen (kg/year)	13	9	30%	12	-3
Gross pollutants (kg/year)	124	13	90%	115	-103
DOBROYD CANAL					
Total suspended solids (kg/year)	1600	343	79%	640	-301
Total Phosphorus (kg/year)	3	2	27%	1	1
Total Nitrogen (kg/year)	11	8	30%	8	-0.4
Gross pollutants (kg/year)	108	10.9	90%	92	-81

Target achieved
Target not achieved
Reduced load compared to existing conditions
Increased load compared to existing conditions

6.3.3 Tunnel discharge quality

As detailed in **section 2.4.2**, the tunnels will require drainage infrastructure to capture groundwater ingress, stormwater ingress at portals, spills, maintenance washdown water, fire suppressant deluge and other potential water ingress events.

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 streams would need to be collected and treated separately.

As detailed in **section 2.4.2**, operational water treatment plants would be provided for the Rozelle tunnels at the Rozelle interchange and for the mainline tunnels at Darley Road, Leichhardt. Groundwater would be collected and pumped to the water treatment plant. Sources other than groundwater that are captured by the tunnel drainage system will be collected in one of the tunnel sumps. Water in the sump will be tested and along with knowledge of its source (ie washdown or a spill) a determination will be made whether it can be pumped to and discharged at surface or will require removal directly from the sump by tanker for treatment and disposal elsewhere. The decision to pump to surface will need to consider the capacity of the water treatment facilities to accommodate and treat the additional flows.

Treated flows from the Rozelle plant would drain via a constructed wetland to Rozelle Bay. Treated flows from a plant at Darley Road 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 combined mainline tunnel (23 litres per second) and Rozelle tunnels (22 litres per second) would generate up to 1,418 megalitres per year of treated groundwater. This is significantly more than the predicted mean annual stormwater runoff volume of around 121 megalitres per year.

Elevated metals and nutrients were recorded during groundwater sampling (see **Table 4-5** and Table 4-6).

The groundwater is also brackish and, subject to further investigation during detailed design, may be unsuitable in terms of the opportunity to reuse the water for irrigation of Blackmore Park or the Sydney Secondary College Leichhardt Campus oval, for example.

Metal, nutrient and ammonia loading to Hawthorne Canal and Rozelle Bay is likely to increase as a result of the continuous treated groundwater discharges. In order to prevent adverse impacts on downstream water quality within Rozelle Bay and Hawthorne Canal, treatment facilities will be designed so that the effluent will be of suitable quality for discharge to the receiving environment (see **section 8.2.3**).

The operational water treatment plant at Rozelle and Darley Road will treat iron and manganese (see **section 8.2.3**). The proposed constructed wetland at Rozelle will provide ‘polishing’ treatment to the treated groundwater flows removing a proportion of the nutrient (forms of nitrogen and phosphorus) 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 will be investigated during detailed design with consideration to other factors such as available space, increased power requirements and increased waste production.

A summary of the groundwater quality considering ANZECC (2000) guideline criteria, receiving water quality and proposed treatment measures is presented in **Table 6-10**. It is assumed there would be no nutrient treatment (as described above) at Darley Road. A qualitative assessment of the impacts on ambient water quality is provided below.

With consideration of groundwater quality and proposed treatment (see **Table 6-10)**, the concentration of the key constituents in the treated discharge to Rozelle Bay are unlikely to be significantly higher than the ambient 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 to ambient water quality are likely to be negligible and localised to near the outlet.

With consideration of groundwater quality and proposed treatment (see **Table 6-10)**, treated discharge concentrations of key constituents are unlikely to be significantly higher than concentrations in Hawthorne Canal. Due to the mixing and dilution affect which would occur at the outlet to the receiving waters, impacts to ambient water quality are likely to be negligible. Any minor impacts are likely to be localised and near to the outlet.

The impacts associated with discharge quality from the Arncliffe operational water treatment plant were assessed as part of the New M5 EIS. No adverse impacts are likely to occur as a result of the minor additional flow (1.6 litres per second) draining to the Arncliffe operational water treatment plant.

Table 6-10 Summary of tunnel groundwater pollutants of concern and treatment processes

Tunnel	Groundwater ingress to tunnel (L/s)	Receiving water body	Constituents which exceeded relevant ANZECC criteria[1]	Relative concentration[2]	Applicable treatment processes	Receiving environment
Rozelle	22	Rozelle Bay	Iron	High[3]	WTP[7] + Wetland Polishing	Estuarine bay
			Manganese	High[3]	WTP + Wetland Polishing	
			Ammonia	Medium[3]	Wetland Polishing	
			Total Nitrogen	Low[5]	Wetland Polishing	
			Total Phosphorus	Less than receiving[6]	Wetland Polishing	
			Reactive Phosphorus	Less than receiving[6]	Wetland Polishing	
Mainline	23	Hawthorne Canal	Iron	High[3]	WTP	Estuarine waterway
			Manganese	High[3]	WTP	
			Ammonia	Unknown	Further investigation into treatment during detailed design.	
			Total Nitrogen	Low[5]	Further investigation into treatment during detailed design.	
			Total Phosphorus	Low[3]	Further investigation into treatment during detailed design.	
			Reactive Phosphorus	Less than receiving[6]	Further investigation into treatment during detailed design.	

Notes:
[1] Constituent groundwater mean concentration exceeds ANZECC (2000) marine water 95 per cent species protection for toxicants and/or recreational water quality guideline level.
[2] Relative difference between constituent groundwater and receiving water body mean concentrations.
[3] Constituent groundwater greater than 10 times receiving water concentration.
[4] Constituent groundwater is between five and 10 times receiving water concentration.
[5] Constituent groundwater less than five times receiving water concentration.
[6] Constituent groundwater is less than the receiving water concentration.
[7] WTP = Assumes water treatment plant discharge criteria as per **section 8.2.3**.

6.3.4 Scour and channel geomorphology

There is potential for sediment to be scoured and mobilised where stormwater or wastewater is discharged to receiving waterways and bays including Rozelle Bay, Iron Cove, and Whites Creek. This could increase turbidity locally and lead to mobilisation of contaminants bound to sediments. Scour protection and energy dissipation measures will be assessed and provided as required at outlets (see **section 8.2.3**).

Stormwater discharges from the St Peters interchange were assessed as part of the New M5 EIS. The proposed ancillary facilities at St Peters interchange may slightly increase discharge volumes at the existing outlet. There is potential for localised disturbance of sediment to occur near to the existing outlet if appropriate scour protection and/or energy dissipation measures are not already in place (see **section 8.2.3**). Any minor increases in flow volume are unlikely to have a material impact on the mobilisation of contaminated sediments during flow events within other areas of Alexandra Canal given the minor surface area of the ancillary facilities in the context of the overall Alexandra Canal catchment.

The project includes widening and improvement works to the channel and bank at Whites Creek Annandale to manage flooding and drainage. The channel form would be naturalised with works extending back to the railway bridge to integrate with Sydney Waters proposed channel naturalisation works (see **section 4.2.1**). The naturalisation works would be finalised during detailed design but are likely to incorporate features such as sandstone blocks and vegetated benches to provide ecological benefits to the channel. The proposed channel bed and bank treatments would be hard lined therefore impacts on channel form and geomorphology are unlikely to occur once the works are complete. Any vegetated zones (eg benches) would be susceptible to erosion and should be protected during the vegetation establishment period.

6.3.5 Erosion and sedimentation

Once the construction phase of a project is completed, there is a period within the operational phase where recently disturbed soils are potentially susceptible to scour and erosion from stormwater runoff. This will be an issue in areas where soft landscaping is proposed for the project, including public open space areas at Rozelle interchange, cut batter or fill embankments and reinstatement of construction ancillary facilities where topsoil is settling and vegetation is establishing.

The potential for sediment transport and sedimentation issues to occur during operation of the project is influenced by factors such as severity of storm events, the slope and corridor of disturbance within an area, and the management controls that are implemented on site.

The erosion of landscaped areas during rainfall events could potentially cause sediment loads to enter into waterways through the stormwater pipe network. Landscaping at Rozelle interchange presents the greatest risk due to the extent of landscaping proposed.

Suitable stabilisation and management techniques would be deployed during the vegetation establishment period to minimise the potential for erosion within areas at risk. Provided appropriate controls are implemented, short term impacts during the establishment period are expected to be manageable with negligible impacts on receiving water quality.

6.3.6 Spills

Spills of oils, lubricants, hydraulic fluids and chemicals could potentially occur during the operation of the project due to vehicle or plant and equipment leakages or a vehicle crash. Any contaminant spill within the project footprint has the potential to pollute downstream waterways, as a result of being conveyed to waterways via the stormwater network. The severity of the potential impact depends on the magnitude and/or location of the spill in relation to sensitive receptors, emergency response procedures and/or management controls implemented on site, and nature of the receiving environment. Surface roads within close proximity to Rozelle Bay and Iron Cove are likely to present the greatest risk due to the short distance and time it would take contaminants to reach the receiving waters.

Spill control measures, as outlined in **section 8.2.3** would be required to reduce the potential for environmental impacts to occur at discharge points. Provided appropriate controls are implemented, there would be a low risk of impacts on receiving water quality.

6.4 Riparian corridors

Works may require removal of planted riparian vegetation adjacent to Whites Creek for the upgrade of the intersection of The Crescent and City West Link, refer to **Appendix S** (Technical working paper: Biodiversity) of the EIS. With consideration to the highly disturbed environment, the removal of the planted riparian vegetation is unlikely to impact on surface water quality or the stability of Whites Creek, a concrete channel. Although the upgraded road is likely to increase shade within the concrete channel, the reduction in light is unlikely to change the water temperature given the tidal water movement at this location.

7 Assessment of cumulative impacts

7.1 WestConnex projects

A summary of the key potential surface water and flooding impacts, mitigation measures and residual impacts identified through a review of EIS documents associated with the four other WestConnex projects are summarised in the following sections and in **Table 7-1**. The following WestConnex EIS documents were reviewed:

- Kings Georges Road Intersection Environmental Impact Statement, Appendix L, Flooding and drainage investigation (Lyall and Associates August 2014)
- M4 Widening Environmental Impact Statement (SMEC 2014)
- M4 East EIS, Surface Water: Flooding and Drainage (Lyall and Associates 2015a)
- M4 East Environmental Impact Statement, Appendix O, Technical Working paper: Soil and water quality assessment (GHD 2015)
- New M5 Environmental Impact Statement, Appendix N, Technical Working paper: Surface Water (AECOM 2015)
- New M5 Environmental Impact Statement, Appendix P, Technical Working paper: Flooding (Lyall and Associates 2015b).

7.1.1 M4 East

The M4-M5 Link project would connect directly to the M4 East at the Wattle Street interchange. Any potential cumulative surface water quality impacts could impact on the one common receptor, Dobroyd Canal and downstream environments (Iron Cove, Parramatta River Estuary).

The impacts of the M4 East project on surface water and flooding at the Wattle Street interchange were assessed as part of that EIS and subsequent detailed design. Management measures were identified to mitigate impacts on surrounding properties for both the construction and operational phases. The objective was to manage impacts on flood risk to an acceptable level where practicable and feasible, by working to achieve the requirements of the planning conditions.

As discussed in **section 4.4.1**, the M4-M5 Link connection to the Wattle Street interchange would not alter the surface layout or levels. Accordingly, there are no cumulative impacts on flooding in relation to the project anticipated at the Wattle Street interchange.

7.1.2 New M5

The M4-M5 Link project would connect directly to the New M5 at the St Peters interchange. Any potential cumulative surface water quality impacts could impact on the one common receptor, Alexandra Canal and downstream sensitive environments (Cooks River and Botany Bay).

The impacts of the New M5 project on surface water and flooding at the St Peters interchange were assessed as part of the EIS and ongoing design. Management measures were identified to mitigate impacts on surrounding properties for both the construction and operational phases of the New M5 project. The objective was to manage impacts on flood risk to an acceptable level, where practicable and feasible, by working to achieve the requirements of the planning conditions.

As discussed in **section 4.4.1**, the M4-M5 Link connection to the St Peters interchange would not significantly alter the surface layout or levels and the new ventilation facility would be located above the PMF flood level. The proposed ventilation facility would result in a negligible increase in runoff volume to Alexandra Canal. The potential for scour at the outlet would be controlled through appropriate mitigation as required. Accordingly, there are no cumulative impacts on flooding, water quality or geomorphology/scour in relation to the project anticipated at the St Peters interchange.

7.1.3 M4 Widening and King Georges Road Interchange Upgrade

M4 Widening project and Kings Georges Road Interchange Upgrade project have no common direct surface water receptors to the M4-M5 Link project but do have common downstream sensitive environments (Parramatta River Estuary, Cooks River and Botany Bay). There are unlikely to be cumulative impacts on the common sensitive downstream environments provided controls are implemented, maintained and monitored.

As the M4 Widening project and Kings Georges Road Interchange Upgrade project have no common surface catchments to the M4-M5 Link project there are no cumulative flood impacts anticipated.

7.1.4 Summary

Based on a review of the respective EIS documents that have been approved the M4 East, New M5, M4 Widening and King Georges Road Interchange Upgrade are considered unlikely to have a significant impact on receiving water receptors or sensitive environments provided the proposed management measures are implemented, maintained and monitored.

Therefore, with due consideration of the proposed management measures to be implemented as part of the M4-M5 Link project (see **section 8**) there are minimal adverse cumulative surface water quality or flooding impacts anticipated. The residual risk to common receptors and sensitive environments downstream would be low provided the proposed management measures are implemented, maintained and monitored.

7.2 Other projects

Cumulative impacts associated with other key projects proposed in the vicinity of the M4-M5 Link project footprint including the Rozelle Rail Yards Site Management Works, Transport for NSW CBD and South East Light Rail – Rozelle maintenance depot, The Bays Precinct, Sydney Water stormwater channel renewal / naturalisation works, Sydney Metro City and Southwest, and Western Harbour Tunnel and Beaches Link have been considered. A summary of the key potential surface water and flood impacts, mitigation measures and residual impacts related to these other key projects are summarised in **Table 7-1**.

Rozelle Rail Yards – Site Management Works

Roads and Maritime are carrying out a suite of site management works on part of the Rozelle Rail Yards. These works will be undertaken prior to the commencement of the M4-M5 Link project. *The Rozelle Rail Yards – Site Management Works Review of Environmental Factors* (Roads and Maritime 2016) indicates that stormwater runoff quality, drainage and flooding will be managed in accordance with legislation and good practice during construction and after completion of the site management works. 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 until commencement of the construction of the M4-M5 Link project. Therefore, no cumulative flood, drainage or water quality impacts are anticipated.

CBD and South East Light Rail

The CBD and South East Light Rail Rozelle maintenance depot is located immediately to the west of the Rozelle Rail Yards. This development has planning approval with design ongoing. Site clearance activities have been undertaken in 2016. Surface water from the Rozelle maintenance depot is discharged to the Rozelle Rail Yards. *The CBD and South East Light Rail Project Environmental Impact Statement* (Parsons Brinkerhoff 2013) indicates that stormwater runoff quality, drainage and flooding will be managed in accordance with legislation and good practice during construction and operation. Therefore no cumulative flood, drainage or water quality impacts are anticipated.

A review of preliminary designs and discussions with the project team for the CBD and South East Light Rail Rozelle maintenance depot shows a new drainage system to capture and manage surface water at the site. This will manage surface water from the proposed depot and maintenance area with two discharge points to the east of the depot. As there is no formal drainage system to discharge into, the Rozelle maintenance depot design proposes to discharge to the surface to then flow towards the Rozelle Rail Yards. The proposed discharge point from the Rozelle maintenance depot has been cumulatively considered in the M4-M5 Link project flood modelling. This included modifying the topography on the north western side of the Rozelle interchange design to enable the overland flows from the Rozelle maintenance depot and catchment to the west, to flow onto the site and be conveyed within a channel to Rozelle Bay. The detailed design for M4-M5 Link will need to consider the final detailed design for the Rozelle maintenance depot for stormwater drainage.

Sydney Metro City and Southwest

Waterloo Station, part of the Sydney Metro City and Southwest project is located within the Alexandra Canal catchment. Any potential cumulative surface water impacts could impact on Alexandra Canal and downstream sensitive environments (Cooks River and Botany Bay). The impacts of the Waterloo Station on surface water and flooding were assessed as part of that *Sydney Metro Chatswood to Sydenham Environmental Impact Statement* (Transport for NSW 2016). Surface water management measures were identified to mitigate impacts during construction. The aboveground station infrastructure would be located within the footprint of existing development and would have a negligible impact on the existing surface hydrology. Waterloo Station and ancillary infrastructure would have a negligible impact on existing flood behaviour during operation and minimal impacts during construction. Management measures were identified to mitigate impacts on surrounding properties for both the construction and operational phases.

The Marrickville dive site is proposed to be located to the west of the New M5 interchange, but is located in the Eastern Channel catchment, which drains directly to the Cooks River. The site is flood affected and flood mitigation measures to compensate for loss of overland flowpaths and flood storage have been designed to minimise flood impacts in and around Eastern Channel. No flood impacts were identified for the Cooks River as a result of the proposed works at the Marrickville dive site. Therefore no cumulative flood impacts with this project are anticipated. The Marrickville dive site has no common direct surface water receptors with the M4-M5 Link project but does have common downstream sensitive environments (Cooks River and Botany Bay). There are unlikely to be cumulative impacts to the common sensitive downstream environments provided controls are implemented, maintained and monitored.

The Bays Precinct, Sydney Water stormwater channel renewal/naturalisation and Western Harbour Tunnel

The Bays Precinct, Sydney Water stormwater channel renewal / naturalisation and Western Harbour Tunnel and Beaches Link projects are in their early planning stages, and as such no environmental assessments were available for review at the time of this assessment. Therefore, cumulative surface water impacts cannot be fully understood at this stage due to insufficient information available regarding the impacts, design and management of surface water flows and infrastructure associated with these projects. However, a preliminary qualitative assessment has been undertaken here.

The Bays Precinct Transformation Plan (UrbanGrowth NSW 2015) has set a high benchmark for controlling water quality and it is assumed that The Bays Precinct project would incorporate surface water and flood management measures during construction and operation in accordance with legislative requirements to prevent adverse impacts to the common receiving receptors of Whites Creek, White Bay and Rozelle Bay and flooding impacts to local properties. Similarly, it is assumed that management measures would be implemented during the construction works at Whites Creek and Johnstons Creek to manage potential impacts to the creeks and downstream environment from both a water quality and flood management perspective.

The greatest risk of the Sydney Water channel works in the common receptors of Whites Creek and Johnstons Creek relates to sedimentation of the waterways during earthworks. This would likely be managed by Sydney Water during construction using best practice techniques in accordance with relevant legislation. The works are also likely to be designed to avoid flooding impacts during operation. Therefore, no surface water and flooding cumulative impacts are anticipated. Consultation with Sydney Water would be undertaken throughout the detailed design process.

The Western Harbour Tunnel and Beaches Link contractor would manage a portion of the Rozelle civil and tunnel site near to the Western Harbour Tunnel entry and exit ramps north of the City West Link/The Crescent intersection when this area is no longer needed for construction of the M4-M5 Link project, extending the use of this construction site. Whilst no EIS for the proposed future Western Harbour Tunnel and Beaches Link is available for review it is assumed that construction activities and the operation of the proposed future Western Harbour Tunnel and Beaches Link would be undertaken with appropriate surface water management measures in place in accordance with legislative requirements to prevent adverse impacts to the common receiving receptor of Rozelle Bay as part of Sydney Harbour. No surface water and flooding cumulative impacts are therefore anticipated, however a cumulative impact assessment of these aspects would be undertaken by the environmental impact assessment for the proposed future Western Harbour Tunnel and Beaches Link project.

Accordingly, no adverse cumulative surface water quality impacts are anticipated with implementation of appropriate management measures as part of the project, and as such the residual risk to the environment would be low.

Table 7-1 Summary of potential impacts from other surrounding projects and their mitigation

Common receiving receptors	Common downstream sensitive receptors	Potential impacts on common receiving receptors during construction of M4-M5 Link	Construction mitigation measures	Potential impacts on common receiving receptors during operation of M4-M5 Link	Operational mitigation measures	Construction and operation residual impacts
M4 East						
Dobroyd Canal	Parramatta River estuary	Increased pollutant loading to Dobroyd Canal associated with stormwater runoff. Discharge of poorly treated tunnel water to Dobroyd Canal.	Soil and water management plan and associated measures in accordance with Blue Book. Staging of works Stockpile management Water Quality Monitoring Construction water treatment plant.	Increased pollutant loading to Dobroyd Canal. Impacts on drainage infrastructure capacity near to Wattle Street interchange. Flood impacts due to redirection of overland flows at Wattle Street interchange.	Drainage upgrades. Flood mitigation required for overland flow paths impacted by Wattle Street interchange. Stormwater quality treatment measures. Water quality monitoring. Operational tunnel water treatment plant.	Unlikely to be significant impacts on downstream receptors or sensitive receiving environments provided controls are implemented, maintained and monitored.
New M5						
Alexandra Canal	Cooks River and Botany Bay	Minor impacts on local overland flows and existing minor drainage paths. Increased sedimentation and pollutant loading to Alexandra Canal as a result of unmitigated construction discharges. Discharge of poorly treated tunnel water to Alexandra Canal. Negligible increase in	Where undesirable flood impacts are identified, appropriate mitigation will be implemented for overland flow paths impacted by construction works. Soil and water management plan and associated measures in accordance with Blue Book. Staging of works Stockpile management	Negligible increase in runoff volume and pollutant loading to Alexandra Canal associated with new ancillary facilities at St Peters interchange Increases in Alexandra Canal flow rate, velocities and water level would also be negligible. Potential for localised sediment disturbance if appropriate scour	Where undesirable flood impacts are identified, appropriate mitigation will be implemented for overland flow paths impacted at St Peters interchange. Stormwater quality treatment measures. Water quality monitoring. Operational tunnel water treatment plant Appropriate scour	Unlikely to be significant impacts on downstream receptors or sensitive receiving environments provided controls are implemented, maintained and monitored.

Common receiving receptors	Common downstream sensitive receptors	Potential impacts on common receiving receptors during construction of M4-M5 Link	Construction mitigation measures	Potential impacts on common receiving receptors during operation of M4-M5 Link	Operational mitigation measures	Construction and operation residual impacts
		baseflow to Alexandra due to construction wastewater discharges. Potential for localised sediment disturbance if appropriate scour protection / energy dissipation measures not already installed at existing outlet.	Construction water treatment plant Water quality monitoring. Appropriate scour protection and energy dissipation as required.	protection / energy dissipation measures not already installed at existing outlet. Flood impacts due to redirection of overland flows at St Peters interchange. Slight increase in tunnel wastewater discharging from Arncliffe operational water treatment plant to the Cooks River due to portion of M4M5 Link tunnel drainage draining to New M5 system.	protection and energy dissipation as required.	
King Georges Road Interchange Upgrade						
None	Cooks River and Botany Bay	No common receptors.	Soil and water management plan and associated measures in accordance with Blue Book. Spill kits and training.	No common receptors.	Upgrade of an existing water quality pond. Pavement drainage upgrades. Spill containment facilities.	No common receptors. Unlikely to be significant impacts on common sensitive receiving environments downstream provided controls are implemented, maintained and monitored.
M4 Widening						
None	Parramatta	No common receptors	Soil and water	No common receptors.	Swales.	No common receiving

Common receiving receptors	Common downstream sensitive receptors	Potential impacts on common receiving receptors during construction of M4-M5 Link	Construction mitigation measures	Potential impacts on common receiving receptors during operation of M4-M5 Link	Operational mitigation measures	Construction and operation residual impacts
	River Estuary		management plan and associated measures in accordance with Blue Book. Staging of works Stockpile management Managing disturbance and mobilisation of sediment within Duck River channel during in channel works. Water quality monitoring.		Spill management basins. Scour protection measures.	receptors. Unlikely to be significant impacts on common sensitive receiving environments downstream provided controls are implemented, maintained and monitored.
Rozelle Rail Yards site management works						
Easton Park drain, Whites Creek and Rozelle Bay	Sydney Harbour	Increased sedimentation and pollutant loading to receiving receptors as a result of unmitigated construction discharges. Increased temporary flows to drainage network. Impact to local overland flows and existing minor drainage paths.	Soil and Water management plan and associated measures (sediment and erosion controls) in accordance with Blue Book. Staging of works to minimise surface disturbance. Conveyance of flows from western external catchment through the site. Temporary drainage measures Storage of equipment and other obstructions	Not applicable as M4-M5 Link project will have commenced within the Rozelle Rail Yards.	Not applicable as M4-M5 Link project will have commenced within the Rozelle Rail Yards.	Unlikely to be significant impacts on common sensitive receiving environments downstream provided controls are implemented, maintained and monitored.

Common receiving receptors	Common downstream sensitive receptors	Potential impacts on common receiving receptors during construction of M4-M5 Link	Construction mitigation measures	Potential impacts on common receiving receptors during operation of M4-M5 Link	Operational mitigation measures	Construction and operation residual impacts
			to floodwater (e.g. stockpiles) on high ground. Protection of existing drainage infrastructure from surface water flows. Diversion of overflows from sediment basin to a low point onsite.			
CBD and South East Light Rail Rozelle maintenance depot						
Easton Park drain and Rozelle Bay	Sydney Harbour	Increased sedimentation and pollutant loading to receiving receptors as a result of unmitigated construction discharges.	Sediment basin and discharge of stormwater runoff onto Rozelle Rail Yards through a series of small outfalls to replicate overland flow.	Increased pollutant loading to receiving receptors. Concentrated flows (rather than overland flow) being discharged onto Rozelle Rail Yards.	Discharge of stormwater runoff onto Rozelle Rail Yards through a series of small outfalls to replicate overland flow. Treatment of stormwater runoff. Recycling of wash-down water.	Unlikely to be significant impacts on stormwater flooding or significant impacts on common receiving receptors provided controls are implemented, maintained and monitored.
The Bays Precinct						
White Bay, Rozelle Bay, Whites Creek	Sydney Harbour	Increased sedimentation and pollutant loading to downstream receptors as a result of unmitigated construction discharges. Impacts on flood risk	Unknown.	Increase in potable water demand. Increased pollutant loading to downstream receptors. Impacts on flood risk to surrounding properties.	Unknown.	Unknown.

Common receiving receptors	Common downstream sensitive receptors	Potential impacts on common receiving receptors during construction of M4-M5 Link	Construction mitigation measures	Potential impacts on common receiving receptors during operation of M4-M5 Link	Operational mitigation measures	Construction and operation residual impacts
		to surrounding properties.				
Sydney Water naturalisation projects						
Whites Creek Johnstons Creek	Sydney Harbour	Increased sedimentation and pollutant loading to Whites Creek and Johnstons Creek as a result of disturbance and mobilisation of sediments during construction works within and adjacent to the creeks. Impacts on flood risk to surrounding properties.	Unknown.	Alterations (improvement or reduction) to flood conveyance in Whites Creek and Johnstons Creek.	Unknown.	Unknown.
Western Harbour Tunnel						
Rozelle Bay	Sydney Harbour	Increased sedimentation and pollutant loading to downstream receptors as a result of unmitigated construction discharges from tunnel wastewater and stormwater runoff.	Unknown.	Increased pollutant loading to downstream receptors as a result of stormwater runoff and tunnel wastewater discharges.	Unknown.	Unknown.
Sydney Metro City and Southwest						
Alexandra Canal	Sydney Harbour, Cooks River	Waterloo Station site within the Alexandra Canal catchment is at	Erosion and sediment controls, including the redirection and capture	Waterloo Station site within the Alexandra Canal catchment is at	On-site detention as required and where space permits.	Unlikely to be significant impacts on stormwater flooding or

Common receiving receptors	Common downstream sensitive receptors	Potential impacts on common receiving receptors during construction of M4-M5 Link	Construction mitigation measures	Potential impacts on common receiving receptors during operation of M4-M5 Link	Operational mitigation measures	Construction and operation residual impacts
	and Botany Bay	risk of flooding during construction. Flooding of the construction site could result in floodwater entering excavations or stockpiles of construction materials and spoil being washed downstream to Alexandra Canal. Works at Waterloo station are expected to have minimal impacts on flooding. The proposed Marrickville dive site is within the Eastern Channel catchment and is at risk of flooding during construction. Works at the dive site would need to be carefully managed to minimise local flood impacts.	of construction site runoff, would be used to manage drainage on construction sites. Detailed construction planning for flood risk at Waterloo Station including identification of measures to avoid flood impacts during construction.	risk of flooding during operation. Waterloo Station and ancillary infrastructure would have a negligible impact on existing flood behaviour.	Station entries above ground rail system facilities at Waterloo Station to be located above PMF flood level or 0.5 metres above 100 year ARI flood level where necessary. The proposed Marrickville tunnel dive structure is to be protected from inundation in the PMF and drainage infrastructure has been designed to compensate for the loss of overland flowpaths and flood storage.	significant impacts on common receiving receptors or common sensitive downstream receptors provided controls are implemented, maintained and monitored.

8 Management of impacts

8.1 Flooding

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 3.4.4**. In terms of flooding, public interest and safety 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
- Designing the tunnel drainage system to safely manage local runoff from the open tunnel dives, deluge flows and accidental spills.

Incidents in tunnels, including flooding, are covered in **Chapter 25** (Hazard and risk) of the EIS, together with the implementation of design features to minimise the potential for and manage incidents, the provision of emergency egress points/cross-passages to prevent people becoming trapped, and manage traffic flow during incidents.

Traffic management systems during the operation of the project will ensure that traffic is directed away from an incident (eg flooding) and avoid traffic moving toward floodwater.

8.1.1 Proposed flood mitigation strategy

A Flood Mitigation Strategy (FMS) will be prepared for flood prone or flood affected land within the project footprint prior to construction, to demonstrate that the existing flooding characteristics will not be exacerbated as a consequence of the project. The strategy will be prepared by a suitably qualified and experienced person in consultation with directly affected landowners, the NSW Office of Water, OEH, Sydney Water and relevant councils. It will include, but not be limited to:

- The identification of flood risks to the project and adjoining areas, including the consideration of local drainage catchment assessments, and climate change implications on rainfall, drainage and tidal characteristics
- Identification of design and mitigation measures that will be implemented to protect proposed operations and not worsen existing flood characteristics or soil erosion and scouring during construction and operation
- 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
    - 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
    - No inundation of floor levels which are currently not inundated 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.

The strategy will also need to consider any existing emergency response plans, with relevant information provided to SES and councils to assist in the preparation of new or necessary updates to relevant plans.

Sections 8.1.2 and **8.1.3** lists measures which should be considered during the preparation of the FMS in regards to the project-related flood risks and impacts.

Flood review report

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).

8.1.2 Management during construction phase

During the construction phase, some of the works will occur within the extent of various flood event magnitudes as outlined in **section 5.2**. Flood management plans will be developed prior to construction of any temporary ancillary facilities, including construction ancillary facilities as part of the CEMP, to guide the design of construction ancillary facilities and thereby minimise potential impacts of flooding. This will be in line with minimising risk to the surrounding environment.

Further assessment of the construction ancillary facilities and measures to manage flooding onsite and mitigate flood impacts during construction will be undertaken during detailed design. Inherent flood risks will be managed through the following methods:

- Detailed flood modelling to understand the effects of likely rainfall events. Construction layouts will be finalised accordingly. This may include:
  - Allocating carparks in areas where floodwater storage occurs
  - Earthworks and stockpiles located outside the 20 year ARI flood extent, where possible
  - Site buildings or infrastructure vulnerable to flooding (such as ventilation facilities or water treatment works) located on higher ground or elevated, to raise floor levels above expected flood levels.
- Temporary bunding (including noise barriers) or flood protection barriers around parts of the site that will be adversely affected by floodwaters, such as tunnel dive shafts, portals and cut and cover sections. The flood level adopted for design of temporary protection will need to 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
- Installation of breaks or flaps in fencing or site hoarding to allow existing overland flowpaths into and out of sites in a controlled manner, where appropriate. This is relevant to the Pyrmont Bridge Road tunnel site (C9) where there is an existing flow path on Bignell Road
- Where transverse drainage structures are to be upgraded or replaced during the project, existing transverse drainage structures will be left in place and remain operational during the process. If this is not achievable, temporary drainage and detention areas will be required. At the Rozelle civil and tunnel site (C5), it is recommended that the permanent floodwater conveyance solution is installed as soon as possible to manage risk during construction

- All mitigation works will be designed so as to not exacerbate impacts to surrounding property
- A contingency plan to manage flooding 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 flood extent, including the development of suitable procedures for flood warning, emergency management, site evacuation and planning
- During construction of new bridge structures, such as at The Crescent over Whites Creek near Rozelle interchange, the construction approach should seek to minimise impacts associated with impeding the conveyance of flow. Temporary falsework and access road crossings over Whites Creek are to be designed and staged to minimise the impact of construction activities on flooding conditions in adjacent development. Temporary works or infrastructure are to be removed as soon as possible once no longer required
- Runoff generated will be managed using existing or temporary drainage arrangements. Where required, storage of runoff will be provided to mitigate risk of overloading the receiving drainage system
- Undertake regular inspection and maintenance activities, such as cleaning of pit grates, channels and sediment basins to minimise risk of waterway blockage
- Siphonic based water management systems implemented during construction are removed and, where applicable, replaced with an adequate permanent drainage system.

The FMS will need to include details and procedures to manage the risk of adverse flood impacts on surrounding properties. This will require a more detailed assessment into the impacts construction activities will have on the existing flood behaviour and also identify measures which are required to mitigate those impacts. This will be an iterative process to inform detailed site layouts and staging diagrams. Results from construction related flood impact assessments will be provided as input to any emergency management procedures developed as part of the CEMP.

Where a property is identified as potentially being impacted (i.e. potential increase in flood levels), a floor level survey will need to be undertaken to determine whether construction activities will increase flood damages in adjacent development.

The layout of construction sites will need to be designed to:

- Limit the extent of works located in high flood risk areas
- Divert overland flow either through or around work areas in a controlled manner
- Minimise adverse impacts on flood behaviour for adjacent development.

Measures to manage residual flood impacts will include:

- Staging the construction to limit the extent and duration of temporary works in the floodplain
- Developing flood emergency response procedures to make sure construction equipment and materials are removed from floodplain areas at the completion of each work activity or should a weather warning for impending flood producing rain be issued
- Providing temporary flood protection to properties identified as being at risk of adverse flood impacts during any stage of construction of the project.

Management measures for each construction ancillary facility are provided in **Table 8-1**.

Table 8-1 Construction ancillary facilities and potential flood mitigation measures

Construction ancillary facility	Specific mitigation measures
C1a Wattle Street civil and tunnel site (part of M4 East project footprint)	None required. Construction activities will not impact on the mitigation measures implemented as part of the M4 East project.
C2a Haberfield civil and tunnel site (part of M4 East project footprint)	None required.
C3a Northcote Street civil site (part of M4 East project footprint)	None required.
C1b Parramatta Road West civil and tunnel site	None required. No topographic changes are proposed for Parramatta Road, Bland Street and Alt Street as part of the construction activities. As such the overland flowpaths would not be affected.
C2b Haberfield civil site (part of M4 East project footprint)	None required.
C3b Parramatta Road East civil site	None required.
C4 Darley Road civil and tunnel site	The indicative site layout has taken into consideration flood risk and hazards, with car parking allocated to the western side of the site which is more vulnerable to flooding. Bunding to protect tunnel ramps and vulnerable infrastructure to prevent floodwater ingress. There might be some localised increases on water depths on Darley Road adjacent to the site. Surrounding properties are unlikely to be impacted due to the small volume of water that would be displaced as a consequence of water exclusion measures.
C5 Rozelle civil and tunnel site	The indicative site layout has taken into consideration flood risk and the requirements for the conveyance of flood water through the site. Where setback from flooded areas is not possible, bunding will be required to protect tunnel ramps and vulnerable infrastructure to prevent floodwater ingress. Alternatively floor levels could be raised above expected flood levels. Construction of the permanent conveyance system as early as possible during construction to enable flood risk to the project to be managed and to mitigate impacts on surrounding properties. Temporary drainage measures required whilst installing the permanent arrangement.
C6 The Crescent civil site	Local drainage flow paths will be taken into consideration to divert flows safely around the laydown area.

Construction ancillary facility	Specific mitigation measures
C7 Victoria Road civil site	None required.
C8 Iron Cove civil site	Bunding of ramps to prevent floodwater ingress to the tunnel dive structures. Temporary drainage works would be implemented to minimise impacts on existing development as far as practicable by managing runoff on Victoria Road.
C9 Pyrmont Bridge Road tunnel site	The indicative site layout has taken into consideration risk of flooding on Bignell Lane, which functions as a preferential flowpath through the site. Vulnerable uses, such as the tunnel dive structure is located away from flooding on Bignell Lane. The existing flow path on Bignell Lane will be retained by the installation of breaks or flaps in fencing or site hoarding, to allow the overland flow path into and out of site. The overland flow path will be managed and controlled along existing and proposed roads. Use of noise walls or other flood protection barriers around the perimeter of the site to prevent ingress of flood water from Parramatta Road to the south and Mallett Street to the east.
C10 Campbell Road civil and tunnel site (part of New M5 project footprint).	None required. Construction activities will not impact on the mitigation measures implemented as part of New M5 project.

8.1.3 Management during operational phase

The assessment of flood impacts associated with the project has provided an understanding of the scale and nature of the flood risk to the project infrastructure and its operation, as well as the risks for the surrounding environment.

The layouts of the different interchanges have been influenced by flood risk and drainage considerations. In addition to the site specific mitigation measures outlined in **section 8.1.3**, a broad outline of other measures to be implemented in order to manage the operational flood risks and impacts as part of the detailed design is provided as follows.

Tunnel portals and ancillary facilities

Tunnel entries and associated flood protection barriers are to be located above the PMF level or the 100 year ARI flood level plus 0.5 metres (whichever is greater). The same hydrologic standard would be applied to tunnel ancillary facilities such as tunnel ventilation and water treatment plants where the ingress of floodwaters would also have the potential to flood the tunnels.

Emergency response facilities

Emergency response facilities including the motorway control centre, tunnel fire water tank, pump buildings and associated electrical substations are to be located above the PMF level or the 100 year ARI flood level plus 0.5 metres (whichever is greater).

Impacts of flooding on existing development

A 100 year ARI flood standard is to be adopted in the assessment of measures required to mitigate any adverse flood impacts attributable to the project. Changes in flood behaviour under PMF conditions are also to be investigated in order to identify potential impacts on critical infrastructure and significant changes in flood hazard as a result of the project.

Potential blockage of major hydraulic structures

When setting finished road level and flood wall heights during detailed design, consideration should be given to the effects that partial blockage of major hydraulic structures might have on flood behaviour.

Potential impacts of future climate change on flood behaviour

Further assessment would need to be undertaken during detailed design to determine the climate change related flood risks to the project and flood impacts from the project, and would confirm requirements for any management measures. The assessment should be undertaken in accordance with the *Practical Considerations of Climate Change – Floodplain Risk Management Guideline* (DECC 2007).

Management of adverse flood impacts on existing development

The assessment of impacts the project might have on flood behaviour for surrounding properties and the mitigation measures required to manage such impacts would be refined during detailed design, through a detailed hydrologic and hydraulic assessment.

Works within the floodplain would be designed to minimise adverse impacts on surrounding development for flooding up to the 100 year ARI event, for example at the Rozelle interchange. Potential impacts for events in excess of the 100 year ARI up to the PMF would also be considered in the context of impacts on critical infrastructure and flood hazards.

The assessment has shown that impacts to surrounding properties can be mitigated so as to not increase flood risk to adjoining properties. If impacts to properties are identified as the assessment is refined during detailed design, then a floor level survey in affected areas would need to be undertaken. This information would be used to determine whether the project would increase flood damages for adjacent development (i.e. properties where there are potential increases in peak flood levels for events up to 100 year ARI).

Where adverse flood impacts for existing properties and potential future development are identified during the detailed design phase, additional mitigation measures would need to be incorporated in the design to minimise these impacts.

Stormwater drainage systems

Further hydrological and hydraulic modelling based on the detailed design would 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 would 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 discharge from the project is predicted to adversely impact on the receiving drainage systems.

8.2 Water quality

Except as may be provided by an Environment Protection Licence, the project will be constructed and operated to comply with section 120 of the POEO Act, which prohibits the pollution of waters. Specific management measures are detailed below.

8.2.1 Management of construction impacts

Soil and water management plan

A 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 (DECCW, 2008), commonly referred to as the 'Blue Book'.

Erosion and sediment control/waterway and riparian area protection

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. A soil conservation specialist would be engaged for the duration of construction to provide advice regarding erosion and sediment control.

The following controls would be implemented as part of the ESCP to address potential erosion and sediment control issues:

- Surface runoff generated during construction would be captured in basins or low point sumps, tested (and treated if required) prior to reuse or discharge under a site specific arrangement
- The design, construction and management of sediment sumps/basins to capture stormwater runoff and sediment during the construction phase would be in accordance with The Blue Book (Landcom 2004). The number, location and size of these basins/sumps will be confirmed during detailed design and in accordance with the requirements of the relevant Environment Protection Licence. The Blue Book recommends that where receiving waters are sensitive, sediment basins should be sized for an 80th percentile or 85th percentile five day rainfall depth for disturbance periods of less than or greater than six months respectively
- Internal construction traffic would be restricted to access tracks, delineated through fencing before the start of construction and maintained until construction is complete
- Erosion and sediment controls would be implemented prior to soil disturbance. Lateral flow (i.e. stormwater) would be managed to avoid flow over exposed soils which may result in erosion and impacts to water quality
- Above ground stockpile sites would be located outside the 20 year ARI flood extent, where possible. Appropriate management control measures such as bunding would be in place where construction ancillary facilities are located in the 20 year ARI flood extent (see **Annexure D**)
- The extent of ground disturbance and exposed soil will be minimised to the greatest extent practicable to minimise the potential for erosion
- Disturbed ground and exposed soils will be temporarily stabilised prior to extended periods of site inactivity to minimise the potential for erosion
- 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
- Rainfall forecasts to be monitored daily and the site managed to avoid erosion and sedimentation and to minimise the impact of heavy rainfall and flood events
- Sealed surfaces to be provided within construction ancillary facilities where possible to minimise erosion
- Controls to minimise mobilisation of dirt onto roads would be implemented including, for example, a wheel wash or rumble grid systems installed at exit points
- A soil conservation specialist would be contracted to supervise construction in 'high risk' areas in accordance with the Roads and Maritime Erosion and Sedimentation Management Procedure
- Procedures and protocols to manage potentially contaminated fill, soil, and bedrock, acid sulfate soils and extracted groundwater would be detailed in the CEMP measures to minimise the disturbance of sediments during construction of new stormwater discharge outlets to Rozelle Bay and Iron Cove. Measures would be designed in accordance with *Controlled Activities – Guidelines for outlet structures* (NSW Office of Water 2010). Where practical, permanent scour protection measures required for the operational phase would be installed early in the construction phase
- Works within or adjacent to waterways to be managed in accordance with the *Controlled Activities on Waterfront Land Guidelines* (DPI 2012).

Water quality monitoring

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**.

The monitoring program would commence prior 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).

Samples would be taken monthly, including a range of wet and dry conditions, where possible. This would include upstream (control) and downstream measurement locations. Additional monitoring locations may be required as part of the CSWMP. As a minimum an additional monitoring location should be incorporated within or at a suitable discharge point to White Bay.

New crossings

The proposed bridge crossing and widening at Whites Creek including any temporary work platforms, waterway crossings and/or coffer dams, where feasible and reasonable, must be designed and constructed in a manner which is consistent with:

- *NSW Guidelines for Controlled Activities Watercourse Crossings* (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* (DPI-Fisheries 2013).

Appropriate fish passage will be provided for crossings of fish habitat streams.

Construction water treatment

Temporary construction water treatment plants would be designed to treat wastewater including tunnel groundwater ingress, rainfall runoff in tunnel portals and ventilation outlets, heat and dust suppression water and wash down runoff.

The level of treatment provided would 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.

With consideration to the 'highly disturbed' nature of all receiving waterways and temporary nature of the construction phase, an ANZECC (2000) species protection level of 90 per cent for toxicants is considered appropriate for adoption as a discharge criterion where practical and feasible. The discharge criteria for the treatment facilities will be finalised during the preparation of the CSWMP.

The design of the construction water treatment plants will be undertaken during detailed design. The treatment facilities may consist of:

- Primary settling tanks / ponds to remove sand and silt sediment fractions as well as oil and grease
- pH balance/metals oxidation tank with primary flocculation
- Secondary flocculation tank
- Clarifiers to remove sediment and residual oil
- Sediment dewatering processes
- Inline process and discharge turbidity and pH monitoring with diversion valves to divert out of specification water for retreatment.

Water reuse

As detailed in **section 2.4.1**, where available and practicable, and of appropriate chemical and biological quality, stormwater, recycled water or other water sources would be used in preference to potable water for construction activities, including dust control.

As a minimum, stormwater and groundwater inflows and reclaimed water shall satisfy the following water quality requirements prior to reuse onsite for non-potable uses:

- Workplace health and safety requirements
- Water showing signs of contamination, such as oil and grease, shall not be reused onsite
- pH levels are between 6.5 and 8.5
- Guidelines set out in the tip sheet *Use of Reclaimed Water* (RTA 2006b).

Contaminated runoff and spills

The following measures would be implemented to manage spills of contaminated fluids:

- Areas would be allocated for the storage of fuels, chemicals and other hazardous materials as far away as feasible and reasonable from drainage channels and areas that are unlikely to be flooded during a 20 year ARI event on an impervious, bunded area
- Facilities would be secured and bunded to levels in accordance with the NSW EPA guidelines
- Spills or contaminated runoff would be captured and disposed of at a licensed facility where necessary
- Activities such as re-fuelling, wash down and preparation of construction materials would be undertaken in bunded areas to mitigate risks in relation to spills or leaks of fuels/oils or other hazardous onsite construction material
- The application of good practice in the storage and handling of dangerous and hazardous goods would provide appropriate practical responses to minimise the risk of a spill occurring
- Potential discharges from construction sites such as accidental construction spills or leaks would be managed through the installation of sumps / basins (primarily designed for sediment capture but with capacity to contain the nominated spill volume) constructed in accordance with *Managing Urban Stormwater – Soils and Construction, Volume 1* (Landcom 2004). Captured contaminants resulting from spills or leaks would be treated and disposed of at a licensed facility where necessary
- Soil which has been contaminated with fuel, oils or other chemicals would be disposed as contaminated soil through the projects waste subcontractor.

8.2.2 Residual construction water quality impacts

The proposed surface water management measures aim to minimise short term impacts on the receiving waterways during construction. With the implementation of the management measures, and in the context of the overall catchment, any potential short term impacts are unlikely to have a material impact on ambient water quality within the receiving waterways.

Therefore, the project is likely to have a negligible influence on whether NSWWQOs are protected (if currently met) or achieved (if currently not met) during the construction phase.

8.2.3 Management of operational impacts

Stormwater runoff

Suitable treatment devices would be provided to treat stormwater runoff from impervious surfaces that result from the project. Treatment of stormwater runoff would target the stormwater quality objectives outlined in **section 3.2.11**. Stormwater treatment systems would be installed where space is available. In the case where space is unavailable, the treatment suite would more likely include proprietary stormwater treatment devices. Stormwater treatment systems would incorporate a high flow bypass for a minimum of a three month ARI flow, where practical and appropriate. This would enable treatment of the majority of runoff events whilst protecting treatment devices from scour or damage associated with larger rainfall events.

The final design of treatment trains would be informed by an assessment of the sensitivity of the receiving environments and supported by MUSIC modelling. This would be undertaken during detailed design. Potential opportunities to further reduce the projects annual stormwater pollutant loading through the treatment of external catchments, to achieve the project pollutant load reduction targets (see **section 3.2.11**), will be explored during detailed design. Proposed landscaped areas would be suitably profiled, vegetated and stabilised to control erosion.

A maintenance plan for the management of all stormwater treatment devices will be developed during detailed design. The maintenance plan would outline future maintenance responsibilities, maintenance frequency and specific tasks to be undertaken.

New discharge outlets would be designed with appropriate energy dissipation and scour protection measures as required to minimise the potential for sediment disturbance caused by the operation of new outlets. The design of the outlets, including discharge velocities and energy dissipation/scour protection measures would be informed by appropriate drainage modelling and confirmed during detailed design. The presence and suitability of energy dissipation and scour protection measures at existing outlets would also be assessed during detailed design and appropriate improvements incorporated as required.

Water quality monitoring

A program to monitor potential surface water quality impacts due to the project will be developed and included in the OEMP. The program will include the water quality monitoring parameters and the monitoring locations identified in **Annexure E**.

The monitoring program would continue 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).

Spill controls

An assessment of risk of spills on the motorway, with emphasis placed on the receiving environment, would be undertaken. If warranted in areas of higher sensitivity, such as upstream of Rozelle Bay and Iron Cove, containment facilities would be provided. This would be determined during detailed design.

Spill management and emergency response procedures would also be documented in an OEMP.

Tunnel water treatment facilities

The tunnel operational water treatment facilities would be designed such that effluent will be of suitable quality for discharge to the receiving environment.

The level of 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 to the relevant NSW WQOs.

With consideration to existing water quality within Hawthorne Canal and Rozelle Bay. NSW WQOs and the permanent nature of the tunnel water discharges the ANZECC (2000) ‘marine’ default trigger values for 95 per cent level of species protection may be appropriate for establishing discharge criteria for parameters which require treatment, where practical and feasible. As no ‘marine’ trigger value is available for the key toxicants which are likely to require treatment within the tunnel water (iron and manganese), alternative discharge criteria are provided in **Table 8-2**. The discharge criteria for the treatment facilities will be further developed and finalised within the OEMP.

Table 8-2 Indicative tunnel wastewater discharge criteria

Parameter	Discharge criteria	Reference	Comments
Iron	0.3 mg/L	ANZECC (2000) recreational water quality guideline value	No marine or fresh water trigger value available
Manganese	1.8 mg/L	ANZECC (2000) fresh water 95% species protection	No marine water trigger value available

The constructed wetland within the Rozelle interchange area would be designed to cater for the continuous treated groundwater flows from the water treatment plant. The wetland at Rozelle interchange would also be used to treat a portion of stormwater runoff from the project footprint.

Opportunities to incorporate other forms of nutrient/ammonia removal will be investigated during detailed design for the treatment plant at Darley Road, as required.

8.2.4 Residual operational water quality impacts

As detailed in **section 4.5** the receiving waterways currently do not achieve all the SHPRC water quality objectives with elevated levels of some heavy metals, nutrients, turbidity and pH recorded. The MUSIC modelling indicates that the project would reduce the stormwater pollutant loading to the receiving waterways when compared to the existing conditions.

Tunnel water will be treated and spill controls and water quality monitoring will be implemented to manage impacts to ambient water quality within the receiving waterways. Residual impacts to ambient water quality will generally be negligible with impacts localised to the zone near the outlet where discharges mix with receiving waters. In the context of the entire catchment draining to Sydney Harbour, the project is likely to have a negligible influence on achieving the SHPRC water quality objectives.

8.3 Management of cumulative impacts

An assessment of cumulative impacts associated with other projects in the vicinity of the M4-M5 Link, in particular other WestConnex projects, such as the M4 East and New M5 projects, has been carried out. The assessment also considered other projects such as the CBD and South East Light Rail and Western Harbour Tunnel and Beaches Link (see **section 7**). The projects currently under construction all incorporate surface water and flood management measures during construction and operation to prevent adverse impacts to the common receiving receptors and adjoining properties. Other projects that are still in the planning stages will likely be required to implement similar mitigation measures in accordance with legislative requirements to prevent adverse impacts.

Therefore, with due consideration of the proposed management measures to be implemented as part of the M4-M5 Link project as discussed in **sections 8.1** and **8.2**, there are minimal adverse cumulative surface water quality or flooding impacts anticipated. The residual risk to common receptors and sensitive environments downstream would be low provided the proposed management measures are implemented, maintained and monitored.

9 Conclusion

9.1 Flooding

The risk of flooding posed to the surface features of the M4-M5 Link project has been assessed, taking into account the likely impacts of climate change and cumulative impacts with other projects, as well as the potential impact that the project might have on surrounding properties.

Flood risk has been identified as a consideration at some of the construction sites, including Rozelle Rail Yards, Darley Road, Iron Cove Link and Pyrmont Road Bridge Road. The indicative layouts for the sites have considered the existing flood risk, by locating more vulnerable land uses away from areas of flooding or deeper water. Where this is not possible, a number of mitigation measures have been identified in order to protect the portals and sensitive infrastructure from inundation and minimise the potential to displace flood water.

The flood risk posed to the interchanges at the connection points to the M4 East and New M5 are being managed by the respective projects, therefore no further mitigation is considered to be required. The proposed site of the Rozelle interchange currently functions as an area of significant flood storage and a number of measures have been incorporated into the operational layout to enable floodwater to be conveyed through the site as well as protecting sensitive project infrastructure such as the portals, substations and ventilation facilities. At the Iron Cove Link and Darley Road sites, the proposed change to the road layout and levels and protection of the portals is not considered to have a significant impact on flood risk.

The potential flood risk impacts associated with the project are considered to be acceptable based on the mitigation measures identified. The assessment of flood risk and mitigation measures identified will need to be refined throughout the detailed design process.

9.2 Water quality

Potential impacts on surface water quality during construction of the project are considered minor and manageable with the application of standard mitigation measures.

The CEMP would control potential surface water quality impacts during construction. Construction water treatment plants would be established during the construction phase to treat water to a quality suitable for discharge to the environment.

A CSWMP would be prepared as part of the overall CEMP and a Water Quality Monitoring Program would be prepared and implemented to monitor and avoid or mitigate impacts on surface water quality during construction and operation.

During operation, there is potential for the project to impact surface water quality through discharges of poorly treated tunnel water. Two operational water treatment plants will be designed to treat tunnel flows to a suitable quality for discharge to the receiving environment. Treated flows from the Rozelle plant will be discharged to a wetland providing additional ‘polishing’ treatment prior to discharge. Opportunities to incorporate other forms of nutrient treatment within the treatment plant at Darley Road will be investigated during detailed design, as required.

During operation, there is potential for the project to impact surface water quality through increases in imperviousness that would lead to increases in pollutant loads associated with surface runoff. This would be managed through a range of treatment devices such as wetlands, bioretention systems, and good practice inline pollution control measures or proprietary treatment devices. Current provisions are sufficient to reduce the stormwater mean annual pollutant loading to Sydney Harbour when compared to existing conditions.

In the context of the entire catchment draining to Sydney Harbour, the project is likely to have a negligible influence on achieving the SHPRC water quality objectives.

9.3 Hydrology and geomorphology

The discharge of treated construction water would have a minor increase in base flow rates to receiving waterways. The flow variability within the receiving waterways is dominated by tides at the proposed discharge locations.

During operation, minor increases in storm flow to Rozelle Bay, Whites Creek, White Bay, Iron Cove, Alexandra Canal and Hawthorne Canal associated with an increase in impervious surface and the increase in base flow to Hawthorne Canal and Rozelle Bay associated with treated tunnel flows are considered to pose a negligible impact on the flow variability and hydrological attributes of the tidal waterways.

Given the majority of existing waterways are hard lined, increased discharge volumes will not impact on bed or bank stability during construction or operation. Negligible increases in discharge volume to Alexandra Canal during construction and operation are unlikely to have a material impact on the disturbance of bed sediments within the canal. Appropriate energy dissipation and scour protection will be assessed and provided as appropriate at outlet locations to minimise scour and mobilisation of contaminated sediments in the vicinity of the outlet. Naturalisation works on Whites Creek would incorporate surface treatments which provide suitable erosion protection once constructed and established. The naturalisation works would likely provide added ecological benefits to the waterway.

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Annexures

Annexure A Photographs

Photo 1 – Dobroyd Canal at Timbrell Park

Photo 2 – Hawthorne Canal at Blackmore Park

Photo 3 – Easton Park drain adjacent to Lilyfield Road

Photo 4 – Easton Park drain (culverts in foreground) and Whites Creek outlet (background) to Rozelle Bay

Photo 5 – Whites Creek at Brenan Street

Photo 6 – Iron Cove immediately downstream of Iron Cove Bridge

Photo 7 – Alexandra Canal downstream of Canal Road

Photo 8 – Steep embankments along Rozelle Rail Yards

Photo 9 – Median barrier along Victoria Road (Google Street View)

Annexure B Water Quality Data Summary

Table B-1 Dobroyd Canal surface water quality monitoring summary

Parameter		Guideline Criteria		M4 East Dobroyd Canal monitoring[5] – Non–Tidal			M4 East Dobroyd Canal Monitoring[6] – Tidal			M4M5 Dobroyd Canal Monitoring[7] – Tidal		
	Units	ANZECC 2000 Freshwater[1]	ANZECC 2000 Marine[2]	Min	Max	Med	Min	Max	Med	Min	Max	Med
Dissolved Oxygen (Field) (Filtered)	mg/L	-	-	9.02	13.1	10.8	4.43	15	10.86	1.7	20.83	7.95
Electrical Conductivity (Field)	µS/cm	125 – 2000[4]	-	230	2749	643.7	260	52630	25560	216	58650	21219
pH (Field)		6.5 – 8.0[4]	7 – 8.5[3]	7.9	9.07	8.545	6.98	9.15	7.85	5.67	10.3	8.1
Turbidity (Field)	NTU	6-50	0.5-10	10.6	549	50.4	2.5	187	14.4	1	111.6	12.1
Arsenic	mg/L	0.013[8]	-	0.001	0.007	0.003	0.002	0.003	0.0025	0.001	0.014	0.004
Cadmium	mg/L	0.0002	0.0055	-	-	-	0.0001	0.0001	0.0001	<0.0001	<0.001	0.0001
Chromium (III+VI)	mg/L	0.001[9]	0.0044[9]	0.002	0.006	0.0035	0.002	0.003	0.0025	0.0005	0.025	0.003
Copper	mg/L	0.0014	0.0013	0.005	0.051	0.013	0.004	0.028	0.01	0.003	0.113	0.019
Iron	mg/L	-	-	NS	NS	NS	NS	NS	NS	0.2	14.3	1.385
Lead	mg/L	0.0034	0.0044	0.003	0.024	0.0055	0.001	0.014	0.0045	0.002	0.136	0.011
Manganese	mg/L	1.9	-	NS	NS	NS	NS	NS	NS	<0.01	0.159	0.0255
Mercury	mg/L	0.0006	0.0004	NS	NS	NS	NS	NS	NS	<0.00004	0.0002	0.00005
Nickel	mg/L	0.011	0.07	0.001	0.006	0.002	0.002	0.007	0.004	<0.001	0.012	0.003
Zinc	mg/L	0.008	0.015	0.01	0.08	0.0405	0.021	0.074	0.033	0.015	0.474	0.0575
Ferrous Iron	mg/L			NS	NS	NS	NS	NS	NS	<0.05	10.5	0.175
TRH C10 - C40 (Sum of Total)	mg/L	-	-	0.48	0.48	0.48	-	-	-	<100	1540	50
C6 - C 9 Fraction	mg/L	-	-	-	-	-	-	-	-	<20	30	10
C10 - C36 (Sum of Total)	mg/L	-	-	0.43	0.43	0.43	0.05	0.05	0.05	<50	1190	25
Total BTEX	mg/L	-	-	NS	NS	NS	NS	NS	NS	<0.001	<0.001	0.0005

Parameter	Units	Guideline Criteria		M4 East Dobroyd Canal monitoring[5] – Non–Tidal			M4 East Dobroyd Canal Monitoring[6] – Tidal			M4M5 Dobroyd Canal Monitoring[7] – Tidal		
		ANZECC 2000 Freshwater[1]	ANZECC 2000 Marine[2]	Min	Max	Med	Min	Max	Med	Min	Max	Med
Phosphorus	mg/L	0.05[4]	0.03[3]	0.1	0.41	0.23	0.06	0.44	0.1	0.03	2.24	0.19
Reactive Phosphorus	mg/L	-	-	NS	NS	NS	NS	NS	NS	<0.01	0.38	0.04
Kjeldahl Nitrogen Total	mg/L	-	-	0.7	3.3	1.3	0.3	4.9	0.75	<0.2	12	1.25
Nitrate	mg/L	0.7	-	NS	NS	NS	NS	NS	NS	0.04	2.33	0.56
Nitrite	mg/L	-	-	NS	NS	NS	NS	NS	NS	<0.01	0.3	0.04
Nitrogen (Total Oxidised)	mg/L	-	-	1.22	4.23	2.06	0.03	2.35	0.485	0.04	2.39	0.61
Nitrogen (Total)	mg/L	0.5[4]	0.3[3]	2.1	6.4	4.2	0.4	5.2	1.25	<0.5	13.7	2.25
Total Suspended Solids	mg/L	-	-	7	200	22	12	66	39	NS	NS	NS

Notes:

[1] ANZECC (2000) *'freshwater'* default trigger values for 95 per cent level of species protection

[2] ANZECC (2000) *'marine'* default trigger values for 95 per cent level of species protection

[3] ANZECC (2000) *'estuaries'* default trigger values for physical and chemical stressors for south-east Australia for slightly disturbed ecosystems

[4] ANZECC (2000) *'lowland rivers'* default trigger values for physical and chemical stressors for south-east Australia for slightly disturbed ecosystems

[5] M4 East sampling conducted by GHD between June 2015 and May 2016 based on 12 samples collected from DOB1

[6] M4 East sampling conducted by GHD between June 2015 and May 2016 based on 11 samples collected from DOB2

[7] M4-M5 Link sampling conducted by AECOM between July 2016 and May 2017, based on 16 samples collected from SW8 and 16 samples collected from SW09

[8] Based on Arsenic (As V)

[9] Based on Chromium (Cr VI)

5.2 = Exceeds one or more relevant guideline criteria

NS = No sample collected

'-' = Sample collected but below detection limit

Table B-2 Hawthorne Canal surface water quality monitoring summary

Parameter		Guideline Criteria		M4 East Hawthorne Canal Monitoring - Tidal[5]			M4M5 Hawthorne Canal Monitoring - Tidal [6]		
	Units	ANZECC 2000 Freshwater[1]	ANZECC 2000 Marine[2]	Min	Max	Med	Min	Max	Med
Dissolved Oxygen (Field) (Filtered)	mg/L	-	-	3.94	13.83	9.34	1.05	51.81	5.115
Electrical Conductivity (Field)	µS/cm	125 – 2000[4]	-	267	40140	12072	3032	51650	42333.5
pH (Field)		6.5 – 8.0[4]	7 – 8.5[3]	6.81	8.38	7.885	5.35	7.88	7.605
Turbidity (Field)	NTU	6-50	0.5-10	4.3	425	31.1	0.1	51.3	8
Arsenic	mg/L	0.013[7]	-	0.001	0.008	0.003	0.0019	<0.01	0.005
Cadmium	mg/L	0.0002	0.0055	0.0002	0.0002	0.0002	<0.0001	<0.001	0.00035
Chromium (III+VI)	mg/L	0.001[9]	0.0044[8]	0.001	0.006	0.001	<0.0005	<0.01	0.005
Copper	mg/L	0.0014	0.0013	0.003	0.067	0.0065	<0.001	0.033	0.005
Iron	mg/L	-	-	NS	NS	NS	<0.1	3.91	0.34
Lead	mg/L	0.0034	0.0044	0.001	0.032	0.004	0.0016	0.056	0.005
Manganese	mg/L	1.9		NS	NS	NS	<0.01	0.062	0.018
Mercury	mg/L	0.0006	0.0004	NS	NS	NS	<0.00004	0.0001	0.00005
Nickel	mg/L	0.011	0.07	0.002	0.006	0.0035	0.0005	<0.01	0.004
Zinc	mg/L	0.008	0.015	0.015	0.127	0.032	0.01	0.124	0.026
Ferrous Iron	mg/L	-	-	NS	NS	NS	<0.05	1.45	0.075
TRH C10 - C40 (Sum of Total)	mg/L	-	-	-	-	-	<100	<100	50
C6 - C 9 Fraction	mg/L	-	-	-	-	-	<20	<100	10
C10 - C36 (Sum of Total)	mg/L	-	-	-	-	-	<50	<50	25
Total BTEX	mg/L	-	-	NS	NS	NS	<0.001	<0.005	0.0005
Phosphorus	mg/L	0.05[4]	0.03[3]	0.03	0.59	0.125	<0.02	6.82	0.07
Reactive Phosphorus	mg/L	-	-	NS	NS	NS	<0.01	0.1	0.03
Kjeldahl Nitrogen Total	mg/L	-	-	0.4	2	0.8	0.4	2	0.25
Nitrate	mg/L	0.7	-	NS	NS	NS	0.01	2.79	0.09

Parameter	Units	Guideline Criteria		M4 East Hawthorne Canal Monitoring - Tidal[5]			M4M5 Hawthorne Canal Monitoring - Tidal [6]		
		ANZECC 2000 Freshwater[1]	ANZECC 2000 Marine[2]	Min	Max	Med	Min	Max	Med
Nitrite	mg/L	-	-	NS	NS	NS	<0.01	0.05	0.005
Nitrogen (Total Oxidised)	mg/L	-	-	0.18	2.75	0.83	0.01	2.84	0.09
Nitrogen (Total)	mg/L	0.5[4]	0.3[3]	0.8	4.5	1.55	<0.5	4.8	0.25
Total Suspended Solids	mg/L	-	-	8	229	20.5	NS	NS	NS

Notes:

[1] ANZECC (2000) *'freshwater'* default trigger values for 95 per cent level of species protection

[2] ANZECC (2000) *'marine'* default trigger values for 95 per cent level of species protection

[3] ANZECC (2000) *'estuaries'* default trigger values for physical and chemical stressors for south-east Australia for slightly disturbed ecosystems

[4] ANZECC (2000) *'lowland rivers'* default trigger values for physical and chemical stressors for south-east Australia for slightly disturbed ecosystems

[5] M4 East sampling conducted by GHD between June 2015 and May 2016 based on 13 samples collected from DSW

[6] M4-M5 Link sampling conducted by AECOM between July 2016 and May 2017, based on 16 samples collected from SW5 and 16 samples collected from SW06

[7] Based on Arsenic (As V.)

[8] Based on Chromium (Cr VI)

5.2 = Exceeds one or more relevant guideline criteria

NS = No sample collected

'-' = Sample collected but below detection limit

Table B-3 Whites Creek surface water quality monitoring summary

Parameter	Units	Guideline Criteria ANZECC 2000 Freshwater[1]	ANZECC 2000 Marine[1]	M4M5 Whites Creek Monitoring[4] – Tidal Min	Max	Med	The Bays Whites Creek Monitoring[5] – Tidal Min	Max	Med[8]
Dissolved Oxygen (Field) (Filtered)	mg/L	-		4.97	35.43	11.855	NS	NS	NS
Electrical Conductivity (Field)	µS/cm	125 – 2000[2]		39.1	39785	1055	NS	NS	NS
pH (Field)		6.5 – 8.0[2]	7 – 8.5[3]	5.38	9.41	7.73	NS	NS	NS
Turbidity (Field)	NTU	6-50	0.5-10	-0.7	18.8	2.45	NS	NS	NS
Total suspended solids		-	-	-	-	-	5.10	16.18	10.00
Arsenic	mg/L	0.013[7]	-	0.0009	0.003	0.005	0.0012	0.0027	0.0013
Cadmium	mg/L	0.002		0.0001	0.0006	0.00035	NS	NS	NS
Chromium (III+VI)	mg/L	0.001[8]	0.0044[8]	0.0008	0.002	0.005	0.0005	0.0008	0.0006
Copper	mg/L	0.0014	0.0013	0.003	0.014	0.005	0.0025	0.0048	0.0036
Iron	mg/L	-	-	0.17	0.89	0.34	0.0370	0.2158	0.1403
Lead	mg/L	0.0034	0.0044	0.002	0.017	0.005	0.00008	0.00096	0.00044
Manganese	mg/L	1.9	-	0.006	0.06	0.018	NS	NS	NS
Mercury	mg/L	0.0006	0.0004	-	-	0.00005	-	-	-
Nickel	mg/L	0.011	0.07	0.001	0.003	0.004	0.0015	0.0019	0.0017
Zinc	mg/L	0.008	0.015	0.034	0.361	0.026	0.027	2.93	1
Ferrous Iron	mg/L	-	-	0.06	0.62	0.075	NS	NS	NS
Silicate		-	-	NS	NS	NS	0.63	4.15	1.98
TRH C10 - C40 (Sum of Total)	mg/L	-	-	-	-	50	NS	NS	NS
C6 - C 9 Fraction	mg/L	-	-	-	-	10	NS	NS	NS
C10 - C36 (Sum of Total)	mg/L	-	-	-	-	25	NS	NS	NS
Total BTEX	mg/L	-	-	0.002	0.002	0.0005	NS	NS	NS
Phosphorus	mg/L	0.05[2]	0.03[5]	0.04	0.48	0.07	0.068	0.18	0.089
Reactive Phosphorus	mg/L	-	-	0.01	0.12	0.03	NS	NS	NS

Parameter	Units	Guideline Criteria		M4M5 Whites Creek Monitoring[4] – Tidal			The Bays Whites Creek Monitoring[5] – Tidal		
		ANZECC 2000 Freshwater[1]	ANZECC 2000 Marine[1]	Min	Max	Med	Min	Max	Med[8]
Reactive Orthophosphate	mg/L	-	-	NS	NS	NS	0.010	0.039	0.026
Kjeldahl Nitrogen Total	mg/L	-	-	0.3	1.3	0.25	NS	NS	NS
Nitrate	mg/L	0.7	-	0.06	1.83	0.09	0.25	1.83	0.80
Nitrite	mg/L	-	-	0.01	0.14	0.005	0.005	0.077	0.049
Nitrogen (Total Oxidised)	mg/L	-	-	0.06	1.89	0.09	NS	NS	NS
Oxides of Nitrogen	mg/L		-	NS	NS	NS	0.256	1.881	0.863
Nitrogen (Total)	mg/L	0.5[2]	0.3[5]	0.5	2.4	0.25	0.73	2.87	1.56

Notes:

[1] ANZECC (2000) *'freshwater'* default trigger values for 95 per cent level of species protection

[2] ANZECC (2000) *'lowland rivers'* default trigger values for physical and chemical stressors for south-east Australia for slightly disturbed ecosystems

[3] ANZECC (2000) *'estuaries'* default trigger values for physical and chemical stressors for south-east Australia for slightly disturbed ecosystems

[4] M4-M5 Link sampling conducted by AECOM between July 2016 and May 2017, based on 16 samples collected from SW2

[5] The Bays sampling conducted by Sydney University between June 2016 and September 2016, based on five samples collected from SW2

[6] ANZECC (2000) *'estuaries'* default trigger values for physical and chemical stressors for south-east Australia for slightly disturbed ecosystems

[7]Based on Arsenic (As V)

[8]Based on Chromium (Cr VI)

5.2 = Exceeds one or more relevant guideline criteria

NS = No sample collected

'-' = Sample collected but below detection limit

Table B-4 Rozelle Bay surface water quality monitoring summary

Parameter	Units	Guideline Criteria ANZECC 2000 Marine[2]	M4M5 Rozelle Bay Monitoring[5] – Tidal			The Bays Monitoring - Tidal		
			Min	Max	Med	Min	Max	Med[6]
Dissolved Oxygen	mg/L	-	-0.16	66.2	5.6	64	89	85
EC	µS/cm	-	402.9	51100	46630.5	47788	51981	50859
pH		7 – 8.53	5.65	7.96	7.61	7.69	8.14	8.02
Turbidity	NTU	0.5-10	-1.4	15	2.35	0.20	3.40	1.40
Total suspended solids	mg/L	-	-	-	-	2.30	11.15	4.40
Arsenic	mg/L	-	-	-	0.005	0.0015	0.0019	0.0018
Cadmium	mg/L	0.0055	-	0.0018	0.0005	-	-	-
Chromium (III+VI)	mg/L	0.0044[7]	-	-	0.005	0.0005	0.0005	0.0005
Copper	mg/L	0.0013	0.002	0.015	0.005	0.0016	0.0052	0.0028
Iron	mg/L	-	0.027	0.67	0.23	0.0025	0.0094	0.0037
Lead	mg/L	0.0044	0.0009	0.015	0.005	0.00004	0.00029	0.00025
Manganese	mg/L	-	0.0068	0.061	0.0059	-	-	-
Mercury	mg/L	0.0004	-	-	0.00005	-	-	-
Nickel	mg/L	0.07	-	-	0.005	0.0017	0.0024	0.0019
Zinc	mg/L	0.015	0.019	0.503	0.0415	0.019	1.559	0.218
Ferrous Iron	mg/L	-	-	0.38	0.07	-	-	-
Silicate	mg/L	-	NS	NS	NS	0.05	1.11	0.27
TRH C10 - C40 (Sum of Total)	mg/L	-	-	-	50	NS	NS	NS
C6 - C 9 Fraction	mg/L	-	-	-	10	NS	NS	NS
C10 - C36 (Sum of Total)	mg/L	-	-	-	25	NS	NS	NS
Total BTEX	mg/L	-	-	0.004	0.0005	NS	NS	NS
Phosphorus	mg/L	0.03[3]	0.02	3.76	0.025	0.032	0.046	0.039
Reactive Phosphorus	mg/L	-	-	0.07	0.02	-	-	-
Reactive Orthophosphate			NS	NS	NS	0.013	0.054	0.016

Parameter	Units	Guideline Criteria ANZECC 2000 Marine[2]	M4M5 Rozelle Bay Monitoring[5] – Tidal			The Bays Monitoring - Tidal		
			Min	Max	Med	Min	Max	Med[6]
Kjeldahl Nitrogen Total	mg/L	-	0.2	-	0.25	-	-	-
Nitrate	mg/L	0.7	0.01	0.9	0.085	0.01	0.94	0.14
Nitrite	mg/L	-	-	0.02	0.005	0.002	0.007	-
Nitrogen (Total Oxidised)	mg/L	-	0.01	0.92	0.085	-	-	-
Oxides of Nitrogen	mg/L		NS	NS	NS	0.008	0.951	0.140
Ammonia			NS	NS	NS	0.013	0.114	0.042
Nitrogen (Total)	mg/L	0.3[3]	0.3	1.3	0.25	0.256	1.430	0.416
Enteroccoci	CFU/100mL		NS	NS	NS	0	1300	28
Chlorophyll a	mg/L	0.003	NS	NS	NS	0.0007	0.0085	0.0032

Notes:

[1] ANZECC (2000) *'freshwater'* default trigger values for 95 per cent level of species protection

[2] ANZECC (2000) *'marine'* default trigger values for 95 per cent level of species protection

[3] ANZECC (2000) *'estuaries'* default trigger values for physical and chemical stressors for south-east Australia for slightly disturbed ecosystems

[4] ANZECC (2000) *'lowland rivers'* default trigger values for physical and chemical stressors for south-east Australia for slightly disturbed ecosystems

[5] M4-M5 Link sampling conducted by AECOM in 2016 between July 2016 and May 2017, based on 16 samples collected from SW1

[6] Where the median values is less than the limit of reporting, the median was assumed to be half of the value of the limit of reporting

[7] Based on Chromium (Cr VI)

5.2 = Exceedance of guideline criteria

NS = No sample collected

'-' = Sample collected but below detection limit

Table B-5 White Bay surface water quality monitoring summary

Parameter	Units	Guideline Criteria ANZECC 2000 Marine[2]	The Bays Monitoring – Tidal[4]		
			Min	Max	Med
Dissolved Oxygen	mg/L	-	5.88	8.14	7.31
EC	µS/cm	-	NS	NS	NS
pH		7 – 8.5[3]	7.86	8.17	8.06
Turbidity	NTU	0.5-10	0.10	2.60	1.40
Total suspended solids	mg/L	-	2.00	33.49	3.12
Arsenic	mg/L	-	0.0015	0.0021	0.0019
Cadmium	mg/L	0.0055			
Chromium (III+VI)	mg/L	0.0044[5]	0.0005	0.0007	0.0006
Copper	mg/L	0.0013	0.0023	0.0037	0.0026
Iron	mg/L	-	0.0028	0.0083	0.0035
Lead	mg/L	0.0044	0.00001	0.00006	0.00002
Manganese	mg/L	-	NS	NS	NS
Mercury	mg/L	0.0004	-	-	-
Nickel	mg/L	0.07	0.0018	0.0018	0.0018
Zinc	mg/L	0.015	0.006	0.86	0.072
Ferrous Iron	mg/L	-	NS	NS	NS
Silicate	mg/L	-	0.048	0.93	0.21
TRH C10 - C40 (Sum of Total)	mg/L	-	NS	NS	NS
C6 - C 9 Fraction	mg/L	-	NS	NS	NS
C10 - C36 (Sum of Total)	mg/L	-	NS	NS	NS
Total BTEX	mg/L	-	NS	NS	NS
Phosphorus	mg/L	0.03[3]	0.024	0.11	0.036
Reactive Phosphorus	mg/L	-	NS	NS	NS
Reactive Orthophosphate			0.007	0.050	0.014

Parameter		Guideline Criteria	The Bays Monitoring – Tidal[4]		
	Units	ANZECC 2000 Marine[2]	Min	Max	Med
Kjeldahl Nitrogen Total	mg/L	-	NS	NS	NS
Nitrate	mg/L	0.7	0.007	0.791	0.093
Nitrite	mg/L	-	0.003	0.006	0.005
Nitrogen (Total Oxidised)	mg/L	-	NS	NS	NS
Oxides of Nitrogen	mg/L	-	0.007	0.796	0.093
Ammonia		-	0.003	0.105	0.019
Nitrogen (Total)	mg/L	0.3[3]	0.195	1.279	0.320
Enteroccoci	CFU/100mL		0	940	5
Chlorophyll a	mg/L	0.003	0.0005	0.0067	0.0018

Notes:

[1] ANZECC (2000) *'freshwater'* default trigger values for 95 per cent level of species protection

[2] ANZECC (2000) *'marine'* default trigger values for 95 per cent level of species protection

[3] ANZECC (2000) *'estuaries'* default trigger values for physical and chemical stressors for south-east Australia for slightly disturbed ecosystems

[4] The Bays precinct water quality sampling conducted by Sydney University between June 2016 and September 2016, based on 12 samples collected from BW2

[5] Based on Chromium (Cr VI)

5.2 = Exceedance of guideline criteria

NS = No sample collected

'-' = Sample collected but below detection limit

Table B-6 Johnstons Creek surface water quality monitoring summary

Parameter		Guideline Criteria		M4M5 Johnstons Creek Monitoring[5] –Tidal			M4M5 Johnstons Creek Monitoring[6] – Non Tidal			The Bays Monitoring[7] – Non Tidal		
	Units	ANZECC 2000 Freshwater[1]	ANZECC 2000 Marine[2]	Min	Max	Med	Min	Max	Med	Min	Max	Med
Dissolved Oxygen (Field) (Filtered)	mg/L	-	-	2.72	14.01	8.3	6.09	10.29	8.74	NS	NS	NS
Electrical Conductivity (Field)	µS/cm	125 – 2000[4]	-	103.6	50444	2945	73.6	6980	593	NS	NS	NS
pH (Field)		6.5 – 8.0[4]	7 – 8.5[3]	6.06	8.69	7.915	5.78	814	8.18	NS	NS	NS
Turbidity (Field)	NTU	6-50	0.5-10	0	119.7	10.65	10.6	222.7	28.65	NS	NS	NS
Total suspended solids				-	-	-	-	-	-	9.3	20.2	10.3
Arsenic	mg/L	0.013[8]	-	-	-	0.0028	-	0.012	0.003	0.0009	0.0013	0.001
Cadmium	mg/L	0.002	0.0055	-	-	0.00005	-	0.0023	0.0001	NS	NS	NS
Chromium (III+VI)	mg/L	0.001[9]	0.0044[9]	0.0009	-	0.001	0.0006	0.012	0.002	0.0008	0.0011	0.0009
Copper	mg/L	0.0014	0.0013	0.007	0.07	0.015	0.007	0.107	0.025	0.0042	0.01	0.0072
Iron	mg/L			-	4.07	0.935	0.41	5.36	1.96	0.020	0.45	0.069
Lead	mg/L	0.0034	0.0044	0.002	0.072	0.011	-	0.071	0.014	0.00009	0.0012	0.00064
Manganese	mg/L	1.9	-	-	0.102	0.031	0.003	0.174	0.042	NS	NS	NS
Mercury	mg/L	0.0006	0.0004	-	0.0001	0.00005	-	-	0.00005	-	-	-
Nickel	mg/L	0.011	0.07	-	0.016	0.002	-	0.008	0.002	0.0012	0.0022	0.0016
Zinc	mg/L	0.008	0.015	0.025	0.187	0.0665	0.021	0.252	0.08	0.0077	0.053	0.0088
Ferrous Iron	mg/L	-	-	-	0.4	0.12	-	0.77	0.19	NS	NS	NS
Silicate	mg/L	-	-	NS	NS	NS	NS	NS	NS	3.87	5.15	4.79
TRH C10 - C40 (Sum of Total)	mg/L	-	-	-	-	50	-	1700	50	NS	NS	NS
C6 - C 9 Fraction	mg/L	-	-	-	-	10	-	-	10	NS	NS	NS
C10 - C36 (Sum of Total)	mg/L	-	-	-	-	25	-	1430	25	NS	NS	NS
Total BTEX	mg/L	-	-	-	-	0.0005	-	-	0.0005	NS	NS	NS
Phosphorus	mg/L	0.05[4]	0.03[3]	-	0.5	0.19	0.11	1.49	0.32	0.13	0.22	0.18

Parameter		Guideline Criteria		M4M5 Johnstons Creek Monitoring[5] –Tidal			M4M5 Johnstons Creek Monitoring[6] – Non Tidal			The Bays Monitoring[7] – Non Tidal		
	Units	ANZECC 2000 Freshwater[1]	ANZECC 2000 Marine[2]	Min	Max	Med	Min	Max	Med	Min	Max	Med
Reactive Phosphorus	mg/L	-	-	-	0.16	0.08	-	0.71	0.11			
Reactive Orthophosphate		-	-	NS	NS	NS	NS	NS	NS	0.068	0.126	0.083
Kjeldahl Nitrogen Total	mg/L	-	-	0.2	2.5	0.95	0.6	11	2.2			
Nitrate	mg/L	0.7	-	0.03	4.84	1.23	0.08	3.48	2.18	2.04	2.5	2.20
Nitrite	mg/L	-	-	-	0.21	0.065	-	0.87	0.12	0.065	0.370	0.227
Nitrogen (Total Oxidised)	mg/L	-	-	0.03	4.95	1.315	0.08	3.6	2.38			
Oxides of Nitrogen	mg/L	-	-	NS	NS	NS	NS	NS	NS	2.29	2.57	2.48
Nitrogen (Total)	mg/L	0.5[4]	0.3[3]	-	6.4	2.8	1.3	14.1	4.7	3.25	3.78	3.48
Ammonia	mg/L	0.9	0.91	NS	NS	NS	NS	NS	NS	0.200	0.713	0.452
Enteroccoci	CFU / 100mL	-	-	NS	NS	NS	NS	NS	NS	4800	32000	4900
Chlorophyll a	mg/L	0.003	0.005	NS	NS	NS	NS	NS	NS	0.0019	0.0026	0.0020

[1] ANZECC (2000) *'freshwater'* default trigger values for 95 per cent level of species protection

[2] ANZECC (2000) *'marine'* default trigger values for 95 per cent level of species protection

[3] ANZECC (2000) *'estuaries'* default trigger values for physical and chemical stressors for south-east Australia for slightly disturbed ecosystems

[4] ANZECC (2000) *'lowland rivers'* default trigger values for physical and chemical stressors for south-east Australia for slightly disturbed ecosystems

[5] M4-M5 Link sampling conducted by AECOM between July 2016 and May 2017, based on 16 samples collected from SW3

[6] M4-M5 Link sampling conducted by AECOM between July 2016 and May 2017, based on 16 samples collected from SW4 and 9 samples collected from SW14

[7] The Bays precinct sampling conducted by Sydney University between June 2016 and September 2016, based on five samples collected from SW1

[8] Based on Arsenic (As V)

[9] Based on Chromium (Cr VI)

5.2 = Exceeds one or more relevant guideline criteria

NS = No sample collected

'-' = Sample collected but below detection limit

Table B-7 Easton Park drain surface water quality monitoring summary

Parameter	Units	Guideline Criteria ANZECC 2000 Marine[2]	M4M5 Easton Park drain Monitoring[5] –Tidal Min	Max	Med
Dissolved Oxygen (Field) (Filtered)	mg/L	-	1.94	11.35	8.215
Electrical Conductivity (Field)	µS/cm	-	29.7	30379	1633
pH (Field)		7 – 8.5[3]	5.87	10.06	7.44
Turbidity (Field)	NTU	0.5-10	-0.2	390.7	4.35
Arsenic	mg/L	-	<0.001	<0.01	0.00225
Cadmium	mg/L	0.0055	<0.0001	<0.001	0.0001
Chromium (III+VI)	mg/L	0.0044[6]	<0.001	<0.01	0.001
Copper	mg/L	0.0013	0.005	0.049	0.0135
Iron	mg/L	-	0.24	3.37	0.515
Lead	mg/L	0.0044	<0.001	0.164	0.01815
Manganese	mg/L	-	0.007	0.072	0.02705
Mercury	mg/L	0.0004	<0.00004	<0.0001	0.00005
Nickel	mg/L	0.07	0.001	0.013	0.00495
Zinc	mg/L	0.015	0.073	0.395	0.1905
Ferrous Iron	mg/L	-	<0.05	1.28	0.135
TRH C10 - C40 (Sum of Total)	mg/L	-	<100	150	50
C6 - C 9 Fraction	mg/L	-	<20	<20	10
C10 - C36 (Sum of Total)	mg/L	-	<50	110	25
Total BTEX	mg/L	-	<0.001	<0.001	0.0005
Phosphorus	mg/L	0.03[3]	<0.05	1.28	0.125
Reactive Phosphorus	mg/L	-	<0.01	0.23	0.045
Kjeldahl Nitrogen Total	mg/L	-	0.4	5.9	0.9
Nitrate	mg/L	0.7	0.29	2.92	1.57

Parameter	Units	Guideline Criteria ANZECC 2000 Marine[2]	M4M5 Easton Park drain Monitoring[5] –Tidal		
			Min	Max	Med
Nitrite	mg/L	-	<0.01	0.11	0.025
Nitrogen (Total Oxidised)	mg/L	-	0.3	2.94	1.605
Nitrogen (Total)	mg/L	0.3[3]	0.8	6.3	2.7

Notes:

[1] ANZECC (2000) *'freshwater'* default trigger values for 95 per cent level of species protection.

[2] ANZECC (2000) *'marine'* default trigger values for 95 per cent level of species protection

[3] ANZECC (2000) *'estuaries'* default trigger values for physical and chemical stressors for south-east Australia for slightly disturbed ecosystems

[4] ANZECC (2000) *'lowland rivers'* default trigger values for physical and chemical stressors for south-east Australia for slightly disturbed ecosystems

[5] M4-M5 Link sampling conducted by AECOM between July 2016 and May 2017, based on 16 samples collected from SW7

[6] Based on Chromium (Cr VI)

5.2 = Exceeds one or more relevant guideline criteria

NS = No sample collected

'-' = Sample collected but below detection limit

Table B-8 Iron Cove surface water quality monitoring summary

Parameter		Guideline Criteria	M4M5 Iron Cove Monitoring[5] –Tidal		
	Units	ANZECC 2000 Marine[2]	Min	Max	Med
Dissolved Oxygen (Field) (Filtered)	mg/L	-	-1.22	9.71	6.66
Electrical Conductivity (Field)	µS/cm	-	465	52825	45057
pH (Field)		7 – 8.5[3]	6.56	8.29	7.96
Turbidity (Field)	NTU	0.5-10	-1.9	647	7.3
Arsenic	mg/L	-	0.0015	<0.01	0.005
Cadmium	mg/L	0.0055	<0.0001	<0.001	0.0005
Chromium (III+VI)	mg/L	0.0044[6]	<0.0005	0.013	0.005
Copper	mg/L	0.0013	0.003	0.022	0.005
Iron	mg/L	-	<0.1	5.43	0.395
Lead	mg/L	0.0044	0.0023	0.063	0.005
Manganese	mg/L	-	<0.01	0.068	0.0238
Mercury	mg/L	0.0004	<0.00004	0.0006	0.00005
Nickel	mg/L	0.07	0.0008	0.0502	0.005
Zinc	mg/L	0.015	0.015	0.306	0.026
Ferrous Iron	mg/L	-	<0.05	0.71	0.09
TRH C10 - C40 (Sum of Total)	mg/L	-	<100	<100	50
C6 - C 9 Fraction	mg/L	-	<20	<20	10
C10 - C36 (Sum of Total)	mg/L	-	<50	<50	25
Total BTEX	mg/L	-	<0.001	<0.001	0.0005
Phosphorus	mg/L	0.03[3]	0.03	0.77	0.025
Reactive Phosphorus	mg/L	-	<0.01	0.08	0.02
Kjeldahl Nitrogen Total	mg/L	-	0.4	<1	0.25
Nitrate	mg/L	0.7	<0.01	1.08	0.085

Parameter	Units	Guideline Criteria ANZECC 2000 Marine[2]	M4M5 Iron Cove Monitoring[5] –Tidal Min	Max	Med
Nitrite	mg/L	-	<0.01	0.02	0.005
Nitrogen (Total Oxidised)	mg/L	-	<0.01	1.1	0.085
Nitrogen (Total)	mg/L	0.3[3]	<0.5	1.5	0.25

Notes:

[1] ANZECC (2000) *'freshwater'* default trigger values for 95 per cent level of species protection

[2] ANZECC (2000) *'marine'* default trigger values for 95 per cent level of species protection

[3] ANZECC (2000) *'estuaries'* default trigger values for physical and chemical stressors for south-east Australia for slightly disturbed ecosystems

[4] ANZECC (2000) *'lowland rivers'* default trigger values for physical and chemical stressors for south-east Australia for slightly disturbed ecosystems

[5] M4-M5 Link sampling conducted by AECOM between November 2016 and May 2017, based on 10 samples collected from SW11 and 10 samples collected from SW12

[6] Based on Chromium (Cr VI)

5.2 = Exceeds one or more relevant guideline criteria

NS = No sample collected

'-' = Sample collected but below detection limit

Table B-9 Alexandra Canal and Sheas Creek surface water quality monitoring summary

Parameter		Guideline Criteria		New M5 Alexandra Canal Monitoring[5] –Tidal			M4M5 Sheas Creek Monitoring[6] –Tidal		
	Units	ANZECC 2000 Freshwater[1]	ANZECC 2000 Marine[2]	Min	Max	Med	Min	Max	Med
Dissolved Oxygen (Field) (Filtered)	mg/L	-	-	2.4	6.75	4.59	5.59	65.18	8.99
Electrical Conductivity (Field)	µS/cm	125 – 2000[4]	-	11483	44865	28091.5	111.2	4830	447
pH (Field)		6.5 – 8.0[4]	7 – 8.5[3]	7.27	7.97	7.46	5.78	9.79	7.78
Turbidity (Field)	NTU	6-50	0.5-10	0	256	6.3	4.6	46.5	10.25
Arsenic	mg/L	0.013[7]	-	0.001	0.003	0.005	<0.001	0.057	0.002
Cadmium	mg/L	0.002	0.0055	-	-	-	<0.0001	0.0014	0.00005
Chromium (III+VI)	mg/L	0.001[8]	0.0044[8]	-	-	-	<0.001	0.143	0.001
Copper	mg/L	0.0014	0.0013	0.003	0.054	0.005	0.008	0.493	0.015
Iron	mg/L	-	-	-	1.38	0.265	0.34	107	0.746
Lead	mg/L	0.0034	0.0044	0.001	0.03	0.005	<0.001	0.392	0.007
Manganese	mg/L	1.9	-	-	0.059	0.03	0.015	1.78	0.0447
Mercury	mg/L	0.0006	0.0004	-	-	-	<0.00004	<0.0001	0.00005
Nickel	mg/L	0.011	0.07	-	0.002	0.005	<0.001	0.277	0.00185
Zinc	mg/L	0.008	0.015	-	0.097	0.039	0.034	0.684	0.0715
Ferrous Iron	mg/L	-		-	0.26	0.055	<0.05	16.3	0.12
TRH C10 - C40 (Sum of Total)	mg/L	-	-	-	-	-	<100	100	50
C6 - C 10	mg/L	-	-	-	-	-	<20	<20	10
C10 - C36 (Sum of Total)	mg/L	-	-	NS	NS	NS	<50	<50	25
Total BTEX	mg/L	-	-	-	-	-	<0.001	<0.001	0.0005
Phosphorus	mg/L	0.05[4]	0.03[3]	0.04	0.19	0.065	<0.01	4.02	0.165
Reactive Phosphorus	mg/L	-	-	-	0.04	0.01	<0.01	0.57	0.055
Kjeldahl Nitrogen Total	mg/L	-	-	-	1.3	0.65	0.2	7.4	1.4
Nitrate	mg/L	0.7	-	0.08	4.69	0.25	0.33	3.17	2.06

Parameter	Units	Guideline Criteria ANZECC 2000 Freshwater[1]	ANZECC 2000 Marine[2]	New M5 Alexandra Canal Monitoring[5] –Tidal Min	Max	Med	M4M5 Sheas Creek Monitoring[6] –Tidal Min	Max	Med
Nitrite	mg/L	-	-	0.01	0.03	0.02	0.03	0.2	0.085
Nitrogen (Total Oxidised)	mg/L	-	-	0.09	4.71	0.27	0.39	3.24	2.185
Nitrogen (Total)	mg/L	0.5[4]	0.3[3]	-	5.4	1.0	0.7	8.8	3.8

Notes:

[1] ANZECC (2000) *'freshwater'* default trigger values for 95 per cent level of species protection

[2] ANZECC (2000) *'marine'* default trigger values for 95 per cent level of species protection

[3] ANZECC (2000) *'estuaries'* default trigger values for physical and chemical stressors for south-east Australia for slightly disturbed ecosystems

[4] ANZECC (2000) *'lowland rivers'* default trigger values for physical and chemical stressors for south-east Australia for slightly disturbed ecosystems

[5] New M5 Link sampling conducted by AECOM between June 2015 and November 2015, based on eight samples collected from SW1

[6] M4-M5 Link sampling conducted by AECOM between July 2016 and May 2017, based on 16 samples collected from SW10

[7] Based on Arsenic (As V)

[8] Based on Chromium (Cr VI)

5.2 = Exceeds one or more relevant guideline criteria

NS = No sample collected

Annexure C Flood Model Development

This annexure details the hydrologic and hydraulic modelling undertaken to establish existing flood conditions and assess the potential flood risks associated with the project, as well as determining potential impacts on surrounding properties and appropriate mitigation requirements.

1. Rozelle interchange

1.1. Previous flood assessments

A number of previous flood assessment reports have been reviewed and used to inform the current investigation:

- Leichhardt Council, 2014, Leichhardt Flood Study (Cardno)
- Sydney Water, 1990, Whites Creek Catchment Management Study.

1.2. Approach

Based on the reported flooding mechanisms for the area originating from creeks and overland surface flows, the assessment approach has adopted a 1D-2D flood model using TUFLOW (Two-dimensional Unsteady Flow) software with direct rainfall on grid. This approach enables the identification of overland flow paths and accounts for floodplain storage within the 2D model.

1.3. Model extent

The extent of the model was influenced by the catchment extents to the north and west of the Rozelle Rail Yard site, as well as allowing for a sufficient length of the Whites Creek watercourse and catchment area.

1.4. Hydrology

Due to the nature of the study area, the hydrologic approach included a combination of deriving hydrographs for inflows to Whites Creek using a rainfall-runoff model, and applying the direct rainfall method to the remainder of the area defined in the TUFLOW hydraulic model.

Direct rainfall

Design rainfalls

Design rainfall hyetographs (graphical representation of the distribution of rainfall over time) were derived for the 5, 10, 20 and 100 year ARI storm events in accordance with Australian Rainfall and Runoff (AR&R) 1987. Design Intensity-Frequency-Duration (IFD) data were obtained for the catchment using the BoM website. An Areal Reduction Factor of one was applied due to the small size of the catchment and temporal patterns for Zone 1 were obtained from AR&R. Storm durations of between 15 minutes and two hours were assessed.

Probable Maximum Precipitation

The Probable Maximum Precipitation (PMP) was calculated using The Estimation of Probable Precipitation in Australia: Generalised Short Duration Method (BoM 2003). PMP rainfall was derived from depth-duration-area envelope curves, application of rough/ smooth factors, elevation adjustment factors and a moisture adjustment factor. The design temporal and spatial distribution was then applied to produce a hyetograph.

Rainfall losses

Rainfall losses were applied within the materials file of the TUFLOW model. An initial loss of 10 millimetres and continuing loss of 2.5 millimetres per hour were applied on permeable areas, in line with AR&R recommendations and values adopted in the *Leichhardt Flood Study* (Cardno 2014). An initial loss of 1.5 millimetres was used for impermeable areas.

Whites Creek hydrograph

In order to establish hydrographs for Whites Creek, a hydrologic model of the catchment was established using the WBNM software. The software is appropriate for use in urban catchments and was also adopted in the hydrologic assessment of the M4 East Design.

Flows were derived for Whites Creek for the five, 10, 20 and 100 year ARI design events as well as the PMF using the following process:

- The catchment and sub-catchments of Whites Creek were determined based on LiDAR, aerial photography and information available on the stormwater drainage systems. This catchment was then compared with the catchment areas delineated in the *Leichhardt Flood Study* (Cardno 2014)
- Percentage imperviousness was identified for each sub-catchment based on latest aerial photography
- A catchment lag parameter of 1.6 was used in accordance with the WBNM guidelines
- Stream lag coefficient of 0.4 was used due to the flow paths being a combination of concrete lined channels and overland flow paths
- An initial rainfall loss of 10 millimetres and continuing loss of 2.5 millimetres per hour were applied for permeable areas. A loss of 1.5 millimetres was applied for impermeable areas. No rainfall losses were included for the PMF event
- Inclusion of IFD parameters.

Hydrology validation

The rainfall and hydrograph boundaries were validated against the inputs and results extracted from the 2014 SOBEK model.

SOBEK model peak flows extracted from the same locations as the TUFLOW model inflows were found to be reasonably well aligned with those generated in WBNM. Differences of between two per cent and 10 per cent were found for the five, 10, 20 and 100 year ARI design events. The WBNM flows for the PMF were 14 per cent higher than those extracted from the SOBEK model. As the estimated peak flows are within 10 per cent to 15 per cent of those from the Leichhardt Flood Study, the hydrologic model parameters adopted for this investigation are considered acceptable. A comparison of the peak flows is provided in **Table C-1**.

Table C-1 Comparison of peak flows for Whites Creek (cubic metres per second)

Source	Event				
	5 year ARI 120 minutes	10 year ARI 120 minutes	20 year ARI 120 minutes	100 year ARI 60 minutes	PMF 30 minutes
Cardno SOBEK	28.2	32.1	39.3	58.3	186.0
WBNM	30.0	35.3	42.3	56.9	211.7

The hyetographs calculated for the application of direct rainfall to the TUFLOW model were also compared to the rainfall inputs from the SOBEK model. Based on the comparison of total rainfalls provided in **Table C-2** it is evident that the rainfall inputs in the Rozelle interchange flood study were marginally higher for the ARI design events. This is most likely a consequence of using slightly different IFD parameters from the BoM. The rainfall adopted for the current investigation is considered to be appropriate for use.

Table C-2 Comparison of total rainfall depths (millimetres)

Source	Event				
	5 year ARI 120 **minutes**	10 year ARI 120 **minutes**	20 year ARI 120 **minutes**	100 year ARI 60 **minutes**	PMF 30 **minutes**
Cardno SOBEK	60	70	83	94	240
TUFLOW Hyetographs	68	78	91	95	240

1.5. Hydraulics

Topography

The model grid was constructed based on LiDAR data, with some manipulation of topography based on site observations.

Pit and pipe network

The 1D component of the model incorporated some of the stormwater drainage network. These systems were embedded into the 2D domain enabling water to exchange between above ground and below ground flow paths. As the potential impacts of the project were being assessed against relatively large events (100 year ARI), only some of the pit and pipe network were included in the model (generally greater than 375 millimetre diameter). Various assumptions regarding pipe invert level and pit size were necessary due to the limited availability of data. This approach was considered sufficient for the inputs required as part of this assessment but will need to be improved (through survey) as part of the detailed design stage.

Boundary conditions

A rainfall boundary was applied to the entire model domain and a boundary was included at the top of Whites Creek to represent the inflow hydrographs.

A downstream boundary of one metre AHD was set for Rozelle Bay and corresponding initial water levels were applied to channels and the pipe network where appropriate. A level of 1 metre AHD was used as this is equivalent to the High High Water Solstices Springs (HHWSS) peak tide level. This is consistent with the levels adopted in the modelling for the *Leichhardt Flood Study* (Cardno 2014) and the modelling undertaken to inform the design of the M4 East.

As a direct rainfall approach had been used, boundaries were applied to the edge of the model domain to prevent ‘glass-walling’ whereby water ponds against the edges of the model.

Roughness

The roughness for the model has been defined using Manning's 'n' values as shown in **Table C-3**.

Table C-3 Manning's Roughness Values used in the TUFLOW Model

Surface	Manning's value
Roads	0.02
Well maintained grass	0.03
Reserves	0.045
Trees	0.08
Scrub	0.05
Fields	0.035
Buildings	10
Channel	0.02
Water (Harbour)	0.03

Development

Directly adjacent to the western side of the Rozelle Rail Yards, a new depot is being constructed for the CBD and South East Light Rail on behalf of Transport for NSW. This includes a Light Rail maintenance facility, with associated tracks and offices. The design for the site and drainage was not available to inform this Rozelle interchange model.

It is recommended that during the detailed design of the Rozelle interchange, the drainage design for the CBD and South East Light Rail Rozelle maintenance depot is obtained to understand the interfaces between the two sites and refine the mitigation measures as appropriate.

Hydraulic model validation

There are no known stage or flow gauges present on Whites Creek and it was therefore not possible to undertake a rigorous calibration of the hydraulic model. Calibration is the benchmarking of the model outputs against previous flood events with known flows or water levels.

The TUFLOW model was validated against the SOBEK model established for the *Leichhardt Flood Study*. The SOBEK model was also not calibrated, however it was validated against model results from the Sydney Water investigation (1990) as well as against data from some historical flood events.

Peak design flood levels from the TUFLOW hydraulic model representing the existing conditions have been compared to the results from the Cardno SOBEK model at key locations along Whites Creek as well as the Sydney Water model results (see **Figure C-1**). A summary comparison of 100 year ARI peak design flood levels is shown in **Table C-4**. Flood levels are generally slightly higher than the Cardno model, by about 0.25 metres, but are lower than the Sydney Water model results.

Table C-4 Comparison of Peak Flood Levels (metres AHD) along Whites Creek for 100 year ARI event

Location	Cardno SOBEK levels	Sydney Water levels	TUFLOW levels	Difference to Cardno (m)	Difference to Sydney Water (m)
P1	3.63	4.13	3.74	+0.11	-0.39
P2	3.70	4.13	3.72	+0.02	-0.41
P3	3.20	3.88	3.42	+0.22	-0.46
P4	3.12	3.58	3.38	+0.26	-0.20
P5	3.08	3.56	3.33	+0.25	-0.23
P6	1.63	1.63	2.84	+1.21	+1.21

Figure C-1 Location of comparison points as listed in Table C-4

In general the 100 year ARI peak flood levels from the TUFLOW model were comparable with those reported in the Leichhardt Flood Study along Whites Creek. Levels in the TUFLOW model were higher at the downstream extent of Whites Creek between the railway culvert and the culvert under The Crescent. However, investigations into the representation of the structures within the SOBEK model found that the railway culvert was undersized. This may explain the difference in water levels at this location.

A comparison of inundation depths within the Rozelle Rail Yards for the 100 year ARI event found that the TUFLOW levels were generally within 0.1 metres of those from the SOBEK model. These variations are within normal acceptable ranges and the parameters adopted in the established TUFLOW hydraulic model are therefore considered appropriate.

1.6. Sensitivity

As there is limited data for calibration a model sensitivity analysis was also carried out by increasing the roughness values applied in the model by 20 per cent as summarised in **Table C-3**. The results of that sensitivity analysis have shown that flood levels would only increase by up to 0.03 metres if roughness values were higher by up to 20 per cent. The model is therefore not considered to be very sensitive to model roughness values.

1.7. Post-development models

The following adjustments were made to the Rozelle interchange TUFLOW Model in order to assess the impact the operational phase would have on flooding behaviour and to also assess the flood risks to the project:

- The 3D concept design surface model for the Rozelle interchange was merged with the available LiDAR survey data

- The new channel and associated overland flow path for the Easton Park drain, western and eastern catchments to collect and direct water within and out of the interchange were incorporated into the 3D concept design surface. A typical cross-section for the proposed channels is shown in **Figure C-2**.
- Flood bunds around the dive structures to protect the portals from floodwater ingress from the PMF within the interchange area
- Inclusion of culverts under City West Link for the channel to discharge into Rozelle Bay. This includes 'low-flow' culverts (4 no. 1.05 metre diameter circular pipes) and culverts for high flows (10 no. 2.4 x 1.2 metres box culverts)
- New bridge structure over Whites Creek to represent the larger road junction at City West Link and The Crescent. To mitigate impacts of the larger structure on water levels in Whites Creek for the larger flow events, the new structure includes two 16 metre spans, one includes the existing Whites Creek channel (approximately nine metres wide). The second opening will provide an overland flow path for floodwater that has either spilled out of Whites Creek or unable to get into the channel as it is at capacity. The topography of land between the existing light rail bridge over Whites Creek and where it discharges into Rozelle Bay has been re-profiled to enable water to spill out of Whites Creek and flow overland and into Rozelle Bay in a controlled manner
- Amendments to the Manning's values to reflect different surfaces.

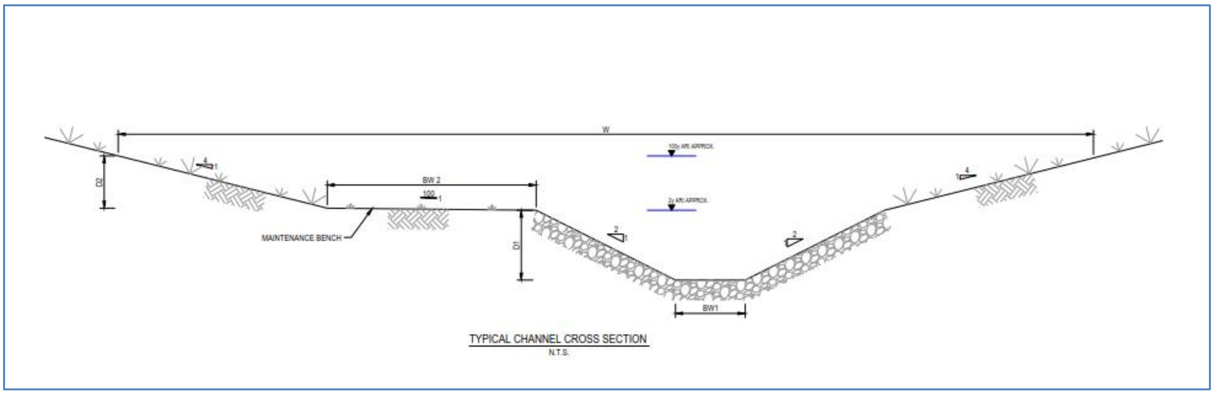

Figure C-2 Typical channel cross section

1.8. Consideration of blockage of waterway structures

The effect of blockage of waterway structures was also considered. *AR&R Project 11 - Blockage of Hydraulic Structures* (Engineers Australia, 2015) provides recommendations for the assessment of waterway blockage due to floating debris. Based on those recommendations, considering the size of the new waterway structures compared to the size of the channel as well as the size and availability of potential floating debris, appropriate blockage factors have been applied to the proposed waterway structures. See **Table C-5** for percentage blockage applied.

Table C-5 Summary of assumed blockage applied to waterway structures

Structure	Comment	Assumed blockage for 100 year ARI	Assumed blockage for PMF
The Crescent bridge at Whites Creek	New twin 16 metre span bridge	10%	20%
Culvert at City West Link	New four x 1.05 metre diameter pipes and 10 x 2.4 x 1.2 metre box culverts	20%	50%
Tunnel portal bridge	New 31 metre single span	10%	20%

Considering the waterway area of two new bridges and the size and availability of floating debris an assumed blockage of 20 per cent has been applied to both new bridges for the 100 year ARI event.

For the PMF a higher blockage was assumed as the potential for blockage during the PMF is considered higher than during more frequent events.

The results of the blockage assessment as summarised in **Table C-6** show that there would only be a minor increase in flood levels of up to 0.2 metres as a result of blockage of the new waterway structures. Blockage of between 10 and 20 per cent would reduce the freeboard at the bridges but would not cause floodwaters to overtop onto City West Link or The Crescent.

In a PMF event the greater potential for blockage at the culverts under the City West Link of up to 50 per cent could lead to an increase in peak flood levels of up to 0.4 metres to the north of City West Link. This increase in peak flood levels would not lead to overtopping of City West Link in the PMF. At The Crescent the increase in peak flood levels would be up to 0.18 metres with a 20 per cent blockage of the new bridge structure in the PMF.

Table C-6 Summary of results for waterway blockage assessment (metres AHD)

Structure	No blockage		With blockage			
	100 year ARI	PMF	100 year ARI	Difference (m)	PMF	Difference (m)
The Crescent bridge at Whites Creek	2.75	5.07	2.82	+0.08	5.25	+0.18
Culvert at City West Link	2.09	3.33	2.26	+0.17	3.73	+0.40
Western channel upstream of tunnel portal bridge	2.33	3.61	2.41	+0.08	3.86	+0.25

2. Iron Cove Link

2.1 Previous flood assessments

The following previous flood assessment reports have been reviewed and used to inform the current investigation:

- Leichhardt Council, 2014, *Leichhardt Flood Study*.

2.2 Approach

Based on the reported flooding mechanisms for the area and associated overland flow, the assessment approach has adopted a 1D-2D flood model using TUFLOW software with direct rainfall on grid. This approach enables the identification of overland flow paths within the 2D model.

2.3 Model Extent

The extent of the model was influenced by the catchment extents to the east of Victoria Road at Iron Cove.

2.4 Hydrology

Due to the nature of the study area, the hydrologic approach included applying the direct rainfall method to the catchment defined in the TUFLOW hydraulic model. The same hydrological inputs used for the Rozelle interchange were used for the Iron Cove Link model.

2.5 Hydraulics

Topography

The model grid was constructed based on LiDAR data, with some manipulation of topography based on site observations. For example, the traffic barrier was included on Victoria Road.

Pit and pipe network

The 1D component of the model incorporated some of the stormwater drainage network in the catchment of Iron Cove Link. These systems were embedded into the 2D domain enabling water to exchange between above ground and below ground flow paths. Information on the diameter and invert levels of the drainage network were extracted from the Dial Before You Dig dataset and the Cardno model.

Boundary Conditions

A rainfall boundary was applied to the entire model domain. As a direct rainfall approach had been used, boundaries were applied to the edge of the model domain to prevent 'glass-walling' whereby water ponds against the edges of the model.

A review of the topographic levels of the area of interest established that the model did not need to include Iron Cove as a downstream boundary condition. The elevations were significantly above the extreme peak storm tide level plus 0.9 metres for climate change allowance (2.8 metres AHD) and so would not be inundated or flood behaviour influenced under such conditions.

Roughness

The roughness for the model has been defined using Manning's 'n' values as per those used in the Rozelle interchange model (see **Table C-3**).

Hydraulic Model Validation

As there are no watercourses present or historical data available it is not possible to undertake rigorous calibration of the hydraulic model.

The TUFLOW model was validated against the SOBEK model established for the *Leichhardt Flood Study*. The SOBEK model was also not calibrated for this area.

Peak design flood levels from the TUFLOW hydraulic model representing the existing conditions have been compared to the results from the Cardno SOBEK model at key locations near the Iron Cove Link (see **Figure C-3**). A summary comparison of 100 year ARI peak design flood levels is shown in **Table C-7**.

The peak water depths generated by the TUFLOW model were generally within 0.05 metres of those from the SOBEK model. These variations are within normal acceptable ranges and the parameters adopted in the established TUFLOW hydraulic model are therefore considered appropriate**.**

Table C-7 Comparison of peak flood depths (metre) around the proposed Iron Cove Link (100 year ARI event)

Location	Cardno SOBEK depths (m)	TUFLOW depths (m)	Difference (m)
P2	0.14	0.11	-0.03
P4	0.02	0.01	-0.01
P5	0.12	0.11	-0.01
P6	0.11	0.15	+0.04
P8	0.08	0.06	-0.02
P23	0.02	0.02	0.00
P25	0.04	0.02	-0.02
P34	0.03	0.06	+0.03
P37	0.03	0.02	+0.02

Figure C-3 Location of comparison points for Iron Cove Link model as listed in Table C-7.

2.6 Sensitivity

A sensitivity analysis was also carried out by increasing the roughness values applied in the model (as summarised in **Table C-3**) by 20 per cent. The results of that sensitivity analysis have shown that flood levels in and around Iron Cove Link increased by up to 0.03 metres. The model is therefore not considered to be sensitive to the assumptions made regarding model roughness.

2.7 Post-development models

The following adjustments were made to the Iron Cove Link TUFLOW model in order to assess the impact the operational phase would have on flood behaviour and to also assess the flood risks to the project:

- The 3D concept design surface model for Iron Cove Link was merged with the available LiDAR survey data
- Flood bunds around the dive structures to protect the portals from floodwater ingress
- Re-alignment of the stormwater drainage network to reflect the widening of Victoria Road to the south
- Changes to the extent of the traffic barrier on Victoria Road
- Amendments to the Manning's roughness values to reflect different surfaces.

2.8 Consideration of blockage of waterway structures

No assessment of blockage of structures was undertaken as there are no new proposed waterway structures in proximity to the Iron Cove Link.

3. Darley Road

3.1 Previous flood assessments

The following previous flood assessment reports have been reviewed and used to inform the current investigation:

- Ashfield and Marrickville Councils, 2013, Hawthorne Canal Flood Study, Final Draft (WMAwater)
- Leichhardt Council, 2014, Leichhardt Flood Study.

3.2 Approach

Based on the reported flooding mechanisms for the area and associated overland flows, the assessment approach has adopted a 1D-2D flood model using TUFLOW software with direct rainfall on grid. This approach enables the identification of overland flow paths within the 2D model.

3.3 Model extent

The extent of the model was influenced by the catchment extents to the east of the Darley Road civil and tunnel site.

3.4 Hydrology

Due to the nature of the study area, the hydrologic approach included applying the direct rainfall method to the catchment defined in the TUFLOW hydraulic model. The same hydrological inputs used for the Rozelle interchange were used for the Darley Road model.

3.5 Hydraulics

Topography

The model grid was constructed based on LiDAR data, with some manipulation of topography based on site observations.

Pit and pipe network

The 1D component of the model incorporated some of the stormwater drainage network. These systems were embedded into the 2D domain enabling water to exchange between above ground and below ground flow paths. Information on the diameter and invert levels of the drainage network was extracted from the Cardno flood model, which was based on a combination of Sydney Water asset information and survey.

Boundary conditions

A rainfall boundary was applied to the entire model domain. As a direct rainfall approach had been used, boundaries were applied to the edge of the model domain to prevent 'glass-walling' whereby water ponds against the edges of the model.

Roughness

The roughness for the model has been defined using Manning's 'n' values as per those used in the Rozelle interchange model (see **Table C-3**).

Hydraulic model validation

As there are no watercourses present it is not possible to undertake rigorous calibration of the hydraulic model.

The TUFLOW model was verified against the SOBEK model established for the *Leichhardt Flood Study* (Cardno 2014). The SOBEK model was also not calibrated for this area.

Peak design flood levels from the TUFLOW hydraulic model representing the existing conditions have been compared to the results from the SOBEK model at key locations near the Darley Road site (see **Figure C-4**). A summary comparison of 100 year ARI peak design flood levels is shown in **Table C-8**.

Table C-8 Comparison of peak flood depths (m) near the Darley Road site (100 year ARI event

Location	Cardno SOBEK depths (m)	TUFLOW depths (m)	Difference (m)
1	0.09	0.07	-0.02
2	0.56	0.54	+0.02
3	0.24	0.29	+0.05
4	0.24	0.25	+0.01
5	0.97	0.94	-0.03
6	0.98	0.92	-0.06
7	0.11	0.09	-0.02
8	0.70	0.76	+0.06
9	0.18	0.13	-0.05
10	0.15	0.08	-0.07

Figure C-4 Location of comparison points for Darley Road model as listed in Table C-8

A comparison of inundation depths within the vicinity of the Darley Road site for the 100 year ARI event found that the TUFLOW levels were generally within 0.1 metres of those from the SOBEK model. These variations are within normal acceptable ranges and the parameters adopted in the established TUFLOW hydraulic model are therefore considered appropriate.

3.6 Sensitivity

Sensitivity analysis was also carried out by increasing the roughness values applied in the model by 20 per cent, as summarised in **Table C-3**. The results of that sensitivity analysis have shown that flood levels in and around Darley Road increased by up to 0.03 metres. The model is therefore not considered to be sensitive to the assumptions made regarding model roughness.

3.7 Post-development models

The following adjustments were made to the Darley Road TUFLOW Model in order to assess the impact the operational phase would have on flood behaviour and to also assess the flood risks to the project.

Flood bunds were included around the perimeter of the site, excluding the car park area to the west. This was considered a conservative assessment of the potential impact that protecting the portals from floodwater ingress from the PMF could have on surrounding properties.

Annexure D Step by Step Flood Risk Assessment

Table D-1 Flood risk assessment for construction and operational sites

	Step 1 Existing Information		Step 2 Flood risk	Step 3 Flooding characteristics	Step 4 Flood risk to the project and potential impacts	Step 5 Proposed layout
	Is there an existing flood risk assessment available to inform the assessment on existing flood conditions?	Is the existing flood risk assessment at an appropriate level of detail to determine existing flood conditions?	Does the existing assessment show the area of interest being partially or fully at risk of flooding for events up the probable maximum flood?	Identify the mechanisms and characteristics of flooding (source, frequency, depths, velocity).	Determine whether flood risk is: · To the project – ie risk of infrastructure being flooded · Likely to be influenced by the project, having a detrimental impact on flood risk to sensitive receivers (surrounding properties)	For sites that are partially flooded, can sufficient easement from areas at risk of flooding be provided in the site layout and topographic changes avoided, so that development is not impacted by and does not impact on flood risk?
Construction						
C1a Wattle Street civil and tunnel site, C2a Haberfield civil and tunnel site, C3a Northcote Street civil site, C2b Haberfield civil site (part of M4 East project footprint)	M4 East EIS report and flood model (2015)	Yes - EIS approved. Assessed flooding for 5, 20, 100, 200 year ARI and PMF.	No - the post-development scenario was not shown to be affected by the PMF. Low risk from Iron Cove Creek and overland flow.	N/A	N/A	N/A
	M4 East Design (2016 draft)	Yes - refinement of EIS model to inform design.	No - proposed M4 East provides mitigation measures to manage risk at Wattle Street interchange portals for PMF. Low risk from Iron Cove Creek and overland			

	Step 1 Existing Information		Step 2 Flood risk	Step 3 Flooding characteristics	Step 4 Flood risk to the project and potential impacts	Step 5 Proposed layout
			flow.			
C1b Parramatta Road West civil and tunnel site, C3b Parramatta Road East civil site	Dobroyd Canal Flood Study (WMAwater 2013)	Yes - Council approved flood study. Assessed 2, 5, 10, 20, 50, 100 year ARI and PMF.	No, the sites are notaffected by mainstream or overland flows in events up to the 100 year ARI and only sits on the fringe of the PMF. Low risk of flooding of the sites in the PMF.			
C4 Darley Road civil and tunnel site	Leichhardt Council Flood Study and flood model (Cardno 2014)	Yes - Council approved flood study. Assessed 5, 100 year ARI and PMF.	Yes -partially flooded in 100 year ARI event and PMF.	· Sources of flooding appear to be ponded water to the west of the site (junction of Darley Road and Canal Road/ Charles Street). · Floodwater seems to be spilling from Light Rail immediately north of the site, onto the western side of the site. · Ponded water from rain falling on the site. Water depths up to approximately one metre and flows of two metre per second	Flood risk posed to the western side of the site and localised ponding on the eastern side.	· The western edge of the site identified for car park use with the portals located on the eastern side of the site on higher ground away from floodwater. Flooding of the car park area is considered acceptable. The use of fencing to permit floodwater to pass onto the western side of the site, combined with minimal changes to topography, means that the development is not likely to have a significant impact in terms of displacing water. · The portals will need to be protected from water ingress from the PMF. This may include use of walls or bunds in small area of the eastern section of site and
	Hawthorne Canal Flood Study and flood	Yes - Council approved flood study. Assessed	Yes - partially flooded in 100 year ARI event and PMF.	· Source of flooding appears to be from ponded water as a	Flood risk posed to the western side of the site.	

	Step 1 Existing Information		Step 2 Flood risk	Step 3 Flooding characteristics	Step 4 Flood risk to the project and potential impacts	Step 5 Proposed layout
	model for Ashfield and Marrickville Council (WMAwater, 2013)	flooding for 2, 5, 10, 20, 50, 100 year ARIs and the PMF.		consequence of overland flow. Localised flooding in southwest section of the site in 100 year ARI event (up to 0.4 metre), velocities <0.2 metres per second. · PMF shows depths of up to 1.2 metres on the western side of the site. Velocity generally <0.2 metres per second but >0.5 metres per second at edge of site.		re-profiling of topography (eg installation of a speed hump) at the entrance to the portal. · The infrastructure that has the potential to displace water (acoustic sheds, buildings) has been located on the eastern side of the site to minimise impacts. The existing site includes a large warehouse building. The majority of the proposed buildings are located within the footprint of the existing building.
C5 Rozelle civil and tunnel site	Leichhardt Council Flood Study and flood model (Cardno 2014)	Yes - Council approved flood study. Assessed 5, 100 year ARI and PMF.	Yes - significant flooding in the 100 year ARI event and PMF.	· The site is subject to overland flow inputs from catchments to the west and north. · Easton Park drain runs through an open section of channel in the northern section of the site before being culverted and discharging into Rozelle Bay. · Flooding from Easton Park drain may occur if the	· There is a risk posed to site infrastructure, with risk of flooding to the portals and other sensitive infrastructure. · Due to extensive flooding at the site during the 100 year ARI and PMF, there is potential for buildings and stockpiles to displace floodwater and impact on existing flood behaviour.	· The indicative site layout has taken into consideration flood risk and the requirements for the conveyance of flood water through the site, with an allowance for the permanent drainage arrangement that will be constructed. · Opportunities to locate portals and flood sensitive infrastructure outside of the 100 year ARI extent has been achieved for some of the facilities. · Where setback from flooded

	Step 1 Existing Information		Step 2 Flood risk	Step 3 Flooding characteristics	Step 4 Flood risk to the project and potential impacts	Step 5 Proposed layout
				capacity of the channel is exceeded or the culvert surcharged. · During PMF events, water from Whites Creek spills over The Crescent road across City West Link and can flow onto the Rozelle Rail Yards. · Water depths of approximately <1 metre for 100 year ARI and >1 metre for the PMF.		areas was not possible, bunding would be used to protect tunnel ramps and vulnerable infrastructure to prevent floodwater ingress. Alternatively raising floor levels above expected flood levels would be considered. · The potential location of acoustic sheds and stockpile areas have been located as close to the southern boundary as possible, where ground levels are higher. This is to minimise potential impacts on the displacement of water. · The construction of the permanent conveyance system would occur as early as possible during the construction phase to enable flood risk to the project to be managed and to mitigate impacts to surrounding properties. Temporary drainage measures will be required whilst installing the permanent arrangement.
C6 The Crescent civil site	Leichhardt Council Flood Study and flood model (Cardno	Yes - Council approved flood study. Assessed 5, 100 year ARI	Yes – the site in events greater than the 100 year ARI	The site is subject to overland flow inputs from The Crescent and breakouts from Whites	There is a low flood risk to the site from local overland flows.	The site layout will consider that local overland flow ill need to be safely conveyed around the laydown areas.

	Step 1 Existing Information		Step 2 Flood risk	Step 3 Flooding characteristics	Step 4 Flood risk to the project and potential impacts	Step 5 Proposed layout
	2014)	and PMF		Creek in the PMF.		
C7 Victoria Road civil site	Leichhardt Council Flood Study and flood model (Cardno 2014)	Yes - Council approved flood study. Assessed 5, 100 year ARI and PMF.	No - mapping suggests no flooding for 100 year and PMF. Low risk of flooding from overland flow sources.	N/A	N/A	N/A
C8 Iron Cove civil site	Leichhardt Council Flood Study and flood model (Cardno 2014)	Yes - Council approved flood study. Assessed 5, 100 year ARI and PMF.	Yes - potential inundation for sections of the sites between Toelle St and Springside in 100 year ARI and PMF.	· The site is subject to runoff from the north and east, from Victoria Road, Wellington Road, Crystal Lane and Terry Street. · Floodwater depths of up to 0.4 metres on Victoria Road north carriageway with peak velocities of 2-3 metres per second for the PMF.	Flood risk posed to the proposed portals and potential for displacement of water due to changes to the road geometry and levels.	· Iron Cove Link is fairly constrained spatially as it has to connect to the existing Victoria Road, so this restricts location of the portals. · Bunding of ramps to prevent floodwater ingress to the tunnel dive structures · Temporary drainage works would be implemented to minimise impacts to existing development as far as practicable by collecting and managing runoff on Victoria Road.
C9 Pyrmont Bridge Road tunnel site	Johnstons Creek Flood Study, City of Sydney (WMAwater 2013)	Yes - Council approved flood study. Assessed 5, 10, 20, 50, 100 year ARI and PMF.	Yes - potential inundation along Bignell Lane in 100 year ARI and PMF.	· Current high density building development concentrates all flows onto Bignell Lane, which acts as the only flowpath for overland flow. • Flood depths	· There is some risk posed to site infrastructure, with risk of flooding to the portals and other sensitive infrastructure (substation, offices), however the site is	· The indicative site layout has taken into consideration risk of flooding on Bignell Lane, which functions as a preferential flowpath through the site. Vulnerable uses, such as the tunnel dive structure is located away from the flooding at the

	Step 1 Existing Information		Step 2 Flood risk	Step 3 Flooding characteristics	Step 4 Flood risk to the project and potential impacts	Step 5 Proposed layout
				generally only 0.1 to 0.2 metres. Ponding at the low point up to 1 metres for the 100 year ARI and PMF on Bignell Road	located towards the top of the catchment and flow rates are therefore not substantial. · The construction site would also demolish the existing buildings and replace with facilities of a smaller footprint, which would allow for less concentrated overland flows paths and would also reduce the potential to displace water and impact surrounding properties.	topographic low point on Bignell Lane. · Use of flood bunds or ramps to prevent ingress into the tunnel portals. · The existing flow path on Bignell Lane would be retained by the installation of breaks or flaps in fencing or site hoarding, to allow the overland flow path into and out of site. The overland flow path would be managed and directed along existing and proposed roads, using kerblines to try to retain flows within road areas and car parks. · The acoustic shed and offices have been located within the footprints of the existing buildings · Installation of noise walls or other flood protection barriers around the perimeter of the site to prevent ingress of flood water from Parramatta Road to the south and Mallett Street to the east.
	Leichhardt Council Flood Study and flood model (Cardno 2014)	Yes - Council approved flood study. Assessed 5, 100 year ARI and PMF.	Yes - potential inundation along Bignell Lane in 100 year ARI and PMF.	· Current high density building development concentrates all flows onto Bignell Lane, which acts as the only flowpath for overland flow. · Flood depths generally only 0.1 to 0.2 metres. Ponding up to one metre for the 100 year ARI on Bignell Road and peak velocity of approximately two metres per second.		
C10 Campbell Road civil and tunnel site (part of New M5 project	New M5 EIS and flood model (2015)	Yes - EIS approved. Assessed flooding for	No - the post-development scenario was not shown to be affected	N/A	N/A	N/A

	Step 1 Existing Information		Step 2 Flood risk	Step 3 Flooding characteristics	Step 4 Flood risk to the project and potential impacts	Step 5 Proposed layout
footprint).		(20,100, 200 year ARI and PMF.	by the PMF. Low risk from overland flow .			
	M4 East Design (2016 draft)	Yes - refinement of EIS model to inform design.	No - New M5 provides mitigation measures to manage risk at St Peters interchange portals for the PMF. Low risk from overland flow .			
Operation						
Wattle Street (M4 East interface)	M4 East EIS report and flood model (2015)	Yes - EIS approved. Assessed flooding for 5, 20, 100, 200 year ARI and PMF.	No - the post-development scenario was not shown to be affected by the PMF. Low risk from Iron Cove Creek and overland flow .	N/A - operational site only includes sub-surface infrastructure	N/A	N/A
	M4 East Design (2016 draft)	Yes - refinement of EIS model to inform design.	No - M4 East provides mitigation measures to manage risk at Wattle Street interchange portals for PMF. Low risk from Iron Cove Creek and overland flow .			
Darley Road	Leichhardt	Yes - Council	Yes -partially	· Sources of flooding	Flood risk posed to the	· The western edge of the

<table>
<tr><th></th><th colspan="2">Step 1 Existing Information</th><th>Step 2 Flood risk</th><th>Step 3 Flooding characteristics</th><th>Step 4 Flood risk to the project and potential impacts</th><th>Step 5 Proposed layout</th></tr>
<tr><td rowspan="2"></td><td>Council Flood Study and flood model (Cardno 2014)</td><td>approved flood study. Assessed 5, 100 year ARI and PMF.</td><td>flooded in 100 year ARI event and PMF.</td><td>appear to be ponded water to the west of the site (junction of Darley Road and Canal Road/ Charles Street).
· Floodwater seems to be spilling from the light rail immediately north of the site, onto the western side of the site.
· Ponded water from rain falling on the site. Water depths up to approximately one metre and flows of two metres per second.</td><td>western side of the site and localised ponding on the eastern side.</td><td rowspan="2">site identified for car park use with the portals located on the eastern side of the site on higher ground away from floodwater. Flooding of the car park area is considered acceptable. The use of fencing to permit floodwater to pass onto the western side of the site, combined with minimal changes to topography, means that the development is not likely to have a significant impact in terms of displacing water.
· The portals will need to be protected from water ingress from the PMF. This may include use of walls or bunds in small area of the eastern section of site and re-profiling of topography (for example, installation of a speed hump) at the entrance to the portal.
· The infrastructure that has the potential to displace water (acoustic sheds, buildings) has been located on the eastern side of the site to minimise impacts. The existing site includes a large warehouse building. The majority of the</td></tr>
<tr><td>Hawthorne Canal Flood Study and flood model for Ashfield and Marrickville Council (WMAwater, 2013)</td><td>Yes - Council approved flood study. Assessed flooding for 2, 5, 10, 20, 50, 100 year ARIs and the PMF.</td><td>Yes - partially flooded in 100 year ARI event and PMF.</td><td>· • Source of flooding appears to be from ponded water as a consequence of overland flow. Localised flooding in southwest section of the site in 100 year ARI event (up to 0.4 metres), velocities <0.2 metres per second.
· PMF shows depths of up to 1.2 metres on the western side of the site. Velocity</td><td>Flood risk posed to the western side of the site.</td></tr>
</table>

	Step 1 Existing Information		Step 2 Flood risk	Step 3 Flooding characteristics	Step 4 Flood risk to the project and potential impacts	Step 5 Proposed layout
				generally <0.2 metres per second but >0.5 metres per second at edge of site.		proposed buildings are located within the footprint of the existing building.
Rozelle interchange	Leichhardt Council Flood Study and flood model (Cardno 2014)	Yes - Council approved flood study. Assessed 5, 100 year ARI and PMF.	Yes - significant flooding in the 100 year ARI event and PMF.	· The site is subject to overland flow inputs from catchments to the west and north. · Easton Park drain runs through an open section of channel in the northern section of the site before being culverted and discharging into Rozelle Bay. · Flooding from Easton Park drain may occur if the capacity of the channel is exceeded or the culvert surcharged. · During PMF events, water from Whites Creek spills over The Crescent road across City West Link and can flow onto the Rozelle Rail Yards. · Water depths of	· There is a risk posed to site infrastructure, with risk of flooding to the portals and other sensitive infrastructure (ventilation facilities, substations). · Due to extensive flooding at the site during the 100year ARI and PMF, there is potential for permanent facilities to displace floodwater and impact on existing flood behaviour.	· The need for providing conveyance of floodwater through the site has significantly influenced the layout and design of the site. · The proposed site layout includes channels to carry the 2 year ARI flows and associated overland flowpaths to convey the 100 year ARI event. · Opportunities to locate portals and flood sensitive infrastructure (ventilation facilities and substations) outside of the 100 year ARI extent has been achieved for some of the facilities. · Where setback from flooded areas was not possible, bunding would be used to protect tunnel ramps and vulnerable infrastructure to prevent floodwater ingress. Alternatively raising floor levels above expected flood levels can be considered. · Road levels on City West

	Step 1 Existing Information		Step 2 Flood risk	Step 3 Flooding characteristics	Step 4 Flood risk to the project and potential impacts	Step 5 Proposed layout
				approximately <one metre for 100 year ARI and >one metre for the PMF.		Link have been raised to provide flood immunity to the Western Harbour Tunnel ramps.
Iron Cove Link	Leichhardt Council Flood Study and flood model (Cardno 2014)	Yes - Council approved flood study. Assessed 5, 100 year ARI and PMF.	Yes - potential inundation for sections of the sites between Toelle St and Springside in 100 year ARI and PMF.	· The site is subject to runoff from the north and east, from Victoria Road, Wellington Road, Crystal Lane and Terry Street. · Floodwater depths of up to 0.4 metres on Victoria Road north carriageway with peak velocities of 2-3 metres per second for the PMF.	Flood risk posed to the proposed portals and potential for displacement of water due to changes to the road geometry and levels.	· Iron Cove Link is constrained spatially as it is connecting to the existing Victoria Road, so this restricts location of the portals. · Bunding of ramps or profiling of road geometry to prevent floodwater ingress to the tunnel dive structures.
St Peters interchange (New M5 interface)	New M5 EIS and flood model (2015)	Yes - EIS approved. Assessed flooding for 20,100, 200 year ARI and PMF.	No - the post-development scenario was not shown to be affected by the PMF. Low risk from overland flow.	N/A - operational site only includes sub-surface infrastructure	N/A	N/A
	New M5 design (2016)	Yes - refinement of EIS model to inform design.	No - New M5 provides mitigation measures to manage risk at St Peters interchange portals for the PMF. Low risk from overland flow.			

Annexure E Water Quality Monitoring Program

Table E-1 Water quality monitoring parameters

In situ field parameters	Analytical sampling
Temperature (˚C) Dissolved Oxygen (mg/L) Electrical Conductivity (µS/cm) Reduction-Oxidation Potential (Redox)(mV) pH Turbidity (NTU).	Organics TRH (C6-C40) BTEXN – Benzene, Toluene, Ethylbenzene, Xylene and Naphthalene Nutrients - Total Nitrogen, TKN, NOx, NO2, NO3, Total Phosphorus and Filterable Reactive Phosphorus 8 Metals (Cu, Cr, As, Ni, Zn, Pb, Hg, Ni) and Manganese (total metals) Ferrous Iron, Total Iron

Table E-2 Monitoring locations

Site reference	Water course	Location	Easting[1]	Northing[1]	Monitoring purpose
Tidal Locations					
SW01	Rozelle Bay	Whites Creek outlet at City West Link/The Crescent, Rozelle	331068	6250619	Downstream of construction
SW02	Whites Creek	Whites Creek Valley Park, Railway Parade Annandale	330675	6250214	Downstream of construction
SW03	Johnstons Creek	Smith Park pedestrian bridge, Neilson Lane Annandale	331348	6249812	Downstream of construction
SW05	Hawthorne Canal	Hawthorne Canal Reserve, Canal Road, Leichhardt	328710	6249937	Upstream of construction
SW06	Hawthorne Canal	Canal Road (between City West Link and Lilyfield Road) Lilyfield	328944	6250424	Downstream of construction
SW07	Easton Park drain	Adjacent to 88-90 Lilyfield Road, Lilyfield	330816	6250769	Upstream of construction
SW08	Dobroyd Canal	Pedestrian bridge between Timbrell Park and Reg Coady Reserve, Dobroyd Parade, Haberfield	327694	6250353	Downstream of construction
SW09	Dobroyd Canal	West of Ramsey Road bridge at Dobroyd Parade, Haberfield	327295	6250337	Upstream of construction
SW11	Iron Cove	Under Iron Cove	TBC	TBC	Downstream of

Site reference	Water course	Location	Easting[1]	Northing[1]	Monitoring purpose
		bridge			construction
SW12	Iron Cove	King Georges Park	TBC	TBC	Downstream of construction
Non-Tidal Locations					
SW04	Johnstons Creek	Adjacent to playground, Chester Street,	331138	6249152	Downstream of construction
SW14	Johnstons Creek	Cruikshank Street	330955	6248607	Upstream of construction
SW10	Sheas Creek	South side of Huntley Street, Alexandria	332869	6246434	Up-stream of construction

An additional monitoring location will also be incorporated at White Bay.

It is noted that SW13 monitored as part of the contamination assessment was not included in the surface water assessment.

Annexure F Stormwater Quality Modelling Catchments

The catchment areas and corresponding treatment assumed in the MUSIC modelling is presented in **Table F-1** and **Figure F-1.**

Table F-1 MUSIC Modelling catchments and assumed treatment measures

Catchment ID	Catchment Description	Area (ha)	Existing treatment	Proposed treatment
0	Victoria Road north of crest	0.29	None	GPT + Hydrodynamic Separator
1	Western Harbour Tunnel ramps	0.55	None	GPT + Wetland
2	Iron Cove portal	0.11	None	GPT + Bioretention
3	Iron Cove portal	0.08	None	GPT + Bioretention
4	The Crescent westbound / culvert to James Craig Road	0.36	None	GPT + Hydrodynamic Separator
5	The Crescent westbound and James Craig Road	0.63	None	GPT + Hydrodynamic Separator
6	Anzac Bridge/M4 East ramp portal	0.30	None	Bioswale
7	Anzac Bridge/M4 East ramp portal	0.17	None	Bioswale
8	The Crescent Bridge	0.93	None	GPT + Hydrodynamic Separator
9	Victoria Road to Anzac Bridge eastbound ramp 1	0.52	None	Bioswale
10	Victoria Road to Anzac Bridge eastbound ramp 2	0.84	None	Bioswale
11	Anzac Bridge westbound ramp	1.17	None	GPT + Hydrodynamic Seperator
12	Victoria Road northbound, south of crest	0.14	None	Bioswale
13	The Crescent eastbound / culvert to Victoria Road bridge	0.52	None	GPT + Hydrodynamic Separator
14	Mousehole	0.38	None	Bioswale
15	Victoria Road southbound (to old outlet)	0.20	GPT	None
16	Victoria Road northbound (to old outlet)	0.19	GPT	None
17	Victoria Road northbound (to new outlet)	0.97	GPT	GPT + Bioretention

Catchment ID	Catchment Description	Area (ha)	Existing treatment	Proposed treatment
18	Victoria Road southbound (to new outlet)	0.35	GPT	GPT + Bioretention
19	City West Link eastbound Western Harbour Tunnel to CWL culvert	0.16	None	GPT + Hydrodynamic Separator
20	Water Treatment Plant and access	0.38	None	Wetland
21	Ventilation facilities	1.07	None	Wetland
22	City West Link westbound west of The Crescent 3	0.47	None	Bioretention
23	City West Link westbound west of The Crescent 2	0.38	None	GPT + Hydrodynamic Seperator
24	New M5 ramps	0.35	None	GPT + Hydrodynamic Separator
25	City West Link eastbound - west of New M5 ramps	0.28	None	Bioretention
26	Western substation, ventilation supply, water, access	0.57	None	Bioretention
27	City West Link eastbound – New M5 ramps to Western Harbour Tunnel ramps	0.27	None	Bioretention
28	City West Link westbound west of The Crescent 1	0.19	None	Bioretention

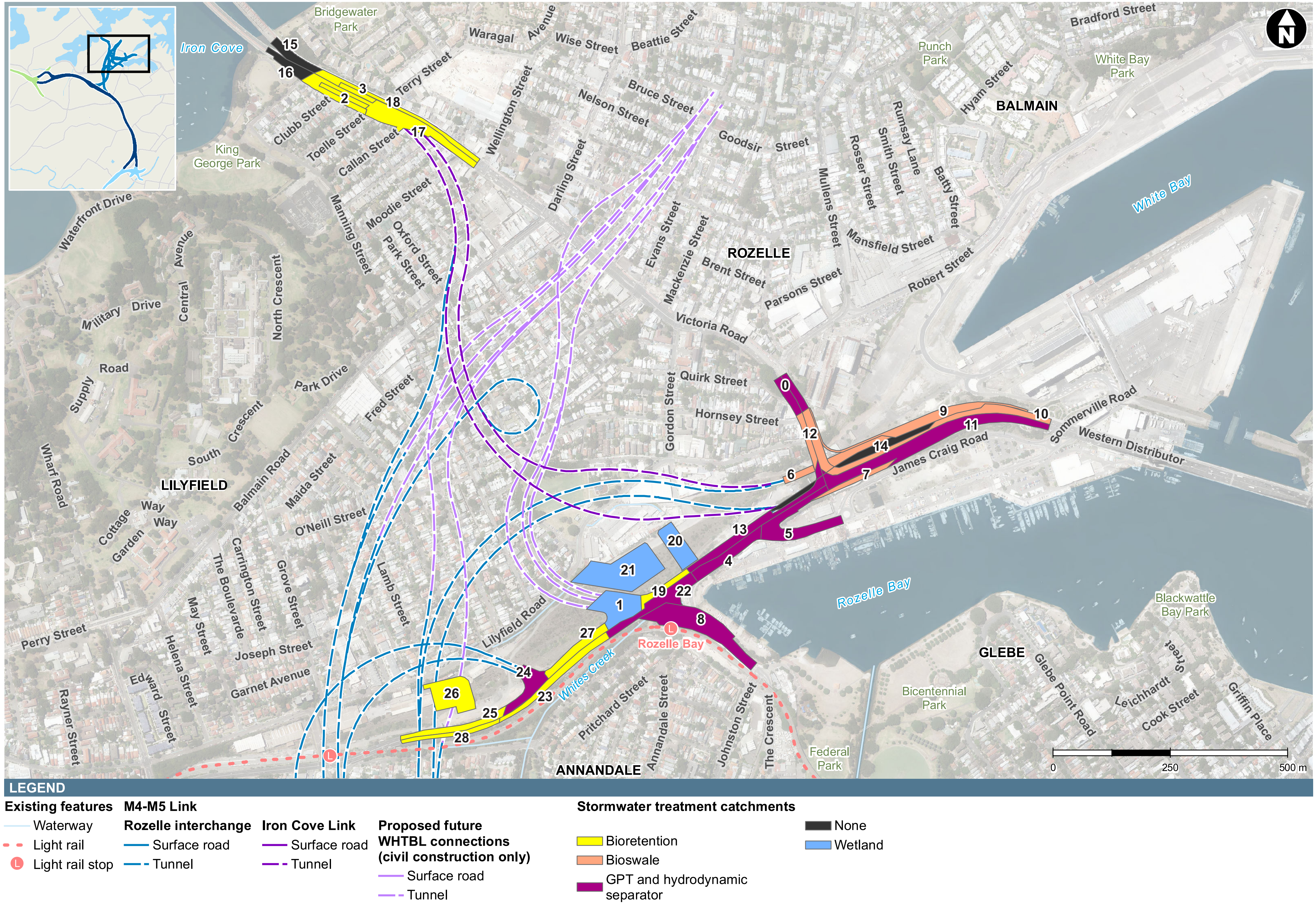

Figure F-1 Stormwater treatment catchment plan

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Annexure G NSW Water Quality Objectives – Indicators and Criteria

Table G-1 NSW Water Quality Objective indicators and criteria (DECCW 2006)

Indicator	Numerical Criteria (Trigger Values)
Aquatic Ecosystems	
Total phosphorus	Lowland rivers: 25 µg/L for rivers flowing to the coast Estuaries: 30 µg/L
Total nitrogen	Lowland rivers: 350 µg/L for rivers flowing to the coast Estuaries: 300µg/L
Chlorophyll-a	Lowland rivers: 5 µg/L Estuaries: 4 µg/L.
Turbidity	Lowland rivers: 6–50 NTU Estuaries: 0.5–10 NTU
Salinity (electrical conductivity)	Lowland rivers: 125–2200 µS/cm
Dissolved oxygen	Lowland rivers: 85–110% Estuaries: 80–110%
pH	Upland rivers: 6.5–8.0 Lowland rivers: 6.5–8.5 Freshwater lakes & reservoirs: 6.5–8.0 Estuaries: 7.0–8.5
Temperature	See ANZECC 2000 Guidelines, table 3.3.1.
Chemical contaminants or toxicants	See ANZECC 2000 Guidelines, chapter 3.4 and table 3.4.1. 90% species protection level considered appropriate for construction. 95% species protection level considered appropriate for for operation.
Biological assessment indicators	This form of assessment directly evaluates whether management goals for ecosystem protection are being achieved (e.g. maintenance of a certain level of species diversity, control of nuisance algae below a certain level, protection of key species, etc). Many potential indicators exist and these may relate to single species, multiple species or whole communities. Recognised protocols using diatoms and algae, macrophytes, macroinvertebrates, and fish populations and/or communities may be used in NSW and interstate (e.g. AusRivAS).
Visual Amenity	
Visual clarity and colour	Natural visual clarity should not be reduced by more than 20%. Natural hue of the water should not be changed by more than 10 points on the Munsell Scale. The natural reflectance of the water should not be changed by more than 50%
Surface films and debris	Oils and petrochemicals should not be noticeable as a visible film on the water, nor should they be detectable by odour. Waters should be free from floating debris and litter.
Nuisance organisms	Macrophytes, phytoplankton scums, filamentous algal mats, blue-green algae, sewage fungus and leeches should not be present in unsightly amounts.
Secondary Contact Recreation	
Faecal coliforms	Median bacterial content in fresh and marine waters of < 1000 faecal coliforms per 100 mL, with 4 out of 5 samples < 4000/100 mL (minimum of 5 samples taken at regular intervals not exceeding one month).
Enterococci	Median bacterial content in fresh and marine waters of < 230 enterococci per 100 mL (maximum number in any one sample: 450-700 organisms/100 mL).

Indicator	Numerical Criteria (Trigger Values)
Algae & blue-green algae	< 15 000 cells/mL
Nuisance organisms	Use visual amenity guidelines. Large numbers of midges and aquatic worms are undesirable.
Chemical contaminants	Waters containing chemicals that are either toxic or irritating to the skin or mucous membranes are unsuitable for recreation. Toxic substances should not exceed values in tables 5.2.3 and 5.2.4 of the ANZECC 2000 Guidelines.
Visual clarity and colour	Use visual amenity guidelines.
Surface films	Use visual amenity guidelines.
Primary Contact Recreation	
Turbidity	A 200 mm diameter black disc should be able to be sighted horizontally from a distance of more than 1.6 m (approximately 6 NTU).
Faecal coliforms	Beachwatch considers waters are unsuitable for swimming if: the median faecal coliform density exceeds 150 colony forming units per 100 millilitres (cfu/100mL) for five samples taken at regular intervals not exceeding one month, or the second highest sample contains equal to or greater than 600 cfu/100mL (faecal coliforms) for five samples taken at regular intervals not exceeding one month. ANZECC 2000 Guidelines recommend: Median over bathing season of < 150 faecal coliforms per 100 mL, with 4 out of 5 samples < 600/100 mL (minimum of 5 samples taken at regular intervals not exceeding one month).
Enterococci	Beachwatch considers waters are unsuitable for swimming if: the median enterococci density exceeds 35 cfu/100mL for five samples taken at regular intervals not exceeding one month, or the second highest sample contains equal to or greater than 100 cfu/100mL (enterococci) for five samples taken at regular intervals not exceeding one month. ANZECC 2000 Guidelines recommend: Median over bathing season of < 35 enterococci per 100 mL (maximum number in any one sample: 60-100 organisms/100 mL).
Protozoans	Pathogenic free-living protozoans should be absent from bodies of fresh water. (Note, it is not necessary to analyse water for these pathogens unless temperature is greater than 24 degrees Celsius).
Algae & blue-green algae	< 15 000 cells/mL
Nuisance organisms	Use visual amenity guidelines. Large numbers of midges and aquatic worms are undesirable.
pH	5.0-9.0
Temperature	15°-35°C for prolonged exposure.
Chemical contaminants	Waters containing chemicals that are either toxic or irritating to the skin or mucus membranes are unsuitable for recreation. Toxic substances should not exceed the concentrations provided in tables 5.2.3 and 5.2.4 of the ANZECC 2000 Guidelines 2000.
Visual clarity and	Use visual amenity guidelines.

Indicator	Numerical Criteria (Trigger Values)
colour	
Surface films	Use visual amenity guidelines.
Aquatic Foods	
Algae & blue-green algae	No guideline is directly applicable, but toxins present in blue-green algae may accumulate in other aquatic organisms.
Faecal coliforms	*Guideline in water for shellfish:* The median faecal coliform concentration should not exceed 14 MPN/100mL; with no more than 10% of the samples exceeding 43 MPN/100 mL. *Standard in edible tissue:* Fish destined for human consumption should not exceed a limit of 2.3 MPN *E Coli* /g of flesh with a standard plate count of 100,000 organisms /g.
Toxicants (as applied to aquaculture activities)	Metals: Copper: less than 5 µgm/L Mercury: less than 1 µgm/L Zinc: less than 5 µgm/L Organochlorines: Chlordane: less than 0.004 µgm/L (saltwater production) PCB's: less than 2 µgm/L.
Physico-chemical indicators (as applied to aquaculture activities)	Suspended solids: less than 40 micrograms per litre (freshwater). Temperature: less than 2 degrees Celsius change over one hour.

Annexure H Tunnel water treatment plant options review

Table H-1 Summary of Treatment Options

	Option 1 – Primary Sedimentation	Option 2 – Primary Sedimentation + Biological Treatment (SBR)	Option 3 – Primary Sedimentation + Ion Exchange	Option 4 – Primary Sedimentation + Reverse Osmosis
Process description	· Buffer tank is aerated to precipitate dissolved iron and manganese. Primary sedimentation removes settleable solids through chemical precipitation and sludge removal. Water filtered prior to discharge	· Buffer tank is aerated to precipitate dissolved iron and manganese. Primary sedimentation removes settleable solids through chemical precipitation and sludge removal. · Biological treatment for nutrient removal. · Water filtered prior to discharge	· Buffer tank is aerated to precipitate dissolved iron and manganese. Primary sedimentation removes settleable solids through chemical precipitation and sludge removal · Ion exchange for nutrient removal · Water filtered prior to discharge	· Buffer tank is aerated to precipitate dissolved iron and manganese. Primary sedimentation removes settleable solids through chemical precipitation and sludge removal · Reverse osmosis for nutrient and TDS removal
Major infrastructure / equipment	· Balance tank (aerated) · Clarifier tank · Chemical dosing units (PAC, caustic, polymer) · Media filters · Sludge tank · Filter press	As per Option 1, plus: · Sequencing batch reactor tanks · Treated water tanks · Blowers · Additional chemicals – nutrients, antifoam	As per Option 1, plus: · Anionic and cationic ion exchange units · Additional chemicals – acid, caustic · Neutraliser waste tank · IX waste to trade waste (assume 5% flow)	As per Option 1, plus: · Reverse osmosis units · Additional chemicals – Acid/ antiscalant. Membrane cleaning · Waste brine to trade waste (approx. 20% flow)
Parameters targeted	· Iron, manganese, total suspended solids, pH	· Iron, manganese, total suspended solids, pH · Nutrients (nitrogen & phosphorous)	· Iron, manganese, total suspended solids, pH · Nutrients (nitrogen & phosphorous)	· Iron, manganese, total suspended solids, pH · Nutrients (nitrogen & phosphorous) · Total dissolved solids

Process performance	· Typical treatment for Sydney groundwater · Successful in meeting target water quality for iron, manganese, suspended solids, turbidity, pH	· In addition to Option 1, SBR will have limited additional nutrient removal. Requires input nutrients to maintain bioreactor viability · Low level nitrogen targets not achieved	· As per Option 1 · IX has high nutrient removal capacity · Requires strong chemical regeneration solutions for IX · Requires higher skilled operator	· As per Option 1 · RO removes all dissolved solids, including target nutrients · Membrane process has high power consumption · Membranes require chemical cleaning · Waste brine is approx. 20% of total treated water volume – requires trade waste disposal · Requires higher skilled operator
Other factors	· Dewatered sludge to be trucked off-site for disposal · Will not achieve ANZECC guidelines for nitrogen and phosphorus	· Large footprint requirement · Increased power requirement (due to aeration process) · Increased chemical dosing (nutrient dosing and antifoam) · Will not achieve ANZECC guidelines for nitrogen and phosphorus	· Increased power requirement for ion exchange plant · Produces chemical waste to be trucked off-site as trade waste	· High power requirement for membrane filtration process · Produces high volume of waste stream (brine), requires connection to sewer for trade waste · Treated water available for use as non-potable water

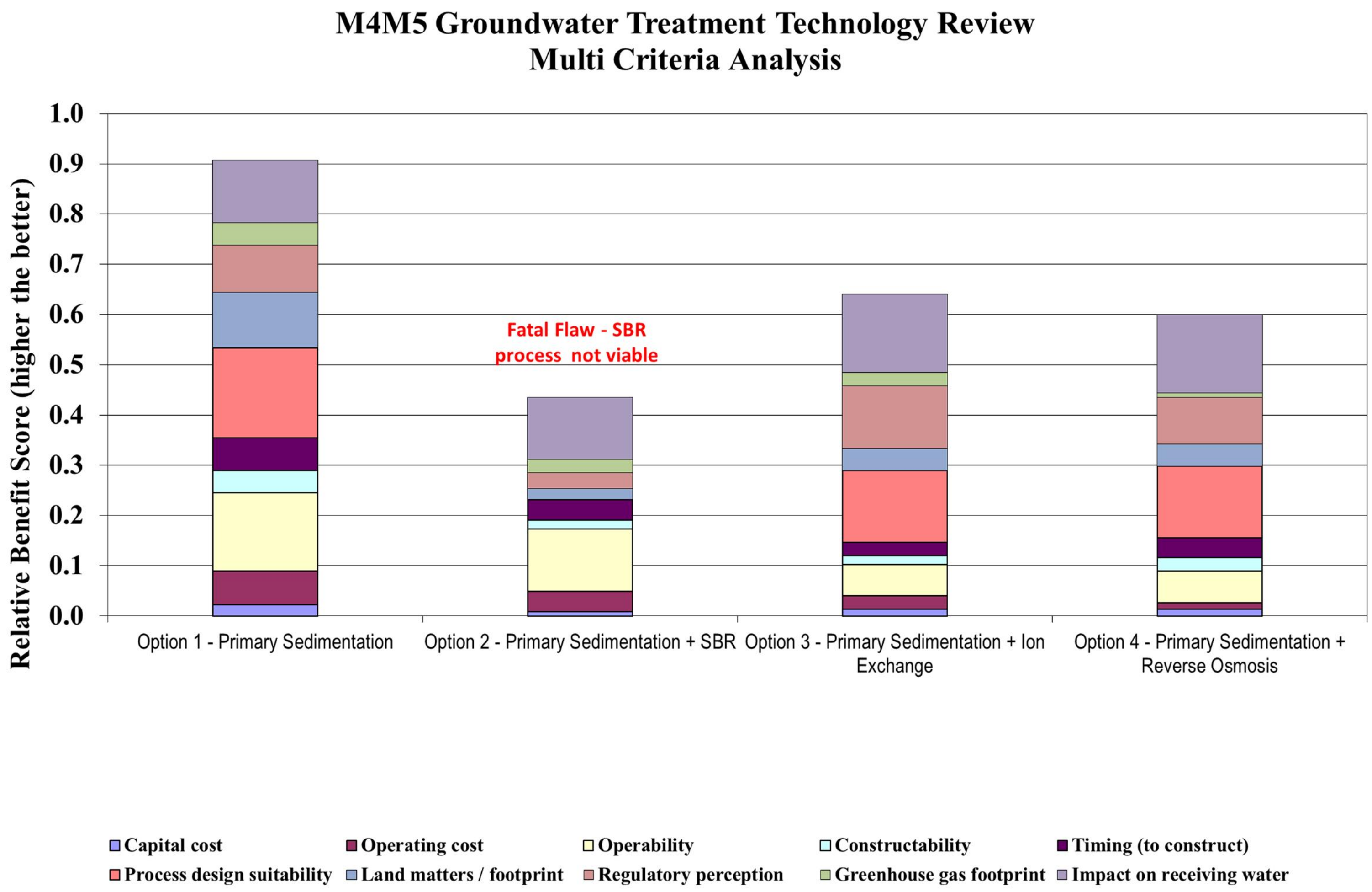

Figure H-1 MCA Comparison

Table H-2 MCA scoring and weighted criteria

Criteria	Description	Weight	Option 1 - Primary Sedimentation (Note 1)	Option 2 - Primary Sedimentation + SBR	Option 3 - Primary Sedimentation + Ion Exchange	Option 4 - Primary Sedimentation + Reverse Osmosis
Capital cost	Lowest capital cost	2.22%	5	2	3	3
Operating cost	Lowest operating cost: power, chemicals, labour, third party waste transporters, etc.	6.67%	5	3	2	1
Operability	Labour intensiveness, process complexity, etc.	15.56%	5	4	2	2
Constructability	Impact on adjacent community, construction requirements, noise, etc.	4.44%	5	2	2	3
Timing (to construct)	Will the solution have a long construction or commissioning period? Will the solution be constructed in the appropriate timeframe?	6.67%	5	3	2	3
Process design suitability	Will the process achieve the water quality targeted by the treatment process? (Note 2)	17.78%	5	0	4	4
Land matters / footprint	Is land available? Will procurement of easements be required?	11.11%	5	1	2	2
Regulatory perception	Will solution be accepted by the regulatory authorities long term, will the solution require NSW EPA negotiations?	15.56%	3	1	4	3

Criteria	Description	Weight	Option 1 - Primary Sedimentation (Note 1)	Option 2 - Primary Sedimentation + SBR	Option 3 - Primary Sedimentation + Ion Exchange	Option 4 - Primary Sedimentation + Reverse Osmosis
Greenhouse gas footprint	Does the solution have a low greenhouse gas footprint?	4.44%	5	3	3	1
Impact on receiving water	Will the discharge quality have any detrimental impacts on the receiving environment?	15.56%	4	4	5	5
		100.00%				
5= best						
1= worst						
Notes	1. This option reflects the accepted groundwater treatment process strategies for other Sydney transport and power tunnel infrastructure					
	2. Process design suitability considers the ability of the final process plant configuration to reliably achieve the parameters targeted for the respective treatment processes					

Table H-3 Criteria Ranking

	Ranking/Scoring: AECOM Project team				Capital cost	Operating cost	Operability	Constructability	Timing (to construct)	Process design suitability	Land matters / footprint	Regulatory perception	Greenhouse gas footprint	Impact on receiving water	0	0	0	0	0			**Relative Importance**
Rank	Category	Criteria	Definition		**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**	**O**	**Comments**		
10	Financial	Lowest capital cost	Capital cost	**A**		0	0	0	0	0	0	0	1	0								2.22%
6	Financial	Lowest operating cost: power, chemicals, labour, third party waste transporters, etc.	Operating cost	**B**	1		0	1	1	0	0	0	0	0								6.67%
2	Reliability	Labour intensiveness, process complexity, etc.	Operability	**C**	1	1		1	0	0	1	1	1	1								15.56%
8	Implementation	Impact on adjacent community, construction requirements, noise, etc.	Constructability	**D**	1	0	0		1	0	0	0	0	0								4.44%
6	Implementation	Will the solution have a long construction or commissioning period? Will the solution be constructed in the appropriate timeframe?	Timing (to construct)	**E**	1	0	1	0		0	0	0	1	0								6.67%
1	Reliability	Will the process achieve the specified treated water quality?	Process design suitability	**F**	1	1	1	1	1		1	1	1	0								17.78%
5	Implementation	Is land available? Will procurement of easements be required?	Land matters / footprint	**G**	1	1	0	1	1	0		0	1	0								11.11%
2	Implementation	Will solution be accepted by the regulatory authorities long term, will the solution require EPA negotiations?	Regulatory perception	**H**	1	1	0	1	1	0	1		1	1								15.56%
8	Implementation	Does the solution have a low greenhouse gas footprint?	Greenhouse gas footprint	**I**	0	1	0	1	0	0	0	0		0								4.44%
2	Reliability	Will the discharge quality have any detrimental impacts on the receiving environment?	Impact on receiving water	**J**	1	1	0	1	1	1	1	0	1									15.56%

Appendix R

Technical working paper: Contamination

WestConnex

Roads and Maritime Services

WestConnex – M4-M5 Link

Technical working paper: Contamination

August 2017

Client: Roads and Maritime Services

ABN: 76 236 371 088

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Glossary of terms and abbreviations

Term	Definition
ACM	Asbestos Containing Materials
ADWG	Australian Drinking Water Guidelines
AHD	Australian Height Datum
AMG	Australian Map Grid
ANZECC	Australian and New Zealand Environment and Conservation Council
ASLP	Australian Standard Leaching Procedure
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
ASSMAC	Acid Sulfate Soil Management Advisory Council
AST	Above ground Storage Tank
BTEXN	Benzene, Toluene, Ethylbenzene, Xylenes and Naphthalene
CEMP	Construction Environmental Management Plan
CLM Act	*Contaminated Land Management Act 1997*
CoPC	Contaminants of Potential Concern
CPAH	Carcinogenic PAHs
CSJ	CPB Samsung John Holland
CSWMP	Construction Soil and Water Management Plan
CSM	Conceptual Site Model
D2E	Down to Earth
DEC	NSW Department of Environment and Conservation
DECC	NSW Department of Environment and Climate Change
DP&E	NSW Department of Planning and Environment
DP-Water	NSW Department of Primary Industries (Water)
DUAP	NSW Department of Urban Affairs and Planning
EHC	*Environmentally Hazardous Chemicals Act 1985*
EILs	Ecological Investigation Levels
EPL	Environment Protection Licence
ESA	Environmental Site Assessment
HILs	Health Investigation Levels
HSLs	Health Screening Levels
LOR	Limit of Reporting
metres BTOC	Metres Below Top of Casing
NEPM	National Environment Protection (Assessment of Site Contamination) Measure
NEPC	National Environment Protection Council
NEHF	National Environment Health Forum
NHMRC	National Health and Medical Research Council
NSW EPA	NSW Environment Protection Authority
NOW	NSW Office of Water (now the NSW Department of Primary Industries – Water)
OCP	Organochlorine Pesticides
OEH	NSW Office of Environment and Heritage
OEMP	Operational Environmental Management Plan
OPP	Organophosphate Pesticides
PASS	Potential Acid Sulfate Soils
PAH	Polycyclic Aromatic Hydrocarbons
PCB	Polychlorinated Biphenyls
PID	Photoionisation Detector
POEO	*Protection of the Environment Operations Act 1997*
PSI	Preliminary Site Investigation
QA/QC	Quality Assurance and Quality Control
RAP	Remedial/Remediation Action Plan
Roads and Maritime	NSW Roads and Maritime Services
RPD	Relative Percent Difference
SAQP	Sampling Analysis and Quality Plan
SEPP	State Environmental Planning Policy

Term	Definition
SQP	Sampling Quality Plan
SMC	Sydney Motorway Corporation
SPOCAS	Suspension Peroxide Oxidation – Combined Acidity and Sulfate
SVOC	Semi Volatile Organic Hydrocarbons
TCLP	Toxicity Characteristic Leaching Procedure
TPH	Total Petroleum Hydrocarbons
TRH	Total Recoverable Hydrocarbons
UPSS	Underground Petroleum Storage System
USEPA	United States Environmental Protection Agency
USCS	Unified Soil Classification Scheme
UST	Underground Storage Tank
VENM	Virgin Excavated Natural Material
VOC	Volatile Organic Compound

Executive summary

Introduction

NSW Roads and Maritime Services (Roads and Maritime) is seeking approval to construct and operate the WestConnex M4-M5 Link (the project), which would comprise a new multi-lane road link between the M4 East Motorway at Haberfield and the New M5 Motorway at St Peters. The project would also include an interchange at Lilyfield and Rozelle (the Rozelle interchange) and a tunnel connection between Anzac Bridge and Victoria Road, east of Iron Cove Bridge (Iron Cove Link). In addition, construction of tunnels, ramps and associated infrastructure to provide connections to the proposed future Western Harbour Tunnel and Beaches Link project would be carried out at the Rozelle interchange.

Purpose and objective

The purpose of this technical working paper is to inform the environmental impact statement (EIS) and address the Secretary's Environment Assessment Requirements (SEARs) by:

- Identifying potential areas and contaminants of concern within the project footprint, which comprises the location of all operational infrastructure and areas where construction activities would occur
- Assessing the potential for groundwater contamination to be present along the tunnel alignment
- Providing a preliminary qualitative assessment, and desktop review of available quantitative data, in relation to contamination risk posed during construction and operation of the project
- Assessing where further investigation should be undertaken or appropriate management procedures should be implemented for the construction and operational phases of the project
- Assessing whether the land is contaminated and if so, whether remediation may be required including confirmation that future assessment and/or remediation would be undertaken in accordance with the current guidelines.

The overall objective of this technical working paper is to identify potential contamination issues associated with land impacted by the project so further assessment can be undertaken or appropriate mitigation measures can be put in place to manage contamination as part of the construction and operation of the project.

Scope

To inform the EIS and address the SEARs, the following scope of work was completed:

- Preliminary screening review of project background/historical information
- Inspection of the project footprint to assist with the identification of potential on and off-site sources of contamination and to understand the general condition of the project footprint
- Review and evaluation of desktop information, including previous contamination reports, relevant to identified areas of contamination concern within the project footprint
- Completion of a number of discrete (Stage 1) desktop preliminary site investigations (PSIs) where ancillary facilities and ground disturbance works are proposed. Based on the findings of the PSIs, intrusive (Stage 2) site investigations were also undertaken at selected locations where a high potential for contamination was identified
- Assessment of the potential impacts of the project and identification of the need for further assessment and/or management measures where required.

To achieve the desired performance outcome, which is to ensure that risks arising from the disturbance and excavation of land and disposal of soil are minimised, including disturbance to acid sulfate soils and site contamination, the following methodology has been adopted:

- Identification of potential or known soil, sediment and groundwater contamination in the project footprint by assessing the existing environment, including review and assessment of relevant reports and soil and groundwater investigation data
- Assessment of the potential contamination impacts of the project during construction and operation phases
- Identification and description of mitigation measures to manage potential or known soil, sediment and groundwater contamination during construction and operation.

During the preparation of this report, the entire project footprint has been assessed, including surface works, ancillary facilities and subsurface works (including tunnelling). Particular emphasis was given to those areas where historical land use activities have impacted soil, sediment and groundwater which may require remediation and/or management during the construction and operation of the project.

Key findings

Based on a review of background information, including NSW Environment Protection Authority (NSW EPA) and local council searches, a number of properties located within the project footprint were identified as having a high risk of contamination which should be investigated during project planning (see **section 4**). These properties generally comprise sites that have potentially been the subject of historically contaminating land uses, including:

- Former industrial and transport infrastructure, along with reclamation within the Rozelle Rail Yards
- Commercial/industrial properties present within or adjacent to the project footprint including but not limited to those on the edge of the Rozelle Rail Yards, manufacturing industries, workshops, timber mills and boat yards
- Areas of historical land reclamation (including unregulated filling activities), particularly along the harbour foreshore near Rozelle Bay
- Structures potentially containing hazardous materials that would be demolished for the project.

Construction impacts and mitigation measures summary

A Construction Environmental Management Plan (CEMP) would be prepared for the project. The CEMP would include management measures for areas within the project footprint identified as being potentially contaminated.

Ancillary facilities and areas within the project footprint that have been assessed as low risk do not require further assessment or remediation and would be managed through the implementation of the CEMP. Sites which are assessed as potentially containing soil or groundwater contamination that could pose an unacceptable risk to human or ecological receptors during construction of the project would require further intrusive site investigation. The following sites would require the completion of targeted site investigations, waste characterisation and preparation of management procedures for acid sulfate soils and hazardous materials assessment as part of the Construction Soil and Water Management Plan (CSWMP) to inform the appropriate management of contamination during the intrusive construction program:

- Ancillary facilities and associated areas of construction disturbance within the project footprint comprising:
  - Parramatta Road West civil and tunnel site at Ashfield (C1b)
  - Darley Road civil and tunnel site at Leichhardt (C4)
  - Rozelle civil and tunnel site at Rozelle (C5)
  - The Crescent civil site at Annandale (C6)
  - Iron Cove Link civil site at Rozelle (C8)
  - Pyrmont Bridge Road tunnel site at Annandale (C9)
  - Campbell Road civil and tunnel site at St Peters (C10) (for areas not previously investigated as part of the New M5 project)

- All contamination investigations will be undertaken by a suitably qualified and experienced person in accordance with guidelines made or approved under the *Contaminated Land Management Act 1997* (NSW)
- Subject to the outcomes of the additional investigations, Remediation Action Plan (RAPs) may be required and implemented in the event that site remediation is warranted prior to construction
- Intrusive works undertaken within the Campbell Road civil and tunnel site (C10) at St Peters that are within the former Alexandria Landfill Environment Protection Licence (EPL) boundary would be required to comply with the existing Golder (2016) remediation action plan (RAP), Landfill Closure Management Plan, EPL and New M5 conditions of approval
- Groundwater and surface water captured as a result of tunnelling activities may be contaminated with suspended solids and increased pH due to tunnel grouting or activities
- Sediment disturbed during the installation of the coffer dam(s) in Rozelle Bay is likely to be contaminated
- Temporary water treatment plants would be constructed at each construction ancillary facility where groundwater is extracted during dewatering and tunnelling. The water encountered during construction and operation would require appropriate monitoring and treatment prior to discharge to receiving water bodies
- The CEMP would incorporate the Roads and Maritime *Unexpected Discovery of Contaminated Lands Procedure* (2013) and an asbestos management plan. The CEMP prepared for implementation during the project and should encompass all construction activities. The plan will accurately reflect the conditions likely to be encountered during construction at various locations within the project footprint
- A CSWMP must be prepared for implementation (as part of the CEMP) during construction of the project
- Management procedures for acid sulfate soils as part of the CSWMP would be prepared for implementation during the project which should encompass the management of potential or actual acid sulfate soils which may be disturbed as part of construction activities associated with the project. The plans will accurately reflect the conditions that may be encountered during construction at various locations within the project footprint.

Operation impacts and mitigation measures summary

Following the completion of construction works, additional site investigations would be required to confirm the suitability of remaining project land proposed to be redeveloped or to meet site handover obligations. In the event that residual contamination is identified, remediation works would be undertaken in accordance with an approved RAP.

The following would be undertaken and implemented prior to the operational phase of the project:

- A NSW EPA Accredited Site Auditor would be engaged to review all contamination reports and evaluate the suitability of a site for a specified use as part of the project
- An Operational Environmental Management Plan (OEMP) must be prepared to manage potential impacts on groundwater and surface water during the operational phases of the project.

Conclusions and recommendations

Based on the findings of this technical working paper, there is potential for localised areas of soil, acid sulfate soil, sediment, fill and groundwater contamination associated with historically contaminating land uses that may be encountered during construction, and further assessment is warranted in some instances. The discovery of contaminated materials is considered most likely to occur during near surface excavation works associated with road and tunnel construction activities.

Following adoption of the mitigation and management measures, which have been recommended to be implemented during the construction and operational phases of the project, the desired performance outcome, which is to ensure that risks arising from the disturbance and excavation of land and disposal of soil are minimised, including disturbance to acid sulfate soils and site contamination, would be satisfactorily achieved.

1 Introduction

NSW Roads and Maritime Services (Roads and Maritime) is seeking approval to construct and operate the WestConnex M4-M5 Link (the project), which would comprise a new multi-lane road link between the M4 East Motorway at Haberfield and the New M5 Motorway at St Peters. The project would also include an interchange at Lilyfield and Rozelle (the Rozelle interchange) and a tunnel connection between Anzac Bridge and Victoria Road, east of Iron Cove Bridge (Iron Cove Link). In addition, construction of tunnels, ramps and associated infrastructure to provide connections to the proposed future Western Harbour Tunnel and Beaches Link project would be carried out at the Rozelle interchange.

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.

Approval is being sought under Part 5.1 of the *Environmental Planning and Assessment Act 1979* (NSW) (EP&A Act) for the project. A request has been made for the NSW Minister for Planning to specifically declare the project to be State significant infrastructure and also critical State significant infrastructure. An environmental impact statement (EIS) is therefore required.

1.1 Overview of WestConnex and related projects

The M4-M5 Link is part of the WestConnex program of works. Separate planning applications and assessments have been completed for each of the approved WestConnex projects. Roads and Maritime has commissioned Sydney Motorway Corporation (SMC) to deliver WestConnex, on behalf of the NSW Government. However, Roads and Maritime is the proponent for the project.

In addition to linking to other WestConnex projects, the M4-M5 Link would provide connections to the proposed future Western Harbour Tunnel and Beaches Link, the Sydney Gateway (via the St Peters interchange) and the F6 Extension (via the New M5).

The WestConnex program of works, as well as related projects, are shown in **Figure 1-1** and described in **Table 1-1**.

Table 1-1 WestConnex and related projects

Project	Description	Status
WestConnex program of works		
M4 Widening	Widening of the existing M4 Motorway from Parramatta to Homebush.	Planning approval under the 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.

Project	Description	Status
M4-M5 Link (the project)	Tunnels connecting to the M4 East at Haberfield (via the Wattle Street interchange) and the New M5 at St Peters (via the St Peters interchange), a new interchange at Rozelle and a link to Victoria Road (the Iron Cove Link). The Rozelle interchange also includes ramps and tunnels for connections to the proposed future Western Harbour Tunnel and Beaches Link project.	The subject of this EIS.
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.
Western Harbour Tunnel and Beaches Link	The Western Harbour Tunnel component would connect to the M4-M5 Link at the Rozelle interchange, cross underneath Sydney Harbour between the Birchgrove and Waverton areas, and connect with the Warringah Freeway at North Sydney. The Beaches Link component would comprise a tunnel that would connect to the Warringah Freeway, cross underneath Middle Harbour and connect with the Burnt Bridge Creek Deviation at Balgowlah and Wakehurst Parkway at Seaforth. It would also involve the duplication of the Wakehurst Parkway between Seaforth and Frenchs Forest.	Planning underway by Roads and Maritime and subject to separate environmental assessment and approval.
F6 Extension	A proposed 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.

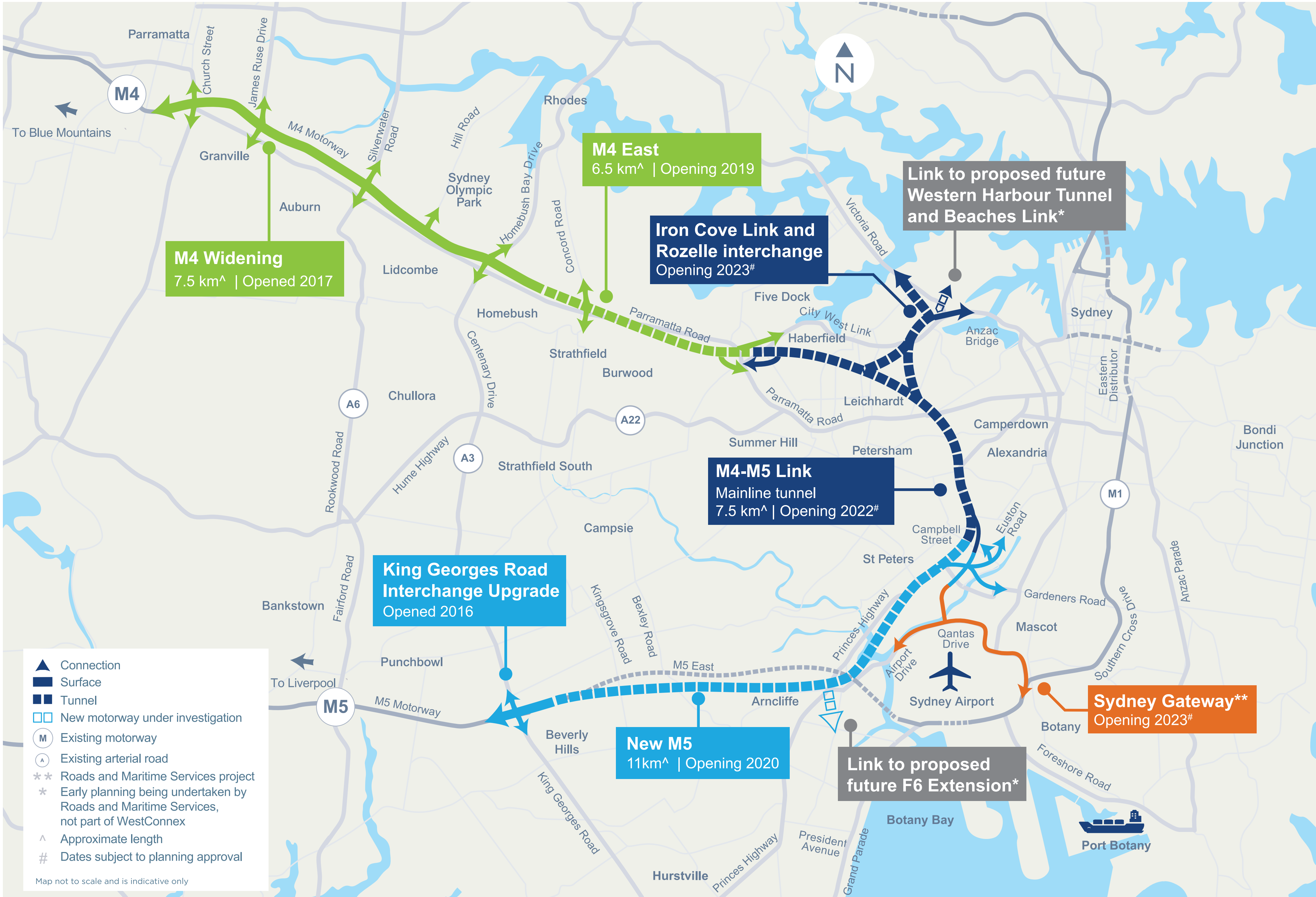


Figure 1-1 Overview of WestConnex and related projects

1.2 Purpose of this report

The purpose of this technical working paper is to inform the EIS and address the Secretary's Environment Assessment Requirements (SEARs) by:

- Completing desktop and intrusive site investigation works to inform the understanding of contamination conditions within the project footprint
- Identifying potential areas and contaminants of concern within the project footprint
- Assessing the potential for groundwater contamination to be present along the tunnel alignment
- Providing a preliminary qualitative assessment, and desktop review of available quantitative data, in relation to contamination risk posed during construction and operation of the project
- Assessing where further investigation should be undertaken or appropriate management procedures should be implemented for the construction and operational phases of the project
- Assessing whether the land may be contaminated and if so, whether remediation may be required including confirmation that future assessment and/or remediation would be undertaken in accordance with the current guidelines.

1.3 SEARs and Agency comments

In preparing this Contamination Assessment Technical Report, the SEARs issued for the project which is relevant to soil and groundwater contamination has been addressed. **Table 1-2** lists the applicable SEARs and where they have been addressed in this report. **Table 1-3** lists the applicable agency comments and where they have been addressed in the report.

Table 1-2 Relevant SEARs addressed in this report

SEARs		
Soils (contamination specific)		
Key issue and desired performance outcomes	**Requirement**	**Section where addressed in this report**
The environmental values of the 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, and in the area likely to be impacted by, the project.	**Section 4, 5, 6** and **8**
	2. The proponent must assess the impact of the project on acid sulfate soils (including impacts of acid runoff offsite) in accordance with the current guidelines and detail the mitigation measures proposed to minimise potential impacts.	**Section 4, 5, 6** and **8**

SEARs		
Soils (contamination specific)		
	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 the current guidelines.	
	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.	**Section 4**, **5**, **6**, **8** and **Appendix T** (Technical working paper: Groundwater) of the EIS.

Table 1-3 Relevant agency comments have been addressed in this report

Agency letters	
NSW Department of Primary Industries (Water)	
Requirement	**Section where addressed in this report**
• The SSI report notes construction of the project has the potential for disturbance of contaminated soils (**section 4.7.2**, page 55). The disturbance of contaminated groundwater is another potential soil, water and contamination-related impact that should be addressed.	**Section 4, 5** and **6**
• The SSI report indicates the project is partly located within Zone 2 of the Botany Sands Groundwater Source Management Zone. It notes within Zone 2, the use of groundwater is banned from domestic use in order to minimise the risk to bore users and to prevent the spread of contamination through pumping (refer to **section 4.9.1**, page 61). As the tunnels are proposed to be constructed in previous industrial areas and highly urbanised areas where potential contamination exists, the tunnels should be carefully designed so as not to exacerbate mobilisation of contaminated groundwater and/or prevent contaminated groundwater flow.	**Section 4, 5** and **6** and **Appendix T** (Technical working paper: Groundwater) of the EIS
Marrickville Council	
Requirement	**Section where addressed in this report**
• Rigorous contaminated land assessments should be undertaken. To date these have been lacking in other WestConnex EISs.	**Section 4, 5, 6** and **8**
• Council is working with a number of regional councils in improving the water quality and environmental health of the Cooks River and Parramatta River. A comprehensive assessment would be needed to evaluate the water quality issues and surface water contamination risks during construction and at operation stages.	**Section 4, 5 and 6** and **Appendix Q** (Technical working paper: Surface water and flooding) of the EIS
• The volume of the groundwater intercepted by the tunnels as seepage is expected to be considerable. The accumulated seepage may be contaminated since the tunnels would be constructed through some old industrial sites with a history of contamination. There would need to be a requirement for ongoing monitoring, treatment and disposal of seepage, with appropriate standards and guidelines. The details of seepage collection locations, pumps, pipe works and treatment facilities would need to be outlined in the EIS. There may be opportunities for reusing the treated seepage volume for non-potable use where high-grade water (or potable water) is not required.	**Section 5.2** and **6.2**
NSW Health	
Requirement	**Section where addressed in this report**
• There is a potential of contaminated land to be discovered in some construction and operational areas of this proposal. We recommend that all contaminated land should be identified and managed in accordance with relevant Australian and international guidelines.	**Section 8**

2 The project

2.1 Project location

The project would be generally located within the City of Sydney and Inner West local government areas (LGAs). The project is located about two to seven kilometres south, southwest and west of the Sydney central business district (CBD) and would cross the suburbs of Ashfield, Haberfield, Leichhardt, Lilyfield, Rozelle, Annandale, Stanmore, Camperdown, Newtown and St Peters. The local context of the project is shown in **Figure 2-1**.

2.2 Overview of the project

Key components of the project are shown in **Figure 2-1** and would include:

- Twin mainline motorway tunnels between the M4 East at Haberfield and the New M5 at St Peters. Each tunnel would be around 7.5 kilometres long and would generally accommodate up to four lanes of traffic in each direction
- Connections of the mainline tunnels to the M4 East project, comprising:
  - A tunnel-to-tunnel connection to the M4 East mainline stub tunnels east of Parramatta Road near Alt Street at Haberfield
  - Entry and exit ramp connections between the mainline tunnels and the Wattle Street interchange at Haberfield (which is currently being constructed as part of the M4 East project)
  - Minor physical integration works with the surface road network at the Wattle Street interchange including road pavement and line marking
- Connections of the mainline tunnels to the New M5 project, comprising:
  - A tunnel-to-tunnel connection to the New M5 mainline stub tunnels north of the Princes Highway near the intersection of Mary Street and Bakers Lane at St Peters
  - Entry and exit ramp connections between the mainline tunnels and the St Peters interchange at St Peters (which is currently being constructed as part of the New M5 project)
  - Minor physical integration works with the surface road network at the St Peters interchange including road pavement and line marking
- An underground interchange at Leichhardt and Annandale (the Inner West subsurface interchange) that would link the mainline tunnels with the Rozelle interchange and the Iron Cove Link (see below)
- A new interchange at Lilyfield and Rozelle (the Rozelle interchange) that would connect the M4-M5 Link mainline tunnels with:
  - City West Link
  - Anzac Bridge
  - The Iron Cove Link (see below)
  - The proposed future Western Harbour Tunnel and Beaches Link
- Construction of connections to the proposed future Western Harbour Tunnel and Beaches Link project as part of the Rozelle interchange, including:
  - Tunnels that would allow for underground mainline 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)
  - A dive structure and tunnel portals within the Rozelle Rail Yards, north of the City West Link / The Crescent intersection
  - Entry and exit ramps that would extend north underground from the tunnel portals in the

Rozelle Rail Yards to join the mainline connections to the proposed future Western Harbour Tunnel and Beaches Link

  - A ventilation outlet and ancillary facilities as part of the Rozelle ventilation facility (see below)

- Twin tunnels that would connect Victoria Road near the eastern abutment of Iron Cove Bridge and Anzac Bridge (the Iron Cove Link). Underground entry and exit ramps would also provide a tunnel connection between the Iron Cove Link and the New M5 / St Peters interchange (via the M4-M5 Link mainline tunnels)
- The Rozelle surface works, including:
  - Realigning The Crescent at Annandale, including a new bridge over Whites Creek and modifications to the intersection with City West Link
  - A new intersection on City West Link around 300 metres west of the realigned position of The Crescent, which would provide a connection to and from the New M5/St Peters interchange (via the M4-M5 Link mainline tunnels)
  - Widening and improvement works to the channel and bank of Whites Creek between the light rail bridge and Rozelle Bay at Annandale, to manage flooding and drainage for the surface road network
  - Reconstructing the intersection of The Crescent and Victoria Road at Rozelle, including construction of a new bridge at Victoria Road
  - New and upgraded pedestrian and cyclist infrastructure
  - Landscaping, including the provision of new open space within the Rozelle Rail Yards
- The Iron Cove Link surface works, including:
  - Dive structures and tunnel portals between the westbound and eastbound Victoria Road carriageways, to connect Victoria Road east of Iron Cove Bridge with the Iron Cove Link
  - Realignment of the westbound (southern) carriageway of Victoria Road between Springside Street and the eastern abutment of Iron Cove Bridge
  - Modifications to the existing intersections between Victoria Road and Terry, Clubb, Toelle and Callan streets
  - Landscaping and the establishment of pedestrian and cycle infrastructure
- Five motorway operations complexes; one at Leichhardt (MOC1), three at Rozelle (Rozelle West (MOC2), Rozelle East (MOC3) and Iron Cove Link (MOC4)), and one at St Peters (MOC5). The types of facilities that would be contained within the motorway operations complexes would include substations, water treatment plants, ventilation facilities and outlets, offices, on-site storage and parking for employees
- Tunnel ventilation systems, including ventilation supply and exhaust facilities, axial fans, ventilation outlets and ventilation tunnels
- Three new ventilation facilities, including:
  - The Rozelle ventilation facility at Rozelle
  - The Iron Cove Link ventilation facility at Rozelle
  - The Campbell Road ventilation facility at St Peters
- Fitout (mechanical and electrical) of part of the Parramatta Road ventilation facility at Haberfield (which is currently being constructed as part of M4 East project) for use by the M4-M5 Link project
- Drainage infrastructure to collect surface and groundwater for treatment at dedicated facilities. Water treatment would occur at
  - Two operational water treatment facilities (at Leichhardt and Rozelle)
  - The constructed wetland within the Rozelle Rail Yards
  - A bioretention facility for stormwater runoff within the informal car park at King George Park at

Rozelle (adjacent to Manning Street). A section of the existing informal car park would also be upgraded, including sealing the car park surface and landscaping

- Treated water would flow back to existing watercourses via new, upgraded and existing infrastructure
- Ancillary infrastructure and operational facilities for electronic tolling and traffic control and signage (including electronic signage)
- Emergency access and evacuation facilities, including pedestrian and vehicular cross and long passages and fire and life safety systems
- Utility works, including protection and/or adjustment of existing utilities, removal of redundant utilities and installation of new utilities. A Utilities Management Strategy has been prepared for the project that identifies management options for utilities, including relocation or adjustment. Refer to **Appendix F** (Utilities Management Strategy) of the EIS.

The project does not include:

- Site management works at the Rozelle Rail Yards. These works were separately assessed and determined by Roads and Maritime through a Review of Environmental Factors under Part 5 of the EP&A Act (refer to **Chapter 2** (Assessment process) of the EIS)
- Ongoing motorway maintenance activities during operation
- Operation of the components of the Rozelle interchange which are the tunnels, ramps and associated infrastructure being constructed to provide connections to the proposed future Western Harbour Tunnel and Beaches Link project.

Temporary construction ancillary facilities and temporary works to facilitate the construction of the project would also be required.

2.2.1 Staged construction and opening of the project

It is anticipated the project would be constructed and opened to traffic in two stages (as shown in **Figure 2-1**).

Stage 1 would include:

- Construction of the mainline tunnels between the M4 East at Haberfield and the New M5 at St Peters, stub tunnels to the Rozelle interchange (at the Inner West subsurface interchange) and ancillary infrastructure at the Darley Road motorway operations complex (MOC1) and Campbell Road motorway operations complex (MOC5)
- These works are anticipated to commence in 2018 with the mainline tunnels open to traffic in 2022. At the completion of Stage 1, the mainline tunnels would operate with two traffic lanes in each direction. This would increase to generally four lanes at the completion of Stage 2, when the full project is operational.

Stage 2 would include:

- Construction of the Rozelle interchange and Iron Cove Link including:
  - Connections to the stub tunnels at the Inner West subsurface interchange (built during Stage 1)
  - Ancillary infrastructure at the Rozelle West motorway operations complex (MOC2), Rozelle East motorway operations complex (MOC3) and Iron Cove Link motorway operations complex (MOC4)
  - Connections to the surface road network at Lilyfield and Rozelle
  - Construction of tunnels, ramps and associated infrastructure as part of the Rozelle interchange to provide connections to the proposed future Western Harbour Tunnel and Beaches Link project
- Stage 2 works are expected to commence in 2019 with these components of the project open to traffic in 2023.

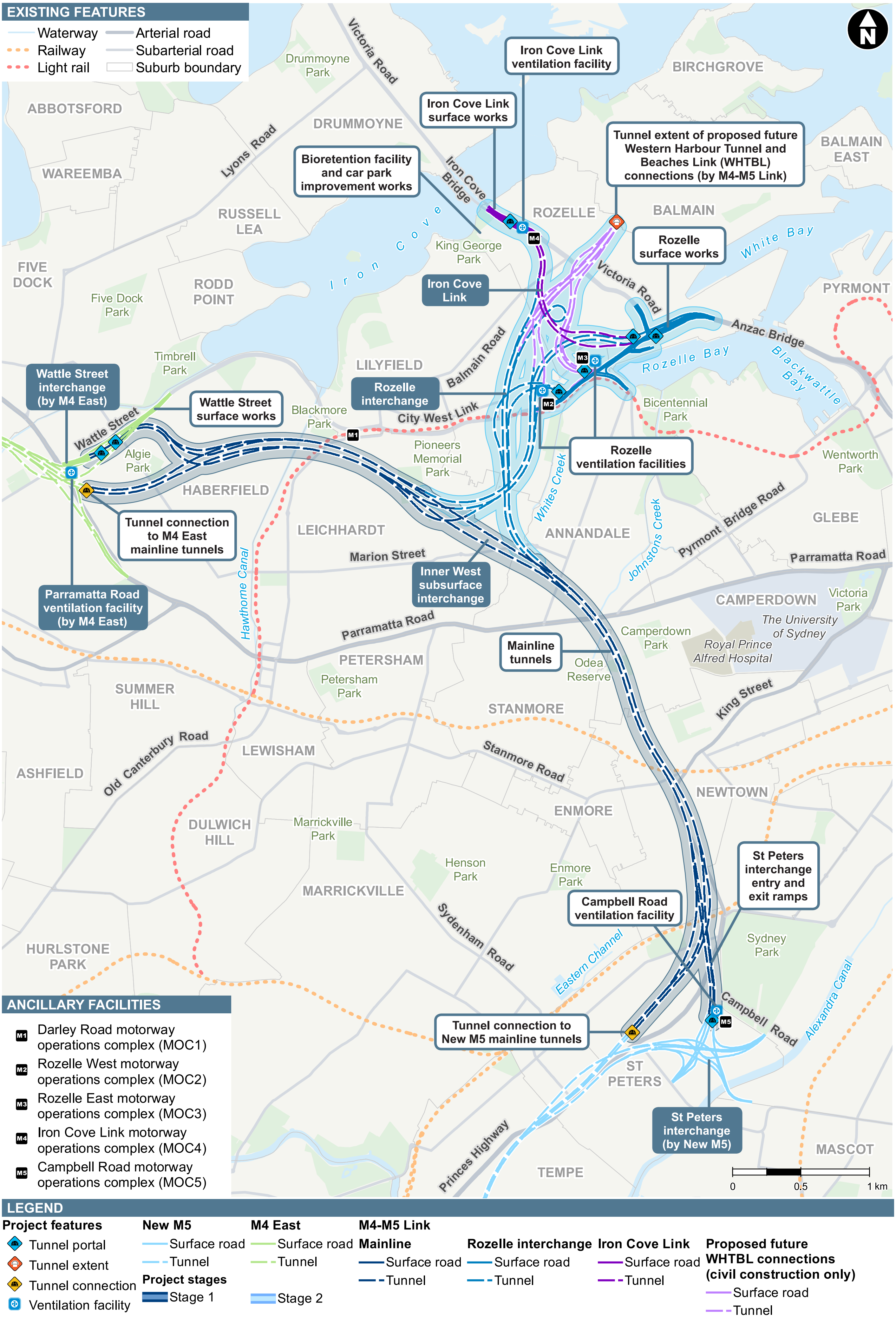


Figure 2-1 Overview of the project

2.3 Construction activities

An overview of the key construction features of the project is shown in **Figure 2-2** and would generally include:

- Enabling and temporary works, including provision of construction power and water supply, ancillary site establishment including establishment of acoustic sheds and construction hoarding, demolition works, property adjustments and public and active 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.

A more detailed overview of construction activities is provided in **Table 2-1**.

Table 2-1 Overview of construction activities

Component	Typical activities
Site establishment and enabling works	• Vegetation clearing and removal • Utility works • Traffic management measures • Install safety and environmental controls • Install site fencing and hoarding • Establish temporary noise attenuation measures • Demolish buildings and structures • Carry out site clearing • Heritage salvage or conservation works (if required) • Establish construction ancillary facilities and access • Establish acoustic sheds • Supply utilities (including construction power) to construction facilities • Establish temporary pedestrian and cyclist diversions.
Tunnelling	• Construct temporary access tunnels • Excavation of mainline tunnels, entry and exit ramps and associated tunnelled infrastructure and install ground support • Spoil management and haulage • Finishing works in tunnel and provision of permanent tunnel services • Test plant and equipment.

Component	Typical activities
Surface earthworks and structures	• Vegetation clearing and removal • Topsoil stripping • Excavate new cut and fill areas • Construct dive and cut-and-cover tunnel structures • Install stabilisation and excavation support (retention systems) such as sheet pile walls, diaphragm walls and secant pile walls (where required) • Construct required retaining structures • Excavate new road levels.
Bridge works	• Construct piers and abutments • Construct headstock • Construct bridge deck, slabs and girders • Demolish and remove redundant bridges.
Drainage	• Construct new pits and pipes • Construct new groundwater drainage system • Connect drainage to existing network • Construct sumps in tunnels as required • Construct water quality basins, constructed wetland and bioretention facility and basin • Construct drainage channels • Construct spill containment basin • Construct onsite detention tanks • Adjustments to existing drainage infrastructure where impacted • Carry out widening and naturalisation of a section of Whites Creek • Demolish and remove redundant drainage.
Pavement	• Lay select layers and base • Lay road pavement surfacing • Construct pavement drainage.
Operational ancillary facilities	• Install ventilation systems and facilities • Construct water treatment facilities • Construct fire pump rooms and install water tanks • Test and commission plant and equipment • Construct electrical substations to supply permanent power to the project.

Component	Typical activities
Finishing works	• Line mark to new road surfaces • Erect directional and other signage and other roadside furniture such as street lighting • Erect toll gantries and other control systems • Construct pedestrian and cycle paths • Carry out earthworks at disturbed areas to establish the finished landform • Carry out landscaping • Closure and backfill of temporary access tunnels (except where these are to be used for inspection and/or maintenance purposes) • Site demobilisation and preparation of the site for a future use.

Twelve construction ancillary facilities are described in this EIS (as 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).

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 number, location and layout of construction ancillary facilities would be finalised as part of detailed construction planning during detailed design and would meet the environmental performance outcomes stated in the EIS and the Submissions and Preferred Infrastructure Report and satisfy criteria identified in any relevant conditions of approval.

The construction ancillary facilities would be used for a mix of civil surface works, tunnelling support, construction workforce parking and administrative purposes. Wherever possible, construction sites would be co-located with the operational footprint to minimise property acquisition and temporary disruption. The layout and access arrangements for the construction ancillary facilities are based on the concept design only and would be confirmed and refined in response to submissions received during the exhibition of this EIS and during detailed design.

2.3.1 Construction program

The total period of construction works for the project is expected to be around five years, with commissioning occurring concurrently with the final stages of construction. An indicative construction program is shown in **Table 2-2**.

Table 2-2 Indicative construction program

Construction activity	Indicative construction timeframe																							
	2018				2019				2020				2021				2022				2023			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Mainline tunnels																								
Site establishment and establishment of construction ancillary facilities			■	■	■	■	■	■	■	■														
Utility works and connections			■	■	■	■	■	■																
Tunnel construction				■	■	■	■	■	■	■	■	■	■											
Portal construction				■	■	■	■	■																
Construction of permanent operational facilities												■	■	■	■	■								
Mechanical and electrical fitout works														■	■	■								
Establishment of tolling facilities															■	■								
Site rehabilitation and landscaping																■	■	■	■					
Surface road works																	■	■	■					
Demobilisation and rehabilitation																			■	■				
Testing and commissioning																■	■	■	■	■				
Rozelle interchange and Iron Cove Link																								
Site establishment and establishment of construction ancillary facilities				■	■	■	■	■	■															
Utility works and connections and site remediation				■	■	■	■	■																
Tunnel construction									■	■	■	■	■	■	■	■	■	■						
Portal construction						■	■	■	■															
Construction of surface road works						■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■			

Construction activity	Indicative construction timeframe																							
	2018				2019				2020				2021				2022				2023			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Construction of permanent operational facilities						■	■	■	■	■	■	■	■	■	■	■								
Mechanical and electrical fitout works													■	■	■	■	■	■	■	■				
Establishment of tolling facilities																		■	■					
Site rehabilitation and landscaping																			■	■	■			
Demobilisation and rehabilitation																						■	■	
Testing and commissioning																			■	■	■	■	■	

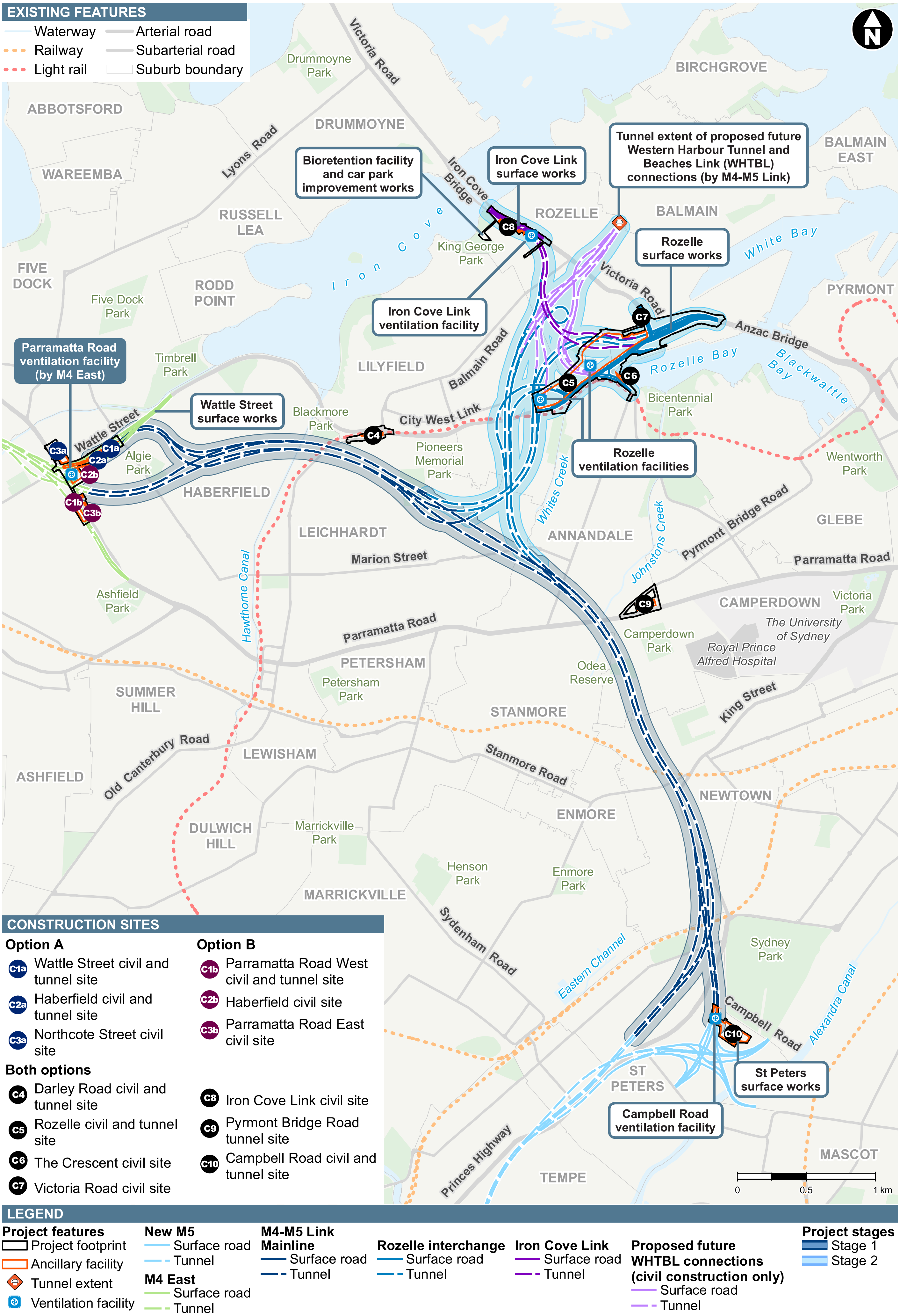


Figure 2-2 Overview of project footprint and ancillary facilities

3 Assessment methodology

3.1 Relevant legislation, guidelines and policies

The relevant legislation, policies and guidelines for contaminated land in NSW that have been considered during the preparation of this report include:

- *Contaminated Land Management Act 1997* (NSW) (CLM Act)
- *Protection of the Environment Operations Act 1997* (NSW) (POEO Act)
- *Environmentally Hazardous Chemicals Act 1985* (NSW) (EHC Act)
- State Environment Planning Policy No 55 – Remediation of Land (SEPP 55).

The following guidelines which are relevant to the assessment of potentially contaminated land in NSW that have been considered during the preparation of this report include:

- (NSW Environment Protection Authority (NSW EPA 2015). *Guidelines on the Duty to Report Contamination under the Contaminated Land Management Act 1997*
- (NSW Department of Environment and Conservation (DEC 2006). *Guidelines for the Site Auditor Scheme* (2nd Edition)
- (NSW Department of Urban Affairs and Planning (DUAP) and NSW EPA 1998). *Managing Land Contamination*, Planning Guidelines SEPP 55-Remediation of Land
- (NSW DEC 2007). *Guidelines for the Assessment and Management of Groundwater Contamination*
- (National Environment Protection Council (NEPC) 1999). *National Environment Protection (Assessment of Site Contamination) Measure 2013* (ASC NEPM 2013)
- (NSW EPA 2016). *Environmental Guidelines: Solid Waste Landfills*, Second Edition
- NSW Office of Environment and Heritage (OEH) 2011). *Guidelines for Consultants Reporting on Contaminated Sites*
- (NSW EPA 2012). *Guidelines for the Assessment and Management of Sites Impacted by Hazardous Ground Gasses*
- Australian and New Zealand Environment and Conservation Council (ANZECC) & Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) (2000). *National Water Quality Management Strategy, Paper No. 4*, *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*, Volume 1, The Guidelines, October 2000
- Acid Sulfate Soils Management Advisory Committee (ASSMAC), 1998. *Acid Sulfate Soils Assessment Guidelines*. August 1998.

3.2 Methodology

To achieve the desired performance outcome, which is to ensure that risks arising from the disturbance and excavation of land and disposal of soil are minimised, including disturbance to acid sulfate soils and site contamination, the following methodology has been adopted:

1. Identification of potential or known soil and groundwater contamination in the project footprint by assessing the existing environment, including review and assessment of previous reports and soil and groundwater investigation data relevant to the project
2. Assessment of the potential contamination impacts of the project during construction and operation
3. Identification and description of mitigation measures to manage potential or known soil and groundwater contamination during construction and operation.

The methodologies for the following are outlined in **sections 3.2.1** to **3.2.3** and include:

- Assessment of the existing environment for the project footprint
- Preliminary qualitative risk assessment for the potential construction and operational impacts.

3.2.1 Methodology for assessing the project footprint

Recent contamination assessment and investigation reports have been prepared by AECOM and other consultants for the proposed ancillary facilities and surrounding areas incorporating the project footprint. The assessments included the following:

- Review of background information including relevant historical reports relating to each ancillary facility and the project footprint
- Review of relevant Lands Title Office documents for land within the ancillary facility boundary to evaluate whether historical land uses were likely to have caused soil and groundwater contamination
- Review of council records, including section 149 certificates for land within the ancillary facility boundary to evaluate whether the presence of contaminated land has been identified on Council records
- Search of the NSW EPA records of notices and list of NSW contaminated sites notified to NSW EPA
- Review of available historical photographs, including aerial photographs, for the ancillary facilities and project footprint, which may provide an indication of historically contaminating land uses
- Review of historical businesses within and in proximity to the ancillary facilities and project footprint from information provided in the 1950, 1970 and 1991 Universal Business Directories Pty Ltd (UBD) business directories to identify potentially contaminating industries
- A preliminary assessment of the nature and location of infrastructure, hazardous materials and other features located within and in proximity to the ancillary facilities and project footprint, both current and historical
- Review of available published geological and hydrogeological information for the ancillary facilities and project footprint
- Search of the NSW Government's groundwater bore database for groundwater bores within a one kilometre radius of the ancillary facilities, to assist in gaining an understanding of regional hydrogeology
- 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 project footprint and surrounds.

Intrusive investigations were also undertaken along the tunnel alignment, including:

- Combined geotechnical and contamination investigations completed within the project footprint
- Soil and groundwater investigations at the Rozelle Rail Yards, where a high potential for contamination was identified to be present as a result of historical land use activities and where significant earthworks are required to be undertaken for the project
- Soil and sediment investigations in areas of proposed intrusive construction works at The Crescent and adjacent Rozelle Bay where a high potential for contamination was identified to be present as a result of historical land use activities.

Based on this information, the areas and contaminants of concern around ancillary facilities and the project footprint were identified. A list of the reports used to support the assessment of contamination risks associated with each ancillary facility and surrounding areas incorporating the project footprint is provided in **Table 3-1** and summarised in **sections 4.1** to **4.13**.

Table 3-1 Previous reports for the assessment of the ancillary facilities and surrounding areas incorporating the project footprint

Area	Previous Reports
C1a – Wattle Street civil and tunnel site at Haberfield	• GHD (2014) WestConnex Delivery Authority Phase II Contamination & Acid Sulfate Soil Investigation and Assessment • GHD Pty Ltd (GHD) (2015) Appendix P of the Environmental Impact Statement M4 Motorway East Soil and Land Contamination Assessment • Ramboll Environ (2016a) RE: Technical Note – Environmental Advice – WCX M4E Eastern Ventilation Facility • Ramboll Environ (2016b) RE: Technical Note – Environmental Advice – WCX M4E Wattle Street Civil Compound – Reg Coady Reserve • Ramboll Environ (2016c) Phase Environmental Site Assessment, WestConnex M4 East, draft in preparation • Down to Earth (D2E) Waste and Material Classification, Cnr Parramatta Road and Walker Avenue, Haberfield
C2a – Haberfield civil and tunnel site C2b – Haberfield civil site	• GHD (2014) WestConnex Delivery Authority Phase II Contamination & Acid Sulfate Soil Investigation and Assessment • GHD Pty Ltd (GHD) (2015) Appendix P of the Environmental Impact Statement M4 Motorway East Soil and Land Contamination Assessment • Ramboll Environ (2016a) RE: Technical Note – Environmental Advice – WCX M4E Eastern Ventilation Facility • Ramboll Environ (2016c) Phase Environmental Site Assessment, WestConnex M4 East, draft in preparation • Down to Earth (D2E) Waste and Material Classification, Cnr Parramatta Road and Walker Avenue, Haberfield
C3a – Northcote Street civil site at Haberfield	• GHD Pty Ltd (GHD) (2015) Appendix P of the Environmental Impact Statement M4 Motorway East Soil and Land Contamination Assessment
C1b – Parramatta Road West civil and tunnel site at Ashfield	• GHD Pty Ltd (GHD) (2015) Appendix P of the Environmental Impact Statement M4 Motorway East Soil and Land Contamination Assessment
C3b – Parramatta Road East civil site at Haberfield	• GHD Pty Ltd (GHD) (2015) Appendix P of the Environmental Impact Statement M4 Motorway East Soil and Land Contamination Assessment
C4 – Darley Road civil and tunnel site at Leichhardt	• AECOM, 2016a. Stage 1 Preliminary Site Investigation, Hawthorne Canal • PPK Environment and Infrastructure (PPK), 2001. Phase 1 Environmental Site Assessment 7 Darley Road, Leichhardt, NSW • Environmental Investigation Services (EIS), 2002. Environmental Site Screening for Proposed Supermarket Development, 7 Darley Road, Leichhardt, NSW • HLA-Envirosciences Pty Ltd (HLA), 2007. Additional Environmental Site Assessment, 7 Darley Road, Leichhardt, NSW

Area	Previous Reports
C5 – Rozelle civil and tunnel site at Rozelle	• ERM, 2002. Stage 1 and 2 Environmental Site Assessment, Brenan Street, Lilyfield • Parsons Brinkerhoff Pty Ltd (PB), 2003a. Rozelle Marshalling Yards Redevelopment, Environmental Site Assessment • PB, 2003b. Rozelle Marshalling Yards Redevelopment, Remedial Action Plan (Final Report) • GHD Pty Ltd, 2004. Rozelle Marshalling Yards, Statement of Environmental Effects – Site Preparation Works (Final Draft) • ENSR Australia Pty Ltd, 2008. Advice Relating to Management of Contamination, Bays Precinct (Draft) • Coffey Environmental Pty Ltd (Coffey), 2009 North West Metro Contract 136 Contamination Assessment Report • Sinclair Knight Merz (SKM), 2009. Technical Paper for Spoil Management for the CBD Metro Environment Assessment • SKM, 2011. Asbestos Assessment – Rozelle Marshalling Yard • SKM, 2009. CBD Metro Environment Assessment: Contaminated Lands Constraints Assessment • AECOM, 2016b. WestConnex M4-M5 Link Rozelle Interchange Phase 1 Environmental Site Assessment • AECOM, 2016c WestConnex M4-M5 Link Factual Contamination Report • Roads and Maritime Services, 2016. Rozelle Rail Yards – Site Management Works Review of Environmental Factors
C6 – The Crescent civil site at Annandale	• AECOM, 2016b. WestConnex M4-M5 Link Rozelle Interchange Phase 1 Environmental Site Assessment • AECOM, 2016c WestConnex M4-M5 Link Factual Contamination Report • Jacobs (2015b) Lots 21/22, DP1151746 Rozelle Bay – NSW Roads & Maritime Services, Site Access and Management Procedures. Final, ExeC1a4/0341
C7 – Victoria Road civil site at Rozelle	• AECOM, 2016b. WestConnex M4-M5 Link Rozelle Interchange Phase 1 Environmental Site Assessment
C8 – Iron Cove Link civil site at Rozelle	• AECOM, 2016d. Preliminary Site Investigation, Iron Cove Portal and Construction ancillary facilities
C9 – Pyrmont Bridge Road tunnel site at Annandale	• AECOM, 2016e. Preliminary site Investigation, Pyrmont Bridge Road Tunnel Site.

Area	Previous Reports
C10 – Campbell Road civil and tunnel site at St Peters	• AECOM, 2014. Phase 1 Environmental Site Assessment, Alexandria Landfill Site Acquisition Area, St Peters • AECOM, 2015a. Phase 1 Environmental Site Assessment, Local Road Upgrades, St Peters, Mascot and Alexandria, NSW • AECOM, 2015b. WestConnex Stage 2: M5 Factual Contamination Assessment. 60327128_CI_RPT03_Draft_20150422 • AECOM, 2015c. Characterisation of the Bradshaw Mountain Stockpile – Resource Recovery Order for Potential Excavated Natural Material Exemption (Draft) • AECOM, 2015d. Phase 2 Environmental Site Assessment Alexandria Landfill, 10-16 Albert Street, NSW. 60327128_Draft Phase 2 ESA_20150506_A • AECOM, 2015e. Alexandria Landfill Closure Hydrogeological Assessment, Alexandria Landfill, 10-16 Albert Street, St Peters, NSW. 60327128_Draft Hydro Report_20150512_RevA • AECOM, 2015f. Alexandria Landfill, Landfill Management Closure Plan. 60327128_Draft LCMP_20151021_RevC • AECOM, 2015g. WestConnex New M5, Technical Working Paper: Contamination

3.2.2 Tunnel alignment

To assess the potential for groundwater contamination to be present along the proposed tunnel alignment, information from the following sources was reviewed to identify former and current potentially contaminating land uses:

- Search of the NSW EPA list of contaminated sites notified to NSW EPA and the 'Contaminated Land: Record of Notices' within around 500 metres of the tunnel alignment
- Selected historical images including aerial photographs for the tunnel alignment and surrounds
- Selected historical survey maps for the tunnel alignment and surrounds
- Review of available groundwater monitoring results
- Information from the previous reports listed in **Table 3-1** were also used to assess potential impacts on the tunnel alignment.

Given the length of the tunnel alignment and the location of proposed ancillary facilities, tunnel portals and interchange locations, the tunnel alignment was split into the following sections for ease of interpretation (see **sections 4.14.1** to **4.14.5**)

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

3.2.3 Preliminary qualitative risk assessment methodology

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 methodology for the risk assessment is detailed in **Table 3-2**.

Table 3-2 Preliminary qualitative risk assessment methodology

<table>
<tr><th colspan="2">Preliminary qualitative risk assessment methodology</th></tr>
<tr><th>Construction</th><th>Operation</th></tr>
<tr><td colspan="2">Identification of areas and contaminants of concern</td></tr>
<tr><td colspan="2">Identified using the methodology outlined in section 3.2.1.</td></tr>
<tr><td colspan="2">Likelihood of contamination to be present and likely extent of impacts</td></tr>
<tr><td colspan="2">Identified by review of information presented in section 4.</td></tr>
<tr><td colspan="2">Potential migration pathways</td></tr>
<tr><td>• Dust generation
• Excavation and disposal or reuse of soils
• Extraction and disposal or reuse of groundwater from dewatering or drainage
• Migration of groundwater via preferential pathways
• Surface water erosion.</td><td>• Extraction of groundwater in drainage systems
• Migration of groundwater via preferential pathways
• Surface water erosion.</td></tr>
<tr><td colspan="2">Potential receptors</td></tr>
<tr><td>• Project construction workers and visitors
• Surrounding land users such as the general public and nearby residents and commercial workers
• Receiving water bodies.</td><td>• Intrusive maintenance workers
• Future site users of final land use such as commercial, open space or residential
• Ecological receptors
• Receiving water bodies.</td></tr>
<tr><td colspan="2">Potential exposure pathways</td></tr>
<tr><td>• Direct contact, ingestion or inhalation by human receptors
• Uptake by aquatic flora and intake by aquatic fauna.</td><td>• Direct contact, ingestion or inhalation by human receptors and fauna
• Uptake by terrestrial and aquatic flora and intake by aquatic fauna.</td></tr>
</table>

To identify the risk rating, the preliminary qualitative contamination risk assessment matrix in **Table 3-3** was used. See **Table 5-1** for the risk assessment of construction impacts and **Table 6-1** for the risk assessment of operation impacts.

Table 3-3 Preliminary qualitative risk assessment matrix

Consequence	Likelihood of soil or groundwater contamination to be present				
	Very unlikely to be present at concentrations above the relevant assessment criteria and limited in extent	**Potentially present at concentrations above the relevant assessment criteria and limited in extent**	**Potentially present at concentrations above the relevant assessment criteria and widespread**	**Most likely present at concentrations above the relevant assessment criteria and widespread**	**Known to be present at concentrations above the relevant assessment criteria and widespread**
No or unlikely exposure pathway for human or ecological receptor's either now or during or post construction*	Low	Low	Low	Medium	Medium
Exposure pathway for human or ecological receptors likely to be present and complete either now, during or post construction*	Low	Medium	Medium	High	High
Exposure pathway for human or ecological receptors present and are complete either now, during or post construction*	Medium	Medium	High	High	High

Notes: * without implementation of appropriate controls or remediation as recommended in the management of construction and operational impacts - **section 8**.

4 Existing environment

4.1 C1a – Wattle Street civil and tunnel site at Haberfield

4.1.1 Site description and surrounding land use

The Wattle Street civil and tunnel site at Haberfield (C1a) would be used where Option A is selected as the preferred construction option at Haberfield. Refer to **Chapter 6** (Construction work) of the EIS for further information on Option A and Option B.

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 is shown in **Figure 4-1** and would be located in an area comprising former residential 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 northeast and southwest and is surrounded by the land uses described in **Table 4-1**.

Table 4-1 Surrounding land use – Wattle Street civil and tunnel site at Haberfield (C1a)

Direction	Description of surrounding land use and proximity to the site
North	• Wattle Street followed by low density residential properties and Reg Coady Reserve (120 metres topographically down-gradient) (northeast) • Dobroyd Canal (Iron Cove Creek) (250 metres topographically down-gradient from the centre of C1a)
South	• Low density residential properties
East	• Ramsay Street followed by low density residential properties (topographically down-gradient)
West	• Parramatta Road • M4 East construction ancillary facilities and commercial/industrial properties along Parramatta Road. Some/all of these construction ancillary facilities would subsequently be used for M4-M5 Link construction.

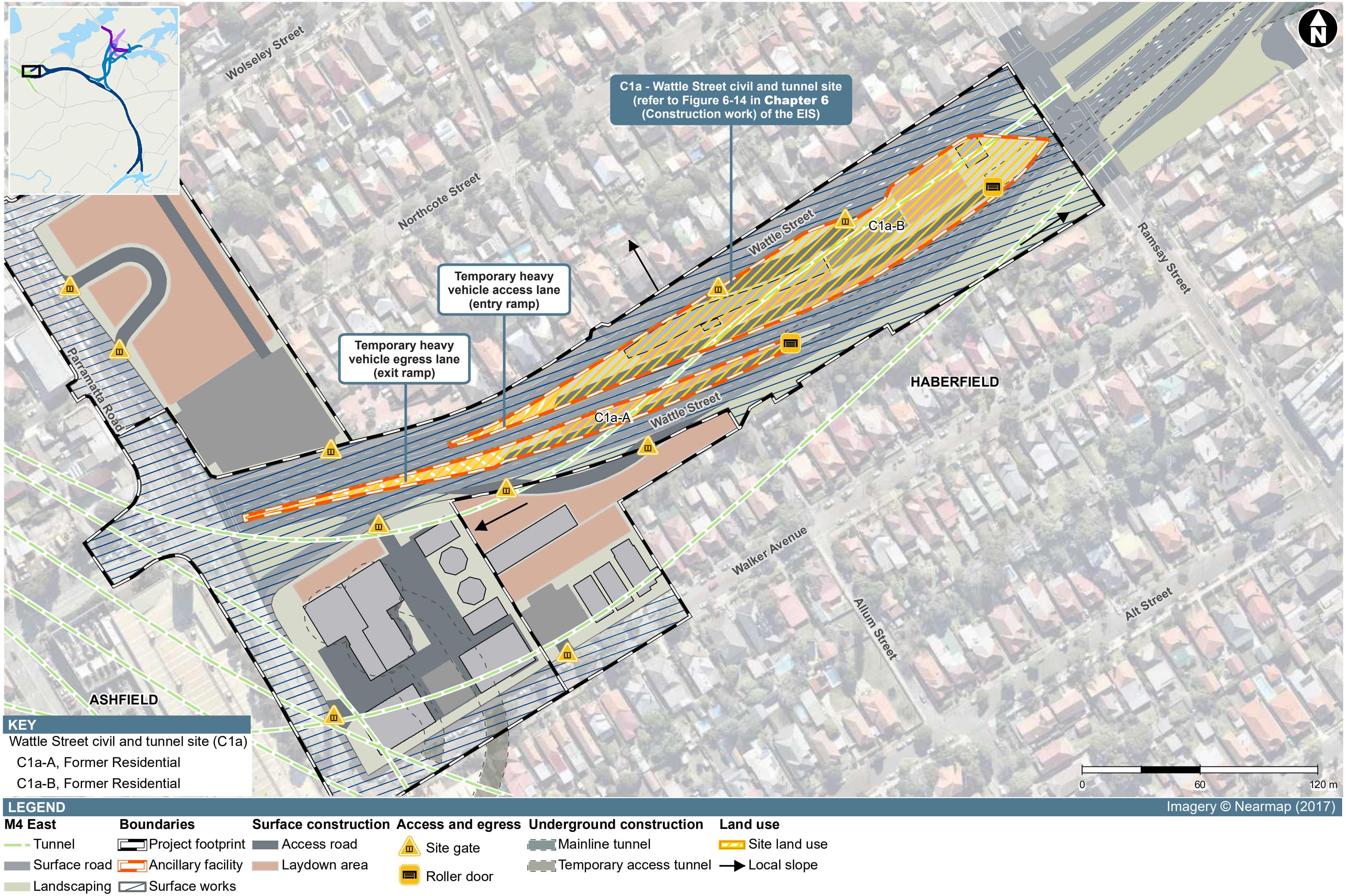


Figure 4-1 Wattle Street civil and tunnel site at Haberfield (C1a)

4.1.2 Previous intrusive investigations

Limited investigations were undertaken by GHD (2015) to inform the M4 East EIS, within the Wattle Street civil and tunnel site (C1a) at Haberfield. GHD concluded that acquired commercial and residential properties may contain hazardous building materials and that further assessment should be completed prior to the commencement of demolition works. In addition, the Soil and Land Contamination Assessment (GHD September 2015), concluded that 'While contamination such as asbestos (reported at depth), metals, polycyclic aromatic hydrocarbons (PAHs) and hydrocarbons are not considered to present an imminent risk to human health or the environment, they would require appropriate management during the construction phase, the risks can be managed through a Construction Environmental Management Plan (CEMP) that would include an unexpected finds protocol to handle any latent contamination, groundwater, waste management and acid sulfate soils.'

The closest down-gradient groundwater monitoring well is 200 metres to the southwest of the site. The monitoring well was sampled by GHD (2015) for: metals; total recoverable hydrocarbons (TRH); benzene, toluene, ethylbenzene and xylenes (BTEX); PAHs; volatile organic compounds (VOCs) and organochlorine pesticides (OCPs). Concentrations of copper, nickel and zinc exceeded the ASC NEPM (NEPC 2013) Groundwater Investigation Levels (GILs) for freshwater.

Following M4 East project approval and prior to M4 East establishment works as part of the M4 East project, Ramboll Environ (2016a) prepared a technical note containing environmental advice for the management of contamination at a site located at the corner of Wattle Street and Parramatta Road within the M4-M5 Link project footprint and immediately south and adjacent to the proposed C1a ancillary facility within the C2a or C2b ancillary facility.

The objective of the technical note was to provide the M4 East contractor with guidance in relation to site specific circumstances and procedures that should be implemented for the management of contaminated materials at the site. The technical note reviewed the findings of the GHD Phase 2 Contamination and Acid Sulfate Soil Investigation and Assessment (September 2014) completed within the vicinity of the site, along with a Ramboll Environ Phase 2 Contaminated Land Assessment (2016c), and a Down to Earth (D2E) waste classification (June 2016). The results of the technical note are summarised as follows:

- GHD (2014) installed one well within 500 metres of the site, screened in the Hawkesbury Sandstone aquifer, which reported a standing water level 4.98 metres below top of casing. Two boreholes drilled 20 metres south and southwest of the site reported 0.7 metres of fill materials with no exceedances in the soil samples analysed. One borehole was converted to a monitoring well screened within the shale aquifer, with a standing water level of 2.595 metres below top of casing
- Ramboll Environ (2016c) investigated nine locations at four sites within the site in M4 East footprint and collected 26 soil samples and four groundwater samples. The locations were chosen to target potential contamination which could be encountered during construction works, such as during the excavation of the wheel wash and the sedimentation basin. Friable asbestos was detected in three locations at depths 0.2, 0.5 and 0.6 metres below ground level. One piece of bonded asbestos containing materials was identified on the surface at one location and one minor zinc exceedance of the ecological investigation level in shallow topsoil was reported at one location. Elevated metals in groundwater were reported to exceed the ANZECC 95 per cent trigger values for the protection of aquatic ecosystems in marine waters. Lead was also reported to exceed the ANZECC (2000) recreational guideline at one location. Ramboll Environ (2016b) considered these exceedances in groundwater to be representative of background concentrations
- Based on the results of Ramboll Environ (2016c) classified the material as Special Waste – Asbestos unless it could be demonstrated that the material was free of asbestos by a Sampling Quality Plan (SQP). The area where asbestos containing material (ACM) fragment was detected was considered to be classified as General Solid Waste following removal of identified ACM fragment(s). Ramboll Environ (2016a) considered the natural materials below the fill materials to be classified as Virgin Excavated Natural Material (VENM)

- D2E (2016) undertook *in situ* waste classification sampling over an area of 10,000 m^2 to a depth of 1.7 metres below ground level – the anticipated subgrade level for surface works. Ramboll (2016a) noted that the assessed area only partly covered the site compound and also extended beyond the compound boundary. D2E concluded that the fill material which extended to 0.6 metres below ground surface would be classified as General Solid Waste with the exception of a 25.7 metre hotspot of asbestos contaminated soils (fibres and fragment[s]). D2E (2016) considered the natural materials below the fill materials to be classified as VENM. D2E undertook a second waste classification on the remaining portion of the site over an area of 4000 square metres. D2E concluded that the "upper soil/fill horizon" was classified as General Solid Waste and the underlying natural soils met the definition of VENM
- A.D. Envirotech (ADE 2016) completed an Asbestos Materials Inspection and Risk Assessment of the topsoil and materials within the former location of the central building footing at 1A Wattle Street Haberfield following notification of an unexpected find by the M4 East contractor. A 50 square metre delineated exclusion zone was established which included the former building footing, soil at surface, building material and soil to a depth of 0.5 metres below ground level. An assessment was undertaken which included a site walkover, one test-pit, collection of two soil samples and collection of two potential fibre cement samples for analysis. Results indicated fibre cement samples contained asbestos; soil samples did not indicate the presence of asbestos.

Ramboll Environ (2016a) indicated the materials impacted by friable and bonded asbestos would be managed as part of the Construction Contaminated Land Management Plan (CCLMP) (November 2015) and associated sub-plan Asbestos Management Plan (AMP) (December 2015). Ramboll Environ (2016a) detailed a remediation and validation strategy specific to the identified contaminants within the site.

Ramboll Environ (2016b) prepared another technical note for the M4 East Wattle Street Civil Compound located at Reg Coady Reserve (dated 15 August 2016) to be used during site establishment of the construction ancillary facilities and construction of motorway infrastructure as part of the M4 East project. It is noted that Reg Coady Reserve is located approximately 120 metres topographically down-gradient of the proposed M4-M5 Link project footprint (Wattle Street civil and tunnel site (C1a)).

The technical note reviewed available previous investigation reports and concluded that there were seven areas of environmental concern within Reg Coady Reserve. Contaminants of concern identified in soil included ACM, friable asbestos, lead, TRH, zinc, Total PAHs and acid sulfate soils. Ramboll Environ (2016b) indicated that the impacted materials would be managed in accordance with the CCLMP (November 2015) and the AMP (December 2015). The technical note also detailed a remediation and validation strategy specific to the identified contaminants within the M4 East Wattle Street civil compound.

4.1.3 Site history

A review of historical aerial photographs for the area and certificates of titles for selected commercial/industrial properties was undertaken for the GHD 2015 report prepared as part of the WestConnex M4 East EIS. Key findings relevant to the Wattle Street civil and tunnel site at Haberfield were:

- 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 notified to the NSW EPA and the public register under section 308 of the *Protection of the Environment Operations Act 1997* (NSW) (POEO Act) was undertaken on 2 September 2015. There were no sites identified within 500 metres of the site (GHD 2015). Demolition of properties acquired for the M4 East project commenced in March 2016.

4.1.4 Soil and geology

The Wattle Street civil and tunnel site at Haberfield is underlain by Gymea erosional soils. The soils are underlain by Hawkesbury Sandstone which consists of medium to coarse grained quartz sandstone, very minor shale and laminate lenses and Ashfield Shale which consists of shale and laminate.

GHD (2015) noted that generalised stratigraphy within the vicinity of the site (M4 East EIS Section 6: Dobroyd Canal [Iron Cove Creek] to Bland Street [including Wattle Street]) comprised:

- Concrete or hardstand at ground level – thickness 0.1 to 0.13 metres
- Fill comprising gravelly and sandy clays from ground level to 0.13 metres – thickness 0.25 to 0.7 metres
- Residual clay with traces of gravels from 0.25 to 2.5 metres – thickness 1.1 to 1.9 metres
- Weathered shale from 1.5 to 2.5 metres – thickness not determined
- Sandstone from 2.3 metres – thickness not determined.

4.1.5 Hydrogeology

Based on previous investigations and registered groundwater bore data presented in the GHD 2015 report, shallow groundwater in the surrounding area is at between 2.5 and five metres below ground surface in sandstone and weathered shale. Monitoring well HB_BH03 is screened within the sandstone near the C1a ancillary facility and the standing water level was monitored at between two and 2.5 metres below ground level (*M4-M5 Link Groundwater Monitoring Interpretive Report – June to November 2016* AECOM 2017a).

4.1.6 Acid sulfate soils

According to information provided by NSW Department of Planning and Environment (DP&E) (Acid Sulfate Data Source Accessed 05/02/2015) acid sulfate risk map, the site is within Class 5 mapped land Class 2 land is located around 200 metres to the northeast (see **Figure 4-2**). Areas mapped as Class 5 have no known occurrence of acid sulfate soils. Works within 500 metres of adjacent Class 1, 2, 3 or 4 land that is below one metre Australian Height Datum (AHD) presents an environmental risk if the water table is lowered.

4.1.7 Areas and contaminants of concern

The key areas and contaminants of concern within the Wattle Street civil and tunnel site at Haberfield are summarised in **Table 4-2**.

Table 4-2 Areas and contaminants of concern – Wattle Street civil and tunnel site at Haberfield (C1a)

Property	Description	CoPC*
C1a Former residential properties	No areas of concern expected with the exception of: • Residual contamination arising from the demolition/construction of former buildings • Use of lead paint which may have resulted in localised areas of ACM fragments and lead paint flakes in soil Use of the site as a construction ancillary facilities for the WestConnex M4 East project and associated potential for construction leaks and spills • Demolition activities, use of plant and machinery and excavation activities. The site will be demobilised and earthworks carried out by the M4 East contractor to provide finished levels that are generally consistent with the original ground surface before being handed over to the M4-M5 Link contractor. At the completion of M4-M5 Link construction, the landscaping (where applicable) and residual land obligations as detailed in the M4 East Urban Design and Landscape Plan and Residual Land Management Plan will be carried out.	Lead, asbestos, metals, PAHs and hydrocarbons
Off-site sources	Potential contaminating land uses are located topographically down-gradient of the site and are therefore unlikely to impact the Wattle Street civil and tunnel site.	None anticipated

Note: * CoPC Contaminants of Potential Concern

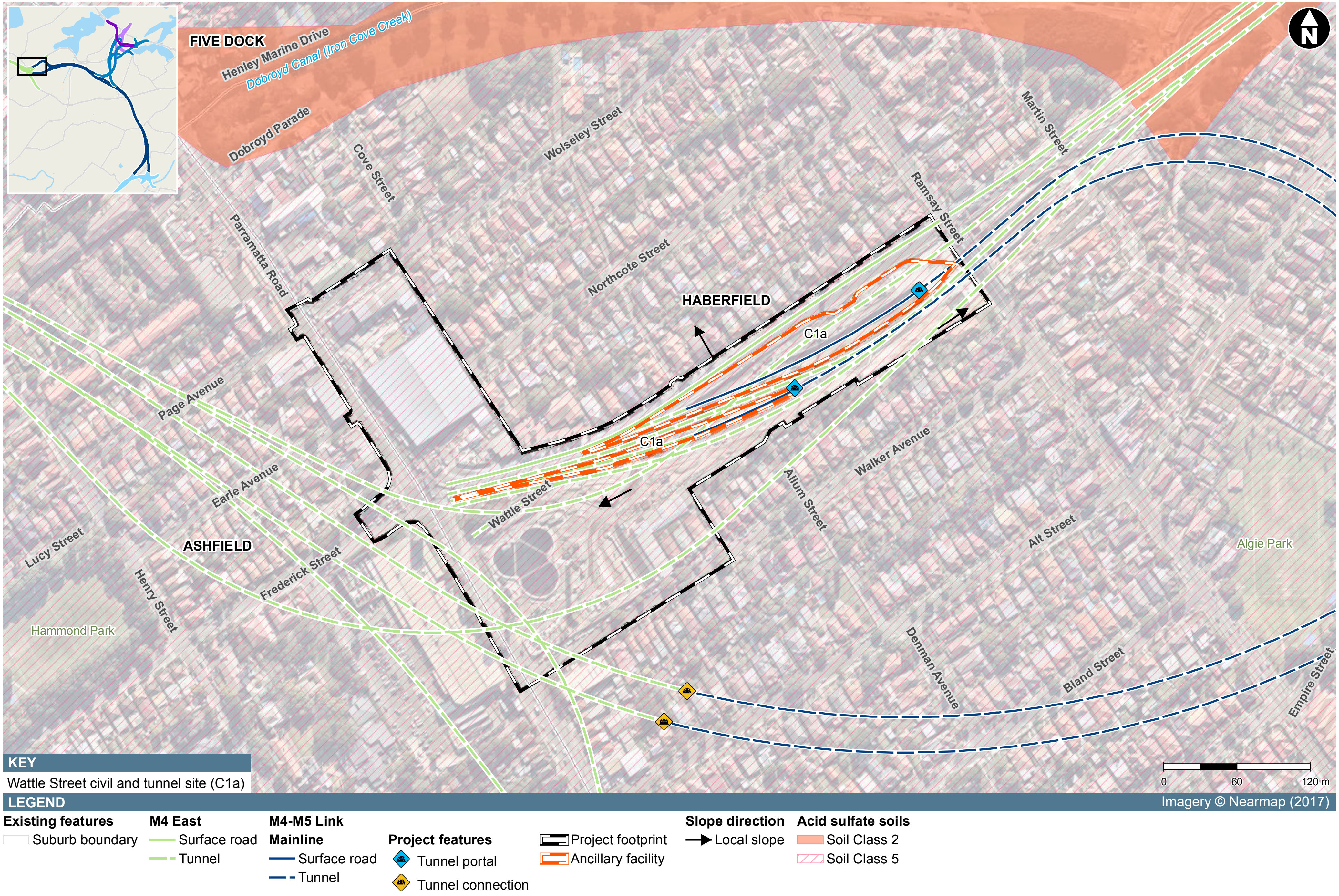


Figure 4-2 Wattle Street civil and tunnel site at Haberfield (C1a) - acid sulfate soils

4.2 C2a – Haberfield civil and tunnel site at Haberfield

4.2.1 Site description and surrounding land use

The Haberfield civil and tunnel site at Haberfield (C2a) would be used where Option A is selected as the preferred construction option at Haberfield. This site would be used as Haberfield civil site at Haberfield (C2b) if Option B is selected as the preferred option at Haberfield. Refer to **Chapter 6** (Construction work) of the EIS for further information on Option A and Option B.

The site is shown in **Figure 4-3** and 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 at Haberfield slopes to the southwest and is surrounded by the land uses described in **Table 4-3**.

Table 4-3 Surrounding land use – Haberfield civil and tunnel site at Haberfield (C2a) or Haberfield civil site at Haberfield (C2b)

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

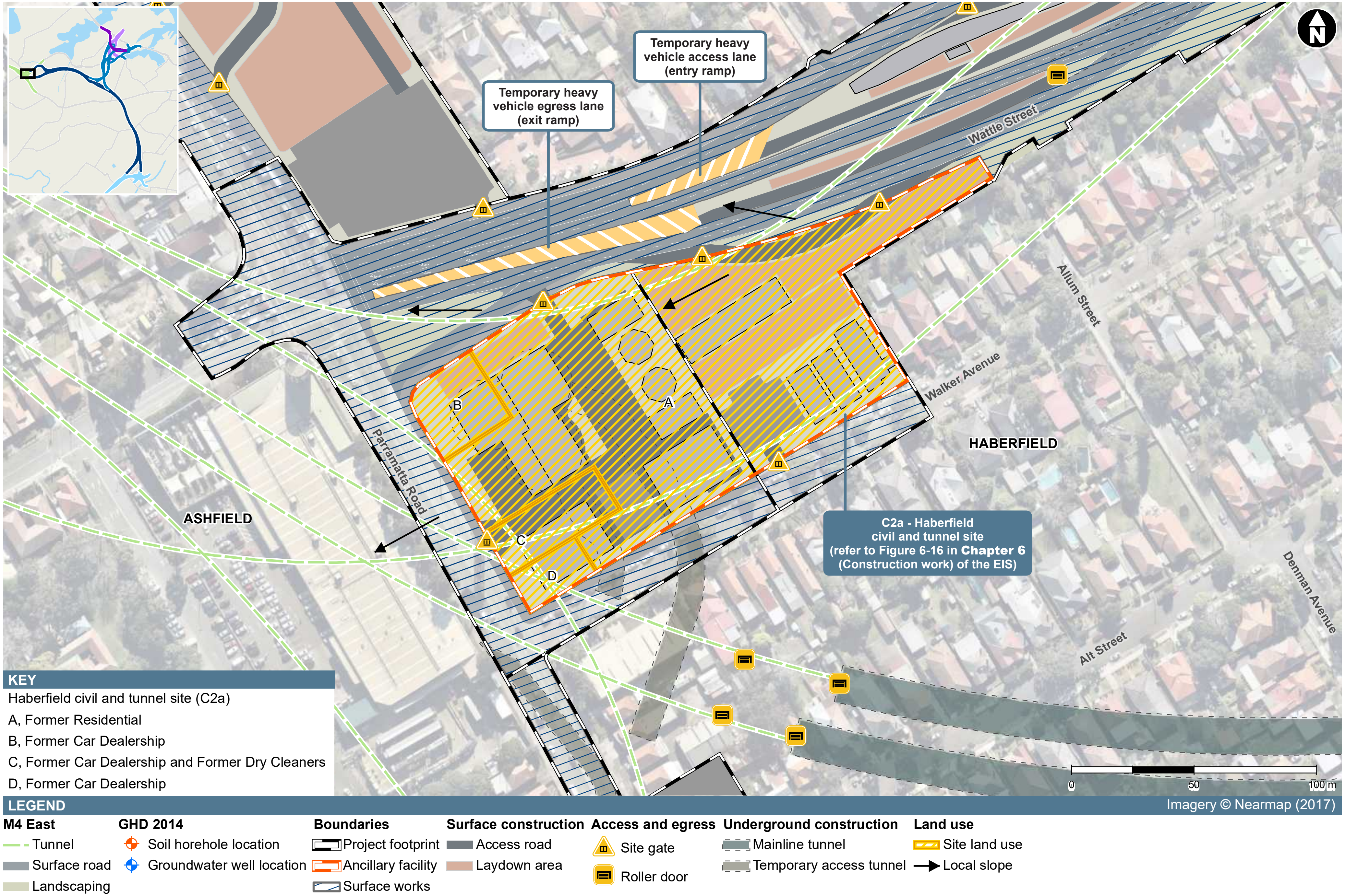


Figure 4-3 Haberfield civil and tunnel site at Haberfield (C2a)

4.2.2 Previous intrusive investigations

GHD (2015) undertook limited investigations to inform the M4 East EIS (Appendix P, September 2015), which encompasses the site of the Haberfield ancillary facility. The GHD report concluded that acquired commercial and residential properties may contain hazardous building materials and that further assessment should be completed prior to any demolition works. In addition, the Soil and Land Contamination Assessment (GHD September 2015), concluded that 'While contamination such as asbestos (reported at depth), metals, PAHs and hydrocarbons are not considered to present an imminent risk to human health or the environment, they would require appropriate management during the construction phase, The risks can be managed through an EMP that would include an unexpected finds protocol to handle any latent contamination, groundwater, waste management and acid sulfate soils.'

Prior to establishment of the M4 East project site, Ramboll Environ (2016a) prepared a technical note containing environmental advice for the management of contamination. It is noted that the site is located at the corner of Wattle Street and Parramatta Road within the proposed M4-M5 Link project footprint and immediately south and adjacent to the C1a ancillary facility within the C2a or C2b ancillary facility. The findings of this technical memo are summarised previously in **section 4.1.2**.

4.2.3 Site history

A review of historical aerial photographs for the area and certificates of titles for selected commercial/industrial properties were undertaken for the GHD 2015 report. Key information relevant to the Haberfield ancillary facility is described in **Table 4-4**.

Table 4-4 Site history pre-M4 East works – Haberfield civil and tunnel site at Haberfield (C2a) or Haberfield civil site at Haberfield (C2b)

Property	Site history summary
A 14 residential houses and one unit block	• All properties appear to have been residential properties since at least the 1930s to the present day based on the historical aerial photographs.
B Car Dealership	• According to the historical titles the property was owned by various private owners (1912 to 1962 and 1973 to 1976), Motor Car Dealer Herbert Thomas Millington (1962 to 1973), British and Continental Cars (1976 to 2013) and Sonar Australia Pty Ltd (2013 to 2015) • The historical aerial photographs showed that the site consisted of three residential houses until the 1960s. Based on this information it appears that the site was used as a car dealership since 1962.
C Car Dealership (former dry cleaner)	• According to the historical titles the property was owned by a merchant (1895 to 1919), a laundry proprietor (1919 to 1954), leased to a laundry proprietorship (1954 to 1982) and APS Property Management Pty Ltd (2013 to present) • The historical aerials showed that a commercial type building was located on the site until the 1980s where the building appeared to have been demolished and replaced with the present day car dealership yard and garage building at the rear • GHD (2015) identified a former laundry/dry cleaner located on the corner of Walker Avenue and Parramatta Road, located around 100 metres north of the C3b site which was classified by GHD as moderate potential for contamination a borehole sampled on the corner of this property did not report any detections of asbestos or any exceedances of the ASC NEPM (NEPC, 2013) health investigation levels for proposed recreational open space and commercial/industrial land uses and no exceedances of the ASC NEPM (NEPC, 2013) management limits for residential/parkland land use

Property	Site history summary
	• Lotsearch (2017) 1970 UBD Business Directory search identified a Bells Laundry located at 225 Parramatta Road, Haberfield within the C2a or C2b ancillary facility. The Bells Laundry site was listed in the 1950 UBD Business Directory as 227 Parramatta Road within the C2a or C2b ancillary facility.
D Car Dealership	• According to the historical titles the property was owned by various private owners (1892 to 1968), Pye Motors Pty Ltd (1968 to 1984), various commercial leases (1984 to 1997), Careful Car Company Pty Ltd (1997 to 2013) and APS Property Management (2013 to 2015) • The property appeared to be a commercial building or shop that fronted onto Parramatta Road until it was demolished in the 1970s and the present • Based on the above information it appears the property was used as a car dealership since 1968. The commercial use of the site prior to 1968 is unknown.

4.2.4 Soil and geology

The Haberfield ancillary facility is underlain by Gymea erosional soils. The soils are underlain by Hawkesbury Sandstone which consists of medium to coarse grained quartz sandstone, very minor shale and laminate lenses and Ashfield Shale which consists of shale and laminate.

GHD (2015) noted that generalised stratigraphy within the vicinity of the C2a or C2b site (M4 East EIS Section 6: Dobroyd Canal [Iron Cove Creek] to Bland Street [including Wattle Street]) comprised:

- Concrete or hardstand at ground level – thickness 0.1 to 0.13 metres
- Fill comprising gravelly and sandy clays from ground level to 0.13 metres – thickness 0.25 to 0.7 metres
- Residual clay with traces of gravels from 0.25 to 2.5 metres – thickness 1.1 to 1.9 metres
- Weathered shale from 1.5 to 2.5 metres – thickness not determined
- Sandstone from 2.3 metres – thickness not determined.

4.2.5 Hydrogeology

Based on previous investigations and registered groundwater bore data presented in the GHD 2015 report, shallow groundwater in the surrounding area is at between 2.5 and five metres below ground level in sandstone and weathered shale.

4.2.6 Acid sulfate soils

According to information provided by DP&E (Acid Sulfate Data Source Accessed 05/02/2015: NSW Crown Copyright – Planning and Environment Creative Commons 3.0 © Commonwealth of Australia) acid sulfate risk map, the site is within Class 5 mapped land with Class 2 land located 370 metres to the north and 490 metres to the northeast (see **Figure 4-4**). Areas mapped as Class 5 have no known occurrence of acid sulfate soils. Works within 500 metres of adjacent Class 1, 2, 3 or 4 land that is below one metre AHD, presents an environmental risk if the water table is lowered.

4.2.7 Areas and contaminants of concern

The key areas and contaminants of concern within the site are described in **Table 4-5**.

Table 4-5 Areas and contaminants of concern – Haberfield civil and tunnel site at Haberfield (C2a) or Haberfield civil site at Haberfield (C2b)

Property	Description	CoPC
C2a/C2b ancillary facility	Use of the site as a construction ancillary facility for the WestConnex M4 East project and associated potential for construction leaks and spills. Demolition activities, use of plant and machinery and excavation activities. The site will 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. At the completion of M4-M5 Link construction, the landscaping (where applicable) and residual land obligations as detailed in the M4 East Urban Design and Landscape Plan and Residual Land Management Plan will be carried out.	Lead, asbestos, metals, PAHs and hydrocarbons
A 14 former residential houses and one unit block	No areas of concern expected with the exception of the demolition/construction of former buildings and use of lead paint which may have resulted in localised areas of ACM and lead paint flakes in soil.	Lead, asbestos
B Car Dealership	Small scale mechanical workshops may have been operational within the property, which may have historically stored and handled oils, fuels and solvents. Three houses were also historically demolished within the property which may have resulted in localised areas of ACM fragments and lead paint flakes in soil.	TRH, BTEXN, PAHs, VOCs, lead, asbestos
C Car Dealership (former dry cleaner)	A laundry may have operated on the site between 1919 and 1982, which may have included dry cleaning. Dry cleaners historically used white spirits, kerosene, carbon tetrachloride, trichloroethylene (TCE), perchloroethylene (Perc), as cleaning solvents until the 1990s. Fluorocarbon based dry cleaning was used in Australia from 1990 until it was banned in 1997 [1,1,2 trichloro-1,2,2-trifluroethane and 1,1,1-Trichloroethane (TCA)]. The former commercial building was also demolished within the property which may have resulted in localised areas of ACM fragments and lead paint flakes in soil.	TRH, VHCs, lead, asbestos
D Car Dealership	Small scale mechanical workshops may have been operational within the property, which may have historically stored and handled oils, fuels and solvents. A former building in the centre of the property was demolished in the 1970s, which may have resulted in localised areas of ACM fragments and lead paint flakes in soil.	TRH, BTEXN, PAHs, VOCs, lead, asbestos
Off-site sources	Potential contaminating land uses are located topographically down-gradient of the site and are therefore unlikely to impact the Parramatta Road ventilation facility site.	Nil

Figure 4-4 Haberfield civil and tunnel site at Haberfield (C2a) - acid sulfate soils

4.3 C3a – Northcote Street civil site at Haberfield

4.3.1 Site description and surrounding land use

The Northcote Street civil site at Haberfield (C3a) would be used where Option A is selected as the preferred construction option at Haberfield. Refer to **Chapter 6** (Construction work) of the EIS for further information on Option A and Option B.

The site is shown in **Figure 4-5** and 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 Northcote Street civil site slopes to the west and is surrounded by the land use described in **Table 4-6**.

Table 4-6 Surrounding land use – Northcote Street civil site at Haberfield (C3a)

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 • C2a Haberfield civil and tunnel site at Haberfield (see **section 4.2**) • Residential properties (45 metres across gradient) along Wattle Street • Bunnings warehouse (45 metres down-gradient) front Parramatta Road.
East	• Residential properties (adjacent and up-gradient) along Northcote Street.
West	• Parramatta Road • Various retail shops and fast food restaurants (20 metres down-gradient) • Residential properties (70 metres down-gradient).

Figure 4-5 Northcote Street civil site at Haberfield (C3a)

There were no sites listed on the NSW EPA record of notices or list of sites notified to the NSW EPA within 500 metres of the site (GHD 2015).

4.3.2 Previous intrusive investigations

GHD (2015) undertook limited investigations to inform the M4 East EIS (Appendix P, September 2015), which encompasses the Northcote Street civil site at Haberfield. The GHD report concluded that acquired commercial and residential properties may contain hazardous building materials and recommended that further assessment should be completed prior to any demolition works. In addition, the Soil and Land Contamination Assessment (GHD September 2015), concluded that 'While contamination such as asbestos (reported at depth), metals, PAHs and hydrocarbons are not considered to present an imminent risk to human health or the environment, they would require appropriate management during the construction phase, The risks can be managed through an EMP that would include an unexpected finds protocol to handle any latent contamination, groundwater, waste management and acid sulfate soils.'

4.3.3 Site history

A review of historical aerial photographs for the area and certificates of titles for selected commercial/industrial properties were undertaken for the GHD 2015 report. The information was reviewed and the Northcote Street civil site history is described in **Table 4-7**. The site history predates building demolition works which commenced in 2016 for the M4 East project.

Table 4-7 Site history pre-M4 East Works – Northcote Street civil site at Haberfield (C3a)

Property	Site history summary
C3a-A Six residential houses	• The six houses appeared to be present since the 1930 historical aerial photograph until 2016.
C3a-B Garden shop and service station	• The property was owned by various private owners (1907 to 1963 and 2000 to 2015), Amoco Australia Pty Ltd (a petroleum company) (1963 to 1980) and Garden Art Foundations (1980 to 2000) • Based on the historical aerials the property was formerly residential, and contained a corner shop or hotel which was demolished, and an Amoco service station constructed in the 1960s • The service station was then used as a garden shop from 1980 until 2016.
C3a-C Car Mechanic Workshop	• According to historical titles the property was previously owned by The Northcotstate Company Ltd (1907 to 1911), various private owners (1911 to 1973 and 1981 to 1998), Cousins Truck Sales (NSW) Pty Ltd, Moranda Pty Ltd (1979 to 1981) and Bill and Tina Hatzivasiloiou H Jax Quickfit Properties (1998 to 2015) • Based on the historical aerials the property was previously three residential properties until they were demolished and a truck dealership constructed in the late 1970s/early 1980s • The property was then used as a wheel alignment and tyre workshop until 2016.
C3a-D Car Dealership	• According to historical titles the property was previously owned by The Northcote Estate Company Ltd (1907 to 1914) and various private owners (1911 to 2015) • Based on the historical aerials the property was previously two residential properties that were demolished and converted into a commercial business in the 1970s • In the 1980s there was an additional commercial rectangular building in the centre of the site and cars parked across the site. The additional building

Property	Site history summary
	was demolished by the mid-1990s • Based on the historical aerials it appears that the site has been used as a car dealership and a possible mechanics until 2016.
C3a-E Liquor store	• According to historical titles the property was owned by The Northcote Estate Company Ltd (1907 to 1911), various private owners (1907 to 1988), Pesutu Pty Ltd (liquor retailer) (1988 to 2009) and Reo Costi lease to Liquorland (2009 to 2015) • Based on the historical aerials it appears that the site was formerly part of four residential houses that were demolished in the late 1960s/early 1970s. The site was then used as a liquor shop and car park since 1988 • The use of the property between the 1970s and 1988 is unknown • The property was used as a Liquor store until 2016.
C3a-F Automotive Workshop	• According to historical titles the property was previously owned by The Northcote Estate Company Ltd (1910 to 1912), various private owners (1912 to 1965, 1970 to 1977 and 2011 to 2015), the Commissioner of Main Roads (1965 to 1970), and British and Continental Cars (Haberfield) Pty Ltd (1977 to 2011) • Based on the historical aerials the property was previously part of three residential properties that were acquired and demolished for the widening of Wattle Street in the 1960s • The property was then used as a car dealership until 2011 and was then converted for use as a mechanics workshop until 2016.

4.3.4 Soil and geology

The Northcote Street civil site at Haberfield is underlain by Gymea erosional soils. The soils are underlain by Hawkesbury Sandstone which consists of medium to coarse grained quartz sandstone, very minor shale and laminate lenses and Ashfield Shale which consists of shale and laminate.

GHD (2015) noted that generalised stratigraphy within the vicinity of the C3a (M4 East EIS Section 6: Dobroyd Canal [Iron Cove Creek] to Bland Street [including Wattle Street]) comprised:

- Concrete or hardstand at ground level – thickness 0.1 to 0.13 metres
- Fill comprising gravelly and sandy clays from ground level to 0.13 metres – thickness 0.25 to 0.7 metres
- Residual clay with traces of gravels from 0.25 to 2.5 metres – thickness 1.1 to 1.9 metres
- Weathered shale from 1.5 to 2.5 metres – thickness not determined
- Sandstone from 2.3 metres – thickness not determined.

4.3.5 Hydrogeology

Based on previous investigations and registered groundwater bore data presented in the GHD 2015 report, shallow groundwater in the surrounding area is at between 2.5 and five metres below ground level in sandstone and weathered shale.

4.3.6 Acid sulfate soils

According to information provided by DP&E (Acid Sulfate Data Source Accessed 05/02/2015: NSW Crown Copyright – Planning and Environment Creative Commons 3.0© Commonwealth of Australia) acid sulfate risk map the site is within Class 5 mapped land with Class 2 land located 150 metres north and 430 metres to the northeast (see **Figure 4-6**). Areas mapped as Class 5 have no known occurrence of acid sulfate soils. Works within 500 metres of adjacent Class 1, 2, 3 or 4 land that is below one metre AHD presents an environmental risk if the water table is lowered.

4.3.7 Areas and contaminants of concern

The key areas and contaminants of concern within the Northcote Street civil site are described in **Table 4-8**.

Table 4-8 Areas and contaminants of concern – Northcote Street civil site at Haberfield (C3a)

Area	Description	CoPC
C3a Northcote Street civil site	Use of the site as a construction ancillary facility for the WestConnex M4 East project and associated potential for construction leaks and spills. Demolition activities, use of plant and machinery and excavation activities. The site will 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. At the completion of M4-M5 Link construction, the residual land obligations as detailed in the M4 East Residual Land Management Plan will be carried out.	TRH, BTEX, PAHs, VOCs, lead, asbestos
Northeast corner of the site (C3a/2)	The property on the corner of Wolseley Street and Parramatta Road was formerly a petrol station that may have also contained a mechanics workshop. Based on the appearance of the building and site it is possible that the former underground petroleum storage system (UPSS) including underground storage tanks (USTs) and pipelines may still be *in situ*. There is a medium to high risk of soil and groundwater contamination from historical leaks from the former UPSS.	TRH, BTEX, PAHs and lead
Central (C3a/3 and C3a/4) and southern portion of the site (C3a/6)	Three properties within the site contained or likely contained mechanical workshops which may have historically stored and handled oils, fuels and solvents. The properties may have formally contained hoists, underground waste oil tanks, oil/water interceptor pits, inspection pits and drains which could leak into the subsurface.	TRH, BTEX, PAHs, VOCs, lead

Figure 4-6 Northcote Street civil site at Haberfield (C3a) - acid sulfate soils

4.4 C1b – Parramatta Road West civil and tunnel site at Ashfield

4.4.1 Site description and surrounding area

The Parramatta Road West civil and tunnel site (C1b) at Ashfield would be used where Option B is selected as the preferred construction option at Haberfield and Ashfield. Refer to **Chapter 6** (Construction work) of the EIS for further information on Option A and Option B.

The C1b site is shown in **Figure 4-7** and is located within the Inner West LGA. The land is currently utilised for commercial purposes (including a car dealership and associated maintenance facilities). The C1b site drains north towards Dobroyd Canal (Iron Cove Creek) and is surrounded by land uses as detailed in **Table 4-9**.

Table 4-9 Surrounding land use – Parramatta Road West civil and tunnel site, Ashfield (C1b)

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, residential and commercial/industrial land use, followed by 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), and currently occupied by the M4 East contractor for construction purposes (M4 East Parramatta Road civil site C10) and low to medium density residential along Bland and Chandos Streets.
East	• C3b site – 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 and Alt Streets • Chaya’s Family Day Care on Alt Street (about 50 metres west of the C1b site).

It is understood that this site would be demobilised and earthworks would be carried out to restore the surface levels to generally pre-construction levels at the end of construction. The future use of the land would be determined in accordance with the Residual Land Management Plan to be prepared for the project.

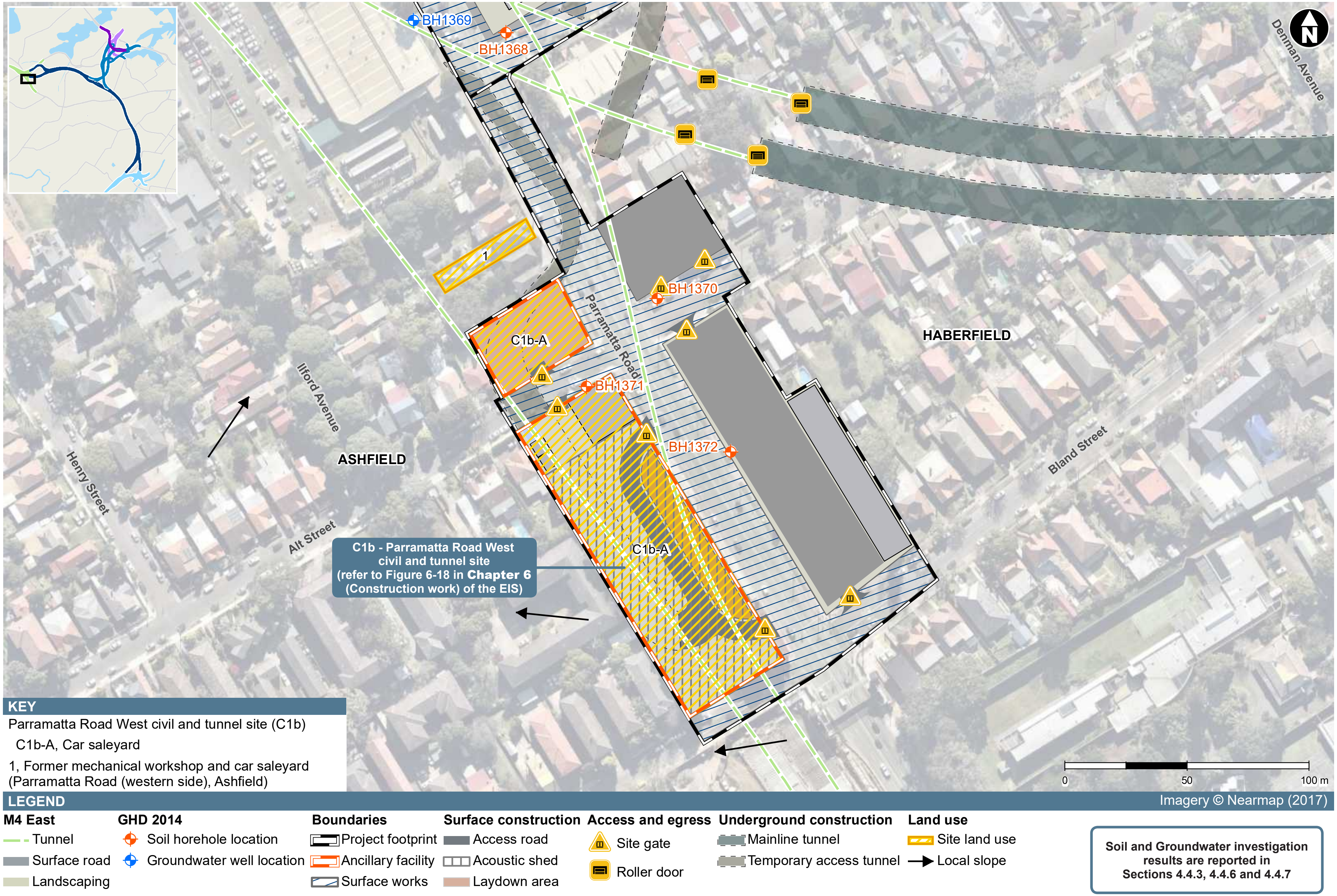


Figure 4-7 Parramatta Road West civil and tunnel site at Ashfield (C1b)

4.4.2 Previous investigations

AECOM is aware of the following relevant reports completed for the site and surrounding lands (obtained from the M4 East EIS and requested by AECOM as part of this Technical Contamination Assessment):

- GHD Pty Ltd (GHD) (2015) Appendix P of the Environmental Impact Statement M4 Motorway East Soil and Land Contamination Assessment, September 2015
- Lotsearch (2017) Environmental Risk and Planning Report – Parramatta Road, Ashfield, NSW 2131, 6 June 2017.

4.4.3 Site history

A review of historical aerial photographs for the area was provided in the Lotsearch 2017 report and site history information provided in the GHD (2015) M4 East EIS – Soil and Land Contamination Assessment. Key information relevant to the Parramatta Road West civil and tunnel site is described in **Table 4-10**.

Table 4-10 Site history – Parramatta Road West civil and tunnel site, Ashfield (C1b)

Property	Site history summary
C1b Parramatta Road West civil and tunnel site	• GHD (2015) noted that the site and surrounds comprised predominantly residential land use throughout 1930s to 1960s. In 1970s commercial buildings and car yards were visible on both sides of Parramatta Road between Alt Street and Bland Street. In 1990 commercial development had increased along Parramatta Road and development had further increased between 1990 and 2002 • GHD (2015) and Lotsearch (2017) noted that a search of the NSW EPA register did not identify any contaminated sites, any notified contaminated sites and any licensed activities within a 500 metre radius of the site, with the exception of CPB contractors for WestConnex M4 East road construction works located 180 metres northwest of the site • The site appears to have been used as a car sales yard since the 1970s, confirmed by 1970 UBD Business Directory search provided by Lotsearch (2017) • The Lotsearch (2017) 1970 UBD Business Directory search also indicated that part of the site was owned by Muirs Motors Pty Ltd and part was owned by Palmers Car Sales • The Lotsearch (2017) 1950 UBD Business Directory search indicated the site was used by various commercial/industrial businesses including Purdle's Service Station at 252 Parramatta Road Ashfield. 130 Bland Street, Ashfield was the only site in possession by Muirs Motors in 1950.
C3b Parramatta Road East civil site (east of C1b on the opposite side of Parramatta Road)	• As above • The Lotsearch (2017) 1970 UBD Business Directory search indicated the site was owned by Renno Motors Pty Ltd. A newsagency and television repairs and sales business was also present on the C3b site • A borehole.
1 Former mechanical workshop and car saleyard (Parramatta Road, Ashfield)	• GHD (2015) identified a mechanical workshop and car saleyard located around 20 metres north of the C1b site which was classified by GHD as high potential for contamination. No detailed information on this property was noted in the GHD (2015) report • The Lotsearch (2017) report noted that the 1991 UBD Business Directory search indicated that a Motor brake lining manufacturer and/or distributor was present at this site.

4.4.4 Soils and geology

According to the NSW Department of Industry, Resources and Energy (2017), 1:100,000 Sydney geology map sheet, the site geology consists of the following units:

- Triassic Ashfield Shale of the Wianamatta Group, characterised by black to dark grey shale and laminate
- According to information provided by OEH the soil landscape within the site consists mostly of Blacktown Residual Soils.

GHD (2015) noted that generalised stratigraphy within the vicinity of the C1b (M4 East EIS Section 6: Dobroyd Canal [Iron Cove Creek] to Bland Street [including Wattle Street]) comprised:

- Concrete or hardstand at ground level – thickness 0.1 to 0.13 metres
- Fill comprising gravelly and sandy clays from ground level to 0.13 metres – thickness 0.25 to 0.7 metres
- Residual clay with traces of gravels from 0.25 to 2.5 metres – thickness 1.1 to 1.9 metres
- Weathered shale from 1.5 to 2.5 metres – thickness not determined
- Sandstone from 2.3 metres – thickness not determined.

4.4.5 Hydrogeology

According to data provided by the NSW Department of Primary Industries (Water) (DPI-Water), Water Administration Ministerial Corporation and Commonwealth of Australia (Bureau of Meteorology) in the Lotsearch (2017) report, there are no registered groundwater wells located within the C1b site and six registered groundwater wells were within 500 metres of the C1b site. The purpose of all groundwater wells within 500 metres of the C1b site was for monitoring.

GHD (2015) noted that a groundwater monitoring well BH1369 was installed as part of the GHD 2014 investigation, about 100 metres north of the C1b site on the western side of Parramatta Road. The screened stratum was noted to be weathered shale and the standing water level was noted to be 2.594 metres below top of casing. The depth of the monitoring well was 8.5 metres below ground level.

GHD (2015) also noted that a groundwater monitoring well BH1373 was installed as part of the GHD 2014 investigation about 40 metres south of the C1b and C3b sites on Bland Street. The screened stratum was noted to be weathered shale and the standing water level was noted to be 1.71 metres below top of casing. The depth of the monitoring well was 8.0 metres below ground level.

Deep groundwater is expected to be present as a porous and extensive productive aquifer in the underlying Hawkesbury Sandstone. GHD (2015) noted the hydrogeology is dominated by shale, siltstone and other sedimentary basins with low potential for groundwater movement and salinity levels greater than 14,000 milligrams per litre (Department of Water Resources 1987). Groundwater is expected to be shallow and flow in a northerly direction towards Dobroyd Canal (Iron Cove Creek).

4.4.6 Acid sulfate soils

The site and surrounding areas are predominantly mapped with Class 5 acid sulfate risk potential. This equates to a generally low risk except where works have the potential to lower the water table below one metre AHD (see **Figure 4-8)**.

GHD (2015) noted that no acid sulfate soil testing was undertaken as part of their assessment as minimal construction disturbance was proposed as part of the M4 East works within the vicinity of disturbed terrain/reclaimed land.

4.4.7 Areas and contaminants of concern

The following areas and contaminants of concern were identified in **Table 4-11**.

Table 4-11 Activities and areas of potential concern – Parramatta Road West civil and tunnel site, Ashfield (C1b)

Area	Potential contamination sources	Main PCoC
Previously identified contamination in soil and groundwater		
GHD undertook soil sampling works at one borehole (BH1371) on the C1b site in 2014 and two groundwater monitoring wells (BH1369 and BH1373) within the project footprint	Data provided in GHD (2015) from boreholes sampled by GHD in 2014 indicated: • No visual or olfactory evidence of soil contamination was observed during sampling • Exceedances of benzo(a)pyrene toxicity equivalency quotient (B[a]P TEQ) in BH1371 (located on the northern portion of C1b, adjacent to Alt Street) sample depth 0.5 to 0.6 metres below ground surface was 7.9 milligrams per kilogram and exceeded the ASC NEPM (NEPC, 2013) criterion for recreational land use • BH1373 (installed around 40 metres south of C1b and C3b, screened in weathered shale) detected concentrations of B(a)P TEQ in soil at 0.5 metres and 2.0 metres in exceedance of health investigation level C for proposed recreational open space • Groundwater monitoring well BH1369 (installed around 100 metres north of site 3b) and BH1373 (installed around 40 metres south of site 3b and site 1b), both screened in shale, detected concentrations of metals copper, nickel and zinc in exceedance of groundwater investigation levels • Waste classification assessment and TCLP B(a)P analysis of sample BH1371 0.5-0.6 indicated the material would be classified as general solid waste • Waste classification assessment and TCLP B(a)P analysis of samples BH1373 0.5 and 2.0 indicated the material would be classified as general solid waste.	• PAHs • Metals
Former and current car sales and servicing and former service station		
Within the C1b ancillary facility and project footprint	The C1b site and adjacent C3b site have been used for the purposes of car sales yards and servicing since the 1970s. In addition, historical land use surrounding the site has identified service stations, mechanics and garages. It's possible that former underground petroleum storage system (UPSS) including underground storage tanks (USTs) and pipelines may be present on the site to support these site uses. There is also potential for soil and groundwater contamination from historical leaks from the former UPSS. Three properties within the site contained or likely contained mechanical workshops which may have	• Metals (mainly lead) • Total recoverable hydrocarbons (TRH) • Benzene, toluene, ethylbenzene and xylene (BTEX) • Polycyclic aromatic hydrocarbons (PAHs) • Volatile organic compounds

Area	Potential contamination sources	Main PCoC
	historically stored and handled oils, fuels and solvents. The properties may have formally contained hoists, underground waste oil tanks, oil/water interceptor pits, inspection pits and drains which could leak into the subsurface.	(VOCs)
Hazardous building materials		
Numerous buildings within and surrounding the site were present on historical aerial photographs prior to 1970. In addition, the GHD (2015) report noted that the site and surrounding areas predominantly comprised residential land use up to 1970 when commercial/industrial development along Parramatta Road increased.	Potential that C1b site and adjacent areas within the project footprint currently or formally contained buildings that are or were potentially constructed with ACM, lead paint or contained fittings with PCBs. Demolition or degradation of the buildings (paint flaking, ACM weathering) may have resulted in contamination of surface soils. GHD (2015) also noted that there are numerous buildings within the Haberfield project footprint which are being acquired as part of the M4 East works which have the potential to contain hazardous building materials.	• Lead • Asbestos • PCBs
Imported fill		
Areas of the site and immediate surrounds may have been filled using sources of uncontrolled and potentially contaminated fill.	Areas of the site and surrounding areas may have been filled using sources of uncontrolled and potentially contaminated fill.	• Metals • TRH • BTEX • PAHs • Phenols • OCPs • OPPs • PCBs • VOCs • Asbestos

Figure 4-8 Parramatta road West civil and tunnel site at Ashfield (C1b) - acid sulfate soils

4.5 C2b – Haberfield civil site at Haberfield

The Haberfield civil site (C2b) would be used for civil construction where Option B is selected as the preferred construction option at Haberfield. If Option A is selected as the preferred option at Haberfield, the Haberfield civil and tunnel site (C2a) would be used (see **section 4.2**).

It is noted that the ancillary facility boundary for C2b is smaller than the ancillary facility boundary for C2a. The construction activities within this site would differ under Option A (site would support tunnelling) and Option B (site would not support tunnelling), as discussed in **sections 5** and **8** – the assessment and management of construction impacts. Therefore information relevant to the site description and surrounding area, previous investigations, site history, soils and geology, hydrogeology, acid sulfate soils, areas and contaminants of potential concern remain the same as those discussed in **sections 4.2.1** to **4.2.7**.

The Haberfield civil site (C2b) is shown in **Figure 4-9** and acid sulfate soils in **Figure 4-10**.

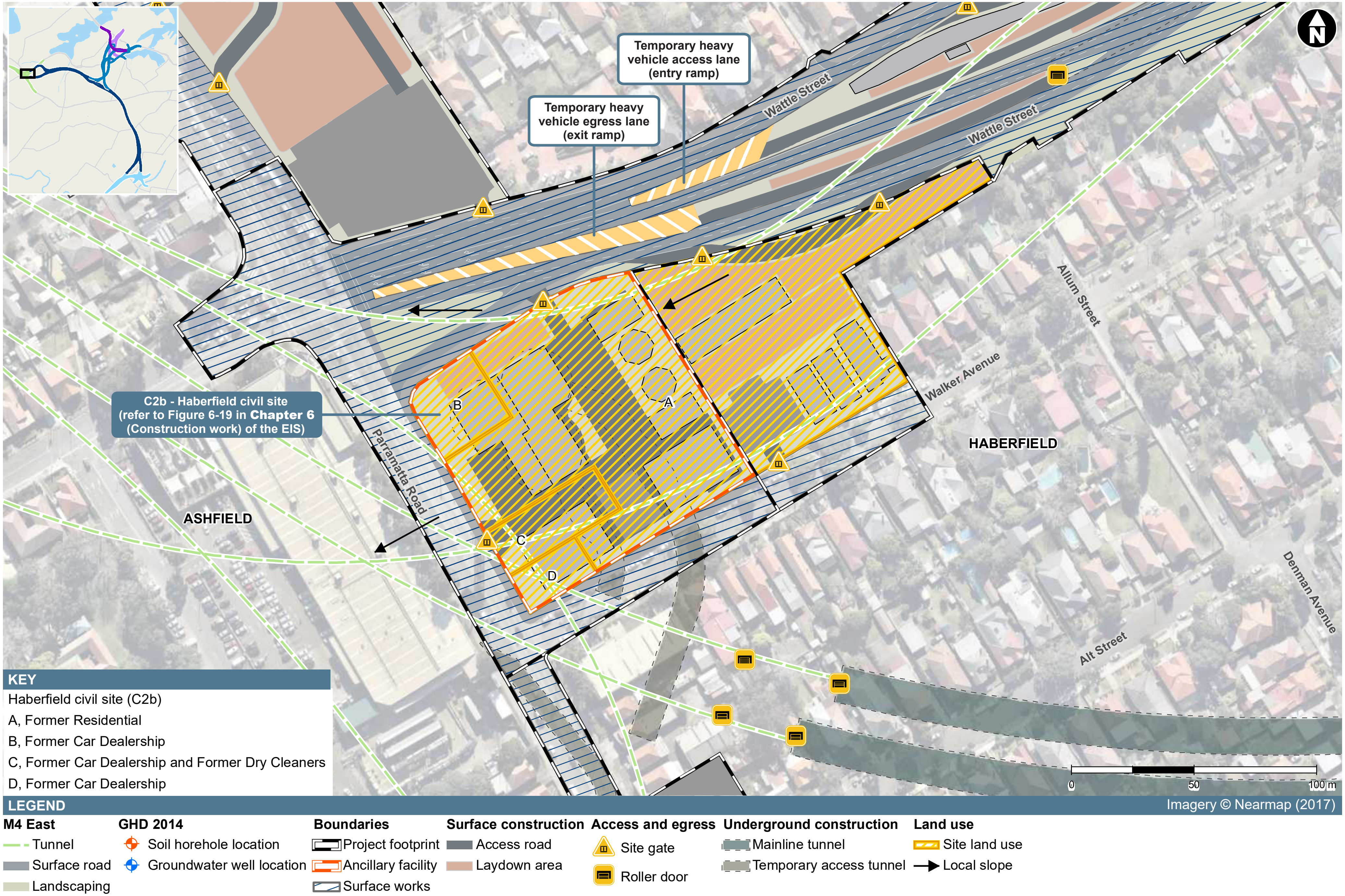


Figure 4-9 Haberfield civil site at Haberfield (C2b)

Figure 4-10 Haberfield civil site at Haberfield (C2b) - acid sulfate soils

4.6 C3b – Parramatta Road East civil site at Haberfield

4.6.1 Site description and surrounding area

The Parramatta Road East civil site (C3b) would be used where Option B is selected as the preferred construction option at Haberfield. Refer to **Chapter 6** (Construction work) of the EIS for further information on Option A and Option B.

The site is shown in **Figure 4-11** and would be located within the Inner West Council LGA in 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 uses as detailed in **Table 4-12**.

The site would be demobilised and earthworks would be carried out to restore the surface levels to generally pre-construction levels at the end of construction. The future use of the land would be determined in accordance with the Residual Land Management Plan to be prepared for the project.

Table 4-12 Surrounding land use – Parramatta Road East civil site, Haberfield (C3b)

Direction	Description of surrounding land use and proximity to the site
North	• Alt Street and Walker Avenue • Former laundry/dry cleaner as identified by GHD (2015) on corner of Walker Avenue and Parramatta Road • Further north, residential and commercial/industrial land use (including car sales yard identified by GHD (2015), followed by 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 contractor for construction purposes (M4 East Parramatta Road civil site C10) and 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 • C1b site currently Muirs Holden Automotive servicing and sales and Roads and Maritime land with 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).

4.6.2 Previous investigations

AECOM is aware of the following relevant reports completed for the site and surrounding lands (obtained from the M4 East EIS and requested by AECOM as part of this Technical Contamination Assessment):

- GHD Pty Ltd (GHD) (2015) Appendix P of the Environmental Impact Statement M4 Motorway East Soil and Land Contamination Assessment, September 2015
- Lotsearch (2017) Environmental Risk and Planning Report – Parramatta Road, Ashfield, NSW 2131, 6 June 2017.

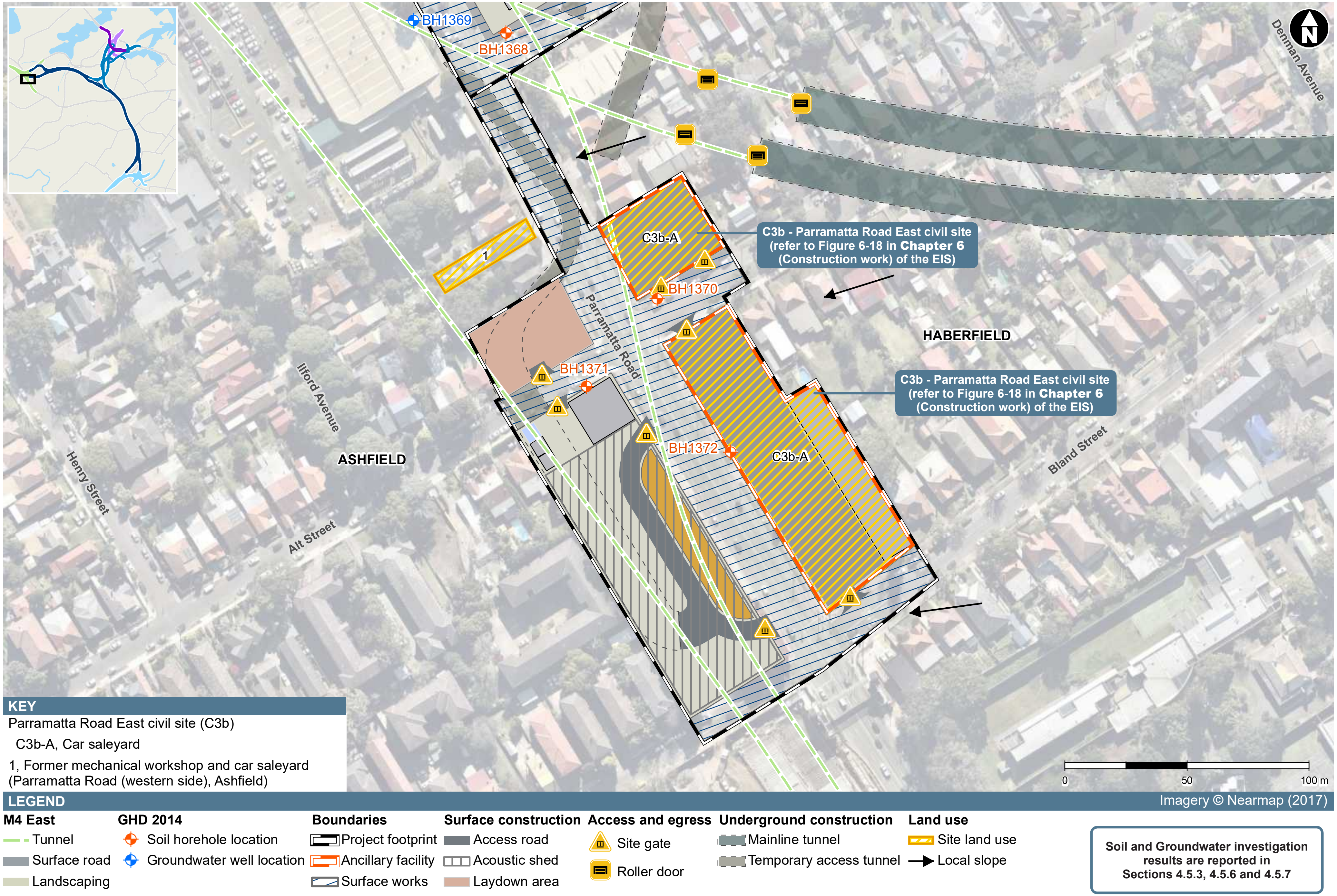


Figure 4-11 Parramatta Road East civil site at Haberfield (C3b)

4.6.3 Site history

A review of historical aerial photographs for the area was provided in the Lotsearch 2017 report and site history information provided in the GHD (2015) M4 East EIS – Soil and Land Contamination Assessment. Key information relevant to the Parramatta Road West civil and tunnel site is described in **Table 4-13**.

Table 4-13 Site history – Parramatta Road East civil site, Haberfield (C3b)

Property	Site history summary
C3b Parramatta Road East civil site	• The Lotsearch (2017) 1970 UBD Business Directory search indicated the site was owned by Renno Motors Pty Ltd. A newsagency and television repairs and sales business was also present on the C3b site • A borehole BH1370 was drilled by GHD in 2014 on Alt Street adjacent the northern portion of the C3b site • A borehole BH1372 was drilled by GHD in 2014 on the western boundary of the southern portion of the C3b site adjacent Parramatta Road • No asbestos was detected at these locations and no exceedances of the ASC NEPM (NEPC 2013) health investigation levels for proposed recreational open space and commercial/industrial land uses and the management limits for residential/parkland were reported by GHD (2015) at these two boreholes • GHD (2015) classified the C3b site as moderate potential for contamination.
C1b Parramatta Road West civil and tunnel site (west of C3b on the opposite side of Parramatta Road)	• GHD (2015) noted that the site and surrounds comprised predominantly residential land use throughout 1930s to 1960s. In the 1970s, commercial buildings and car yards were visible on both sides of Parramatta Road between Alt Street and Bland Street. By 1990, commercial development had increased along Parramatta Road and development had further increased between 1990 and 2002 • GHD (2015) and Lotsearch (2017) noted that a search of the NSW EPA register did not identify any contaminated sites, any notified contaminated sites or any licensed activities within a 500 metre radius of the site, with the exception of CPB contractors for WestConnex M4 East construction works located 180 metres northwest of the site • The site appears to have been used as a car sales yard since the 1970s, confirmed by 1970 UBD Business Directory search provided by Lotsearch (2017) • The Lotsearch (2017) 1970 UBD Business Directory search also indicated that part of the site was owned by Muirs Motors Pty Ltd and part was owned by Palmers Car Sales • The Lotsearch (2017) 1950 UBD Business Directory search indicated the site was used by various commercial/industrial businesses including Purdle's Service Station at 252 Parramatta Road, Ashfield. 130 Bland Street, Ashfield was the only site in possession by Muirs Motors in 1950.
1 Former mechanical workshop and car saleyard (Parramatta Road, Ashfield)	• GHD (2015) identified a mechanical workshop and car saleyard located around 20 metres north of the C1b site which was classified by GHD as high potential for contamination. No detailed information on this property was noted in the GHD (2015) report • The Lotsearch (2017) report noted that the 1991 UBD Business Directory search indicated that a motor brake lining manufacturer and/or distributor was present at this site.

4.6.4 Soils and geology

According to the NSW Department of Industry, Resources and Energy (2017), 1:100,000 Sydney geology map sheet, the site geology consists of the following units:

- Triassic Ashfield Shale of the Wianamatta Group, characterised by black to dark grey shale and laminate
- According to information provided by OEH the soil landscape within the site consists mostly of Blacktown Residual Soils.

GHD (2015) noted that generalised stratigraphy within the vicinity of the C3b (M4 East EIS Section 6: Dobroyd Canal [Iron Cove Creek] to Bland Street [including Wattle Street]) comprised:

- Concrete or hardstand at ground level – thickness 0.1 to 0.13 metres
- Fill comprising gravelly and sandy clays from ground level to 0.13 metres – thickness 0.25 to 0.7 metres
- Residual clay with traces of gravels from 0.25 to 2.5 metres – thickness 1.1 to 1.9 metres
- Weathered shale from 1.5 to 2.5 metres – thickness not determined
- Sandstone from 2.3 metres – thickness not determined.

4.6.5 Hydrogeology

According to data provided by the (DPI-Water), Water Administration Ministerial Corporation and Commonwealth of Australia (Bureau of Meteorology) in the Lotsearch (2017) report, there are no registered groundwater wells located within the C1b site and six registered groundwater wells were within 500 metres of the C1b site. The purpose of all groundwater wells within 500 metres of the C1b site was for monitoring.

GHD (2015) noted that a groundwater monitoring well BH1369 was installed as part of the GHD 2014 investigation about 100 metres north of the C1b site on the western side of Parramatta Road. The screened stratum was noted to be weathered shale and the standing water level was noted to be 2.594 metres below top of casing. The depth of the monitoring well was 8.5 metres below ground level.

GHD (2015) also noted that a groundwater monitoring well BH1373 was installed as part of the GHD 2014 investigation about 40 metres south of the C1b and C3b sites on Bland Street. The screened stratum was noted to be weathered shale and the standing water level was noted to be 1.71 metres below top of casing. The depth of the monitoring well was 8.0 metres below ground level.

Deep groundwater is expected to be present as a porous and extensive productive aquifer in the underlying Hawkesbury Sandstone. GHD (2015) noted the hydrogeology is dominated by shale, siltstone and other sedimentary basins with low potential for groundwater movement and salinity levels greater than 14,000 milligrams per litre (NSW Department of Water Resources, 1987).

Groundwater is expected to be shallow and flow in a northerly direction towards Dobroyd Canal (Iron Cove Creek).

4.6.6 Acid sulfate soils

The site and surrounding areas are predominantly mapped with soil class 5 acid sulfate risk potential, see **Figure 4-12**. Soil class 5 indicates there is no known occurrence of acid sulfate soils. Works within 500 metres of adjacent Class 1, 2, 3 or 4 land that is below five metres AHD and by which the water table is likely to be lowered below one metre AHD on adjacent Class 1, 2, 3 or 4 land requires development consent and management procedures for acid sulfate soils. These conditions have not been mapped in the vicinity of the site.

GHD (2015) noted that no acid sulfate soil testing was undertaken as part of their assessment, as minimal construction disturbance was proposed as part of the M4 East works within the vicinity of disturbed terrain/reclaimed land.

4.6.7 Areas and contaminants of concern

The areas and contaminants of concern identified are outlined in **Table 4-14**.

Table 4-14 Activities and areas of potential concern – Parramatta Road East civil site, Haberfield (C3b)

Area	Potential contamination sources	Main PCoC
Previously identified contamination in soil and groundwater		
GHD undertook soil sampling works at two boreholes (BH1370 and BH1372) on the C3b site in 2014 and one groundwater monitoring well was installed within the project footprint	Data provided in GHD (2015) from boreholes sampled by GHD in 2014 indicated: • No visual or olfactory evidence of soil contamination was observed during sampling • From the soil samples collected and analysed at both boreholes (BH1370 and BH1372) no asbestos detected; no exceedances of the ASC NEPM (NEPC 2013) health investigation levels for proposed recreational open space and commercial/industrial land use; and no exceedances of the management limits for residential/parkland • Groundwater monitoring well BH1369 installed around 100 metres north of site C3b and BH1373 installed around 40 metres south of site C3b and site C1b, both screened in shale, detected concentrations of metals copper, nickel and zinc in exceedance of groundwater investigation levels • Waste classification assessment of soil samples collected and analysed at both boreholes (BH1370 and BH1372) indicated the material would be classified as general solid waste.	• Metals
Former and current car sales and servicing and former service station		
Within the C3b ancillary facility and project footprint	The C3b site and adjacent C1b site have been used for the purposes of car sales yards and servicing since the 1970s. In addition, historical land use surrounding the site has identified service stations, mechanics and garages. It's possible that former UPSS including USTs and pipelines may be present on the site to support these uses. There is also potential for soil and groundwater contamination from historical leaks from the former UPSS. Three properties within the site contained or likely contained mechanical workshops which may have historically stored and handled oils, fuels and solvents. The properties may have formally contained hoists, underground waste oil tanks, oil/water interceptor pits, inspection pits and drains which could leak into the subsurface.	• Metals (mainly lead) • Total recoverable hydrocarbons (TRH) • Benzene, toluene, ethylbenzene and xylene (BTEX) • Polycyclic aromatic hydrocarbons (PAHs) • Volatile organic compounds (VOCs)

Area	Potential contamination sources	Main PCoC
Hazardous building materials		
Numerous buildings within and surrounding the site were present on historical aerial photographs prior to 1970. In addition, the GHD (2015) report noted that the site and surrounding areas predominantly comprised residential land use up to 1970 when commercial/industrial development along Parramatta Road increased.	Potential that C3b site and adjacent areas within the Haberfield project footprint currently or formally contained buildings that are or were potentially constructed with ACM, lead paint or contained fittings with PCBs. Demolition or degradation of the buildings (paint flaking, ACM weathering) may have resulted in contamination of surface soils. GHD (2015) also noted that there are numerous buildings within the Haberfield project footprint which are being acquired as part of the M4 East works which have the potential to contain hazardous building materials.	• Lead • Asbestos • PCBs
Imported fill		
Areas of the site and immediate surrounds may have been filled using sources of uncontrolled and potentially contaminated fill.	Areas of the site and surrounding areas may have been filled using sources of uncontrolled and potentially contaminated fill.	• Metals • TRH • BTEX • PAHs • Phenols • OCPs • OPPs • PCBs • VOCs • Asbestos

Figure 4-12 Parramatta Road East civil site at Haberfield (C3b) - acid sulfate soils

4.7 C4 – Darley Road civil and tunnel site at Leichhardt

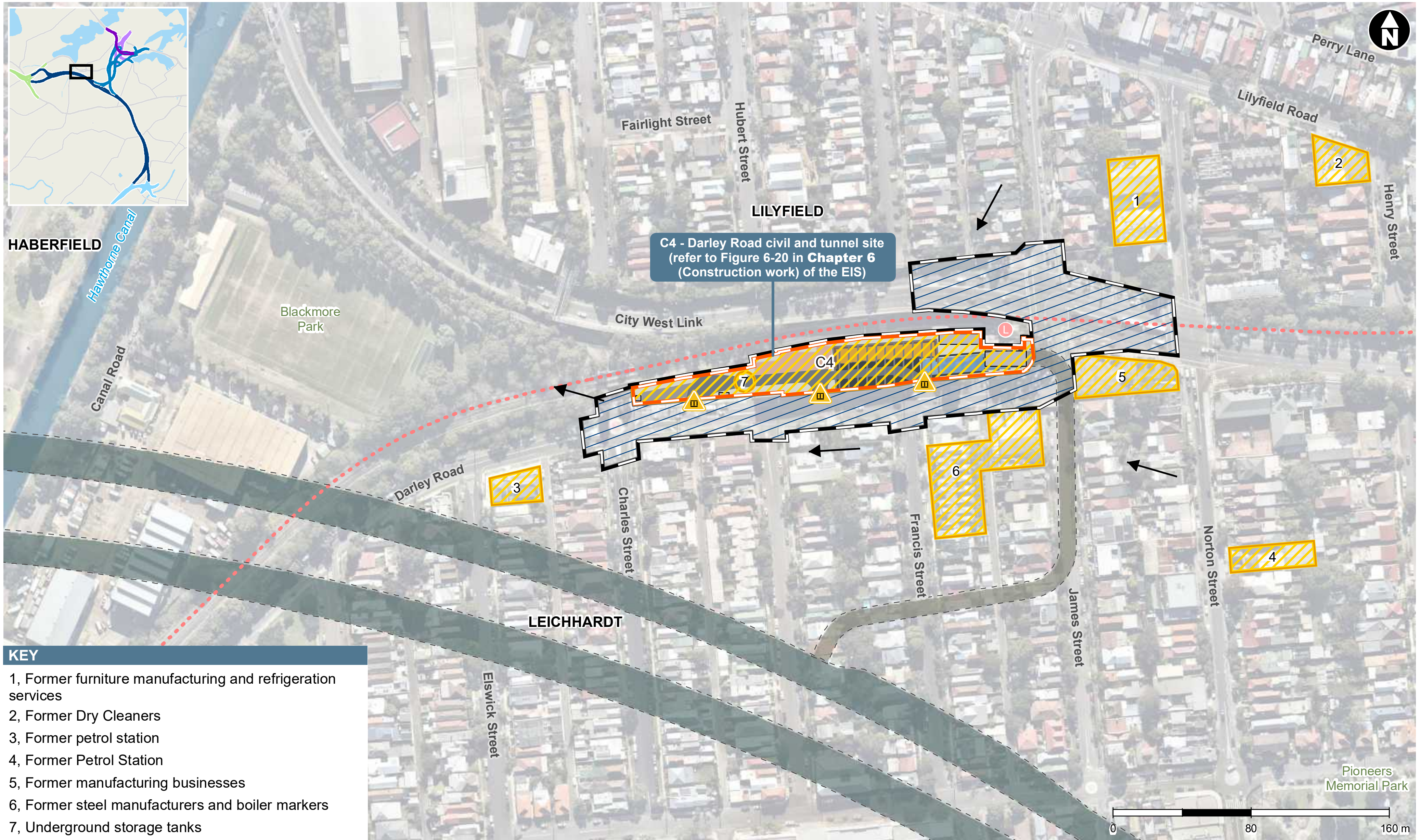
4.7.1 Site description and surrounding land use

The Darley Road civil and tunnel site (C4) is shown in **Figure 4-13** on land owned by Transport for NSW which is currently being leased and consists of a two storey brick building with a fibre cement roof which has been renovated and is now used as a commercial retail outlet. The land is enclosed by a security fence and the western portion of the land is paved with bitumen for use as a car park. The eastern portion of the Transport for NSW land consists of a paved area and landscaped area. The land is bound to the north by the North Leichhardt light rail stop and associated light rail line, to the south by Darley Road and Canal Road to the west.

The Darley Road tunnel site slopes to the west and is surrounded by the land uses listed in **Table 4-15**.

Table 4-15 Surrounding land use – Darley Road civil and tunnel site at Leichhardt (C4)

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 fronting 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 followed by Blackmore Park • Hawthorne Canal 300 metres west of C4 adjacent to Blackmore Park and Canal Road.



KEY

1, Former furniture manufacturing and refrigeration services
2, Former Dry Cleaners
3, Former petrol station
4, Former Petrol Station
5, Former manufacturing businesses
6, Former steel manufacturers and boiler markers
7, Underground storage tanks

LEGEND

Imagery © Nearmap (2017)

Existing features
- Light rail
- Light rail stop

Boundaries
- Project footprint
- Ancillary facility
- Surface works

Surface construction
- Access road
- Acoustic shed
- Laydown area

Access and egress
- Site gate

Underground construction
- Mainline tunnel
- Temporary access tunnel

Land use
- Site land use
- Local slope

Figure 4-13 Darley Road civil and tunnel site at Leichhardt (C4)

4.7.2 Previous intrusive investigations

AECOM is aware of the previous soil and groundwater investigations undertaken within the Darley Road civil and tunnel site at Leichhardt (C4):

- Environmental Investigation Services, 2002. *Environmental Site Screening for Proposed Supermarket Development, 7 Darley Road, Leichhardt, NSW*
- HLA-Envirosciences Pty Ltd (HLA), 2007. *Additional Environmental Site Assessment, 7 Darley Road, Leichhardt, NSW.* December, 2007.

One borehole (HB_BH15) was completed to the east of the Darley Road civil and tunnel site (C4) site as part of the combined geotechnical and contamination investigations (AECOM 2016c).

4.7.3 Site history

The site history is detailed in the AECOM 2016a report and summarised in **Table 4-16**.

Table 4-16 Site history – Darley Road civil and tunnel site at Leichhardt (C4)

Property	Site history summary
C4 Transport for NSW land	• 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 • C.A.M Pre Mixed Concrete Engineering Pty Ltd was located on the land in 1950 according to the UBD records. A loader, silo and several vehicles were visible on the land in the 1951 historical aerial photograph • The present day building was constructed prior to 1970 and was extended on the eastern side in 1986 along with an increase in sealed areas on the land • Land title information indicated that the land was formerly owned for the most part by the Commissioner for Railways and was also formerly used as a bakery, for rolled steel guttering production, for furniture and homewares retail, for the storage of cars and for the preparation and packaging of cakes • The presence of a possible underground storage tank (UST) was identified in the western car park. Dangerous Goods records from WorkCover NSW reviewed in the HLA (2007) report indicated that in 1974 there was an application to install a 2000 gallon UST to store mineral spirits. A letter to WorkCover from Fitform Holdings Pty Ltd dated 15 November 1996 stated that the tanks were filled with sand in November 1995 • The land was formally notified to the NSW EPA under section 60 of the CLM Act by RailCorp. The NSW EPA decided that regulation of the land was not required.

Property	Site history summary
Surrounding land	• Surrounding businesses within 150 metres and up-gradient of the Darley Road tunnel site in 1950 according to UBD records included: C.S Chadwick Pty Ltd (timber mill); K.L McNally (carriers and cartage); Roy Furniture Manufacturers Pty Ltd; Darkes Refrigeration Service; L Goldie & Sons (manufacturing) and Master Tile Co Pty Ltd Simpson; J.M & Co Pty Ltd (steel fabricators and manufacturers) located 40 metres south of the site and Barber Bros (motor garage and petrol station) • Surrounding businesses within 150 metres and up-gradient of the Darley Road tunnel site in 1970 according to UBD records included: Consolidated Gasket Company (gasket manufacturing); Kelso Manufacturing Co Pty Ltd; Mascox Pty Ltd (steel manufacturing and boiler makers); Simpson, J.M & Co Pty Ltd (steel fabricators and manufacturers); Lee Bagwell TV & Electrics (service and supplies); Martins Service Station; L Goldie & Sons (manufacturing); Master Tile Co Pty Ltd; Roy Furniture Manufacturers Pty Ltd ; United Display Pty Ltd (manufacturing); and C.S Chadwick Pty Ltd (timber mill) • Surrounding businesses in 1991 according to the UBD records included: Wawns Laboratories Pty Ltd; Wonder Pool Pty Ltd (Pharmaceuticals); Abbott Leichhardt Auto Electrical Service; Monza Smash Repairs • A search of the NSW EPA contaminated sites register identified that the Sydney Buses Leichhardt Depot located around 500 metres east and up-gradient of the Darley Road civil and tunnel site at Leichhardt has former notices under the CLM Act. Contaminants of concern at the Sydney Buses Leichhardt Depot were TPH, PAHs, phenols and metals in groundwater that had migrated off the depot to the west towards Hawthorne Canal. The notice was repealed in 2009 when the NSW EPA considered the site had been remediated to a level that no longer posed a significant risk of harm for the land use and state of the land at the time of determination.

4.7.4 Soil and geology

The Environmental Investigation Services 2002 site investigation scope included the drilling and sampling of 12 boreholes (BH1 to BH9 and BH101 to BH103) within the C4 site. The Environmental Investigation Services investigation identified fill to depths generally between 0.25 and 1.5 metres across the site. The fill was generally less than 0.5 metres deep and up to 1.5 metres deep at the western end of the site. The fill consisted of clay, sand and gravel with minor inclusions of brick and slag. Encountered fill material was underlain by medium plasticity sandy clay and weathered sandstone. The HLA (2007) report included the drilling of six boreholes (BH01 to BH06) to a maximum depth of 5.5 metres below ground level across the site and described the same conditions as Environmental Investigation Services 2002 report.

4.7.5 Hydrogeology

According to data provided by the (DPI-Water), Water Administration Ministerial Corporation and Commonwealth of Australia (Bureau of Meteorology) in December 2015, there were three registered groundwater wells within the Darley Road tunnel site and 21 registered groundwater wells within one kilometre. All wells were registered as groundwater monitoring wells. No hydrogeological information was recorded for these monitoring wells.

The HLA 2007 report included the installation of one groundwater monitoring well (MW01). The groundwater level was measured at 1.94 metres below top of the well casing (metres bTOC).

To the west of the C4 ancillary facility, a nested monitoring well was constructed within the alluvium of the Hawthorne Canal palaeochannel (HB_BH08s) and the underlying bedrock (HB_BH08d). The standing water level in the alluvium is shallow ranging from 0.3 to 0.6m during 2016 and 2017. Since the wells were constructed in May 2016 the groundwater in the sandstone has consistently been artesian with a hydraulic head of about 1 to 2 metres. Groundwater flow in the alluvium and sandstone is towards Hawthorne Canal and Rozelle Bay.

4.7.6 Acid sulfate soils

According to information provided by DP&E (Acid Sulfate Data Source Accessed 03/06/2015: NSW Crown Copyright – Planning and Environment Creative Commons 3.0 © Commonwealth of Australia), the following acid sulfate soil classes were mapped within the site (see **Figure 4-14**):

- Soil Class 2: Works below the natural ground surface or works by which the water table is likely to be lowered requires development consent and management procedures for acid sulfate soils. The constructed wetland was within land mapped as Soil Class 2
- Soil Class 5: No known occurrence of acid sulfate soils. Works within 500 metres of adjacent Class 1, 2, 3 or 4 land that is below five metres AHD and by which the water table is likely to be lowered below one metre AHD requires development consent and management procedures for acid sulfate soils. The C4 compound was within land mapped as Soil Class 5.

4.7.7 Intrusive investigation results

The Environmental Investigation Services 2002 and HLA 2007 reports included the analysis of soil samples for metals, organochlorine pesticides, PCBs, polycyclic aromatic hydrocarbons, total petroleum hydrocarbons (TPH C6-C36) and BTEX within the C4 site. The results were all less than the current ASC NEPM Health Investigation Level (HIL) and Health Screening Levels (HSLs) for commercial/industrial land use. The results are summarised in **Table 4-17**.

Table 4-17 Summary of Environmental Investigation Services 2002 and HLA 2007 soil analytical results – Darley Road civil and tunnel site at Leichhardt (C4)

Contaminant	Soil concentration range (mg/kg)			
	EIS 2002 report		HLA 2007 report	
	Minimum	Maximum	Minimum	Maximum
Arsenic	4.7	48	<1	60
Cadmium	<0.5	2.8	<0.1	0.9
Chromium (total)	6.7	52	5	83
Copper	11	150	<2	93
Lead	42	1200	4	614
Mercury	0.05	0.56	<0.05	1.79
Nickel	5.1	64	<1	79
Zinc	57	1600	<5	509
Benzo(a)pyrene	<0.05	3.6	<0.5	2.3
Carcinogenic PAHs (CPAHs)	–	–	<Laboratory Limit of Report (LOR)	3.6
Total PAHs	<LOR	46	<LOR	33.6
TPH C_{10}-C_{36}	<LOR	670	<LOR	170

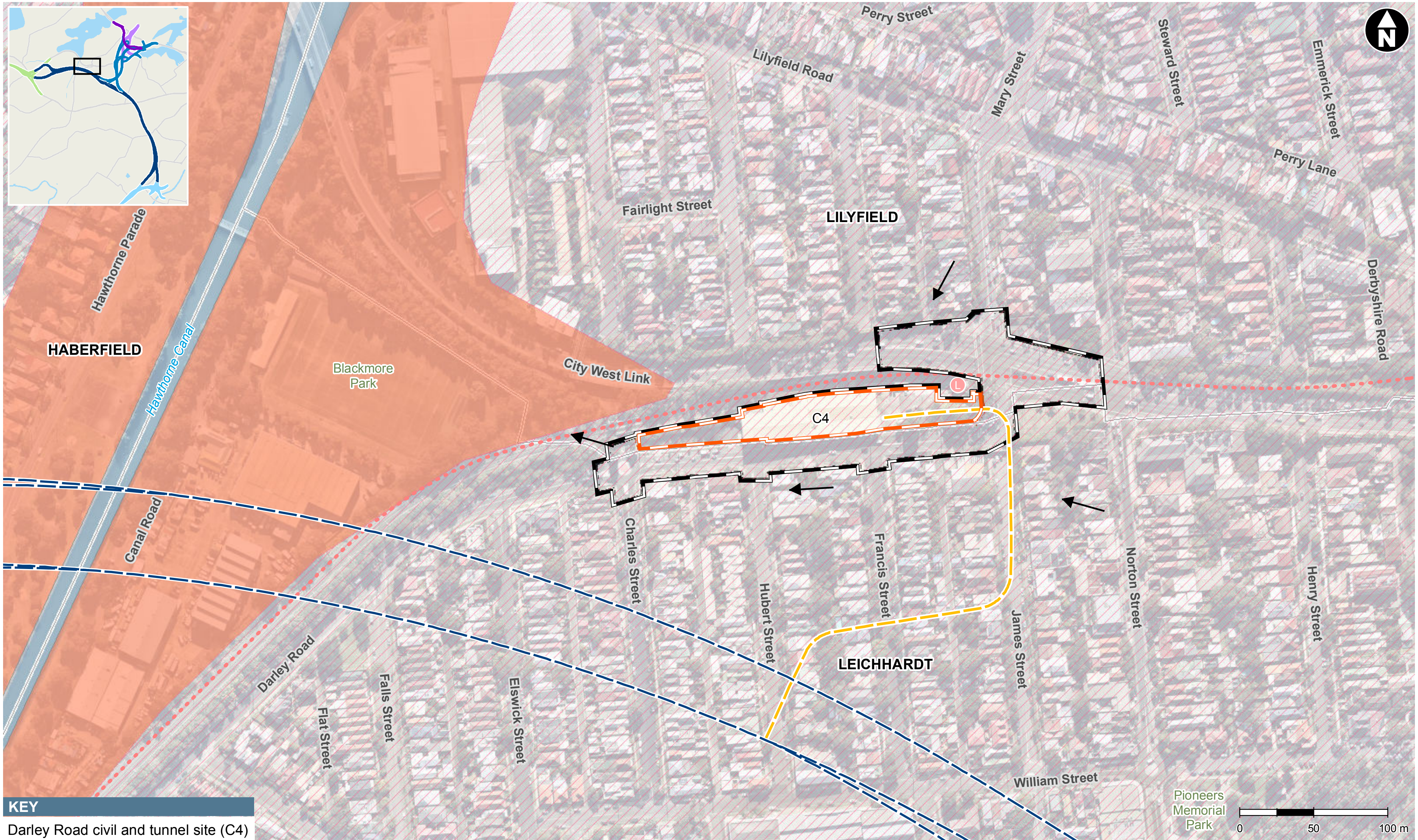
One groundwater sample was collected from MW01 within the site. Groundwater concentrations were less than the Australian and New Zealand Environment Conservation Council (ANZECC 2000) trigger values for 95 per cent marine ecosystems protection with the exception of the concentration of zinc (0.024 milligrams per litre), which exceeded the trigger value of 0.008 milligrams per litre (HLA 2007).

4.7.8 Areas and contaminants of concern

The key areas and contaminants of concern within the site are described in **Table 4-18**.

Table 4-18 Areas and contaminants of concern – Darley Road civil and tunnel site at Leichhardt (C4)

Area	Description	CoPC
C4 Transport for NSW land	A decommissioned UST is located to the west of the Transport for NSW site building. There could be localised petroleum contamination around the UST. Fill from an unknown source is present across the Transport for NSW land with slightly elevated concentrations of metals, PAHs and TPH previously identified. There is also potential for asbestos to be present in the fill from potential uncontrolled filling and demolition of former buildings. The property contains Class 2 mapped land (see **section 4.7.6**). As such works below the natural ground surface or works by which the water table is likely to be lowered requires management procedures for acid sulfate soils.	Metals, PAHs, TRH, asbestos
Off-site Sources	The closest known up-gradient source of potential contamination is the Sydney Buses Leichhardt Depot which was formerly regulated by the NSW EPA due to TPH, PAHs, phenols and metals in groundwater that had migrated off the depot to the west towards Hawthorne Canal. Up-gradient manufacturing sites were also located within 150 metres of the Darley Road civil and tunnel site.	TPH, PAHs, VOCs, SVOCs and metals



LEGEND

Existing features
- Suburb boundary
- Light rail
- Light rail stop

M4-M5 Link

Mainline
- Tunnel
- Temporary access tunnel
- Project footprint
- Ancillary facility

Slope direction
- Local slope

Acid sulfate soils
- Soil Class 2
- Soil Class 5

Figure 4-14 Darley Road civil and tunnel site at Leichhardt (C4) - acid sulfate soils

4.8 C5 – Rozelle civil and tunnel site at Rozelle

4.8.1 Site description and surrounding area

The Rozelle civil and tunnel site at Rozelle (C5) would be located in Lilyfield, within the Inner West Council LGA, primarily within the Rozelle Rail Yards and adjacent commercial and industrial lands to the north. The site is shown in **Figure 4-15**.

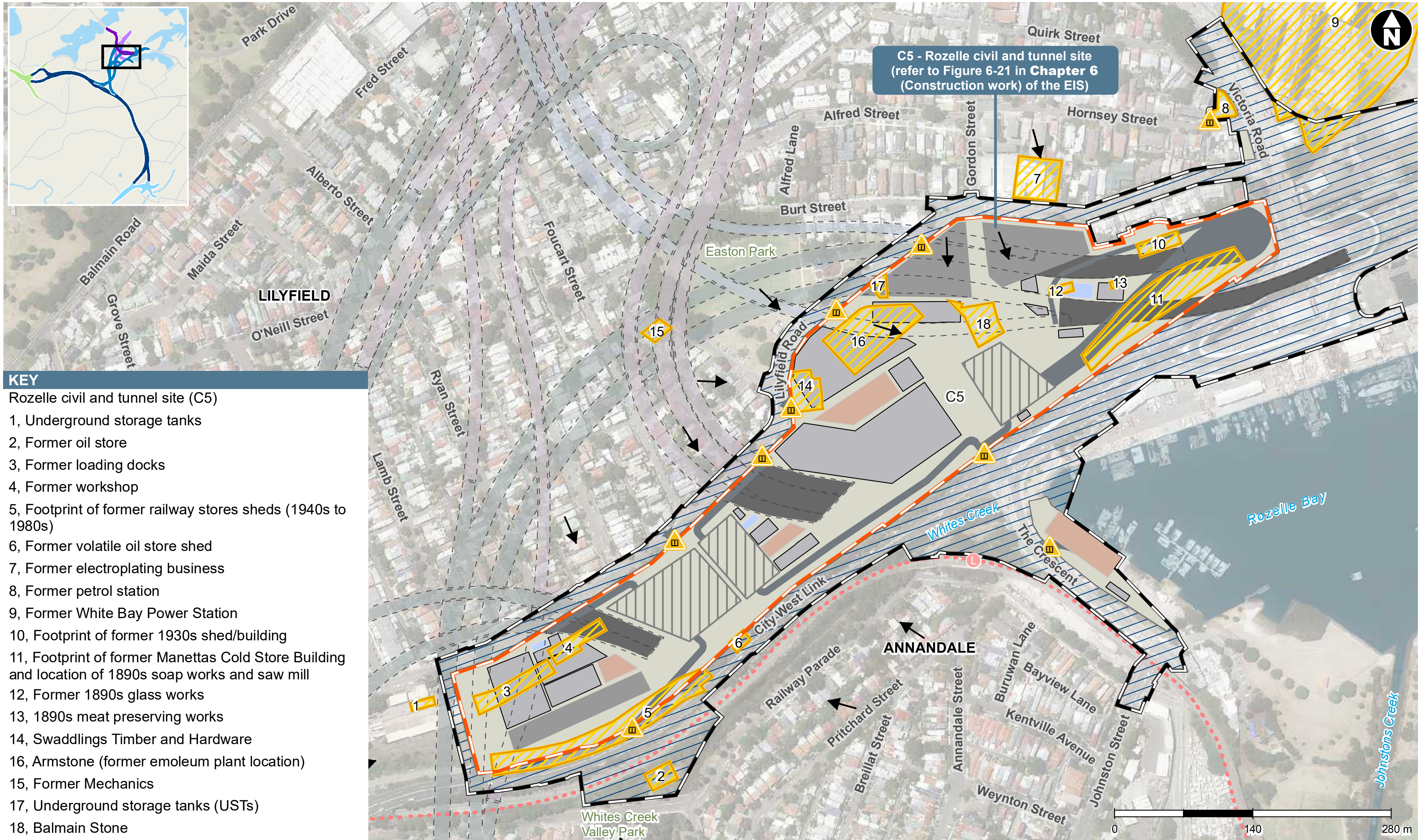
Existing railway tracks, rail related infrastructure (including rail ballast), surface wastes/stockpiles and vegetation are being removed from the Rozelle Rail Yards as part of site management works which were assessed separately in the *Rozelle Rail Yards site management works Review of Environmental Factors* (REF) (Roads and Maritime 2016). The site management works are not being assessed as part of the EIS and will be completed prior to construction of the M4-M5 Link project commencing. These works will be undertaken as a separate activity to the M4-M5 link project and will be undertaken in accordance with activity-specific environmental management measures required as part of that approval.

It is noted that the boundary of the site management works is smaller than the Rozelle civil and tunnel site boundary. The demolition of buildings north of the site management works boundary, south of Lilyfield Road within the Rozelle civil and tunnel site would be undertaken as part of the M4-M5 Link project. These activities and their associated construction impacts (refer **Table 5-1**) and management measures are discussed in **section 8**.

The Rozelle civil and tunnel site drains to Rozelle Bay and is surrounded by land uses as detailed in **Table 4-19**.

Table 4-19 Surrounding land use – C5 Rozelle civil and tunnel site 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 Drive and then wharves and 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 Sydney Light Rail maintenance depot • Low to high density residential properties (topographically up-gradient to the southwest and northwest)



KEY

Rozelle civil and tunnel site (C5)

1, Underground storage tanks
2, Former oil store
3, Former loading docks
4, Former workshop
5, Footprint of former railway stores sheds (1940s to 1980s)
6, Former volatile oil store shed
7, Former electroplating business
8, Former petrol station
9, Former White Bay Power Station
10, Footprint of former 1930s shed/building
11, Footprint of former Manettas Cold Store Building and location of 1890s soap works and saw mill
12, Former 1890s glass works
13, 1890s meat preserving works
14, Swaddlings Timber and Hardware
16, Armstone (former emoleum plant location)
15, Former Mechanics
17, Underground storage tanks (USTs)
18, Balmain Stone

LEGEND

Existing features
- Light rail
- Light rail stop

Boundaries
- Project footprint
- Ancillary facility
- Surface works

Surface construction
- Cut and cover
- Access road
- Acoustic shed
- Laydown area

Access and egress
- Site gate

Underground construction
- Rozelle interchange tunnel
- Iron Cove Link tunnel
- Proposed future WHTBL connections (civil construction only)

Land use
- Site land use
- Local slope

Figure 4-15 Rozelle civil and tunnel site at Rozelle (C5)

4.8.2 Previous intrusive investigations

The investigations detailed in **Table 4-20** have been undertaken within and surrounding the Rozelle civil and tunnel site (C5).

Table 4-20 Previous intrusive investigations – Rozelle civil and tunnel site at Rozelle (C5)

Report	Area	Overview
SKM, 1994	Leased properties	Soil sampling at 10 locations to a maximum depth of one metre and analysis for metals, PAHs, TPH and BTEX. Slightly elevated concentrations of PAHs and metals were detected in the shallow soils.
PB, 2003	Rozelle Rail Yards and leased properties	A total of 67 boreholes and three groundwater monitoring wells (MW1 to MW3) were sampled within the Rozelle Rail Yards, including the Rozelle civil and tunnel site area and the leased properties at 88–94 Lilyfield Road. Samples were analysed for metals (arsenic, copper, lead, mercury and zinc), TRP, BTEX, PAHs, OCPs, PCBs, asbestos, field acid sulfate test, suspension peroxide oxidation combined acidity and sulfur (SPOCAS) and toxicity characteristic leaching procedure (TCLP) for lead and PAHs. The investigation within the Rozelle Rail Yards reported elevated concentrations of lead, arsenic, TRH, benzene and CPAH concentrations. The concentrations were compared to the present day human health based NEPM (2013) guidelines for commercial land use in the AECOM 2016a report. With the exception of the concentration of benzene in one location, the concentrations did not exceed the present day human health based NEPM (2013) guidelines for commercial/industrial use. No light non-aqueous phase liquid (LNAPL) was detected in any of the wells gauged however oil sheen was noted in groundwater purged from MW2. The concentration of arsenic in MW2 and zinc in all wells exceeded the 95 per cent trigger value for marine water.
PB, 2011	Rozelle Rail Yards	The assessment was of a narrow single rail corridor (RailCorp site) within Rozelle Rail Yards. The objectives included determining whether ACM were present on the ground surface and within surface soils, assess and describe the nature, distribution and condition of ACM on the RailCorp site, assess the risk in context of the RailCorp site, document remediation requirements and prepare a remediation costing. The assessment identified asbestos containing train brakes, as well as ACM sheet fragments and conduit pipes within the area assessed.
AECOM, 2016c	Rozelle Rail Yards	A total of 51 boreholes (designated RZ_BH01 to RZ_BH53, excluding RZ_BH33 and BH34) were drilled and sampled within the Rozelle Rail Yards, as part of the combined geotechnical and contamination investigations for the project (see **Figure 4-15**). Twelve groundwater monitoring wells were installed across the Rozelle Rail Yards. The full results were reported in the AECOM 2016c report. The results are summarised in **sections 4.8.7** and **4.8.8**.

Report	Area	Overview
Roads and Maritime, 2017	Rozelle Rail Yards	As part of the site management works REF, contamination investigations and waste classification activities were carried out to inform the proposed site management work activities within Rozelle Rail Yards. The investigation included *in situ* assessment of soil and fill material, railway ballast, drums material and stockpiles which were present on the site at the time of sampling. The results are summarised in **section 4.8.9**.

4.8.3 Site history

The site history is detailed in AECOM (2016b) report and the GML (2017) Non-Aboriginal Heritage Impact Assessment. The relevant site history has been summarised in **Table 4-21**.

Table 4-21 Site History Summary – Rozelle civil and tunnel site at Rozelle (C5)

Area	Site history summary
C5 Rozelle Rail Yards	• 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 (SHFA) in 2000 (which was absorbed into Government Property NSW in 2015) • Other private businesses that operated in the Rozelle Rail Yards based on the UBD historical records and previous reports included: – Jefferies, Donald C (NSW) Pty Ltd (panel beaters supplies, 1970s) – Kircher, H.A (panel beaters, motor painter& electronics, 1970s) – Atlantic Union Oil Company (petroleum, 1932) – Thomas Nationwide Transport Ltd (logistics and transport, 1930s to 1961) – Metals Investigations Pty Ltd (1950s to 1960s) – Rudders Ltd (logistics, 1961) – Alltrans Pty Ltd (logistics, 1970) – Mayne Nickless Ltd (logistics, 1970s) – TNT Ltd (logistics, 1980 to 1984) – Rozelle Terminal Handling Pty Ltd (1984 to 2000s) – Red Funnel Trawlers (boat industry, 1986 to 1992) – Manettas & Co (seafood distributers, 1990s to 2000s) • Historical aerial photographs from 1930 to 2014 showed: – The site consisted mainly of train tracks (train marshalling yard) in 1930 to 1943 – Railway store sheds covering areas of 500 square metres and two hectares located along the southwest boundary were constructed between 1943 and 1951 – A 300 metre long loading dock had been constructed between 1951 and 1965 in the northern portion of the site – An additional building (mechanical workshop) was added to the train loading docks between 1965 and 1970 – The two hectare sized sheds were demolished between 1982 and 1991 – Train carriages were still visible on some of the rail tracks in 2007 – In 2014 vegetation was growing across the site • The rail yards completely ceased operation in 2007

Area	Site history summary
	• No information was found in a search of NSW EPA public records.
City West Link	• Historical aerial photographs showed City West Link was formerly part of the Rozelle Rail Yards until between 1982 and 1991. The construction of City West Link was visible in the 1991 photograph.
Surrounding land	• The Rozelle Rail Yards formerly extended to the south of City West Link to Whites Creek • According to online sources, noxious and offensive industry flourished to the south along the banks of Whites Creek in late 1800s. Bone boilers Peter Tancred, Thomas Elliott, Isaac Tester and Francis Hemming traded along the banks of the creek (http://dictionaryofsydney.org/entry/lilyfield) • Based on the aerials, other factories existed along the creek to the south from before 1930 until the mid to late 1980s. According to the 1950 UBD records, the businesses included Brenbar Manufacturing Co (sports goods manufacturing), Furniture Industries Pty Ltd (furniture manufacturing) and National Engineers Pty. Ltd (electrical engineers), Commonwealth Telegraph Supplies Ltd (nut and bolt manufacturing). In the 1970 UBD the businesses included P.G.H.Furniture Pty Ltd (furniture-tubular steel manufacturers), Audley Bros. Pty Ltd (wood moulding manufacturing) and Crampton's Garage (motor repairs and engineers).

4.8.4 Soil and geology

According to the NSW Department of Industry, Resources and Energy (2014), 1:100,000 geological units and structures, the Rozelle civil and tunnel site geology consists of the following units:

- Man-made fill (dredged, estuarine sand and mud, demolition rubble, industrial and household waste), overlying silty to peaty quartz sand, silt and clay with ferruginous and humic cementation in places and common shell layers. This layer extends across all low-lying areas
- Triassic sandstone consisting of medium to coarse grained quartz sandstone, very minor shale and laminate lenses
- A dyke runs in a northwest to southeast orientation beneath Victoria Road.

According to information provided by OEH, the soil landscapes consist of disturbed terrain and Gymea erosional soils. The disturbed terrain is present in low lying areas and the Gymea erosional soils are located above the Triassic sandstone.

In the AECOM 2016c investigation, anthropogenic fill was encountered in all boreholes to a maximum depth of 5.5 metres below ground level in the Rozelle civil and tunnel site. The greatest depth of fill was encountered along the southern half of the site. The fill primarily consisted of variable layers of sandy gravels, gravelly sands, silty sand, and sandstone cobbles and boulders. The fill contained minor layers of sand, clayey sands and sandy clay in some locations. The findings were similar the previous investigation within the Rozelle Rail Yards (PB 2003a).

Around half of the boreholes drilled in the Rozelle Rail Yards contained anthropogenic inclusions in the fill. Common inclusions were observed to include brick, slag and concrete. Less common inclusions in the fill included metal, timber, cloth, ash, netting, coal and porcelain. Fragments of asbestos cement sheeting were encountered in one borehole, to the east of Gordon Street.

Alluvial soils were encountered across most of the Rozelle Rail Yards. The alluvium extended to depths ranging from 0.6 to 20.1 metres below ground level within the Rozelle civil and tunnel site. The alluvium consisted of layers of sand, medium to high plasticity clay, high plasticity organic clay, peat, clayey sand. Traces of shell fragments and shell layers were also encountered in the alluvium. Groundwater is expected to be tidally influenced within filled areas of Rozelle Rail Yards site and surrounding areas close to the shore. Preferential pathways of groundwater flow are likely to exist in variable fill types and the palaeochannel in the quaternary sediments identified to be present within the Rozelle civil and tunnel site.

Bedrock was encountered in the Rozelle Rail Yards at depths ranging from 0.55 to 20.4 metres belowground level within the Rozelle civil and tunnel site. The depth to bedrock was shallow in the northern half of the site and deep in the southern half of the site. Consistent with the regional geological maps, the bedrock was found to be Triassic Hawkesbury Sandstone, consisting of medium to coarse grained quartz sandstone and very minor shale and laminate lenses.

4.8.5 Hydrogeology

Groundwater flow is expected to be towards Rozelle Bay. Groundwater flow pathways are likely to exist in the various types of fill and the alluvium. A total of 11 groundwater monitoring wells were sampled within the Rozelle civil and tunnel site for groundwater contamination assessment purposes. Of the monitoring wells sampled:

- Five were screened in alluvium (including newly installed monitoring wells RZ_BH01S, RZ_BH44S, RZ_BH47S and RZ_BH49, and existing monitoring well BH57/MW2)
- One was screened across both fill and alluvium (existing monitoring well BH60/MW3)
- Five were screened in sandstone bedrock (newly installed monitoring wells RZ_BH16, RZ_BH19, RZ_BH26, RZ_BH47D and RZ_BH51).

The monitoring well construction and standing water levels are summarised in **Table 4-22**.

Groundwater is present within the alluvial aquifer and the underlying Hawkesbury Sandstone. Groundwater levels measured in nested monitoring wells have demonstrated that groundwater standing water levels in the alluvium are typically lower than those in the underlying Hawkesbury Sandstone. Hence, overall there is upward pressure from the Hawkesbury Sandstone to the alluvium where groundwater from the Hawkesbury Sandstone could be discharging into the alluvium if there is hydraulic connection. Within the alluvium, two sub aquifers separated by a clay horizon have been identified whereby the groundwater standing water levels in the deep 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 overlying shallow alluvium.

Monitored standing water levels ranged from 1.34–2.65 metres AHD. Groundwater is assumed to flow in a general south-easterly direction towards Whites Creek and Rozelle Bay.

Table 4-22 Hydrogeology – Rozelle civil and tunnel site at Rozelle (C5)

Monitoring well location	Screened interval (metres below ground level)	Screened geology	Standing water level (metres AHD)
BH57/MW2	1 to 5	Alluvium	1.82
BH60/MW3	1 to 4	Alluvium/fill	2.65
RZ_BH01(d)	22 to 25	Sandstone	1.56 to 2.47
RZ_BH01(s)	7 to 10	Alluvium	2.00 to 2.04
RZ_BH16(d)	17 to 22	Sandstone	1.56 to 1.71
RZ_BH19	19 to 22	Sandstone	1.46 to 2.46
RZ_BH38	28.25 to 31.25	Sandstone	1.72 to 2.27
RZ_BH44S	12 to15	Alluvium	1.11 to 2.25
RZ_BH44D	25 to 28	Sandstone	1.87 to 2.29
RZ_BH47D	27 to 30	Sandstone	1.55 to 2.3
RZ_BH49A	13.2 to 16.2	Alluvium	1.34 to 1.35

4.8.6 Acid sulfate soils

According to information provided by DP&E, the following acid sulfate soil classes are mapped within the Rozelle civil and tunnel site (see **Figure 4-17**):

- Soil Class 1: Any works require development consent and management procedures for acid sulfate soils. The majority of the site is mapped as Soil Class 1. A small area of the northeast corner of the Rozelle civil and tunnel site is mapped as Class 1
- Soil Class 3: Works more than one metre below the natural ground surface or works by which the water table is likely to be lowered requires development consent and management procedures for acid sulfate soils. Most of the Rozelle civil and tunnel site is mapped as Class 3
- Soil Class 5: No known occurrence of acid sulfate soils. Works within 500 metres of adjacent Class 1, 2, 3 or 4 land that is below five metres AHD and by which the water table is likely to be lowered below one metre AHD on adjacent Class 1, 2, 3 or 4 land requires development consent and management procedures for acid sulfate soils. A narrow strip of the northern boundary of the Rozelle civil and tunnel site, along the cliff line, is mapped as Class 5.

Intrusive investigation results identified potential acid sulfate soils (PASS), primarily in natural alluvium (AECOM 2016c).

4.8.7 Soil investigation results

The analytical results for fill and natural soil samples collected from within Rozelle Rail Yards, including the Rozelle civil and tunnel site, as part of the AECOM (2016c) investigation are summarised in **Table 4-23**. Borehole locations are shown in **Figure 4-16**.

Table 4-23 Summary of soil results (AECOM 2016c) – Rozelle Rail Yards

Analyte	Matrix	Results	Concentration (mg/kg)		
			Minimum	Maximum	Average
Arsenic	Fill	104	<3	1200	33
	Soil	36	<3	22	7.9
Cadmium	Fill	104	<0.3	1100	12
	Soil	36	<0.3	5.2	0.57
Chromium (III+VI)	Fill	104	0.5	79	11
	Soil	36	1.4	43	11
Copper	Fill	104	1.7	680	74
	Soil	36	1.2	150	19
Lead	Fill	104	3	6400	186
	Soil	36	3	320	45
Mercury	Fill	104	<0.01	10	0.27
	Soil	36	<0.01	0.8	0.1
Nickel	Fill	104	0.6	110	12
	Soil	36	<0.5	20	4.7
Zinc	Fill	104	5	250000	2812
	Soil	36	2.3	5900	269
Benzo(a)pyrene	Fill	99	<0.05	40	1.4

Analyte	Matrix	Results	Concentration (mg/kg)		
			Minimum	Maximum	Average
	Soil	36	<0.1	5.4	0.52
Carcinogenic PAHs	Fill	99	<0.2	59	2.1
	Soil	36	<0.2	7.8	0.82
Total PAHs	Fill	99	<0.8	680	16
	Soil	36	<0.8	60	5.8
Asbestos	Fill	53	Detected in three boreholes		
TRH C6-C10	Fill	101	<25	41	13
	Soil	36	<25	150	17
TRH C10-C16	Fill	101	<25	250	17
	Soil	36	<25	660	35
TRH C16-C34	Fill	101	<90	2600	146
	Soil	36	<90	820	87
TRH C34-C40	Fill	101	<100	550	73
	Soil	36	<100	<120	60
F1 (C6-C10 minus BTEX)	Fill	101	<25	38	13
	Soil	36	<25	150	17
F2 (C10-C16 minus naphthalene)	Fill	101	<25	220	17
	Soil	36	<25	660	35
Total BTEX	Fill	101	<0.6	9.1	0.42
	Soil	36	<0.6	0.8	0.32
OCPs	Fill	37	<LOR	<LOR	<LOR
	Soil	2	<LOR	<LOR	<LOR
OPPs	Fill	35	<LOR	<LOR	<LOR
	Soil	1	<LOR	<LOR	<LOR
Total PCBs	Fill	36	<LOR	<LOR	<LOR
	Soil	2	<LOR	<LOR	<LOR

Notes: LOR – limit of reporting

The following results exceeded the ASC NEPM (2013) HIL D criteria for commercial/industrial land use within the Rozelle civil and tunnel site (borehole locations are shown in **Figure 4-16**):

- Cadmium and lead in one sample (RZ_BH03_0.3-0.4)
- CPAHs in one sample (RZ_BH02_0.3-0.4).

The following results were greater than the ASC NEPM (2013) HIL C criteria for open space land use:

- Arsenic, cadmium, lead and zinc in one sample (RZ_BH02_0.3-0.4)
- Lead in two samples (RZ_BH02_0.1 and RZ_BH03_0.3-0.4)

- Carcinogenic PAHs in two samples (RZ_BH02_0.1 and RZ_BH03_0.3-0.4)
- Total PAHs in one sample (RZ_BH02_0.3-0.4).

Concentrations of copper, lead, nickel, zinc, benzo(a)pyrene, TRH C_{10}-C_{16} and TRH C_{16}-C_{34} also exceeded the ASC NEPM (2013) generic ecological investigation levels (EILs) and ecological screening levels (ESLs) for commercial/industrial and open space land uses in samples within the Rozelle civil and tunnel site.

All results were less than the ASC NEPM (2013) and CRC Care (32011) HSLs for open space (HSL C) and commercial land use (HSL D) for all soil types and depths.

4.8.8 Groundwater investigation results

The analytical results for groundwater samples collected from within the Rozelle Rail Yards, including the Rozelle civil and tunnel site as part of the AECOM (2016c) investigation are summarised in **Table 4-24**.

Table 4-24 Summary of groundwater results (AECOM, 2016c) – Rozelle Rail Yards

Analyte	Aquifer	Results	Concentration (mg/L)		
			Minimum	Maximum	Average
Arsenic	Alluvial	5	<0.001	0.002	0.0013
	Sandstone	5	<0.001	0.002	0.0008
Cadmium	Alluvial	5	<0.0001	<0.0001	<LOR
	Sandstone	5	<0.0001	<0.0001	<LOR
Chromium (III+VI)	Alluvial	5	<0.001	<0.001	<LOR
	Sandstone	5	<0.001	<0.001	<LOR
Copper	Alluvial	5	<0.001	<0.001	<LOR
	Sandstone	5	<0.001	0.019	0.0042
Lead	Alluvial	5	<0.001	<0.001	<LOR
	Sandstone	5	<0.001	<0.001	<LOR
Mercury	Alluvial	5	<0.0001	<0.0001	<LOR
	Sandstone		<0.0001	<0.0001	<LOR
Nickel	Alluvial	5	<0.001	0.002	0.008
	Sandstone	5	<0.001	0.01	0.0028
Zinc	Alluvial	5	<0.005	0.012	0.0081
	Sandstone	5	<0.005	0.06	0.0028
TRH C6-C10	Alluvial	5	<LOR	<LOR	<LOR
TRH C10-C40	Sandstone	5	<100	80	N/A
PAHs, SVOC and VOCs	Alluvial	5	<LOR	<LOR	<LOR
	Sandstone	5	<LOR	<LOR	<LOR

All groundwater results from the groundwater wells sampled and analysed within the Rozelle civil and tunnel site were less than the ANZECC (2000) 95 per cent marine trigger values, NHMRC (2015) ADWG and the ASC NEPM (2013) and CRC Care (32011) HSLs for open space (HSL C) and commercial land use (HSL D). Petroleum sourced light non aqueous phase liquid (LNAPL)/phase separated hydrocarbons (PSH) was detected at a single location (BH57/MW2) in a monitoring well installed during a previous (PB 2003) investigation.

4.8.9 Additional Rozelle Rail Yards investigation results

As part of the work undertaken for the Site Management Works REF (Roads and Maritime 2016) additional contamination investigations and waste classification activities were carried out to inform the proposed work activities within the Rozelle Rail Yards. The investigation included *in situ* assessment of soil and fill material, railway ballast, drums material and stockpiles which were present on the site at the time of sampling. Potential impacts of the site management works will be managed and mitigated on-site by the contractor. Management measures will include the preparation and carrying out of a CEMP, which will identify potential impacts, sensitive receivers and associated management measures. The CEMP will include measures for soil and water, contamination, including asbestos, resource use and waste, non-Aboriginal heritage, fauna and flora, traffic management and control, noise and vibration and air quality.

Potential impacts as a result of the finished site phase of the site management works will be minimal and will only occur if the surface cover and erosion and sediment controls are not maintained after completion of the site management works. These potential impacts include sediment and contamination leaving the site and entering the stormwater system. However, provided the site is maintained, the residual impacts of the finished site are not considered to be significant, particularly once appropriate management measures are put in place.

At the completion of the site management works contemplated in the Site Management Works REF (Roads and Maritime 2016), the majority of the Rozelle civil and tunnel site will be stabilised. The site will also contain areas of hardstand and new drainage channels and sediment basins to manage surface water flows. Over time, areas that had been seeded for erosion control will result in low growing vegetation.

4.8.10 Areas and contaminants of concern

The key areas and contaminants of concern within the site are summarised in**Table 4-25**.

Table 4-25 Areas and contaminants of concern – Rozelle civil and tunnel site at Rozelle (C5)

Area	Description	CoPC
C5 Rozelle Rail Yards	Investigations identified fill across the land. The fill contains elevated concentrations of metals, PAHs and TRH above applicable human health and ecological criteria. Asbestos was also identified in fill in several locations and also present as bonded asbestos fragments on the surface. The site is mapped as Class 1, 3 and 5 acid sulfate soil risk. Potential acid sulfate soils have been detected within the alluvial sediments across the Rozelle Rail Yards. LNAPL was identified in one groundwater monitoring well down-gradient of the commercial properties (Armstone, Swaddling's and Balmain Stone). Based on the findings of investigations undertaken to date, fill material present at the site is unlikely to be suitable for off-site reuse and would require disposal to a suitably licensed landfill. Fill material present at the site is heterogeneous and likely to be classified as a mix of general solid, restricted, hazardous and/or special waste in accordance with the criteria outlined in the NSW EPA (2014) Waste Classification Guidelines. Further information is required to refine the understanding of the vertical and lateral distribution of waste types at the site.	Metals, TRH, PAHs, and asbestos Acid sulfate soils
Timber Merchant	Historically used as a timber yard and formerly part of the Rozelle Rail Yards. The land was redeveloped in the late 1990s. The site is mapped as Class 1 and 5 acid sulfate soil risk. Potential acid sulfate soils have been detected within the alluvial sediments to the south of the property in the Rozelle Rail Yards. AECOM is not aware of previous intrusive investigations undertaken.	Metals, PAHs, OCPs, TRH, asbestos Acid sulfate soils
WHT – B Hotel and Crane Business	The land was formerly occupied by soap and candle manufacturers, followed by timber merchants and then Gillespie's Cranes. The land contains diesel USTs. The site is mapped as Soil Class 1 and 5 acid sulfate soil risk.	Metals, PAHs, OCPs, TRH, asbestos Acid sulfate soils
WHT – C Commercial Properties (, Swaddling's and Stonemason)	The land formerly contained an emoleum plant (bitumen manufacturing), timber yard, rail siding and boat repair yard. Limited previous shallow investigations (<1 metres) have been undertaken within the land that identified the presence of fill and slightly elevated PAHs and metals in shallow soils. The site is mapped as Soil Class 1 and 5 acid sulfate soil risk.	Metals, PAHs, TRH, SVOCs, VOCs, TBT, asbestos Acid sulfate soils
Off-site sources	Easton Park to the north of the site is filled with soil containing elevated concentrations of PAHs and metals from an unknown source.	Metals and PAHs

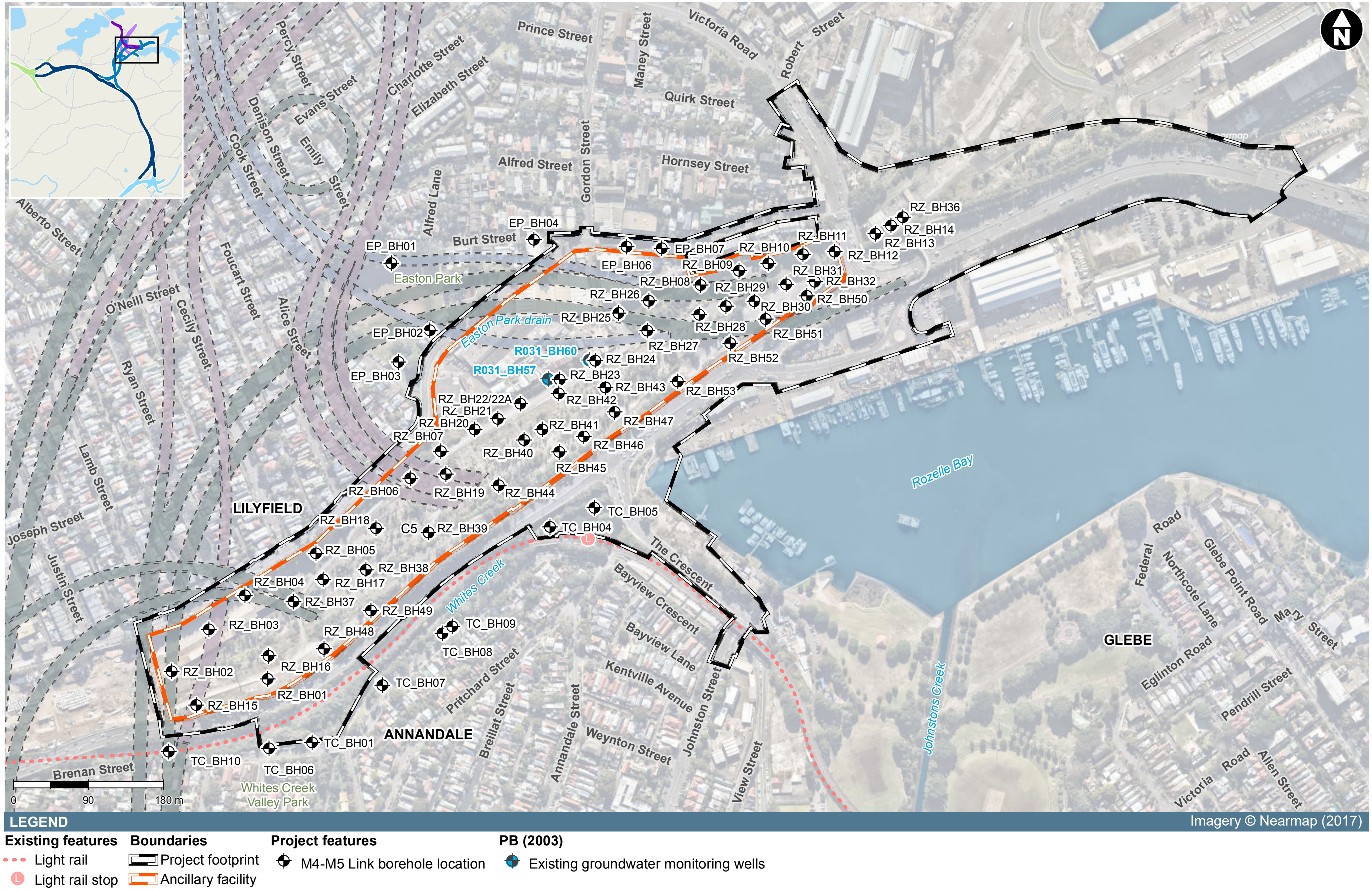


Figure 4-16 Rozelle civil and tunnel site at Rozelle (C5) – borehole and groundwater monitoring well locations

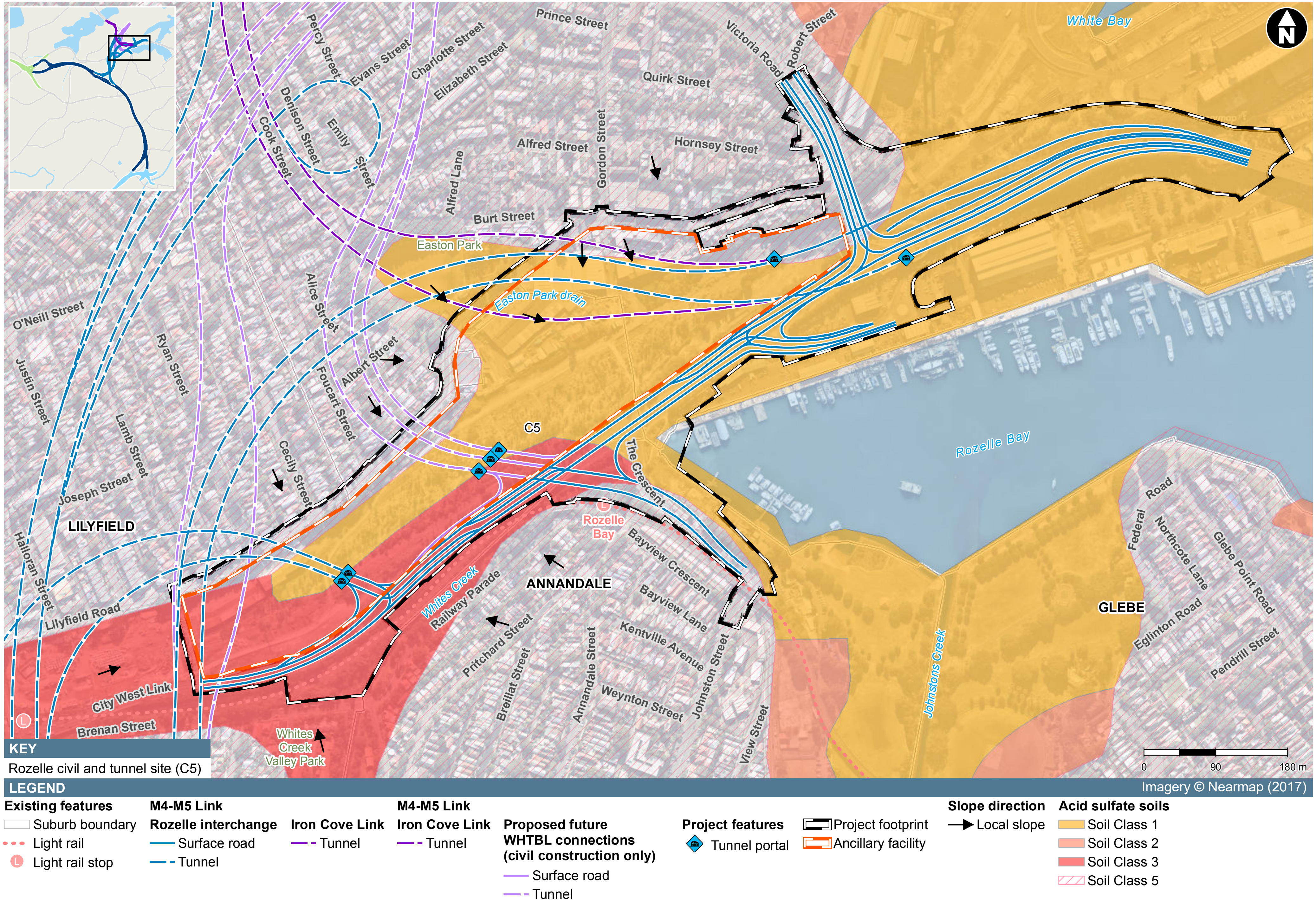


Figure 4-17 Rozelle civil and tunnel site at Rozelle (C5) - acid sulfate soils

4.9 C6 – The Crescent civil site at Annandale

4.9.1 Site description and surrounding area

The Crescent civil site at Annandale (C6) would be located within the Inner West LGA to the south of the Rozelle civil and tunnel site (C5) at Rozelle and City West Link.

The site is shown in **Figure 4-18** and would be located on land that is currently vacant but has historically been used for boat, plant and machinery storage and maintenance. The site is currently owned by Roads and Maritime. Land at The Crescent civil site at Annandale (C6) drains in an easterly direction towards Rozelle Bay, which is located immediately to the east and is surrounded by land uses detailed in **Table 4-26**.

Table 4-26 Surrounding land use – The Crescent civil site at Annandale (C6)

Direction	Description of surrounding land use and proximity to the site
North	• Parkland, pedestrian and cycle pathways which collectively form part of the road verge above Whites Creek and Easton Park drainage into Rozelle Bay, immediately east of the intersection of The Crescent and City West Link roadways • Rozelle Rail Yards site.
South	• The Crescent Roadway and intersection with Johnston Street and Petersham TAFE College Annandale Campus. Above the intersection of these roadways are the light rail tracks • Southeast – Federal Park adjacent Rozelle Bay • Southwest residential land use.
East	• Rozelle Bay, jetties, pontoons and boats on the water.
West	• The Crescent roadway, further west residential land use, 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.

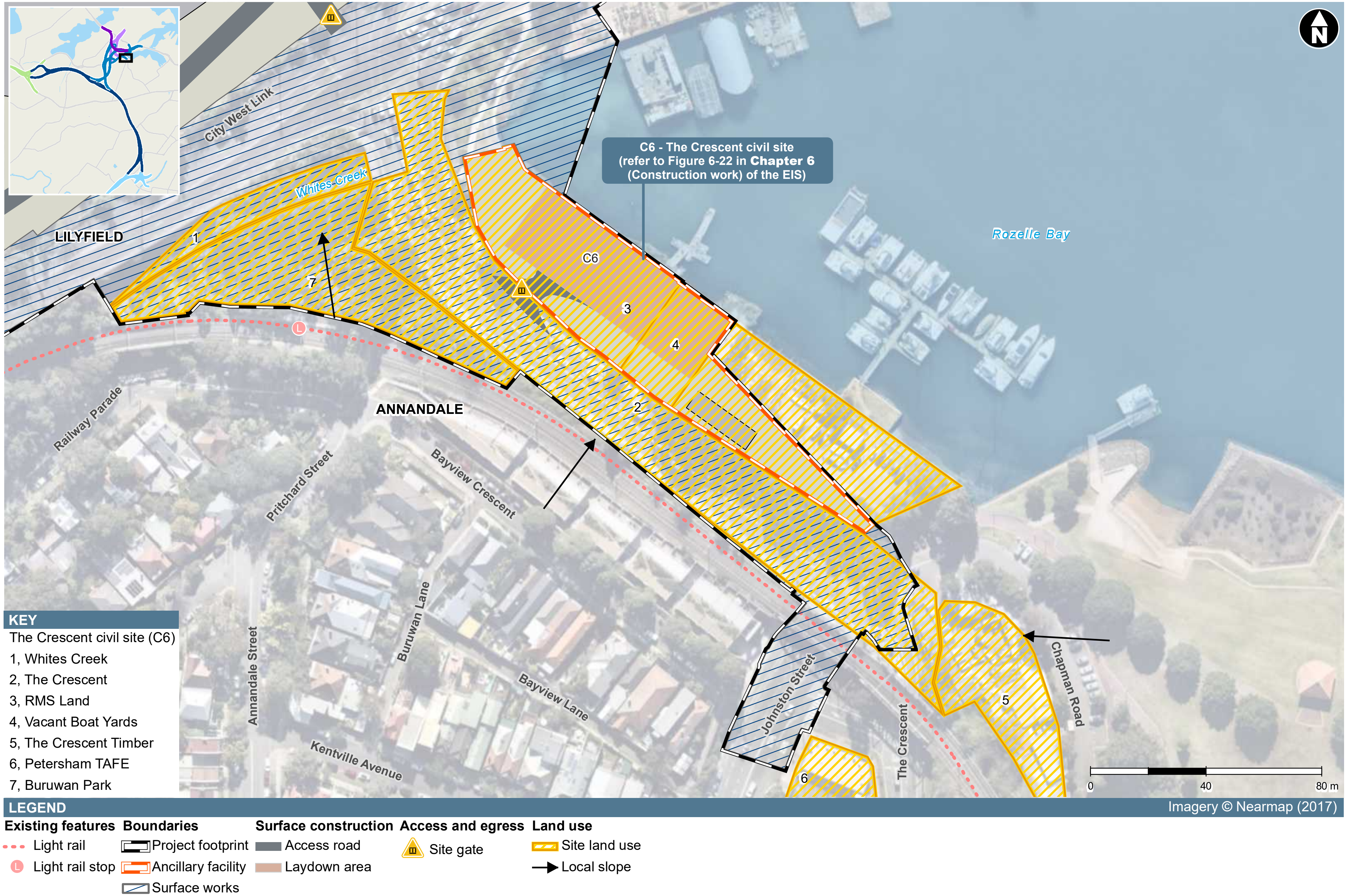


Figure 4-18 The Crescent civil site at Annandale (C6)

4.9.2 Previous reports

AECOM is aware of the previous investigations and management procedure relevant to The Crescent civil site at Annandale (C6):

- Jacobs (2015b) Lots 21/22, DP1151746 Rozelle Bay – NSW Roads & Maritime Services, Site Access and Management Procedures. Final, ExeC1a4/0341 17 June 2015
- AECOM (2016b) WestConnex M4-M5 Link Rozelle Interchange Phase 1 Environmental Site Assessment 4 March.

A summary of the information is provided in **Table 4-27**.

Table 4-27 Previous reports relevant to The Crescent civil site at Annandale (C6)

Report	Area	Overview
Jacobs, 2015	Part C6 – Lot 21 and Lot 22 DP 1151746	The Site Access and Management Procedures (SAMP) was produced by Jacobs using information sourced in the following investigation (not reviewed by AECOM): • Jacobs (2015a) Detailed Site Investigation Lots 21/22, DP1151746, The Crescent, Rozelle NSW. March 2015. The following primary hazards have been identified for the site in its current condition: • Exposure to asbestos (on ground surfaces and within soils) • Exposure to contaminated soil (including fill) and groundwater • Exposure to contaminated sediments along the site foreshore. Jacobs SAMP (2015b) noted that *'The source of contamination in soils was considered to be associated with historical fill and more recent industrial/commercial maritime operations, including the refurbishment of vessels and grit blasting activities, among others. Contamination includes asbestos in soil, heavy metals, polycyclic aromatic hydrocarbons (PAHs) and Tributyltin (TBT)*' Jacobs (2015b) considered the extent of impacted fill is likely to extend across the majority of filled areas from surface to depths of two metres below ground level. Figure 1 within the SAMP shows where concentrations of asbestos, lead, PAHs, and TBT exceeded the adopted assessment criteria used by Jacobs (2015b). Jacobs (2015b) also indicated an exclusion zone (no slashing or other ground surface disturbing works) was provided in Figure 2. AECOM notes that no Figure 2 is included in the SAMP (Jacobs, 2015b) and Figure 2 from Jacobs (2015a) does not show an exclusion zone. Jacobs (2015b) noted that groundwater at the site is likely to be contaminated by the leaching of identified contaminants in soils. Jacobs (2015b) noted that previous investigations undertaken across the foreshore in areas adjacent to the site have reported analytical results for PAH and metals in groundwater above the respective assessment criteria for the protection of drinking water, irrigation and aquatic ecosystems. Jacobs (2015b) noted that vapours (as volatile organic compound concentrations measured with a photoionisation detector) were not measured above the limit of reporting of the detector within test-pits or at ground surfaces of the site. The SAMP details the potential exposure pathways and recommended PPE requirements and recommended management measures for intrusive works undertaken within the site.

Report	Area	Overview
AECOM, 2016b	Surrounding area – including Rozelle project footprint	The Phase 1 ESA incorporated an area of 42 hectares, including land located in proximity to The Crescent civil site at Annandale (C6). Areas of identified potential contamination concern included: • Rozelle Rail Yards • Boat yards and maintenance facilities • Reclaimed land • The Crescent Timber Site. The Crescent Timber Site is located to the south of C6 and is currently used as a car park and commercial building for Crescent Timber and Hardware store. Previous investigations have identified fill materials containing elevated concentrations of lead and CPAH which exceeded the assessment criteria for open space. The site was also found to contain ACM and asbestos fibres in soil. Groundwater beneath the site was found to contain lead and cyanide concentrations greater than ecological assessment criteria and hexachlorobenzene was also detected at low concentrations in groundwater. PASS was also identified.

4.9.3 Site history

It is understood from Jacobs (2015b) that the site has been previously used for marine storage and maintenance purposes, has historically been reclaimed land and was previously part of Rozelle Bay.

Based on the results of the Phase 1 ESA (AECOM 2016b) the land forming part of the Rozelle civil and tunnel site incorporates the following historical land uses:

- Rozelle Rail Yards north and northwest of the site
- Timber yard south of the site
- Former mechanics further south of the site.

The surrounding historical land uses are unlikely to have impacted on the soil and groundwater quality of the C6 site due to being either down-gradient or located greater than 100 metres from the C6 site. However, the long commercial/industrial land use indicates there is a high potential for contaminated soil, fill, sediment and groundwater to be present at this location.

4.9.4 Soils and geology

According to the NSW Department of Industry, Resources and Energy (2017), 1:100,000 Sydney geology map sheet, the site geology consists of the following units:

- Triassic Ashfield Shale of the Wianamatta Group, characterised by black to dark grey shale and laminate
- According to information provided by OEH the soil landscape within the site consists mostly of Blacktown Residual Soils.

4.9.5 Hydrogeology

Groundwater is expected to be shallow and tidally influenced in a northerly (towards Whites Creek) and easterly (towards Rozelle Bay) direction. The expected groundwater flow direction within the project is anticipated to be radial in a predominantly easterly, westerly and northerly direction. Eight groundwater monitoring wells have been constructed within the alluvium and Hawkesbury Sandstone at The Crescent (AECOM 2017a). Groundwater levels are typically shallow with levels in the sandstone being less than one metre below ground level. As at Rozelle, the groundwater standing water levels within the alluvium are lower by up to a metre indicating there is likely to be upward pressure from the groundwater within the sandstone.

4.9.6 Acid sulfate soils

The Crescent civil site at Annandale (C6) and surrounding areas are predominantly mapped with Class 1 acid sulfate risk potential which means any works that disturb more than one tonne of soil, or lower the water table would trigger the requirement for assessment and may require management (see **Figure 4-20**).

4.9.7 Rozelle Bay

As noted in the in the site management works REF (Roads and Maritime 2016) Rozelle Bay is a tidal harbour embayment located immediately adjacent – north and east of The Crescent civil site at Annandale. The morphology and shoreline of the bay have been substantially modified by land reclamation activities. Rozelle Bay receives urban runoff from the suburbs of Rozelle, Lilyfield, Annandale and Forest Lodge.

The 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. AECOM notes that under the ANZECC (2000) guidelines for fresh and marine water quality, the condition of the ecosystem in Rozelle Bay within the project footprint would be characterised as highly disturbed. The portion of Rozelle Bay immediately adjacent The Crescent civil site at Annandale which is included in the project footprint receives stormwater outfall from Easton Park drain and Whites Creek.

As noted in the in the site management works REF (Roads and Maritime 2016) Easton Park drain collects stormwater from a heavily urbanised catchment of about 55 hectares to the north and west of the project footprint, and discharges into Rozelle Bay through a combination of stormwater pipes, lined open channel and culverted reaches and is tidally influenced.

Whites Creek is located close to the corner of City West Link and The Crescent at Ananndale. The watercourse drains a dense urban catchment area of about 262 hectares originating approximately 1.5 kilometres southwest of The Crescent civil site. Whites Creek is a concrete lined open channel spanned by a number of road and rail crossings. The creek discharges into Rozelle Bay immediately east of The Crescent and is tidally influenced.

4.9.8 The Crescent soil investigation results

As part of the preparation of this technical working paper, AECOM collected soil samples at one metre intervals to a maximum depth of four metres below ground level from two boreholes excavated within part of the proposed Crescent civil site at Annandale C6 ancillary facility and The Crescent roadway widening works. AECOM collected soil samples at one metre intervals to a maximum depth of four metres below ground level from four boreholes excavated on the grass verge north of Whites Creek and east of the intersection of The Crescent and City West Link adjacent Rozelle Bay (ie north of the proposed ancillary facility). A further three boreholes were excavated and sampled within Buruwan Park, the site of the proposed Whites Creek widening and footbridge.

All boreholes were located within the vicinity of proposed intrusive works either for the purpose of a construction ancillary facility, piling works for overhead structures and/or cut and cover works as part of road realignment works for the project.

An assessment of the soil analytical results from the samples collected by AECOM adjacent to Rozelle Bay against waste classification criteria indicated that the material is classified as General Solid Waste. However, it is noted that based on the results provided in the Jacobs (2015) SAMP, asbestos containing materials and fines have been identified in soil. Therefore it is recommended that ex-situ sampling occur prior to disposal to confirm the waste classification.

An assessment of the soil analytical results against potential site suitability criteria commercial/industrial – road and open space indicated:

- Selected soil samples exceeded the human health USEPA (2018) residential regional screening levels (RSLs). These criteria were selected as part of the soil human health assessment criteria for proposed recreational open space in the absence of criteria for particular analytes specific to exposure scenarios during proposed recreational open space land use and are therefore considered to be conservative for the proposed land uses (commercial/industrial – road and open space)
- Selected soil samples exceeded the NEPC (2013) NEPM ecological screening level (ESL) for urban residential and public open space for benzo(a)pyrene toxic equivalence quotient (TEQ).

Potential acid sulfate soils were detected in one sample RZ_BH79_2.7. Sample locations are shown in **Figure 4-19**.

4.9.9 Rozelle Bay sediment investigation results

As part of the preparation of this technical working paper, AECOM collected four composite sediment samples from Rozelle Bay immediately adjacent to the existing Whites Creek outlet and four composite sediment samples from Rozelle Bay immediately adjacent to the two existing Easton Park drain outlets. Construction works proposed include placement of two coffer dams in Rozelle Bay adjacent to both drainage outlets to assist with dewatering and expansion of both Easton Park drain and Whites Creek.

An assessment of the sediment analytical results against waste classification criteria indicated exceedances of benzo(a)pyrene and lead in the majority of samples and detections of asbestos. TCLP analysis for lead and benzo(a)pyrene was undertaken on selected samples to confirm the secondary chemical waste classifications. The reported results indicated that the material would be classified as Special Waste (Asbestos) secondary chemical classification Restricted Solid Waste for offsite disposal to landfill.

An assessment of the sediment analytical results against the selected ecological criteria for site reuse indicated the following contaminants of potential concern were detected and/or exceeded the selected ecological assessment criteria:

- Asbestos: Asbestos fines and asbestos containing material were detected in five of eight primary samples analysed
- Perfluroalkylated Substances (PFAS): PFAS compounds Perfluorooctanesulfonic acid (PFOS) and Perfluorohexane sulfonate (PFHxS) were detected in six of eight primary samples analysed
- Metals: Selected sediment samples exceeded the adopted ecological sediment assessment criteria for copper, lead, nickel and zinc
- PAHs: Selected sediment samples exceeded the adopted ecological assessment criteria for benz(a)anthracene, benzo(a)pyrene, phenanthrene and pyrene
- Phathalates: One sample exceeded the adopted ecological assessment criteria for Bis(2-ethyhexyl)phathalate.

An assessment of sediment analytical results against the ASSMAC (1998) guidelines indicated that potential acid sulfate soils were detected in two of eight samples analysed and actual acid sulfate soils were detected in six of eight samples analysed. Management procedures for acid sulfate soils would be adopted as part of the Construction Soil and Water Management Plan (CSWMP) prepared for implementation prior to intrusive works commencing.

4.9.10 Areas and contaminants of concern

The following areas and contaminants of concern were identified.

Table 4-28 Activities and areas of concern – The Crescent civil site at Annandale (C6)

<table>
<tr><th>Area</th><th>Potential contamination sources</th><th>Main PCoC</th></tr>
<tr><td colspan="3">Previously identified contamination in soil, sediment and groundwater</td></tr>
<tr><td>Part C6 – North-eastern boundary of Lot 22 DP 1151746 adjacent Rozelle Bay

Exceedances not detected at sample locations in the southern portion adjacent The Crescent</td><td rowspan="2">Figure 1 in Jacobs SAMP (2015b) indicated exceedances of the adopted assessment criteria at selected locations. Use of the site for marine, plant and machinery storage and maintenance.

Reclaimed land. Imported fill of unknown origin.

Migration of potentially contaminated groundwater onto the site and from the site.

Samples collected by Cardno (2010), SKM (1998) and Jacobs (2014).</td><td rowspan="2">• Lead
• PAHs
• Tributyltin
• Asbestos</td></tr>
<tr><td>Part C6 – Lot 21 DP 1151746</td></tr>
<tr><td colspan="3">Analytical results for soil samples collected by AECOM 2017</td></tr>
<tr><td>C6 –

Lot 22 DP 1151746

Lot 21 DP 1151746

Lot 20 DP 1151746</td><td>Reclaimed land.

Imported fill of unknown origin.</td><td>• Benzo(a)pyrene
• Selected PAHs
• Benzo(a)pyrene
• Selected PAHs</td></tr>
<tr><td colspan="3">Analytical results for sediment samples collected by AECOM 2017</td></tr>
<tr><td>Within project footprint at Whites Creek outlet and Easton Creek drain outlet at Rozelle Bay (sediment)</td><td>Based on analytical results detections and exceedances of the ecological assessment criteria.</td><td>• Asbestos
• PFAS – PFOS and PFHxS
• Metals (copper, lead, nickel and zinc)
• PAHs (benz[a]anthracene, benzo[a]pyrene, phenanthrene, pyrene)
• Phathalates (Bis[2-ethyhexyl]phathalate)</td></tr>
<tr><td colspan="3">Acid sulfate soils</td></tr>
<tr><td>C6 site is predominantly mapped Class 5 (no known occurrence of acid sulfate soils)</td><td>Class 1 mapped land is located within proximity to the site.

Soil analytical results indicated potential acid sulfate soils present on site.</td><td>• PASS/actual acid sulfate soils</td></tr>
<tr><td>Within project footprint at Whites Creek and Easton Creek drain outlet at Rozelle Bay (sediment)</td><td>Based on analytical results PASS/AASS are present.</td><td>• PASS/actual acid sulfate soils</td></tr>
</table>

Area	Potential contamination sources	Main PCoC
Surrounding areas within the Rozelle civil and tunnel site	Potential for up-gradient contaminants to be mobilised via sediment and stormwater flowing into Whites Creek and Easton Park drain into Rozelle Bay. Former timber yard southeast of the C6 site. Rozelle Rail Yards north and northwest of the C6 site within the Rozelle civil and tunnel site. Former mechanics further south of the Rozelle civil and tunnel site, immediately adjacent to the project footprint. Historical filling activities within the project footprint land surrounding Rozelle Bay. Boat maintenance activities and wharfing facilities within and adjacent to Rozelle Bay within the C6 site.	• Metals • Tributyltin • SVOCs • VOCs • TRH • BTEXN • PAHs • PASS/actual acid sulfate soils

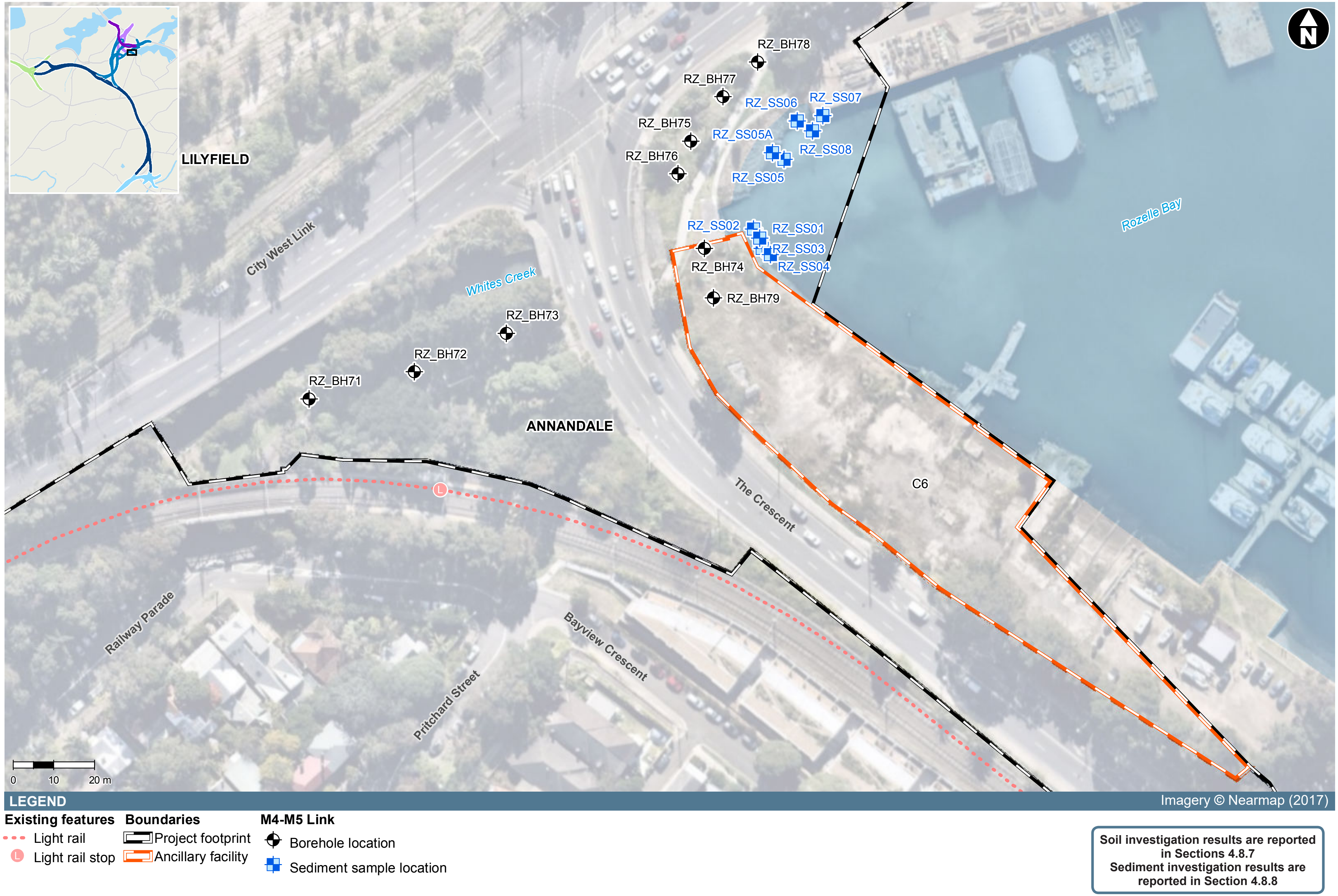


Figure 4-19 The Crescent civil site at Annandale (C6) - Borehole and sediment sample locations

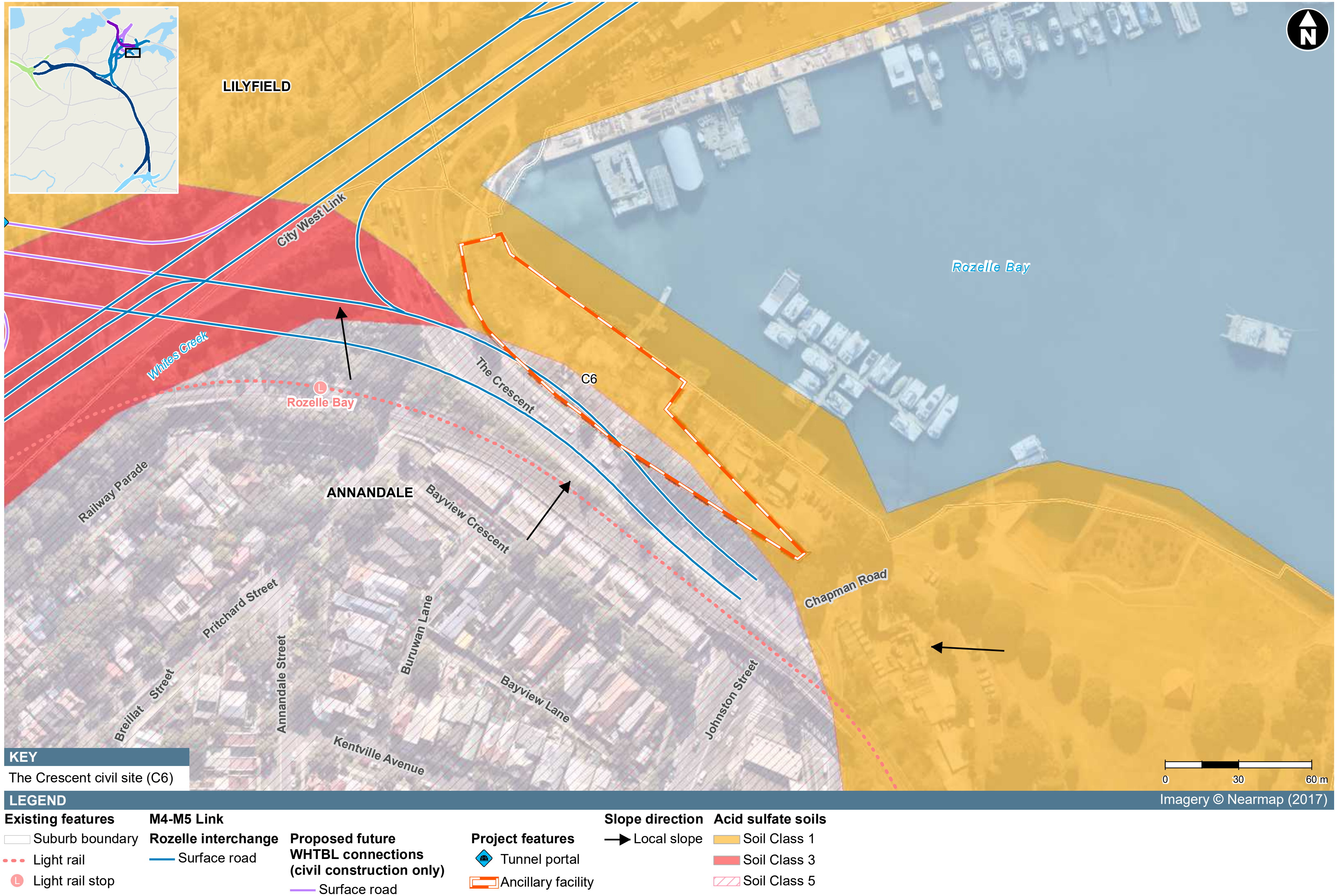


Figure 4-20 The Crescent civil site at Annandale (C6) - acid sulfate soils

4.10 C7 – Victoria Road civil site at Rozelle

4.10.1 Site description and surrounding area

The Victoria Road civil site is located within the suburb of Rozelle and within the Inner West Council LGA. The site is shown in **Figure 4-21** and would be located in an area currently comprising residential and commercial properties. The Victoria Road civil site slopes to the east and southeast and is surrounded by the land uses listed in **Table 4-29**.

Table 4-29 Surrounding land use – Victoria Road civil site at Rozelle (C7)

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 properties 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 followed by the White Bay Power Station and Glebe Island Container Terminal and White Bay.
West	• Medium and low density residential properties.

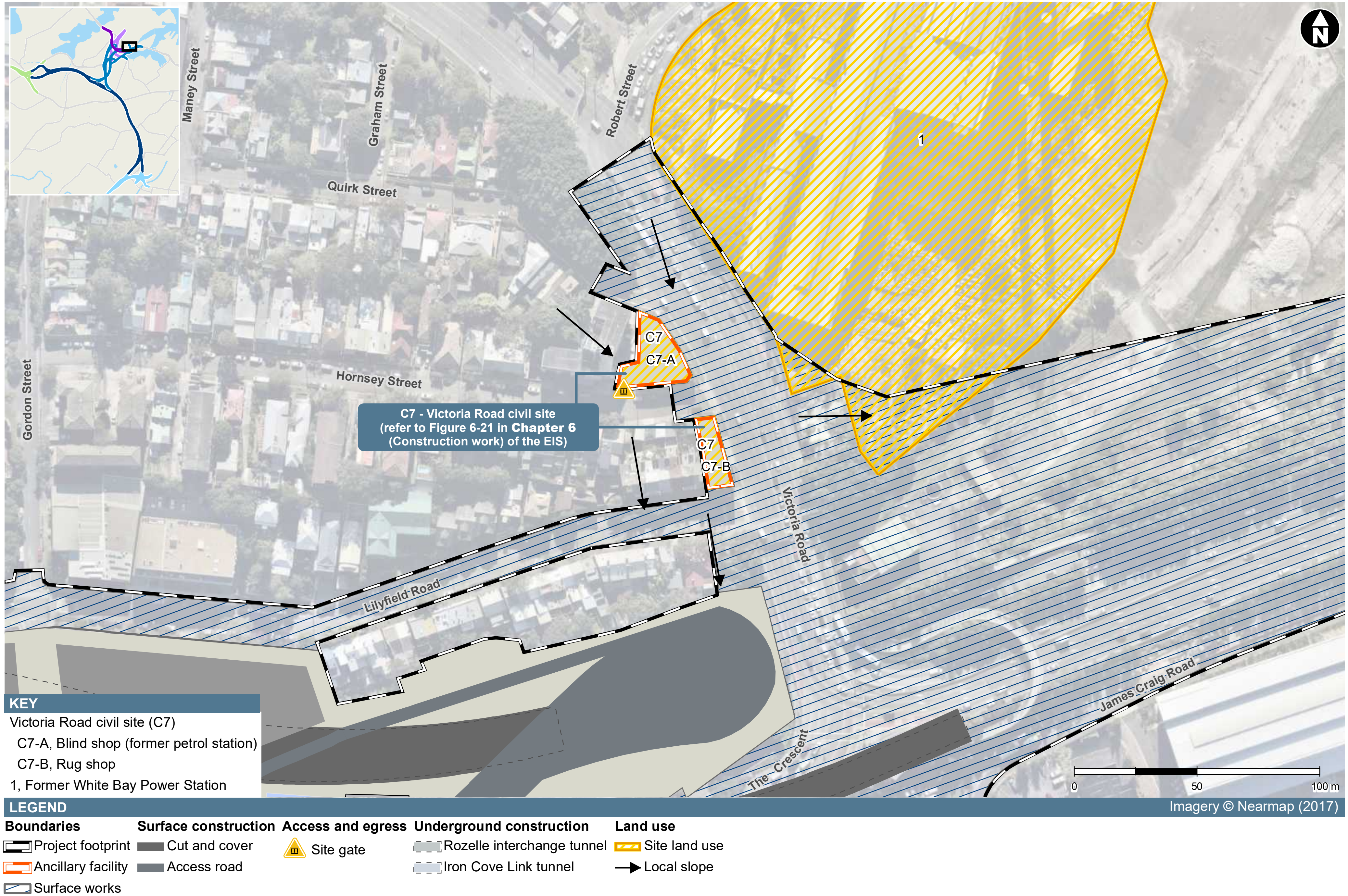


Figure 4-21 Victoria Road civil site at Rozelle (C7)

4.10.2 Previous investigations

AECOM is not aware of soil or groundwater investigations previously completed within the Victoria Road civil site in Rozelle.

4.10.3 Site history

A review of historical aerial photographs, historical UBD business directories and NSW EPA records were undertaken for the AECOM 2016b report. The information is summarised in **Table 4-30**.

Table 4-30 Site History Summary – Victoria Road civil site at Rozelle (C7)

Property	Site history summary
C7-A Blinds Business and residential properties	• In the historical aerial photographs, a small building was located on the land and was present from 1931 to 1951. The building changed in the 1961 aerial photograph and remained the same until after the 2009 aerial when the land appeared redeveloped • According to the UBD business directory data, the land was listed as Ampol Rozelle Service Station in 1991 and White Bay Filling & Service Station Pty Ltd in 1970 • Google Maps Street View© shows that a service station was still in place in December 2009 and appeared to contain seven fuel pumps, six vent pipes and a motor repair garage • In July 2013 a new commercial and residential building had been constructed over the land • No information was found in a search of NSW EPA public records • The land contained a two-storey relatively new commercial and residential building during the site inspection in January 2016.
C7-B Rug Business	• In the historical aerial photographs the land appeared to contain a terrace house up until and including 1951. The present day building was visible in 1961. • No information was found in a search of NSW EPA public records. • The land comprised an old two-storey commercial brick building during the site inspection in January 2016.

4.10.4 Soil and geology

According to the NSW Department of Industry, Resources and Energy (2014), 1:100,000 geological units and structures, the site is underlain by Triassic sandstone consisting of medium to coarse grained quartz sandstone, very minor shale and laminate lenses.

4.10.5 Hydrogeology

According to data provided by the (DPI-Water), Water Administration Ministerial Corporation and Commonwealth of Australia (Bureau of Meteorology) in December 2015, there were no registered groundwater wells within the site and two registered groundwater wells within one kilometre of the site. The wells were registered as groundwater monitoring wells and located 650 metres northeast of the site. The standing water level in the wells was 0.4 metres below ground level. Groundwater was monitored in a number of monitoring wells intersecting the sandstone including RZ_BH50, RZ_BH51, RZ_BH52 and RZ_BH30. The C7 ancillary facility is proposed to be located to the north of the Rozelle Rail Yards on sandstone and consequently is not underlain by alluvium.

The groundwater flow direction is expected to be predominantly towards Rozelle Bay to the south or White Bay to the east. Groundwater is expected to be present beneath the site as either shallow or perched groundwater in residual soils or fill and as deeper groundwater semi-confined or confined within the underlying bedrock.

4.10.6 Acid sulfate soils

According to information provided by DP&E, the site is within land mapped as Soil Class 5 (no known occurrence of acid sulfate soils) and is adjacent to Class 2 mapped land (see **Figure 4-22**). Works within 500 metres of adjacent Class 1, 2, 3 or 4 land that is below five metres AHD and by which the water table is likely to be lowered below one metre AHD on adjacent Class 1, 2, 3 or 4 land requires development consent and development of management procedures for acid sulfate soils.

4.10.7 Areas and contaminant of concern

The key areas and contaminants of concern within the site are summarised in **Table 4-31**.

Table 4-31 Areas and Contaminants of Concern – Victoria Road civil site at Rozelle (C7)

Property	Description	CoPC
C7-A Blinds business and residential properties	A petrol station was located within the land prior to redevelopment as a commercial property. The former underground petroleum storage systems (UPSS) could have caused soil or groundwater contamination.	TRH, BTEXN, PAHs, lead and asbestos
C7-B Rug business	Demolition of former residential building, potential hazardous building materials. The historical use of commercial building prior to use as a retail store is unknown but unlikely to be have used for an activity that could have caused contamination.	Lead and asbestos

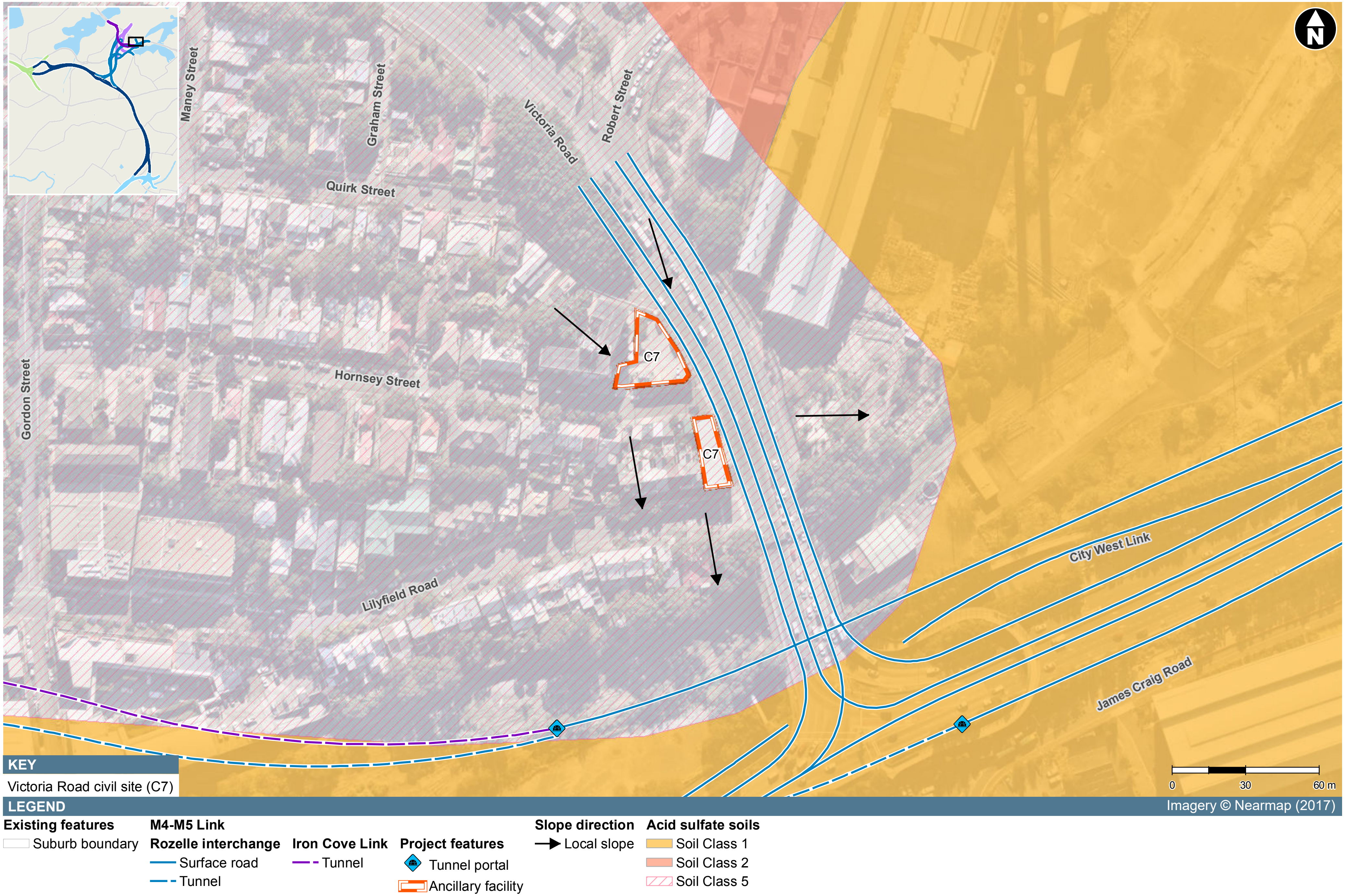


Figure 4-22 Victoria Road civil site at Rozelle (C7) - acid sulfate soils

4.11 C8 – Iron Cove Link civil site at Rozelle

4.11.1 Site description and surrounding area

The Iron Cove Link civil site (C8) is located within Rozelle and the Inner West Council LGA. The site is shown in **Figure 4-23** and would be located in an area currently comprising residential, commercial and industrial properties and road corridor and open space. The surrounding land use is summarised in **Table 4-32**.

Table 4-32 Surrounding land use – Iron Cove Link civil site at Rozelle (C8)

Direction	Description of surrounding land use and proximity to the Iron Cove Link civil site
North	• Bridgewater Park adjacent to Byrnes Street and residential apartments located directly to the north and topographically down-gradient • United 24 service station, Andrew Lyall car dealership and Caltex service station, VRS prestige (mechanics) and a substation are located directly adjacent and topographically up-gradient of the site • Iron Cove Bridge located immediately west and topographically down-gradient of the site.
South	• 7 Eleven service station is located adjacent and topographically up-gradient • Low density residential properties are located adjacent and topographically up-gradient.
East	• Rozelle Primary School is located 200 metres topographically up-gradient • Further east are Rozelle shops and low to medium density residential.
West	• King George Park adjacent and topographically down-gradient • Iron Cove (Parramatta River) located 50 metres and topographically down-gradient.

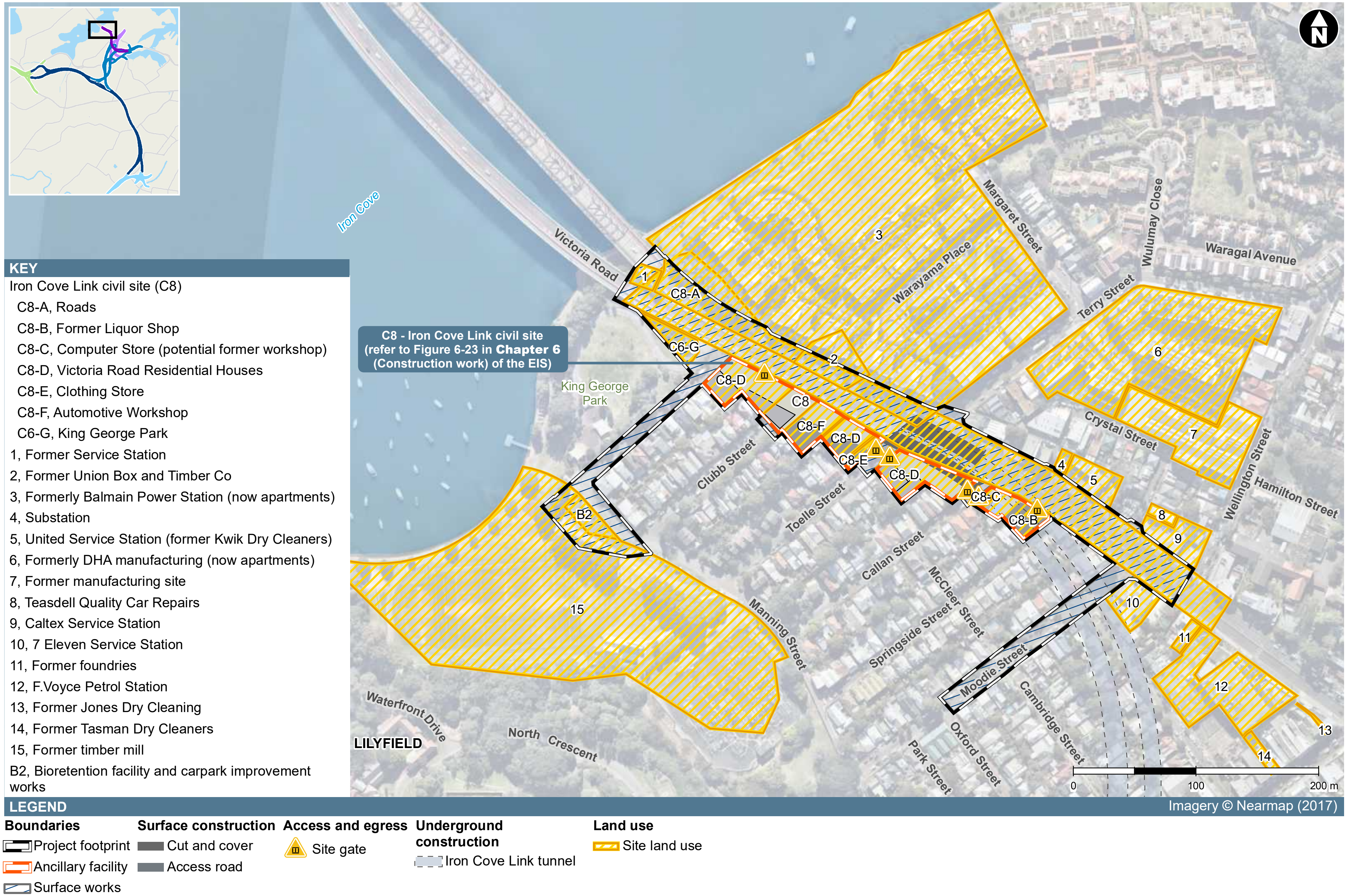


Figure 4-23 Iron Cove civil site at Rozelle (C8)

4.11.2 Previous investigations

An investigation was performed by Golder Associates in 2009 (Golder 2009) to inform the design of foundations for changeable message sign mast arms in the Rozelle area. The report identified that the top of the rock (sandstone) was encountered at depths of between 1.2 and two metres below ground level. There was no contamination investigation undertaken as part of the investigation.

AECOM is not aware of other soil or groundwater investigations previously completed within the Iron Cove Link civil site at Rozelle.

4.11.3 Site history

A review of historical aerial photographs, historical UBD business directories, historical titles, section 149 certificates and NSW EPA records was undertaken for the AECOM 2016c report. The information is summarised in **Table 4-33**.

Table 4-33 Site history summary – Iron Cove Link civil site (C8)

Property	Site history summary
C8-A Roads	• The historical aerial photographs showed that Victoria Road was realigned between 1943 and 1955. Prior to 1955 there were businesses located on Victoria Road west of Toelle Street, which were later demolished to make way for the new road alignment. An additional bridge was constructed on the south side of Iron Cove Bridge between 2007 and 2014; this work included the widening of the road leading to both bridges • 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 polychlorinated biphenyl (PCBs) and asbestos. The NSW EPA notices were revoked in August 1997 following remediation of the site and the site was developed for high density residential and recreational open space land use • According to historical UBD records, there were timber merchants, motor garages, petrol stations, metal founders, laundries and copper and vat maker businesses along Victoria Road in 1950 and 1970.
C8-B Liquor store	• According to historical UBD records, Door and Joinery Pty Ltd (carpenters) and Cavanagh Brothers (carpenters) in 1950, Springside service station was located at the site in 1970 and an Ampol service station was located on the land in 1991 and N.S.W. Sash • The historical aerial photographs showed that there were buildings constructed and demolished between 1930 and 1961. The present day layout appeared the same in 1961 • During the site inspection in September 2016, the land appeared to be a former petrol station, with the original sales building converted into a Liquorland store and the former forecourt into a car park. There was an area of patched bitumen in the concrete in the northern car park which appeared to be the likely location of decommissioned USTs. No vent pipes or evidence of the location of the former fuel dispensing infrastructure was observed.
C8-C Computer and equipment store	• Historical titles records indicated 10 different owners between 1898 and 2016. The property was formerly owned by a joiner from 1918 to 1978. Various private owners held the site until 1991 • There were no historical UBD records for the property • During the site inspection in September 2016, the building had two windows on the building fronting Victoria Road which appeared to be former garage entries. The building also had two garages at the rear of the building off Callan Street. The building age appeared to be pre-1940s.

Property	Site history summary
C8-D Victoria Road residential houses	• Based on the historical aerial photographs it appears the properties have been used for residential properties since at least 1930 • During the site inspection in September 2016, all properties appeared to be used for residential purposes.
C8-E Clothing store	• Historical aerial photographs showed that since 1930 the property has been occupied by a building with only minor changes evident through to 2014 • According to UBD records the property was occupied by Iron Cove Bridge Sandwiches & Pies and Mrs Reid (mixed business) in 1970 and Mrs M White (mixed business and general store) in 1950 • During the site inspection in September 2016, the property appeared to be used as a clothing store.
C8-F Car dealership	• Historical aerial photographs showed that there were changes to the buildings on the property between 1930 and 1961 • According to the Gabriel Motors website (http://www.gabrielmotors.com.au) the mechanics workshop opened on the property in 1977 • There are no historical UBD records for the property and no NSW EPA records.
C8-G King George Park	• Historical aerial photographs showed that there were changes to the park in the form of earthworks between 1930 and 2014.
C8-B2 Car park	• Historical aerial photographs showed that the site was a park in 1930 and then a timber mill which was constructed between 1930 and 1943 and demolished between 1955 and 1961. From 1965 the site appeared to be a grassed area now used for car parking • There were no distinguishable features within the site when the timber mill was present and the operations and buildings of the timber mill appeared to be down topographic gradient of the site.
Up-gradient land	• Commercial and industrial businesses were formally located up-gradient (south) of the property along Victoria Road including the following: – Kwik Dry Cleaners (near the northern boundary) – Mars Steel Products and Winnertons Pty Ltd (metal foundries) and Motorcycle workshop (near the southern boundary) – Speedy Steering Service and Atlanta Spares (mechanics) (20 metres south) – F.Voyce Petrol Station and Space Motors (40 metres southeast) – Traynor Dry Cleaners, Superb Dry Cleaners, Jones Dry Cleaning and Tasman Dry Cleaning (100 to 170 metres southeast) – Unknown manufacturing business (formerly notified to the NSW EPA – regulation not required) (70 metres north).

4.11.4 Soil and geology

According to the NSW Department of Industry, Resources and Energy (2014), 1:100,000 Sydney geology map sheet the Iron Cove civil site geology consists of Triassic sandstone consisting of medium to coarse grained quartz sandstone, very minor shale and laminate lenses.

According to information provided by OEH the soil landscape consists mostly of Gymea Erosional soils and Hawkesbury Colluvial soils.

4.11.5 Hydrogeology

According to data provided by the (DPI-Water), Water Administration Ministerial Corporation and Commonwealth of Australia (Bureau of Meteorology) in December 2015, no registered groundwater wells were located within the proposed Iron Cove civil site and one registered groundwater well was within one kilometre of the Iron Cove civil site. Groundwater is measured alongside Victoria Road within the sandstone in two monitoring wells BH_IC01 and BH_IC02. Groundwater levels within the sandstone are relatively deep at between 4 and 8 metres below ground level, the water table becoming deeper further away from Iron Cove. There is no alluvium containing groundwater at the Iron Cove site.

The closest groundwater well was a monitoring well located 21 metres west in King George Park, with a recorded well depth of 25 metres. The geology of this well was logged as clay to seven metres and siltstone to 25 metres.

The groundwater flow direction at the site is towards the northwest, towards Iron Cove. Deep groundwater is present within porous productive aquifer in the underlying Hawkesbury Sandstone.

4.11.6 Acid sulfate soils

According to information provided by DP&E, the majority of the site is mapped as the following (see **Figure 4-24**):

- Soil Class 2: Works below natural ground surface or works by which the water table is likely to be lowered present an environment risk and require development consent and management procedures for acid sulfate soils. A small area of the northeast corner of the site and the western half of W2 is mapped as Soil Class 2.
- Soil Class 5: No known occurrence of acid sulfate soils. Works within 500 metres of adjacent Class 1, 2, 3 or 4 land that is below five metres AHD and by which the water table is likely to be lowered below one metre AHD on adjacent Class 1, 2, 3 or 4 land requires development consent and management procedures for acid sulfate soils. The whole of the site is mapped as Soil Class 5 with the exception of the areas mapped as Soil Class 2.

4.11.7 Areas and contaminants of concern

The key areas and contaminants of concern within the Iron Cove civil site are summarised in **Table 4-34**.

Table 4-34 Areas and contaminants of concern – Iron Cove Link civil site at Rozelle (C8)

Property	Description	CoPC
C8-A Roads	Former petrol stations, manufacturing and timber industries located at the northwest end of Victoria Road. Imported fill from an unknown source potentially used to raise the level of the road near Iron Cove Bridge. The northeast corner of the area is mapped as Soil Class 1 for acid sulfate soils.	Metals, TRH, VOCs, SVOCs, asbestos Acid sulfate soils
C8-B Liquor store	Former petrol station and carpenters. Former UPSS is a potential source of soil and groundwater contamination. Imported fill from an unknown source potentially used to raise and level the site.	Metals, TRH, BTEX, PAHs, OCPs, PCBs, asbestos
C8-C Computer store	Potentially a former workshop, which may have historically stored and handled oils, fuels and solvents.	Lead, TRH, PAHs and VOCs

Property	Description	CoPC
C8-D Victoria Road residential houses	No areas of concern expected with the exception of the demolition/construction of buildings and use of lead paint which may have resulted in localised areas of ACM fragments and lead paint flakes in soil.	Lead, asbestos
C8-E Clothing store	No known former contaminating land uses.	Nil
C8-F Car dealership	Currently a mechanical workshop which would have historically stored and handled oils, fuels and solvents.	Lead, TRH, PAHs and VOCs
C8-G King George Park	Imported fill from an unknown source potentially used. Other unknown site activities appeared to have occurred on the site based on the historical aerial photographs.	Metals, TRH, BTEX, PAHs, OCPs, PCBs, asbestos
C8-B2 Car park	Imported fill from an unknown source potentially used. Operation of a timber mill on adjacent land in the 1940s and 1950s.	Metals, OCPs, PAHs, asbestos
Up-gradient land	Current and former petrol stations, mechanics, dry cleaners, manufacturing businesses and substation located adjacent and topographically up-gradient of the site.	Metals, TRH, VOCs, SVOCs, PCBs

Figure 4-24 Iron Cove civil site at Rozelle (C8) - acid sulfate soils

4.12 C9 – Pyrmont Bridge Road tunnel site at Annandale

4.12.1 Site description and surrounding area

The Pyrmont Bridge Road tunnel site is located within Annandale in the Inner West Council LGA. The site is shown in **Figure 4-25** and would be located in area currently comprising various commercial properties. The Pyrmont Bridge Road tunnel site at Annandale slopes to the northwest and is surrounded by the land uses listed in **Table 4-35**.

Table 4-35 Surrounding land use – Pyrmont Bridge Road tunnel site at Annandale (C9)

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 280 metres north.
South	• Parramatta Road followed by the Bridge Road School and mixed use commercial and medium to high density residential properties • Alfred's Dry Cleaning located 314 metres topographically up-gradient • Johnstons Creek is also located 150 metres northwest up-gradient.
East	• Booth Street followed by commercial and medium to high density residential properties • Grace Dry Cleaning and Laundry located around 95 metres topographically up-gradient • BP Connect Camperdown service station located around 270 metres topographically up-gradient.
West	• Camperdown Service Centre located around 50 metres topographically down-gradient • James Squires Brewery located adjacent and topographically down-gradient • 7 Eleven service station located 65 metres topographically down-gradient.

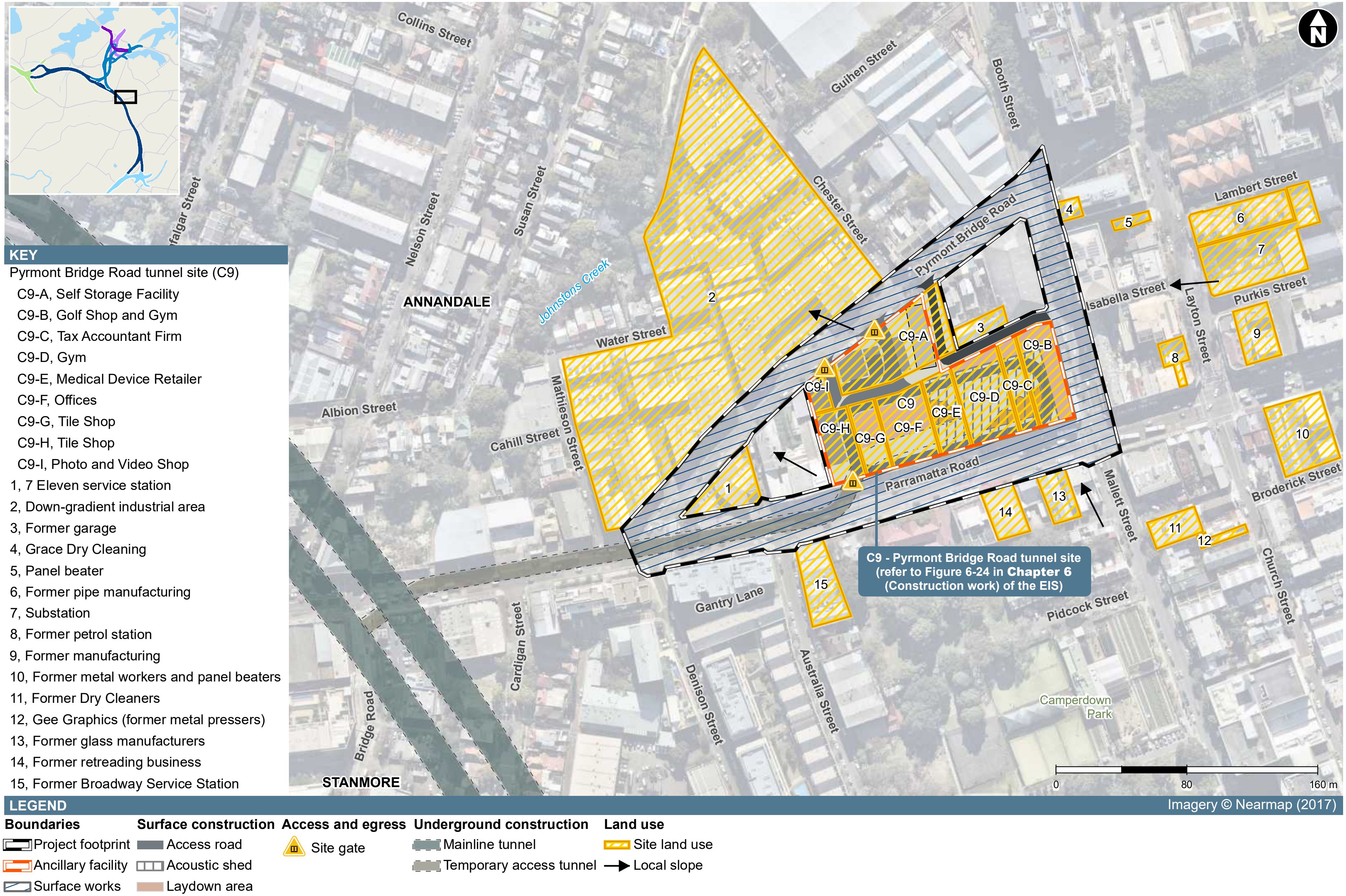


Figure 4-25 Pyrmont Bridge Road tunnel site at Annandale (C9)

4.12.2 Previous investigations

AECOM is not aware of soil or groundwater investigations previously completed within the Pyrmont Bridge Road tunnel site at Annandale.

4.12.3 Site history

A review of historical aerial photographs, historical UBD business directories and NSW EPA records were undertaken for the AECOM 2016d report. The information is summarised in **Table 4-36**.

Table 4-36 Site History Summary – Pyrmont Bridge Road tunnel site at Annandale (C9)

Property	Site history summary
C9-A Self-storage Facility	• The 1948 and 1956 historical survey map showed the property was occupied by Hastings Deering Limited (earth moving equipment manufacturers) • No businesses were identified within the property from the 1950 UBD business directory records. In 1970 Rowell Thiele Ford Pty Ltd (Motor car/truck dealers and spare parts) was located within the property and Millers Self Storage was located on the site in 1991 • The building configuration appeared the same as the present day in all historical aerial photographs between 1930 and 2014 (present day warehouse building) • The property is currently being used as a self-storage facility • The property was not listed on the NSW EPA record of notices or sites notified to the NSW EPA.
C9-B Golf shop and Gym	• The 1948 historical survey map showed the property was occupied by Bedford Trucks Sales and Service • The Australian Incandescent Co (electrical suppliers) was located on the site in 1950 according to the UBD business directory records. W.T Coggins Pty Ltd; a motor accessories wholesaler/car dealership was located at the site in 1950 and 1970 • There were no records available for a business at the property in 1991 • The building configuration appeared the same as the present day in all aerial photographs between 1930 and 2014 • The property is currently being used for a Golf retail store and gym.
C9-C Tax accountant firm	• The property was occupied by the Bank of NSW in the 1948 and 1956 historical survey maps • No UBD business records were available for the property in 1970 or 1991 • The historical aerial photographs showed that prior to 1970 there were previously small buildings or sheds in what is now the rear car park accessed by Bignell Lane. In 1982 there also appeared to be some small sheds along the western boundary of the car park and the ground in the car park appeared disturbed • The property is currently being used as a tax accounting firm • The property was not listed on the NSW EPA record of notices or sites notified to the NSW EPA.

Property	Site history summary
C9-D Gym	• The UBD business directory records showed J.T.A Pryer & Son (blacksmiths and welders), Ferrier, Dickinson and Weir Drysdale Ltd (motor garage/engineers) and J.W. Rigden & Son Pty Ltd (a motor parts and accessories dealer) were located within the site in 1950 • According to the 1956 historical survey map the property was occupied by Pioneer Spring Co Ltd (spring manufacturers) • In 1970 J.W. Rigden & Son Pty Ltd, Australian Brake Lining Co Pty. Ltd (motor brakes manufacture and wholesaler) and Speedy Spring Service Pty Ltd (spring manufacturers) were located within the property. In 1991 the site contained Jay-Jay Jeans Warehouse, a clothing manufacture and wholesaler • Between 1943 and 1970 the site appeared to consist of two long narrow buildings with a driveway between them, and appeared to be part of the building adjacent to the west. The western building had been demolished and replaced with a car park in 1982. A new building had been constructed across the entire property by the 1991 aerial photograph • The property is currently being used by Camperdown Fitness, a gym and personal training facility • The property was not listed on the NSW EPA record of notices or sites notified to the NSW EPA.
C9-E Medical device retailer	• According to the 1956 historical survey map the property was occupied by F.R.S Springs (spring manufacturing) • Spray King Auto Painting International Inc., a motor body repair and accessory wholesaler was located within the property in 1970 according to the UBD business directory records • The building configuration appeared the same in all historical aerial photographs between 1930 and 2014, with the exception of the connection to the adjoining former warehouse between 1943 and 1970 • The property is currently being used as medical device retailer • The property was not listed on the NSW EPA record of notices or sites notified to the NSW EPA.
C9-F Offices	• According to the 1956 historical survey map the property was occupied by the Australian Incandescent Co (electrical supplies/manufacturing) • Thorn Electrical Industries (Aust.) Pty Ltd, a refrigerator wholesaler was located at the property in 1970 • Starkey Laboratories Australia Pty Ltd (hearing aids), James Creative Services Pty Ltd (advertising agency) and Reproduction Tiles (tile merchants) were located within the property in 1991 • The building configuration appeared the same as the present day in all historical aerial photographs between 1943 and 2014. The building was not distinguishable in the 1930 aerial photograph • At the time of the site inspection the property was an office building occupied by a number of businesses • The property was not listed on the NSW EPA record of notices or sites notified to the NSW EPA.

Property	Site history summary
C9-G Tile shop	• According to the 1956 historical survey map the property was occupied by W.R Carpenter & Co Ltd (mechanics and part dealers) • U.R.I. Printing Industries Pty Ltd, a printer lithographic was located at the property in 1991 according to the UBD records. There were no UBD records for 1950 and 1970 • The building configuration appeared the same in all historical aerial photographs between 1930 and 2014 • The location is currently being used as a tile store • The property was not listed on the NSW EPA record of notices or sites notified to the NSW EPA.
C9-H Tile shop	• Bass Products (light fitting manufacturers) and Novelta Textiles Pty Ltd (textile manufacturers) and C.H, Robertson (gasket manufacturers) in 1950 according to UBD business directories • According to the 1956 historical survey map the property was occupied by Consolidated Neon Ltd (light fitting manufacturers) in 1956 • The property was not listed on the NSW EPA record of notices or sites notified to the NSW EPA • The property is currently being used as a tile retail store.
C9-I Photo and Video shop	• Burrows Plating Works Pty Ltd (annunciators and electroplaters) was located within the property in 1950 and 1970 according to the UBD business directory records • The property was not listed on the NSW EPA record of notices or sites notified to the NSW EPA • The property is currently being used as a photography studio.
Surrounding land	• Motor garages, petrol stations, dry cleaners, metal platers and manufacturing businesses were all located topographically up-gradient and within 150 metres of the Pyrmont Bridge Road tunnel site according to the UBD business directory records between 1950 and 1991 • Sites notified to the NSW EPA under section 60 of the CLM Act and topographically up-gradient of the Pyrmont Bridge Road tunnel site: – Former Gee Graphics (27 Church Street, Camperdown), regulation under CLM Act not required (around 100 metres southeast) – Shell Coles Express service station, 124–126 Johnston Street. Annandale, regulation under CLM Act not required (around 700 metres northwest) • O'Dea Reserve, Salisbury Lane, Camperdown (340 metres south), a former uncontrolled landfill in a former brick pit, was formerly regulated by the NSW EPA under the CLM Act 1997 for PAH, lead and TPH contamination, which suggests this location has historically been remediated.

4.12.4 Soil and geology

According to the NSW Department of Industry, Resources and Energy (2016), 1:100,000 scale geological units and structures, the geology of the Pyrmont Bridge Road tunnel site at Annandale consists of the Triassic Ashfield Shale from the Wianamatta Group, which is described as black to dark grey shale and laminate.

4.12.5 Hydrogeology

According to data provided by the (DPI-Water), Water Administration Ministerial Corporation and Commonwealth of Australia (Bureau of Meteorology) in August 2016, there are no registered groundwater wells within the Pyrmont Bridge Road tunnel site at Annandale and 10 registered groundwater wells within one kilometre. All 10 wells were registered as monitoring wells. Further details are listed as follows:

- Four monitoring wells were located in O'Dea Reserve, 423 metres south of the site. The wells were installed to depths of 2.5 to 10.7 metres below ground level
- Two private monitoring wells were registered at 80 Parramatta Road Camperdown, 450 metres east of the site. The wells were installed to depths of 1.8 and 3.2 metres below ground level
- Three private monitoring wells were registered at the Shell Coles Express Annandale, 710–740 metres northwest of the Pyrmont Bridge Road tunnel site. The wells were installed to depths of four metres below ground level. Standing water level in these wells has been registered as 1.75 and 2.4 metres below top of casing
- One private well was registered at a car dealership located at 36–38 Parramatta Road Glebe, 739 metres east of the Pyrmont Bridge Road tunnel site. The well was installed to a depth of 4.4 metres below ground surface, with standing water level of 2.07 metres below top of casing.

Camperdown is underlain by Ashfield Shale which typically displays a weathered profile consisting of clay. At Camperdown five monitoring wells were constructed (AECOM 2017a) that intersected Ashfield Shale and the underlying Hawkesbury Sandstone. The area has a relatively high topography and consequently groundwater level depths range between two and nine metres below ground level and reflect the elevated topography.

Aquifers within one kilometre of the Pyrmont Bridge Road tunnel site at Annandale are described as being porous, extensive and highly productive in the Hawkesbury Sandstone.

Groundwater is expected to flow to the northwest towards Johnstons Creek and Rozelle Bay.

4.12.6 Acid sulfate soils

According to information provided by DP&E, the site is mapped as Soil Class 5: No known occurrence of acid sulfate soils. Works within 500 metres of adjacent Class 1, 2, 3 or 4 land that is below five metres AHD and by which the water table is likely to be lowered below one metre AHD on adjacent Class 1, 2, 3 or 4 land requires development consent and management procedures for acid sulfate soils. Land mapped as Soil Class 3 is located 110 metres northwest of the site (see **Figure 4-26**).

4.12.7 Areas and contaminants of concern

The key areas and contaminants of concern within the Pyrmont Bridge Road tunnel site are summarised in **Table 4-37**.

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Table 4-37 Areas and contaminants of concern – C9 Pyrmont Bridge Road tunnel site at Annandale

Property	Description	CoPC
C9-A Self-storage Facility	Former earth moving machinery manufacturing	Metals, TRH, BTEXN, PAHs, VOCs
C9-B Golf shop and Gym	Potential former workshops and mechanics	Metals, TRH, BTEXN, PAHs, VOCs
C9-C Tax accountant firm	Former carpenters and demolition of former structures at rear of the property	Lead, asbestos and PCBs
C9-D Gym	Former manufacturing and workshops and demolition of former building	Metals, TRH, BTEXN, PAHs, VOCs, asbestos, PCBs
C9-E Medical device retailer	Former manufacturing and workshops	Metals, TRH, BTEXN, PAHs, VOCs
C9-F Offices	Former manufacturing	Metals, TRH, BTEXN, PAHs, VOCs
C9-G Tile shop	Former mechanics workshops	Metals, TRH, BTEXN, PAHs, VOCs
C9-H Tile shop	Former fluorescent light manufacturing	Metals, PCBs
C9-I Photo and Video shop	Former electroplaters	Metals, TRH, cyanide
Off-site sources	Former motor garages, petrol stations, dry cleaners, metal platers and manufacturing businesses had the potential to cause contamination.	Metals, TRH, BTEXN, PAHs, VOCs, SVOCs, cyanide

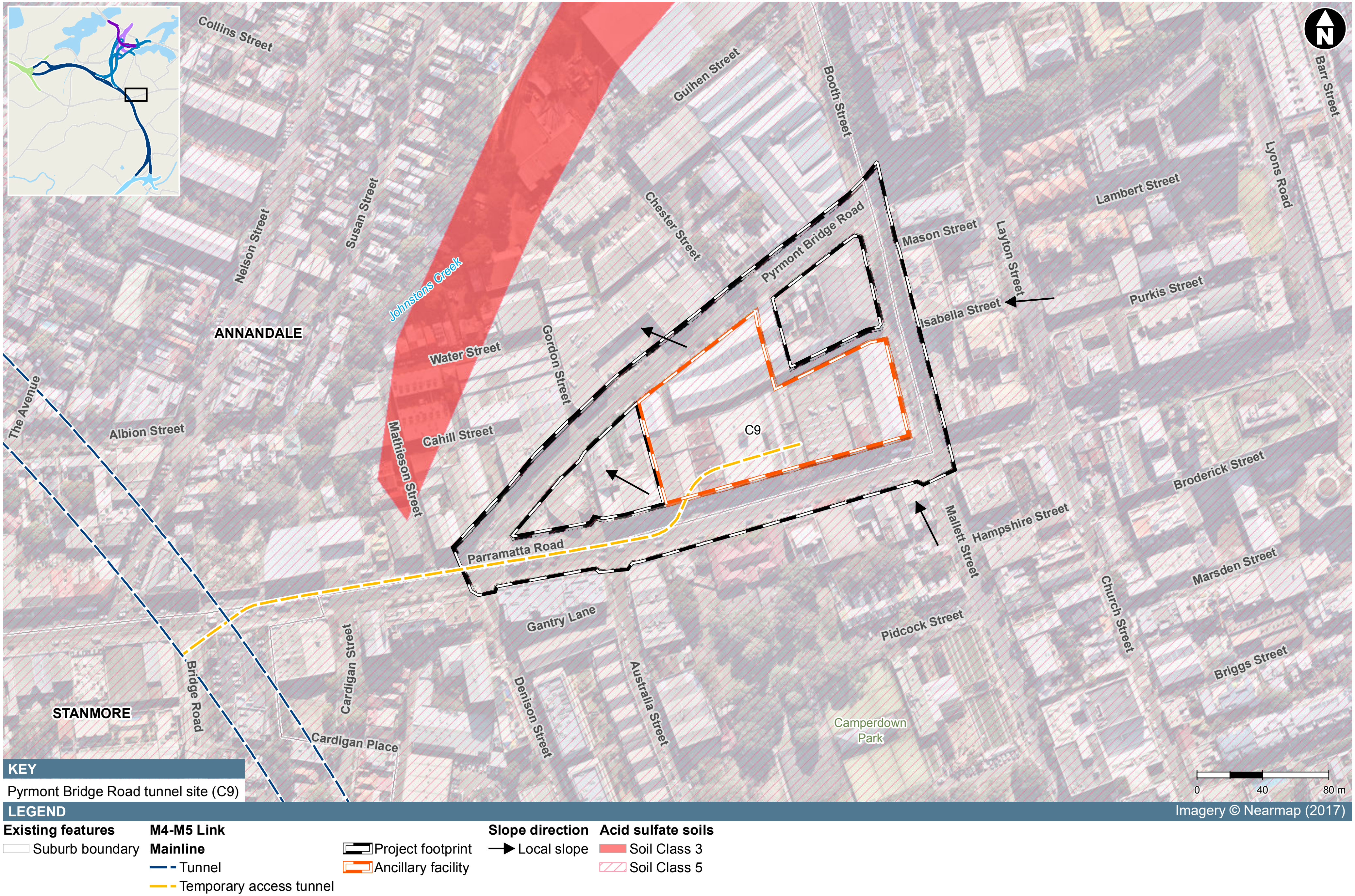


Figure 4-26 Pyrmont Bridge Road tunnel site at Annandale (C9) - acid sulfate soils

4.13 C10 – Campbell Road civil and tunnel site at St Peters

4.13.1 Site description

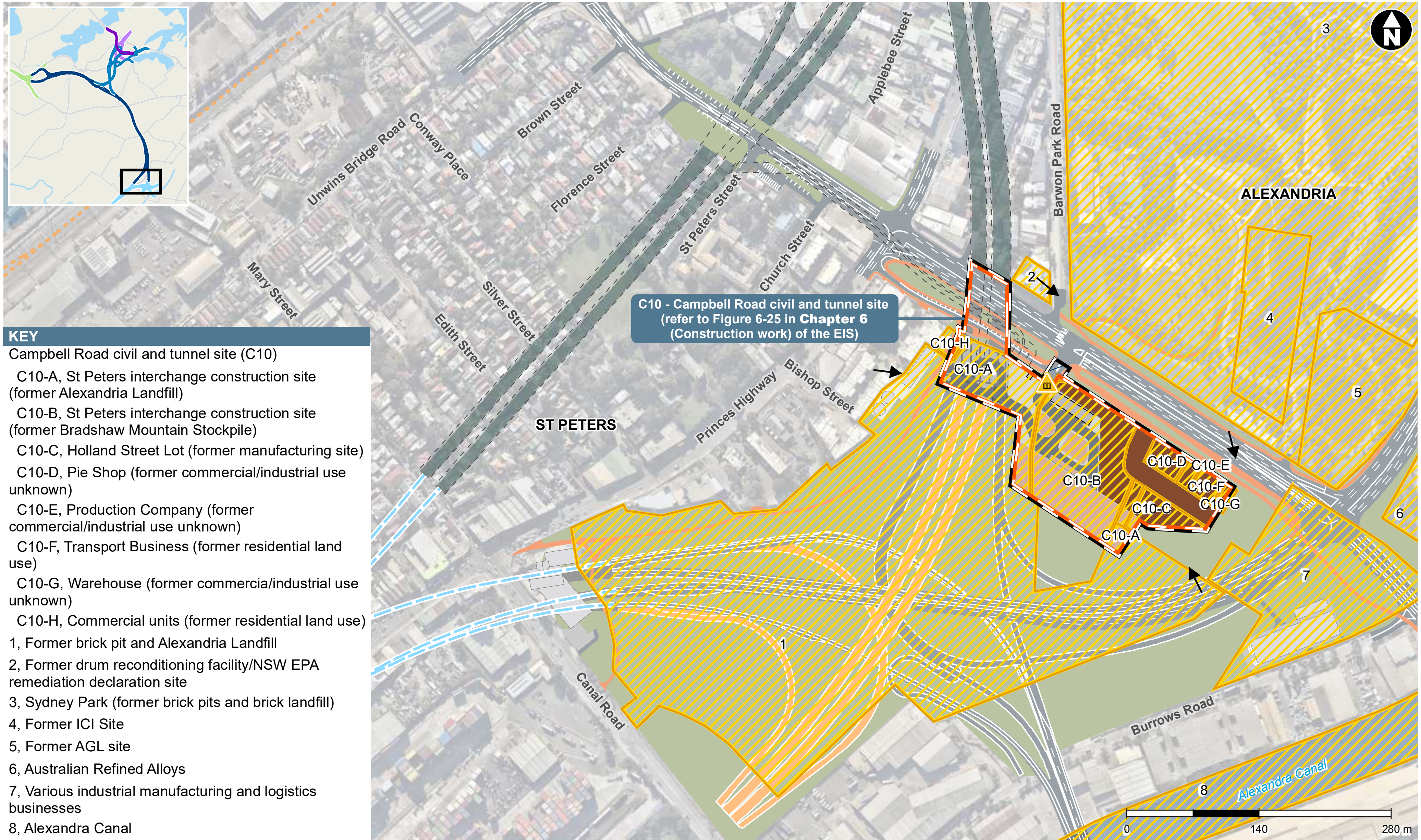
The Campbell Road civil and tunnel site is located at St Peters within the Inner West Council and City of Sydney LGAs. The site is shown in **Figure 4-27** and would be located on land currently being used as a construction site for the New M5 project**.** The findings of contamination investigations previously undertaken for the New M5 project are summarised in **Table 4-41**.

Following approval of the New M5 project, the Campbell Road civil and tunnel site has undergone significant clearance and construction work. It is understood that these works are being managed under the WestConnex New M5 *Construction Contaminated Management Plan* (Document: M5N-ES-PLN-PWD-0033), 17 November 2016.

The Campbell Road civil and tunnel site at St Peters slopes to the southeast and is surrounded by the land uses listed in **Table 4-38.**

Table 4-38 Surrounding land use – Campbell Road civil and tunnel site at St Peters (C10)

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.



KEY

Campbell Road civil and tunnel site (C10)

C10-A, St Peters interchange construction site (former Alexandria Landfill)

C10-B, St Peters interchange construction site (former Bradshaw Mountain Stockpile)

C10-C, Holland Street Lot (former manufacturing site)

C10-D, Pie Shop (former commercial/industrial use unknown)

C10-E, Production Company (former commercial/industrial use unknown)

C10-F, Transport Business (former residential land use)

C10-G, Warehouse (former commercia/industrial use unknown)

C10-H, Commercial units (former residential land use)

1, Former brick pit and Alexandria Landfill

2, Former drum reconditioning facility/NSW EPA remediation declaration site

3, Sydney Park (former brick pits and brick landfill)

4, Former ICI Site

5, Former AGL site

6, Australian Refined Alloys

7, Various industrial manufacturing and logistics businesses

8, Alexandra Canal

LEGEND

Imagery © Nearmap (2017)

Existing features New M5
- Railway
- Proposed future Sydney Gateway connections (non-operational as part of M4-M5 Link)
- Tunnel
- Building
- Surface road
- Shared path
- Land subject to New M5 conditions of approval

Boundaries
- Project footprint
- Ancillary facility
- Surface works

Surface construction
- Access road
- Acoustic shed
- Laydown area

Access and egress
- Site gate

Underground construction
- Mainline tunnel
- Temporary access tunnel

Land use
- Site land use
- Local slope

Figure 4-27 Campbell Road civil and tunnel site at St Peters (C10)

4.13.2 Previous intrusive investigations

The following soil, groundwater and landfill gas investigations have been undertaken that are relevant to the Campbell Road civil and tunnel site:

- AECOM, 2015b. WestConnex Stage 2: M5 Factual Contamination Assessment. 60327128_CI_RPT03_Draft_20150422. 22 April 2015
- AECOM, 2015c. Characterisation of the Bradshaw Mountain Stockpile – Resource Recovery Order for Potential Excavated Natural Material Exemption (Draft). 24 April 2015
- AECOM, 2015d. Phase 2 Environmental Site Assessment Alexandria Landfill, 10-16 Albert Street, NSW. 60327128_Draft Phase 2 ESA_20150506_A. 6 May 2015.

4.13.3 Site history

Key historical information for the Campbell Road civil and tunnel site has been summarised from the previous reports in **Table 4-39**.

Table 4-39 Site History Summary pre-New M5 – Campbell Road civil and tunnel site at St Peters (C10)

Property	Site history summary
C10-A St Peters interchange construction site (former Alexandria Landfill)	• The property was a mixture of unknown commercial/industrial land use and agricultural land use prior to 1908. The property was then a Ralford pit quarry and brick works operated by the Austral Brick Company until 1962 • The City of Sydney 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 (AECOM, 2014) • The property was then acquired by the NSW Government in 2015 • AECOM undertook soil, groundwater, leachate and landfill gas investigations and assessments in 2014 and 2015 (AECOM 2015d) and prepared a Landfill Closure Management Plan (AECOM 2015f) for the property • The property is currently operated by the CPB Contractors, Dragados, Samsung Joint Venture for the construction of the St Peters interchange as part of the New M5 project and is being managed under the WestConnex New M5 Construction Contaminated Management Plan (Document: M5N-ES-PLN-PWD-0033), 17 November 2016 and the Golder Associates (2016). Design Report – Alexandria Landfill & Bradshaw Mountain Remediation Action Plan (RAP). St Peters Interchange – Alexandria Landfill and Bradshaw Mountain Sites (Document: M5N-GOL-MNP-900-300-WT-9401-D), 12 April 2016 • The premises is licensed for road construction under EPL 4627. The Licensee for the site is the CPB Contractors, Dragados, Samsung Joint Venture. The EPL includes requirements for closure of the landfill, including leachate and landfill gas management measures, which must be undertaken in accordance with the landfill closure plan.

Property	Site history summary
C10-B St Peters interchange construction site (former Bradshaw Mountain Stockpile)	• 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 (AECOM, 2014) • AECOM completed an assessment of the stockpiled sandstone against the *Excavated Natural Material Exemption Order* 2014 in 2015 (AECOM 2015c) • The property is currently operated by the CPB Contractors, Dragados, Samsung Joint Venture for the construction of the St Peters interchange as part of the New M5 project and is being managed under the WestConnex New M5 Construction Contaminated Management Plan (Document: M5N-ES-PLN-PWD-0033), 17 November 2016.
C10-C Holland Street Lot	• According to the historical certificates of titles the property was previously occupied by Francis Holbeach (fishing line manufacturing) from 1926 to 1947, Ralph Symonds Pty Ltd (laminated timber veneer manufacturers) from until 1970, Alltrans Storage (S.A) Pty Ltd until 1995, Brambles Australia Ltd until 1999 and then Glenridge Holdings (AECOM 2014) • Based on the historical aerial photographs a factory was constructed on the property in the early 1950s. The factory continued to the east on the adjacent lot. The factory roof on the property was demolished between 1999 and 2004 • The walls of the original factory remained and the property was leased to various businesses as a yard for equipment and stockpiling until acquisition for the New M5 project in 2016 • The property is currently operated by the CPB Contractors, Dragados, Samsung Joint Venture for the construction of the St Peters interchange as part of the New M5 project and is being managed under the WestConnex New M5 Construction Contaminated Management Plan (Document: M5N-ES-PLN-PWD-0033), 17 November 2016.
C10-D Pie shop	• Based on the historical aerial photographs the present day factory building has been present since at least 1978. Prior to 1978 the property contained several smaller commercial or industrial buildings • A pre-1970s survey map showed that the property site was occupied by Helicon Pty Ltd (business type unknown) • The site was most recently used as a pie shop until acquisition for the New M5 project in 2016 • The property is currently occupied by the CPB Contractors, Dragados, Samsung Joint Venture for the construction of the St Peters interchange as part of the New M5 project and is being managed under the WestConnex New M5 *Construction Contaminated Management Plan* (Document: M5N-ES-PLN-PWD-0033), 17 November 2016.

Property	Site history summary
C10-E Production Company	• Based on the historical aerial photographs the current workshop building has been present since the 1960s. Prior to 1960 the property appeared to contain a number of small sheds • The site was most recently used by a production company as a workshop until acquisition for the New M5 project in 2016 • The property is currently occupied by the CPB Contractors, Dragados, Samsung Joint Venture for the construction of the St Peters interchange as part of the New M5 project and is being managed under the WestConnex New M5 Construction Contaminated Management Plan (Document: M5N-ES-PLN-PWD-0033), 17 November 2016.
C10-F Transport Business	• The property contained residential houses from pre 1930 until between 1960 and 1978 when the houses were demolished and a warehouse was constructed on the eastern side of the property. The property appeared undeveloped since • The property was most recently used as a yard for Brownways Transport until acquisition for the New M5 project in 2016 • The property is currently occupied by the CPB Contractors, Dragados, Samsung Joint Venture for the construction of the St Peters interchange as part of the New M5 project and is being managed under the WestConnex New M5 Construction Contaminated Management Plan (Document: M5N-ES-PLN-PWD-0033), 17 November 2016.
C10-G Warehouse	• The property contained residential houses from pre-1930 until between 1961 and 1978 when the present day warehouse building was constructed • The use of the site was unknown at the time of acquisition for the New M5 project in 2016 • The property is currently occupied by the CPB Contractors, Dragados, Samsung Joint Venture for the construction of the St Peters interchange as part of the New M5 project and is being managed under the WestConnex New M5 *Construction Contaminated Management Plan* (Document: M5N-ES-PLN-PWD-0033), 17 November 2016.
C10-H Commercial units	• The property contained residential houses from pre-1930 until the 1990s based on historical aerials. The property was then redeveloped into commercial units • The site was used by various commercial businesses at the time of acquisition for the New M5 project in 2016 • The property is currently occupied by CPB Contractors, Dragados, Samsung Joint Venture for the construction of the St Peters interchange as part of the New M5 project.

Property	Site history summary
Surrounding land	• The St Peters brick pits and brick works were located to the north of Campbell Road. The brick pit quarries were converted into council solid waste landfills and then redeveloped into Sydney Park • There were various industrial properties north of the site area including Hibbards Meters Pty Ltd, Imperial Chemical Industries (ICI), Australian Gas and Light Company (AGL) gasholders, R Clifford and Son Transport, Endochrome Pty Ltd and Universal Constructions • Industrial properties were also located to the east of the site, including F.A Harper and Sons Pty Ltd (unknown business type) and Rudders Ltd (logistics) • A former drum reconditioning facility located on the corner of Barwon Park Road and Campbell Road and topographically up-gradient of the C9 site was formerly declared a remediation site by the NSW in 2006. The declaration was for soil contaminated with PAHs, TPH and BTEXN and groundwater contaminated with naphthalene and TPH migrating off-site.

4.13.4 Soil and geology

AECOM completed intrusive investigations within the Campbell Road civil and tunnel site within the former Alexandria Landfill (C10/1) (AECOM 2015d) and Bradshaw Mountain (C10/2) (AECOM 2015c). The investigations included eight boreholes in the former Alexandria Landfill part of the site and eight boreholes in the Bradshaw Mountain part of the site.

The investigations showed that landfill extends to depths of up to 33.5 metres below ground surface in the portion of the Campbell Road civil and tunnel site within the former Alexandria Landfill. Closer to Albert Street the depth of the fill is less than 2.5 metres below ground surface. The landfill was directly underlain by bedrock.

Prior to reuse, Bradshaw Mountain consisted of crushed sandstone until the depth of the surrounding ground level and then three to 10 metres of underlying fill (non-landfill waste), followed by alluvial sediments consisting of silty sand and clay (Botany Sands) and then bedrock.

AECOM completed geotechnical investigations within and surrounding the Campbell Road civil and tunnel site to inform the WestConnex project (AECOM 2015b). The works included coring 13 boreholes (WXCBH045 to WCXBH60) to a maximum depth of 51 metres below ground surface (-44.26 metres AHD). The investigation found that the landfill overlays laminite and siltstone of the Ashfield Shale group and then Hawkesbury Sandstone.

Much of the soil and fill material (including the Bradshaw Mountain stockpile) identified during previous investigations completed for the New M5 project has been excavated or removed as part of the bulk earthworks required for construction of the St Peters interchange. Any residual landfill waste would be managed in accordance with the Golder Associates (2016) RAP prepared for the St Peters interchange as part of the New M5 project.

4.13.5 Acid sulfate soils

Based on review of the previous Marrickville Council and City of Sydney Acid Sulfate Soil Risk Map Sheets and the presence of Holocene estuarine sediments, there is potential for acid sulfate soils to be present within the site. The north-western half of the site is indicated as Class 2 acid sulfate soils and the south-eastern half as Class 3 acid sulfate soils under the classification scheme (see **Figure 4-28**). Class 2 means that any works below the natural ground surface or works where the groundwater table would be lowered would require development consent. Class 3 means that any work greater than one metre below ground surface or any works that would lower the water table by greater than one metre bgs would require development consent.

4.13.6 Hydrogeology

Four groundwater monitoring wells were previously installed within the Campbell Road civil and tunnel site within the former Alexandria Landfill (C10/1) (AECOM 2015d). The construction details are summarised in **Table 4-40**.

Table 4-40 Groundwater monitoring wells – Campbell Road civil and tunnel site at St Peters (C10)

Well ID	Screened interval (metres btoc)	Screened lithology	Standing water level (metres btoc)	Standing water level (metres AHD)
MW308	30.5 to 33.5	Landfill	21.985	-12.515
MW309	6.2 to 9.8	Botany Sands	4.480	-1.53
MW310	4.7 to 5.1	Botany Sands	4.330	1.14
MW311	9.9 to 12.9	Landfill	12.965	-4.865

The AECOM 2015d report found that the groundwater flow in the Botany Sands, landfill and bedrock was towards the main leachate extraction sump located around 300 metres southwest of the Campbell Road civil and tunnel site in the former Alexandria Landfill. A new leachate extraction system has been installed as part of the landfill closure plan developed for the St Peters interchange, for the New M5 project.

Groundwater is present within the Ashfield Shale and the Botany Sands to the south east. Groundwater levels are influenced by the leachate pumping from the former landfill locally causing groundwater flow to be artificially centred on the landfill. Groundwater quality immediately around the landfill may be influenced by the landfill with both elevated ammonia and nutrients among the contaminants of concern. Groundwater levels monitored in wells SP_BH04, SP_BH09, SP_BH06 (AECOM 2017a) range between 4 and 16 m below ground level and are depressed due to the leachate pumping.

4.13.7 Intrusive investigation results

The findings from the previous investigations (AECOM 2015b, 2015c and 2015d) are summarised in **Table 4-41**.

Table 4-41 Intrusive Investigation Results – Campbell Road civil and tunnel site at St Peters (C10)

Property	Description
C10-A St Peters interchange construction site (former Alexandria Landfill)	• Ten boreholes (BH351, BH353, BH361, BH362, BH364, BH356, BH357, BH407, BH408 and WCX_BH_059) were sampled in the C10-A area. A further 74 boreholes were sampled within the surrounding St Peters interchange construction site/former Alexandria Landfill to the south • Four groundwater monitoring wells (MW1, MW311, MW309 and MW310) were sampled in the C10-A area. A further 13 monitoring wells were sampled within the surrounding St Peters interchange construction site/former Alexandria Landfill to the south • Three landfill gas monitoring wells (LG308, LG310 and LG309) were sampled in the C10-A area. A further 10 monitoring wells were sampled within the surrounding St Peters interchange construction site/former Alexandria Landfill to the south • Concentrations of metals, TRH, CPAHs, PAHs, PCBs, dioxins and asbestos within subsurface soil variably exceeded the adopted human-health based assessment criteria for both the open space and commercial/industrial land use scenarios (ASC NEPM (2013) HIL C and HIL D). Contamination was mainly confined to the fill and randomly distributed both laterally and throughout the full depth of the landfill • Friable asbestos was detected in surface soils at concentration's greater than the assessment criteria for both the open space and commercial/industrial land use scenarios and was widespread across the site • Concentrations of CoPC in natural soils underlying the fill were less than the adopted human-health and ecological based assessment criteria. Analytical results indicated PASS was present in natural soils • Based on the concentrations of methane and flow rates measured, the site was classified as Characteristic Gas Situation 4 (moderate to high risk) definition based on the MWCC (NSW EPA 2012) • Landfill gases carbon dioxide and carbon monoxide were detected at high concentrations with concentrations of hydrogen sulfide exceeding the adopted site assessment criteria • Concentrations of TRH >C10-C34 fractions, benzene, manganese, nickel, sodium, chloride and TDS exceeded the human health based criteria in groundwater. TRH >C10-C34 fractions and benzene were detected in the leachate and not in the Botany Sands or bedrock aquifer • Concentrations of cobalt, cadmium, copper, nickel and zinc exceeded the ecological based assessment criteria in leachate and the bedrock aquifer. Concentrations of metals were highest in the leachate and the bedrock aquifer • Concentrations of ammonia exceeded the adopted groundwater ecological based assessment criteria in leachate and slightly exceeded the criteria in the Botany Sands and bedrock aquifers.

Property	Description
C10-B St Peters interchange construction site (former Bradshaw Mountain Stockpile)	• Nine boreholes (BH398 to BH404) were drilled through the Bradshaw Mountain stockpile and into the underlying fill and Botany Sands within the C10-B area • The stockpile of crushed sandstone was assessed against the excavated natural material (ENM) exemption 2014. With the exception of the base of the stockpile interface with underlying fill, the material met the ENM exemption 2014 criteria • The underlying fill and natural soils were analysed for metals, TRH, BTEXN, PAHs, phenols, OCPs, OPPs, PCBs, SVOCs, VOCs and asbestos and assessed against the ASC NEPM 2013 guidelines for commercial/industrial and open space land use • One exceedance of the ASC NEPM (2013) HIL C for CPAHs was detected within the fill underlying the Bradshaw Mountain stockpile and friable ACM was detected in one sample from the fill underlying the Bradshaw Mountain stockpile • The main inclusions in the fill were observed to be brick and ceramic materials and some ash layers, which is consistent with the historical brickworks use of the site. No landfill waste was identified within the footprint of Bradshaw Mountain at the locations sampled • No observations of contamination were observed in the underlying natural soil • The 95 per cent UCL for all CoPC met the adopted assessment criteria in the samples analysed • Acid sulfate field tests and SPOCAS analysis was also completed for samples collected from the Botany Sands • Based on the field acid sulfate soils tests completed and observations of marine sediments, there is potential for acid sulfate soils to be present within the natural soils in the site. The sulfur trail results from samples analysed for SPOCAS exceeded the ASSMAC (1998) assessment criteria, indicating that management procedures for acid sulfate soils should be prepared as part of the CSWMP and implemented if future disturbance of the underlying natural soil or lowering of the water table is anticipated as part of future works.

4.13.8 Areas and contaminants of concern

The key areas and contaminants of concern within the Campbell Road civil and tunnel site are summarised in **Table 4-42**. Some areas of concern such as the former Alexandria Landfill (located immediately to the south) are currently being remediated/managed as part of the New M5 project in accordance with the following documents:

- Golder Associates (2016). Design Report – Alexandria Landfill & Bradshaw Mountain Remediation Action Plan (RAP). St Peters Interchange – Alexandria Landfill and Bradshaw Mountain Sites (Document: M5N-GOL-MNP-900-300-WT-9401-D), 12 April 2016
- WestConnex New M5 Construction Contaminated Management Plan (Document: M5N-ES-PLN-PWD-0033), 17 November 2016.

As such, the potential contamination risk posed by the presence of contamination following the implementation of remediation and landfill closure works at these locations is considered to be low.

Table 4-42 Areas and Contaminants of Concern – Campbell Road civil and tunnel site at St Peters (C10)

Property	Description	Contaminants of Potential Concern
C10-A St Peters interchange construction site (former Alexandria Landfill)	Former solid waste (non-putrescible) landfill and recycling facility.	Landfill gases (methane, hydrogen sulphide, carbon dioxide and carbon monoxide), leachate (particularly ammonia), metals, PAHs, SVOCS, VOCs and asbestos.
C10-B St Peters interchange construction site (former Bradshaw Mountain Stockpile). Note: The material comprising Bradshaw Mountain has been removed as part of the St Peters interchange construction works program.	Historical uncontrolled filling (non-landfill). A stockpile of ENM is located on the site.	Landfill gases (from adjacent landfill), metals, PAHs and asbestos.
C10-C Holland Street Lot	Historical uncontrolled filling.	Landfill gases (from adjacent landfill), metals, SVOCs, VOCs and asbestos.
C10-D Pie shop	Unknown former commercial/industrial purposes.	Landfill gases (from adjacent landfill), metals, SVOCs, VOCs and asbestos.
C10-E Production Company	Unknown former commercial/industrial purposes.	Landfill gases (from adjacent landfill), metals, TRH, SVOCs, VOCs and asbestos.
C10-F Transport Business	Demolition of former structures and storage/maintenance of trucks.	Lead, TRH, BTEXN, asbestos.
C10-G Warehouse	Demolition of former structures and warehouse.	Lead, TRH, BTEXN, asbestos.
Off-site sources	Sydney Park (former landfill) and former surrounding industrial land use.	Landfill gases (from adjacent landfill), metals, TRH, SVOCs, VOCs.

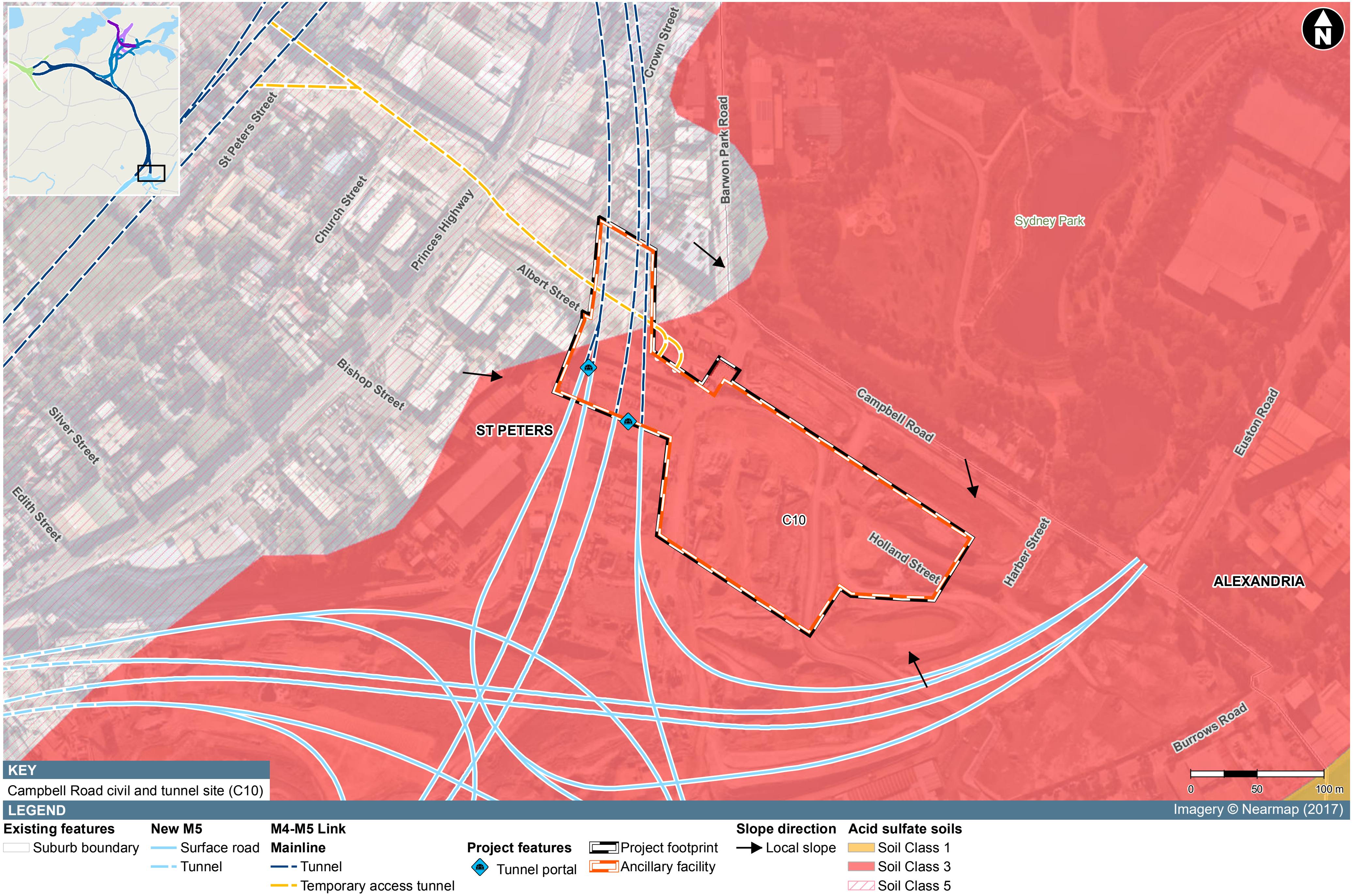


Figure 4-28 Campbell Road civil and tunnel site at St Peters (C10) - acid sulfate soils

4.14 M4-M5 Link project tunnel alignment

In addition to ancillary facilities and the project footprint, evaluation of the proposed M4-M5 Link project tunnel alignment has been undertaken to identify potentially contaminating land uses which may impact soil and groundwater quality in proximity to the tunnel alignment. For the purposes of this working paper, the document has been divided into five sections comprising:

- St Peters to Newtown
- Newtown to Camperdown
- Camperdown to Annandale
- Annandale to Haberfield and Rozelle
- Rozelle to Iron Cove and Balmain.

4.14.1 Tunnel alignment – St Peters to Newtown

Current potentially contaminating land uses

Current and former potentially contaminating land uses identified within 300 metres of the tunnel alignment between St Peters and Newtown are listed in **Table 4-43**.

Table 4-43 Potential Contaminating Land Uses – St Peters to Newtown

Property/area	Activity	Proximity to alignment
Current land uses		
BP Express Service Station 2 Princes Highway, St Peters	Petroleum storage	80 metres east and across topographic gradient of the alignment.
BP Petrol Station 327–339 Princes Highway, Sydenham	Petroleum storage	Directly above the alignment.
Valitel Commercial 310 Princes Highway, St Peters	Dry cleaning (now closed)	300 metres southwest and up topographic gradient of the alignment.
Former land uses		
Former Alexandria Landfill (St Peters interchange)	Former landfill	Adjacent to and south of the alignment.
Sydney Park	Former landfill	60 metres east and down topographic gradient of the alignment.
Former Taubmans Factory 73 Mary Street, St Peters	Paint manufacturing	170 metres northwest and up topographic gradient of the alignment.
Former clay pit 60 Mary Street, St Peters	Uncontrolled filling	170 metres northwest and up topographic gradient of the alignment.
Former brick pit 9 Unwins Bridge Road, St Peters	Uncontrolled filling	300 metres northwest and up topographic gradient of the alignment.
Former brick pit Camdenville Park May Street, St Peters	Uncontrolled filling	25 metres west and up topographic gradient of the alignment.
Industrial and commercial properties along the Princes Highway	Unknown – potentially workshops and manufacturing	Directly above and adjacent to the alignment.

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 4-44**.

Table 4-44 Contaminated sites notified to or regulated by the NSW EPA – St Peters to Newtown

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 4-45**.

Table 4-45 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
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. Additional monitoring wells were monitored as part of the combined geotechnical and contamination investigations for the M4-M5 Link project (AECOM 2016c). The results are summarised in **Table 4-46** and monitoring well locations are shown in **Figure 4-29**.

Table 4-46 Groundwater quality – tunnel alignment – St Peters to Newtown

Source	Monitoring wells	Summary of results
AECOM, 2015b	MW122 (south Sydney Park)	• Copper (0.003 milligrams per litre) and zinc (0.068 milligrams per litre) exceeded the ANZECC (2000) 95 per cent marine trigger values of 0.0013 milligrams per litre and 0.015 milligrams per litre respectively • Nickel (0.0028 milligrams per litre) exceeded the NHMRC (2015) ADWG of 0.002 micrograms per litre.
	MW115 (northwest Sydney Park)	• Chromium (0.173 milligrams per litre), copper (0.011 micrograms per litre) exceeded the ANZECC (2000) 95 per cent marine trigger values of 0.0044 milligrams per litre and 0.0013 milligrams per litre respectively.
	MW109 (southwest of the former Alexandria Landfill)	• Chromium (0.088 milligrams per litre), copper (0.007 milligrams per litre) and zinc (0.0018 milligrams per litre) exceeded the ANZECC (2000) 95 per cent marine trigger values of 0.0044 milligrams per litre, 0.0013 milligrams per litre and 0.015 milligrams per litre respectively • Chromium also exceeded the NHMRC (2015) ADWG of 0.005 milligrams per litre.
AECOM, 2015d	Former Alexandria Landfill monitoring wells (refer to **section 4.13.7**)	• Concentrations of TRH >C10-C34 fractions, benzene, manganese, nickel, sodium, chloride and TDS exceeded the human-health based criteria in groundwater. TRH >C10-C34 fractions and benzene were detected in the leachate and not in the Botany Sands or bedrock aquifer • Concentrations of cobalt, cadmium, copper, nickel and zinc exceeded the ecological based assessment criteria in leachate and the bedrock aquifer. Concentrations of metals were highest in the leachate and the bedrock aquifer • Concentrations of ammonia exceeded the adopted groundwater ecological based assessment criteria in leachate and slightly exceeded the criteria in the Botany Sands and bedrock aquifers.
AECOM, 2016c	SP_BH02 (east of Sydney Park)	• Nickel (0.012 milligrams per litre) and zinc (0.048 milligrams per litre) exceeded the ANZECC (2000) 95 per cent marine trigger values of 0.07 milligrams per litre and 0.015 milligrams per litre respectively • Benzene (two micrograms per litre) exceeded the NHMRC (2015) ADWG of one microgram per litre • Ethylbenzene (10 micrograms per litre) exceeded ANZECC (2000) low reliability trigger value of five micrograms per litre.

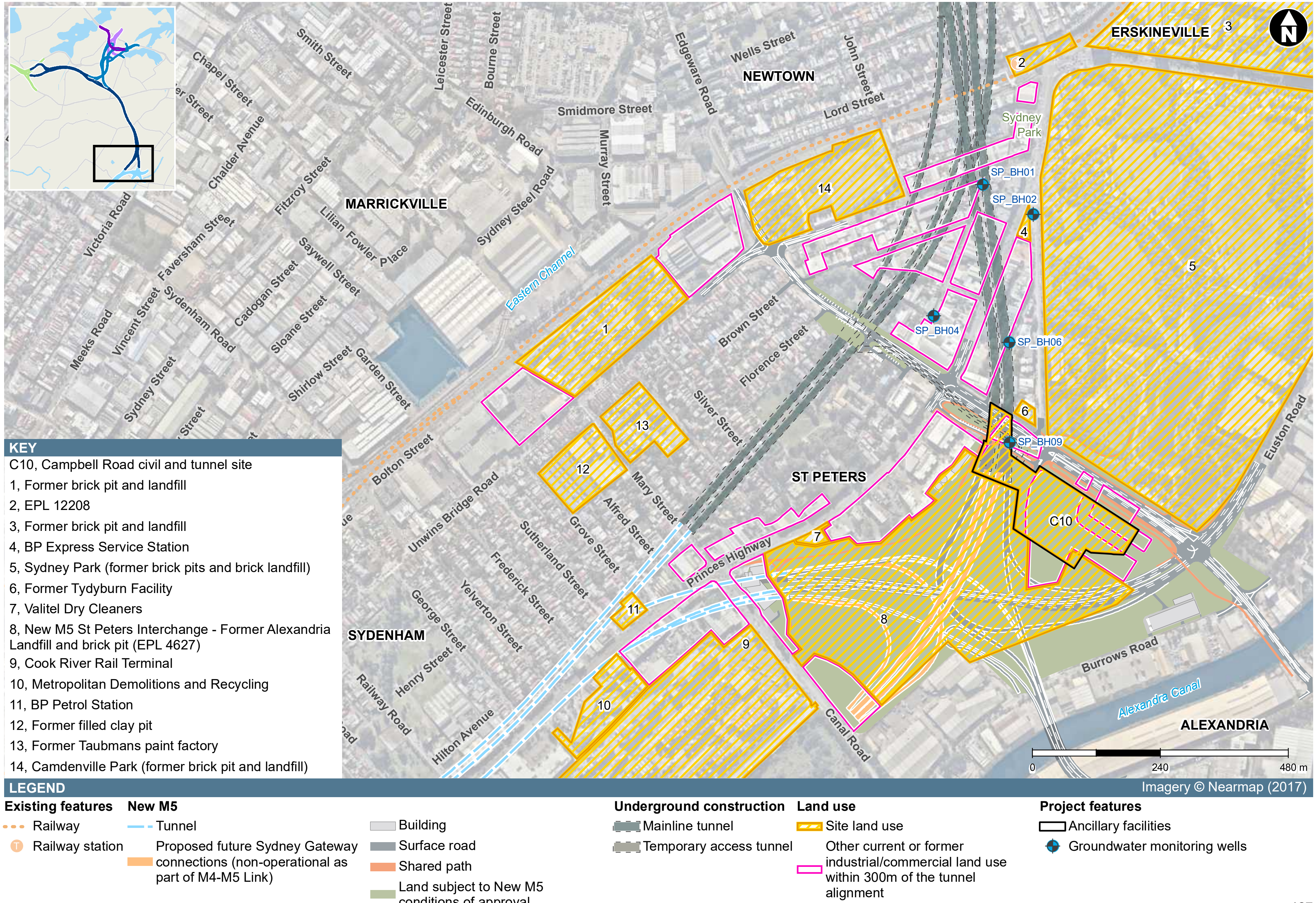


Figure 4-29 Tunnel Alignment - St Peters to Newtown

4.14.2 Tunnel alignment – Newtown to Camperdown

Current and former potentially contaminating land uses

Current and former potentially contaminating land uses identified within 300 metres of the tunnel alignment are listed in **Table 4-47.**

Table 4-47 Current and former potential contaminating land uses – Newtown to Camperdown

Property/area	Activity	Proximity to alignment
Current land uses		
St Peters Laundry 603 King Street, Newtown	Dry cleaning	10 metres east and up topographic gradient of the alignment.
Express Dry Cleaners 583 King Street, Newtown	Dry cleaning	Directly above the alignment.
Laundry Magic 514 King Street, Newtown	Dry cleaning	Directly above the alignment.
Laundrette on King 409 King Street, Newtown	Dry cleaning	20 metres west and up topographic gradient of the alignment.
Aquick Laundry 51 Enmore Road, Newtown	Dry cleaning	80 metres west and up topographic gradient of the alignment.
Enmore Laundrette and Dry Cleaning 139 Enmore Road, Enmore	Dry cleaning	310 metres west and up topographic gradient of the alignment.
Caltex Service Station 26 Enmore Road, Newtown	Petroleum storage	Directly adjacent (west side) and above the alignment.
Former land uses		
Former Industrial Factories 43 Alice Street, Newtown	Unknown – potentially workshops and manufacturing	50 metres west and up topographic gradient of the alignment.
Former Petrol Station 1–11 Enmore Road, Newtown	Petroleum storage	Directly above the alignment.
Former Dry Cleaners 18 Enmore Road, Newtown	Dry cleaning	Directly above the alignment.
Former Petrol Station 333 King Street, Newtown	Petroleum storage	40 metres northeast and up topographic gradient of the alignment.

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 4-48**.

Table 4-48 Contaminated sites notified or regulated by the NSW EPA – Newtown to Camperdown

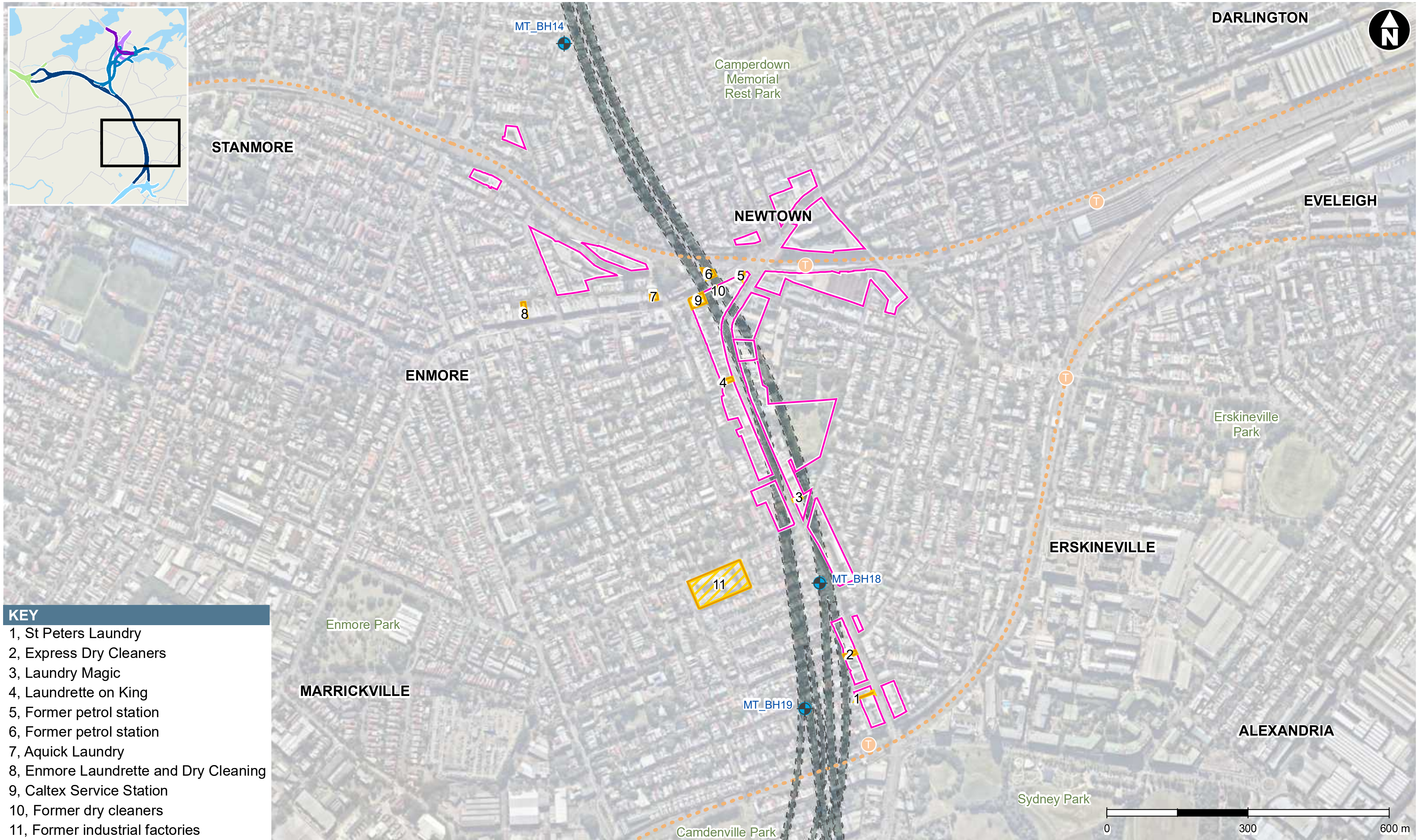
Property	Status	Proximity to alignment
Caltex service station 26 Enmore Road, Newtown	Reported to the NSW EPA under section 60 of the CLM Act. Currently under assessment by the NSW EPA.	Directly adjacent (west side) and above the alignment.

Licensed sites

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

Groundwater quality

Deep groundwater monitoring wells have been installed at depths ranging between 40 and 50 metres below ground surface to measure groundwater levels and evaluate water quality at the proposed tunnelling depth within the vicinity of the Newtown to Camperdown section of the tunnel alignment. No groundwater monitoring wells have been installed within this section of the tunnel alignment specifically for the purposes of monitoring groundwater contamination as part of the M4-M5 Link project.



KEY

1, St Peters Laundry
2, Express Dry Cleaners
3, Laundry Magic
4, Laundrette on King
5, Former petrol station
6, Former petrol station
7, Aquick Laundry
8, Enmore Laundrette and Dry Cleaning
9, Caltex Service Station
10, Former dry cleaners
11, Former industrial factories

LEGEND

Existing features
Railway
Railway station

Underground construction
Mainline tunnel

Land use
Site land use
Other current or former industrial/commercial land use within 300m of the tunnel alignment

Project features
Groundwater monitoring wells

Figure 4-30 Tunnel Alignment - Newtown to Camperdown

4.14.3 Tunnel alignment – Camperdown to Annandale

Current and former potentially contaminating land uses

Current and former potentially contaminating land uses identified within 300 metres of the tunnel alignment are listed in **Table 4-49** and shown in **Figure 4-31**.

Table 4-49 Current and former potential contaminating land uses – Camperdown to Annandale

Property/area	Activity	Proximity to alignment
Current land uses		
7 Eleven 198 Parramatta Road, Camperdown	Petroleum storage	250 metres east and up topographic gradient of the alignment.
Former land uses		
O'Dea Reserve Salisbury Lane, Camperdown	Uncontrolled filling in former clay pit	Directly above the alignment.
Lawrence Dry Cleaners 208 Parramatta Road, Annandale	Dry cleaning	110 metres east and up topographic gradient of the alignment.
Stanmore Industrial Area 5–53 Bridge Road, Stanmore	Various historical manufacturing sites	200 metres west and up topographic gradient of the alignment.
48–52 Nelson Street, Annandale	Various historical manufacturing sites	150 metres north east of the alignment.

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 4-50**.

Table 4-50 Contaminated sites notified to or regulated by the NSW EPA – Camperdown to Annandale

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 (now 7 Eleven) 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

Deep groundwater monitoring wells have been installed at depths ranging between 40 and 50 metres below ground surface to measure groundwater levels and evaluate water quality at the proposed tunnelling depth within the vicinity of the Camperdown to Annandale section of the tunnel alignment. No groundwater monitoring wells have been installed specifically for the purposes of monitoring groundwater contamination as part of the M4-M5 Link project.

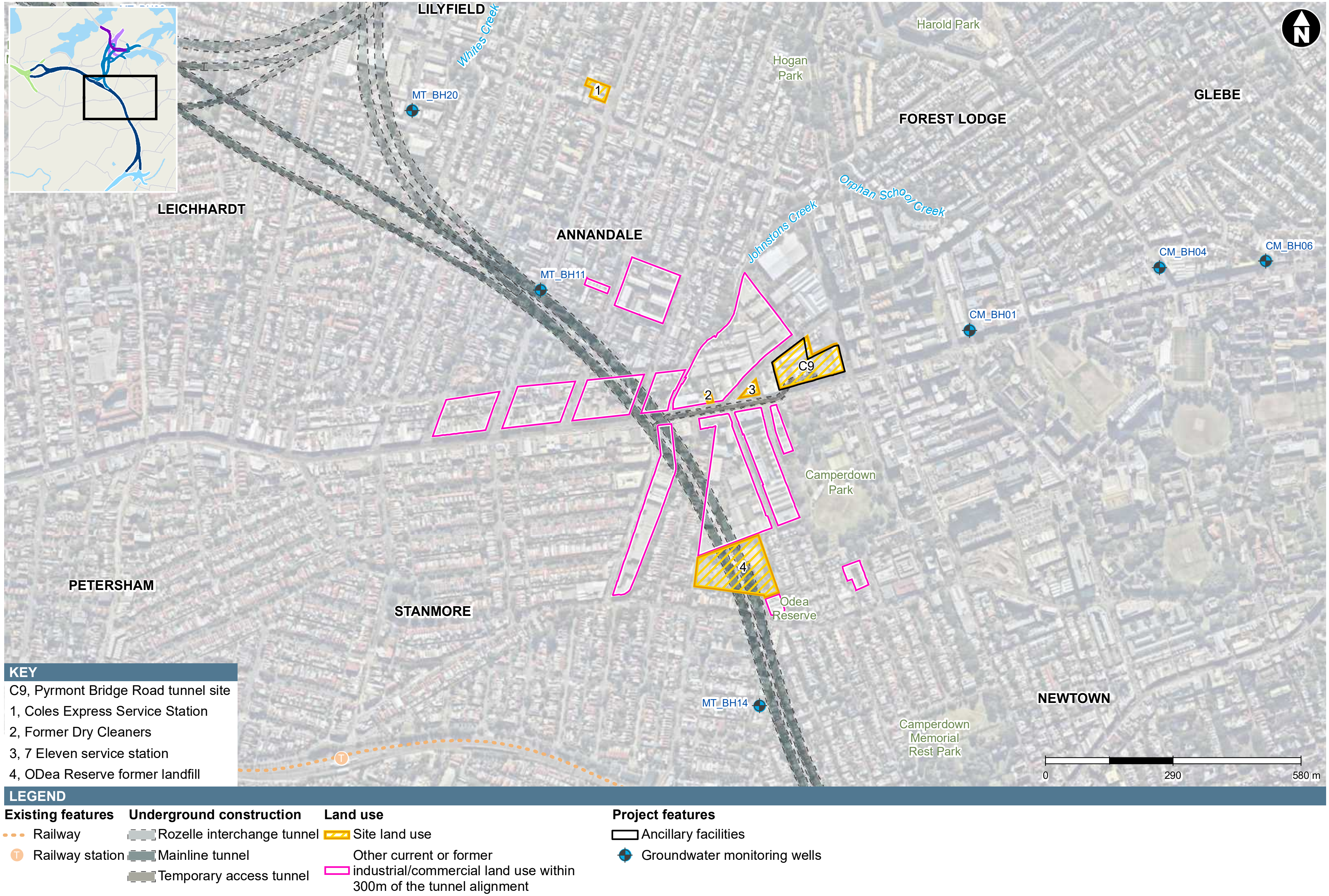


Figure 4-31 Tunnel Alignment - Camperdown to Annandale

4.14.4 Tunnel alignment – Annandale to Haberfield and Rozelle

Current and former potentially contaminating land uses

Current and former potentially contaminating land uses identified within 300 metres of the tunnel alignment are listed in **Table 4-51**.

Table 4-51 Current and former potentially contaminating land uses – Annandale to Haberfield and Rozelle

Property/area	Activity	Proximity to alignment
Current land uses		
Leichhardt Bus Depot Corner Balmain Road and City West Link	Petroleum storage and workshops.	300 metres north of the alignment
Former State Rail Authority Land (now State Transit Authority) Corner William and Derbyshire Streets, Leichhardt. Includes the site and immediately adjacent recreational open space and Bus Depot to the north.	Historical buildings containing hazardous building materials, potential residual contaminated soil and fill material following remediation.	300 metres north of the alignment
RailCorp Leichhardt 7 Darley Road, Leichhardt	Petroleum storage and workshops.	150 metres north of the alignment
Sydney Trains Between Darley Road and Canal Road, Leichhardt	Petroleum storage and workshops.	160 metres north of the alignment
Monza Petrol Station 249–251 Norton Street Leichhardt	Petroleum storage and workshops.	300 metres north of the alignment
Former land uses		
91 Canal Road Lilyfield and Blackmore Park, Leichhardt	Former 5th Ordnance Leichhardt Depot.	200 metres north of the alignment
Sydney Motor Auctions Pty Ltd 29 Derbyshire Road, Leichhardt	Former petroleum storage and workshops.	170 metres north of the alignment
1 Canal Road, Leichhardt	Former Public Works Depot.	Immediately south of the alignment
54–58 Darley Road Leichhardt	Former petrol station.	50 metres north of the alignment
124 James Street, Leichhardt	Former steel manufacturers and boiler makers.	150 metres north of the alignment
Block of land between William Street, Francis Street, North Street and Allen Street, Leichhardt	Former manufacturing including steel and plastic manufacturing.	Directly adjacent to and south of the alignment
120 William Street, Leichhardt	Former metal engineering, electroplating, non-metal founding, timber supplies and panel beaters.	180 metres south of the alignment

Property/area	Activity	Proximity to alignment
Hawthorne Canal	Reclaimed land around Hawthorne Canal.	Directly above the alignment
Algie Park Ramsay Street, Haberfield	Former Cumberland brick pit filled with unknown source (pre-1943).	Directly above and immediately north of the alignment

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 4-52**.

Table 4-52 Contaminated sites notified to or regulated by the NSW EPA – Annandale to Haberfield and Rozelle

Property	Status	Proximity to alignment
Bus Depot (Area E) Cnr Balmain Rd 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 4-53**.

Table 4-53 POEO Register – Annandale to Haberfield and Rozelle

Property	Licence Number	Proximity to alignment
WestConnex M4 East Homebush Bay Drive to Parramatta Road Burwood	EPL 20734	West of alignment

Groundwater quality

Groundwater monitoring was undertaken as part of the combined geotechnical and contamination investigations (AECOM 2016c) for this project (see **Figure 4-32**). Samples were collected and analysed for metals (arsenic, cadmium, chromium, copper, nickel, lead, mercury and zinc), TRH, VOCs and SVOCs. The results are summarised in **Table 4-54**.

Table 4-54 Groundwater quality – tunnel alignment – Annandale to Haberfield and Rozelle

Source	Monitoring wells	Summary of results
AECOM, 2016c	HB_BH08S	• No exceedances
	HB_BH08D	• No exceedances
	HB_BH12	• Zinc (0.016 milligrams per litre) exceeded the ANZECC (2000) 95 per cent ANZECC (2000) 95 per cent marine trigger value of 0.015 milligrams per litre
	HB_BH15	• Nickel (0.15 milligrams per litre) and zinc (0.038 milligrams per litre) exceeded the ANZECC (2000) 95 per cent ANZECC (2000) 95 per cent marine trigger value of 0.07 milligrams per litre and 0.015 milligrams per litre.

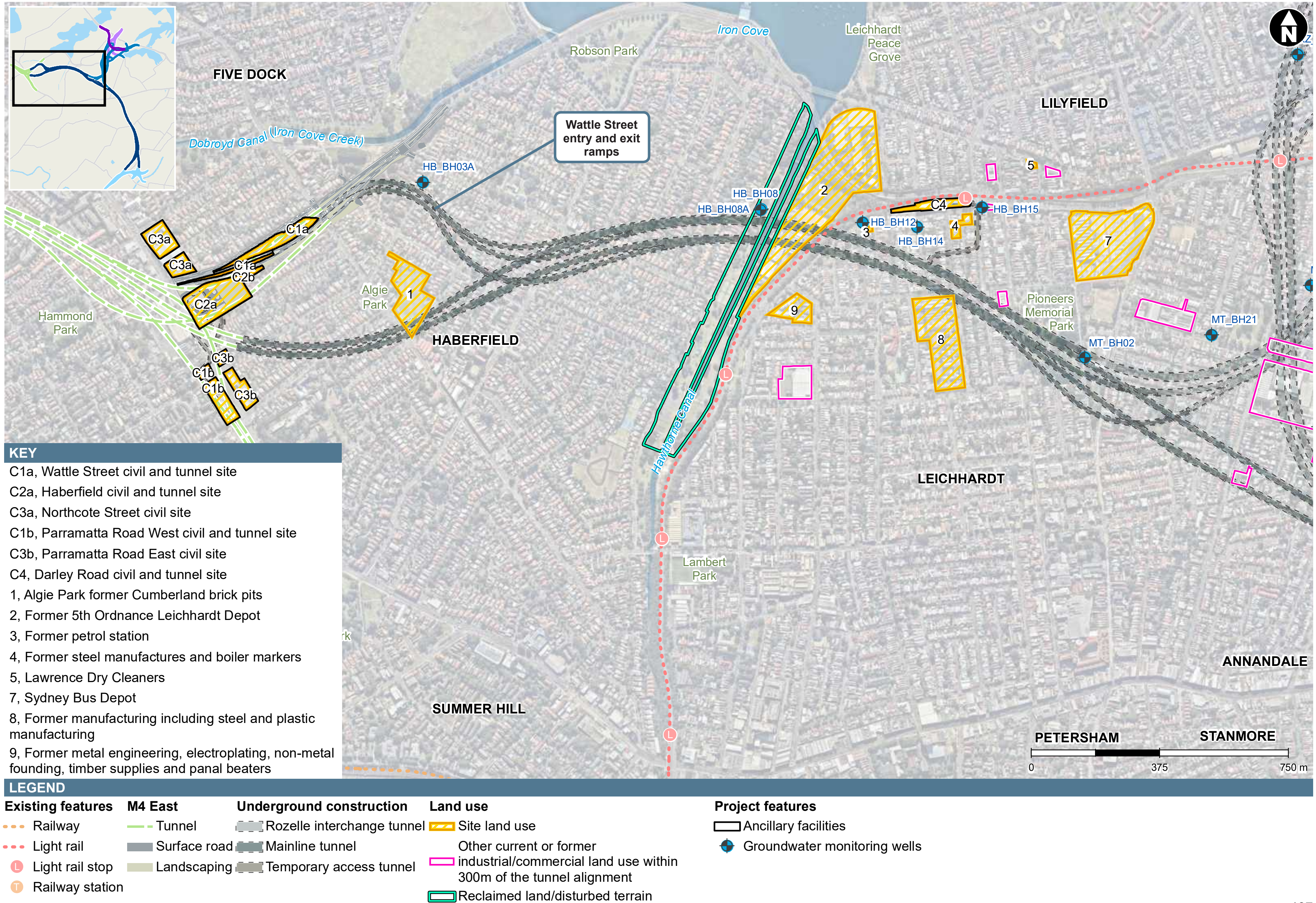


Figure 4-32 Tunnel Alignment - Annandale to Haberfield and Rozelle

4.14.5 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 are listed in **Table 4-55**.

Table 4-55 Potential contaminating land uses – Rozelle to Iron Cove and Balmain

Property/area	Activity	Proximity to alignment
Current land uses		
BP service station 86 Victoria Road, Rozelle	Petroleum storage	100 metres south of the alignment.
7 Eleven service station 178–180 Victoria Road, Rozelle	Petroleum storage	Immediately adjacent to the alignment.
United service station 127 Victoria Road, Rozelle	Petroleum storage	30 metres east and topographically up-gradient of the alignment.
Caltex service station, 121 Victoria Road, Rozelle	Petroleum storage	30 metres northeast and topographically down-gradient of the alignment.
Former land uses		
Kwik Dry Cleaners, 127 Victoria Rd, Rozelle Superb Dry Cleaners, 688 Darling St, Rozelle Tasman Dry Cleaners, 693 Darling St, Rozelle Jones, Dry Cleaners Pty. Ltd, 673 Darling St, Rozelle Traynor Dry Cleaners, 684 Darling St, Rozelle	Dry cleaners historically used white spirits, kerosene, carbon tetrachloride, trichloroethylene (TCE), perchloroethylene (Perc), as cleaning solvents until the 1990s. Fluorocarbon based dry cleaning was used in Australia from 1990 until it was banned in 1997 [1,1,2 trichloro-1,2,2-trifluroethane and 1,1,1-Trichloroethane (TCA)].	30 to 140 metres east and topographically up-gradient of the alignment.
F. Voyce Petrol Station, 138 Victoria Road, Rozelle	Petroleum storage	70 metres east and topographically up-gradient of the alignment.
Former manufacturing sites were located up-gradient of the alignment in the block bound by Terry Street and Wellington Street in Rozelle	Use of chemicals and productions of waste in manufacturing processes.	90 metres east and topographically up-gradient of the alignment.
Mars Steel Products Pty Ltd and Swinnertons Pty Ltd, 68 Victoria Road, Rozelle	Metal foundries typically produce metal, petroleum hydrocarbon and PAH contaminants.	30 metres east and topographically up-gradient of the alignment.

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 4-56**.

Table 4-56 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 polychlorinated biphenyl (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 east 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 1997.	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 1997.	Immediately adjacent to the alignment.

Licensed sites

There were no licensed activities identified under the POEO Act and within 300 metres of the tunnel alignment with the exception of construction activities associated with the Sydney Light rail network located to the west of the Rozelle Rail Yards.

Groundwater quality

Groundwater monitoring was undertaken as part of the combined geotechnical and contamination investigations (AECOM 2016c) for this project (see **Figure 4-33**). Samples were collected and analysed for metals (arsenic, cadmium, chromium, copper, nickel, lead, mercury and zinc), TRH, VOCs and SVOCs. The results are summarised in **Table 4-57**. Groundwater monitoring results for Rozelle civil and tunnel site are reported in **section 4.8.8**.

Table 4-57 Groundwater quality – tunnel alignment – Rozelle to Iron Cove and Balmain

Source	Monitoring wells	Summary of results
AECOM, 2016c	TC_BH01S	No exceedances.
	TC_BH06	No exceedances.
	TC_BH07S	Arsenic (0.02 milligrams per litre) exceeded the NHMRC (2015) ADWG of 0.01 milligrams per litre.
	TC_BH08	No exceedances.

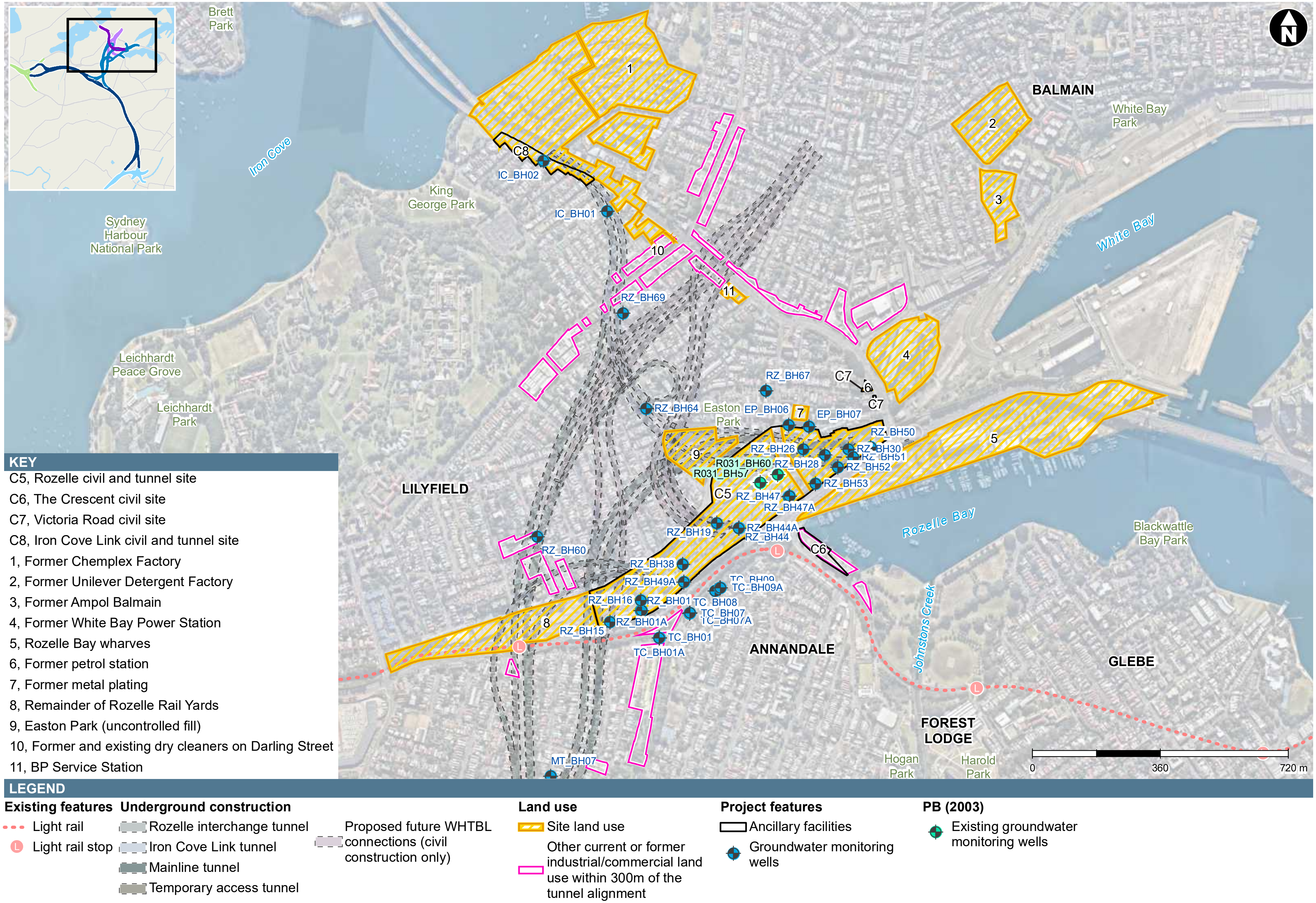


Figure 4-33 Tunnel Alignment - Rozelle to Iron Cove and Balmain

5 Assessment of construction impacts

5.1 Ancillary facilities and project footprint

The assessment of impacts for the ancillary facilities and project footprint are presented in **Table 5-1**. It is noted that the risk rankings presented in **Table 5-1** are prior to the implementation of the management measures identified in **section 8**. Following the implementation of management measures, it is anticipated that any identified high or medium risk rankings for the ancillary facilities and project footprint will ultimately present a low risk. The location of each ancillary facility and project footprint are shown in **Figure 2-2**.

Table 5-1 Assessment of construction impacts – ancillary facilities and project footprint

Area	Construction works	Potential contamination impacts associated with construction phase	Likelihood of soil or groundwater contamination to be present	Consequence	Risk[1]
C1a – Wattle Street civil and tunnel site at Haberfield	• Stockpiling within cut-and-cover structure • Excavations and tunnelling for ramp. The ramp and cut-and-cover structure would be built by the M4 East contractor. The M4-M5 contractor would construct driven tunnel using road headers to connect the ramps with the mainline tunnel. In addition, minor civil and finishing (pavement and line-marking) works on ramps and surface lands along Wattle Street (to Parramatta Road) would be undertaken by the M4-M5 contractor to prepare ramps for use.	No areas of concern were identified within the site or topographically up-gradient of the site with the exception of the demolition of former buildings and use of lead paint which may have resulted in localised areas of ACM fragments and lead paint flakes in soil. Any residual contamination would be managed by the M4 East project construction contractor. An assessment of the site within the project footprint immediately south and adjacent the C1a ancillary facility conducted by Ramboll Environ (2016a) prior to establishment works for the M4 East Eastern Ventilation Facility Tunnel Worksite (C2a or C2b ancillary facility) indicated the presence of friable and bonded asbestos in soils. Management measures including remediation and validation were specified by Ramboll Environ (2016a). The works would include bulk excavation for the construction of the ramp to the tunnel and surface road construction; however no bulk earthworks would be undertaken at the surface. There would be complete pathways from the source (if present) to the receptor for the following if appropriate controls were not implemented: • Inhalation and ingestion risk to site workers from hazardous building materials (if present) • Inhalation or ingestion of hazardous building materials (via dust) (if present). Cross contamination associated with the incorrect handling or disposal of spoil/unexpected finds is a potential impact during construction if appropriate controls and handling	Very unlikely to be present at concentrations above the relevant assessment criteria and limited in extent.	Exposure pathway for human or ecological receptors likely to be present and complete either now, during or post construction (without implementation of appropriate controls).	Low

Area	Construction works	Potential contamination impacts associated with construction phase	Likelihood of soil or groundwater contamination to be present	Consequence	Risk[1]
		procedures are not implemented. The site will 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. Use of the site as a construction ancillary facility for the M4-M5 Link project has the associated potential for leaks and spills. At the completion of M4-M5 Link construction the landscaping (where applicable) and residual land obligations as detailed in the M4 East Urban Design and Landscape Plan and Residual Land Management Plan would be carried out.			

Area	Construction works	Potential contamination impacts associated with construction phase	Likelihood of soil or groundwater contamination to be present	Consequence	Risk[1]
C2a – Haberfield civil and tunnel site at Haberfield	• No excavations or tunnelling to be completed (construction completed during M4 East). Tunnel spoil from the proposed M4-M5 Link mainline tunnel would be transported out via the M4 East stubs to M4 East mainline tunnel • Minor civil construction associated with the substation (including shallow excavation) • Deep excavation for vent tunnels, footings etc. will be carried out by M4 East contractor • Use of existing M4 East facilities (currently under construction).	Historical land uses within the western part of the site may have caused soil and potentially groundwater contamination (eg potential former dry cleaners and workshops associated with former car dealerships and mechanics). 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 fragments and lead paint flakes in surface soil. Demolition activities, use of plant and machinery and excavation activities may mobilise these. Use of the site as a construction ancillary facility for the M4-M5 Link project has the associated potential for leaks and spills. An assessment of the site conducted by Ramboll Environ (2016a) prior to establishment works for the M4 East Eastern Ventilation Facility Tunnel Worksite indicated the presence of friable and bonded asbestos in soils. Management measures including remediation and validation were specified by Ramboll Environ (2016a). The site will 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. At the completion of M4-M5 Link construction the landscaping (where applicable) and residual land obligations as detailed in the M4 East Urban Design and Landscape Plan and Residual Land Management Plan would be carried out.	Very unlikely to be present at concentrations above the relevant assessment criteria and limited in extent.	Exposure pathway for human or ecological receptors likely to be present and complete either now, during or post construction (without implementation of appropriate controls).	Low

Area	Construction works	Potential contamination impacts associated with construction phase	Likelihood of soil or groundwater contamination to be present	Consequence	Risk[1]
C3a – Northcote Street civil site at Haberfield	• No excavations or tunnelling to be completed for the project (construction completed during M4 East) • Use of existing M4 East facilities (currently under construction).	There are historical land uses within the site which may have caused soil and potentially groundwater contamination (potential former petrol station and workshops). Use of the site as a construction ancillary facility for the M4 East project and associated potential for leaks and spills. Demolition activities, use of plant and machinery and excavation activities. The site will 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. Use of the site as a construction ancillary facility for the M4-M5 Link project has the associated potential for leaks and spills. At the completion of M4-M5 Link construction the landscaping (where applicable) and residual land obligations as detailed in the M4 East Urban Design and Landscape Plan and Residual Land Management Plan would be carried out by the M4-M5 Link contractor.	Very unlikely to be present at concentrations above the relevant assessment criteria and limited in extent.	Exposure pathway for human or ecological receptors likely to be present and complete either now, during or post construction (without implementation of appropriate controls).	Low

Area	Construction works	Potential contamination impacts associated with construction phase	Likelihood of soil or groundwater contamination to be present	Consequence	Risk[1]
C1b – Parramatta Road West civil and tunnel site at Ashfield	• Demolition of existing buildings and structures • Utility works including protection and/or adjustment of existing utilities, removal of redundant utilities and installation of new utilities • 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 access tunnel • Tunnel excavation of the mainline tunnels and the Wattle Street entry and exit ramps, stockpiling of excavated material and spoil haulage • Mechanical installation and fitout of the tunnels	Historical and current land uses within the C1b – Muirs site may have caused soil and potentially groundwater contamination ie use for car servicing and potential for underground storage tanks. Historical land uses surrounding the site may also have resulted in soil and groundwater contamination (eg potential former dry cleaner and workshops associated with former car dealerships and mechanics). GHD (2015) identified soil contamination (PAHs) on the C3b site located east and opposite the C1b site on Parramatta Road. Historical demolition of residential and/or commercial/industrial buildings may have resulted in contamination in soil from ACM fragments and potential lead paint. The works would include bulk excavation for the construction of the mainline tunnels, entry and exit ramps and surface road construction; however, no bulk earthworks would be undertaken at the surface. Demolition activities, use of plant and machinery and excavation activities are proposed. There would be complete pathways from the source (if present) to the receptor for the following if appropriate controls were not implemented: • Inhalation and ingestion risk to site workers from hazardous building materials (if present) and PAHs in excavated soil • Inhalation or ingestion of hazardous building materials (via dust) and PAHs in excavated soil (if present). Cross contamination associated with the incorrect handling	Potentially present at concentrations above the relevant assessment criteria and widespread.	Exposure pathway for human or ecological receptors likely to be present and complete either now, during or post construction (without implementation of appropriate controls).	Medium

Area	Construction works	Potential contamination impacts associated with construction phase	Likelihood of soil or groundwater contamination to be present	Consequence	Risk[1]
	• Finishing works including asphalting • Demobilisation including works to prepare the site for a permissible future use.	or disposal of spoil/unexpected finds is a potential impact during construction if appropriate controls and handling procedures are not implemented. Use of the site as a construction ancillary facility for the M4-M5 Link project has the associated potential for leaks and spills.			
C2b – Haberfield civil site at Haberfield	• Establishment of site offices, amenities and temporary infrastructure • Delivery, laydown and storage of materials • Mechanical and electrical fitout of a section of the Parramatta Road ventilation facility (that will be built as part of the M4 East project) • Landscaping • Demobilisation.	Historical land uses within the western part of the site may have caused soil and potentially groundwater contamination (eg potential former dry cleaners and workshops associated with former car dealerships and mechanics). 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 fragments and lead paint flakes in surface soil. An assessment of the site conducted by Ramboll Environ (2016a) prior to establishment works for the M4 East Eastern Ventilation Facility Tunnel Worksite indicated the presence of friable and bonded asbestos in soils. Management measures including remediation and validation were specified by Ramboll Environ (2016a). Demolition activities, use of plant and machinery and excavation activities are proposed. There would be complete pathways from the source (if present) to the receptor for the following if appropriate controls were not implemented: • Inhalation and ingestion risk to site workers from hazardous building materials (if present) and PAHs in surface soil inhalation or ingestion of hazardous building	Very unlikely to be present at concentrations above the relevant assessment criteria and limited in extent.	Exposure pathway for human or ecological receptors likely to be present and complete either now, during or post construction (without implementation of appropriate controls).	Low

Area	Construction works	Potential contamination impacts associated with construction phase	Likelihood of soil or groundwater contamination to be present	Consequence	Risk[1]
		materials (via dust) and PAHs in surface soil (if present). Use of the site as a construction ancillary facility for the M4-M5 Link project has the associated potential for leaks and spills. The site will be demobilised and earthworks carried out to provide finished levels that are consistent with the original ground surface before being handed over to the M4-M5 Link contractor. At the completion of M4-M5 Link construction the landscaping (where applicable) and residual land obligations as detailed in the M4 East Urban Design and Landscape Plan and Residual Land Management Plan would be carried out.			
C3b – Parramatta Road East civil site at Haberfield	• Demolition of existing structures • Establishment of site offices, amenities and temporary infrastructure including temporary noise barriers • Utility works including protection and/or adjustment of existing utilities, removal of redundant utilities and installation of new utilities • Establishment of site offices and workforce	Historical and current land uses within the C3b – Muirs site may have caused soil and potentially groundwater contamination ie use for car servicing and potential for underground storage tanks. Historical land uses surrounding the site may also have resulted in soil and groundwater contamination (eg potential former dry cleaner and workshops associated with former car dealerships and mechanics). GHD (2015) identified soil contamination (PAHs) on the C3b site. Historical demolition of residential and/or commercial/industrial buildings may have resulted in contamination in soil from ACM fragments and potential lead paint. Demolition activities, use of plant and machinery and excavation activities are proposed. There would be complete	Known to be present at concentrations above the relevant assessment criteria and widespread.	Exposure pathway for human or ecological receptors potentially present and complete either now, during or post construction (without implementation of appropriate controls).	Medium

Area	Construction works	Potential contamination impacts associated with construction phase	Likelihood of soil or groundwater contamination to be present	Consequence	Risk[1]
	amenities • Support for the construction of the mainline tunnels and the Wattle Street interchange entry and exit ramps (no tunnelling would occur from the Parramatta Road East civil site (C3b)) • Landscaping • Demobilisation.	pathways from the source (if present) to the receptor for the following if appropriate controls were not implemented: • Inhalation and ingestion risk to site workers from hazardous building materials (if present) and PAHs in surface soil • Inhalation or ingestion of hazardous building materials (via dust) and PAHs in surface soil (if present). Cross contamination associated with the incorrect handling or disposal of spoil/unexpected finds is a potential impact during construction if appropriate controls and handling procedures are not implemented. Use of the site as a construction ancillary facility for the M4-M5 Link project has the associated potential for leaks and spills.			
C4 – Darley Road civil and tunnel site at Leichhardt	• Demolition and UST decommissioning • Excavation for construction adit • Stockpiling • Road works • Construction of permanent operational infrastructure (water treatment facility and substation).	Soil investigations and limited groundwater investigations have been undertaken within the C4 Darley Road site. The previous investigations found that the site contained fill with slightly elevated metals and PAHs, however was found to be suitable for ongoing commercial/industrial land use. There was also a UST which required decommissioning. The proposed works within the C4 Darley Road site would involve the temporary exposure of soils during demolition and construction of hardstand. More extensive excavations would be required for the construction adit at the eastern end of the site and for the permanent relocation of the existing open stormwater channel. There would potentially be complete pathways from the source (if present) to the receptor for the following if	Known to be present at concentrations above the relevant assessment criteria and widespread.	Exposure pathway for human or ecological receptors potentially present and complete either now, during or post construction (without implementation of appropriate controls).	Medium

Area	Construction works	Potential contamination impacts associated with construction phase	Likelihood of soil or groundwater contamination to be present	Consequence	Risk[1]
		appropriate controls were not implemented: • Direct contact, inhalation and ingestion risk to site workers from contaminated soil or hazardous building materials (if present) • Inhalation or ingestion of contaminated soil or hazardous building materials (via dust) (if present) Discharge of contaminated surface water to stormwater and ultimately Hawthorne Canal and Iron Cove. Incorrect handling or disposal of spoil is a potential impact during construction if appropriate controls and procedures are not implemented. Use of the site as a construction ancillary facility for the M4-M5 Link project has the associated potential for leaks and spills. There is a high probability of actual or potential acid sulfate soils at the western end of the C4 Darley Road site. Inappropriate management and disposal could lead to adverse impacts on local soil and water quality.			
C5 – Rozelle civil and tunnel site at Rozelle	• Demolition of structures, including buildings • Excavations for tunnel portals and cut and cover tunnels • Road construction • Stockpiling in acoustic sheds	Recent soil investigations have been completed in the site which identified concentrations of metals (lead, arsenic, cadmium and zinc) and PAHs exceeding the land use criteria for open space and commercial/industrial scenarios in fill and also the presence of asbestos in fill. Petroleum sourced LNAPL was detected in the centre of the site and has not been delineated or the source location identified. Identified potential construction impacts include the following: • Impacts on site workers and the local community (eg	Known to be present at concentrations above the relevant assessment criteria and widespread.	Exposure pathway for human or ecological receptors likely to be present and complete either now, during or post construction	High

Area	Construction works	Potential contamination impacts associated with construction phase	Likelihood of soil or groundwater contamination to be present	Consequence	Risk[1]
	• Construction of temporary carparks, stores, workshops, offices, construction sediment basins, construction water treatment plants and laydown areas • Construction of permanent operational infrastructure including ventilation facility, water treatment facility and substations • Tunnelling (for ventilation/road construction) • Utility works including protection and/or adjustment of existing utilities, removal of redundant utilities and installation of new utilities Drainage infrastructure including upgraded culvert below City West Link to Rozelle Bay.	residents, off-site workers) 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 contamination via overland flow and stormwater runoff, affecting the water quality of Easton Park drain, Whites Creek and Rozelle Bay • Adverse impacts on the environment as a result of the inappropriate management of waste generated by construction activities. There would potentially be complete pathways from the source (where present) to the receptor for the following if appropriate controls were not implemented: • Direct contact, inhalation and ingestion risk to site workers from contaminated soil or hazardous building materials • Inhalation or ingestion of contaminated soil or hazardous building materials (via dust)		(without implementation of appropriate controls).	

Area	Construction works	Potential contamination impacts associated with construction phase	Likelihood of soil or groundwater contamination to be present	Consequence	Risk[1]
		• Discharge of contaminated surface water and extracted groundwater discharged to stormwater and ultimately Rozelle Bay. Incorrect handling or disposal of spoil and other building materials arising from demolition activities is a potential impact during construction if appropriate controls and procedures are not implemented. There is a high probability of actual or potential acid sulfate soils within areas of the site. Inappropriate management and disposal could lead to adverse impacts on local soil and water quality. Use of the site as a construction ancillary facility for the M4-M5 Link project has the associated potential for leaks and spills. A CEMP and associated sub-plans should be prepared with reference to known soil and groundwater contamination risks and appropriate management measures as mentioned in **Table 8-2**.			

Area	Construction works	Potential contamination impacts associated with construction phase	Likelihood of soil or groundwater contamination to be present	Consequence	Risk[1]
C6 – The Crescent civil site at Annandale	• Site establishment • Utility works including protection and/or adjustment of existing utilities, removal of redundant utilities and installation of new utilities • Temporary stockpiling of fill and pavement materials prior to off-site removal • Realignment of The Crescent 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 to facilitate the widening of Whites Creek and Easton Park drain	Soil, sediment and groundwater contamination associated with historical filling and more recent industrial/commercial maritime operations, including the refurbishment of vessels and grit blasting activities has been identified during investigations conducted at the C6 Crescent Civil site. A Site Access Management Plan (Jacobs 2015b) is in place to manage identified contamination on part of the Site (Lots 21/22, DP1151746). Identified potential construction impacts include the following: • Impacts on site workers and the local community (eg residents, off-site workers) 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 Whites Creek and Rozelle Bay • Adverse impacts on the environment as a result of the inappropriate management of waste generated by construction activities. There would potentially be complete pathways from the source (where present) to the receptor for the following if appropriate controls were not implemented:	Known to be present at concentrations above the relevant assessment criteria and widespread.	Exposure pathway for human or ecological receptors likely to be present and complete either now, during or post construction (without implementation of appropriate controls).	High

Area	Construction works	Potential contamination impacts associated with construction phase	Likelihood of soil or groundwater contamination to be present	Consequence	Risk[1]
	• Finishing works including asphalting, line marking and signage installation • Excavating, filling and grading of disturbed areas • Landscaping and construction of pedestrian and cycle paths and bridges.	• Direct contact, inhalation and ingestion risk to site workers from contaminated soil and sediment • Inhalation or ingestion of contaminated soil or hazardous building materials such (via dust) • Discharge of contaminated surface water and sediment to Rozelle Bay ecological receptors • Disturbance of contaminated sediment and mobilisation of contamination within Rozelle Bay to ecological receptors. Cross contamination arising from the incorrect handling of contaminated soil, fill, sediment, groundwater and surface water activities are a potential construction impact if appropriate controls and procedures are not implemented. Use of the site as a construction ancillary facility for the M4-M5 Link project has the associated potential for leaks and spills. There is a high probability of actual or potential acid sulfate soils in soil and sediment within areas of the site. Inappropriate management, exposure during dewatering and disposal could lead to adverse impacts on local soil and water quality and impact on ecological receptors within Rozelle Bay.			

Area	Construction works	Potential contamination impacts associated with construction phase	Likelihood of soil or groundwater contamination to be present	Consequence	Risk[1]
C7 – Victoria Road civil site at Rozelle	• Demolition of existing buildings • Site sheds, laydown areas and/or site offices would be established on site	There are historical land uses within and surrounding the site which may have caused soil and potentially groundwater contamination. Intrusive investigations would be required to assess the risk posed during construction. The likelihood is low given the C7-A site that was a former petrol station was redeveloped as a commercial building. There would potentially be complete pathways from the source (if present) to the receptor for the following if appropriate controls were not implemented: • Direct contact, inhalation and ingestion risk to site workers from contaminated soil, groundwater or hazardous building materials (if present) • Inhalation or ingestion of contaminated soil, groundwater or hazardous building materials (via dust) (if present). Use of the site as a construction ancillary facility for the M4-M5 Link project has the associated potential for leaks and spills.	Very unlikely to be present at concentrations above the relevant assessment criteria and limited in extent.	Exposure pathway for human or ecological receptors likely to be present and complete either now, during or post construction (without implementation of appropriate controls).	Low
C8 – Iron Cove Link civil site at Rozelle	• Demolition • Bulk excavations for tunnel portals and cut and cover tunnels • Soft ground tunnelling • Road construction works • Construction of permanent operational infrastructure including the Iron Cove Link	There are historical land uses within and surrounding the site which may have caused soil and potentially groundwater contamination. Intrusive investigations would be required to assess the risk posed during construction of areas of potential concern (see **section 4.7.7**). The proposed works would involve the excavation and temporary exposure of soil/fill materials during demolition and construction of the ventilation facility outlet, hardstand and site drainage controls. There is potential for complete pathways from the source (if present) to the receptor for the following if appropriate controls were not implemented: • Direct contact, inhalation and ingestion risk to site	Potentially present at concentrations above the relevant assessment criteria and widespread.	Exposure pathway for human or ecological receptors likely to be present and complete either now, during or post construction (without implementation	Medium

Area	Construction works	Potential contamination impacts associated with construction phase	Likelihood of soil or groundwater contamination to be present	Consequence	Risk[1]
	ventilation facility and a substation • Bioretention facility and formalised car-parking • Utility installation, relocation and protection • Landscaping.	workers from excavated contaminated soil or hazardous building materials (if present) • Inhalation or ingestion of contaminated soil or hazardous building materials (via dust) (if present) • Discharge of contaminated surface water to stormwater and ultimately Iron Cove. Incorrect handling or disposal of spoil is another potential impact during construction if appropriate controls and procedures were not implemented. There is a high probability of actual or potential acid sulfate soils within the northeast corner of the construction zone and within the constructed wetland (W2). Inappropriate management and disposal could lead to adverse impacts on local soil and water quality. Use of the site as a construction ancillary facility for the M4-M5 Link project has the associated potential for leaks and spills.		of appropriate controls).	

Area	Construction works	Potential contamination impacts associated with construction phase	Likelihood of soil or groundwater contamination to be present	Consequence	Risk[1]
C9 Pyrmont Bridge Road tunnel site at Annandale	• Demolition • Excavation for construction adit • Minor road works.	There are historical land uses within and surrounding the site which may have caused soil and potentially groundwater contamination. Intrusive investigations would be required to assess the risk posed during construction. The proposed works would involve the temporary exposure of soils during demolition and construction of hardstand and site drainage controls. More extensive excavations would be required for the driven tunnel (adit) portal in the southwest of the site. There is potential for complete pathways from the source (if present) to the receptor for the following if appropriate controls were not implemented: • Direct contact, inhalation and ingestion risk to site workers from contaminated soil or hazardous building materials (if present) • Inhalation or ingestion of contaminated soil or hazardous building materials (via dust) (if present) • Discharge of contaminated surface water to stormwater and ultimately Johnstons Creek, which discharges to Rozelle Bay. Incorrect handling or disposal of spoil is a potential impact during construction if appropriate controls and procedures are not implemented. Use of the site as a construction ancillary facilities for the M4-M5 Link project has the associated potential for leaks and spills.	Potentially present at concentrations above the relevant assessment criteria and widespread.	Exposure pathway for human or ecological receptors likely to be present and complete either now, during or post construction (without implementation of appropriate controls).	Medium

Area	Construction works	Potential contamination impacts associated with construction phase	Likelihood of soil or groundwater contamination to be present	Consequence	Risk[1]
C10 – Campbell Road civil and tunnel site at St Peters	• Road construction works • Tunnelling and associated excavation and stockpiling • Excavation for construction adit to provide construction access to mainline • Construction of cut and cover structures • Construction of permanent operational infrastructure including the Campbell Road ventilation facility.	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 complete pathways from the source to the receptor for the following if appropriate controls during construction are not implemented: • Inhalation risk from landfill gases for site workers and surrounding land users • Explosive risk from landfill gases for site workers and surrounding land users • Direct contact, inhalation and ingestion risk to site workers from leachate, landfill refuse and contaminated soil • Inhalation or ingestion of contamination (via dust) by surrounding human receptors • Discharge of contaminated surface water and groundwater/leachate to Alexandria Canal. Incorrect handling or disposal of spoil is a potential impact during construction if appropriate controls and procedures are not implemented. Use of the site as a construction ancillary facility for the M4-M5 Link project has the associated potential for leaks and spills. There is a high probability of actual or potential acid sulfate soils within parts of the site. Inappropriate management and	Known to be present at concentrations above the relevant assessment criteria and widespread.	Exposure pathway for human or ecological receptors likely to be present and complete either now, during or post construction (without implementation of appropriate controls).	High

Area	Construction works	Potential contamination impacts associated with construction phase	Likelihood of soil or groundwater contamination to be present	Consequence	Risk[1]
		disposal could lead to adverse impacts on local soil and water quality.			

Notes: [1] Refer to Table 3-3 for risk assessment.

5.2 Tunnelling and groundwater treatment and discharge

5.2.1 Potential contamination sources

A review of potential contamination sources along the alignment identified the presence of potential, current and former contamination sources which are summarised in **Table 5-2**.

Table 5-2 Summary of key groundwater contamination sources relevant to proposed tunnelling

Tunnel section	Summary of key groundwater contamination sources	Tunnelling description
St Peters to Newtown Mary Street and the New M5 St Peters interchange at St Peters to Lord Street, Newtown.	• Former controlled and uncontrolled landfills (Alexandria Landfill, Sydney Park Landfill and Camdenville Park) • Service stations • Dry cleaners • Manufacturing.	• At Mary Street, where the tunnel would connect to the New M5 tunnel stub, the tunnel would be at depths of around 40 to 50 metres below ground level • The section of tunnel starting at the New M5 St Peters interchange would dive from the surface to a maximum depth of 50 to 60 metres below ground level at Lord Street, Newtown.
Newtown to Camperdown Lord Street, Newtown to Bishopgate Lane, Camperdown	• Service stations • Dry cleaners • Manufacturing.	• The depth of the tunnel in the section would be around 50 to 60 metres below ground level • No surface portals or adits would be in this section of the tunnel.
Camperdown to Annandale Bishopgate Lane, Camperdown to Whites Creek, Annandale	• Former uncontrolled landfill (O’Dea Reserve) • Service stations • Dry cleaners • Manufacturing.	• The depth of the tunnel in this section would be around 30 to 50 metres below ground level • An adit tunnel would be constructed connecting from the mainline tunnel along Parramatta Road to the C9 Pyrmont Bridge Road compound at the surface.

Tunnel section	Summary of key groundwater contamination sources	Tunnelling description
Annandale to Haberfield Whites Creek, Annandale to Parramatta Road, Haberfield.	• Service stations • Dry cleaners • Manufacturing • Former uncontrolled landfill (Algie Park).	• The tunnel would be at depths 40 to 50 metres and then at depths of around 30 to 40 metres below ground level west of Hawthorne Creek, before the southern branch would connect to the M4 East and the northern branch to the surface cut-and-cover tunnel in Wattle Street • Adit tunnel from C4 Darley Road compound surface to the mainline tunnel near Hubert Street. The adit tunnel would run south beneath James Street before turning west and joining the mainline tunnel at Hubert Street • Parramatta Road west, Ashfield: The temporary access tunnel to the C1b Parramatta Road West civil and tunnel site is generally located within the northern portion of the C1b compound and traverses north along Parramatta Road.
Rozelle to Iron Cove and Balmain City West Link, Annandale to Wellington Street and Theodore Street, Balmain	• Service stations • Dry cleaners • Manufacturing.	• Tunnel depths would range from 10 to 25 metres below ground level to greater than 25 metres below ground level (from 0 metres to around 60 metres) • The tunnels would emerge at the surface at three locations within Rozelle Rail Yards: at the western end (City West Link to New M5), in the middle (City West Link/The Crescent to the proposed future Western Harbour Tunnel), and the eastern end (M4/Iron Cove Link to Anzac Bridge) • The Western Harbour Tunnel portal would emerge just inside Rozelle Rail Yards (south of Lilyfield Road) • Iron Cove Bridge link tunnel would connect to the surface between the northern (eastbound) and southern (westbound) carriageways of Victoria Road.

5.2.2 Potential impacts

During tunnel construction, groundwater would be extracted from the tunnelling process, which would 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 (TWA) by Sydney Water; or
- Transported to a liquid waste facility.

Potential impacts on receiving water bodies and ecological receptors through the disturbance of contaminated sediments 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 impacts on workers include exposure to extracted contaminated groundwater from either direct contact or inhalation of vapours or vapours encountered during tunnelling, which would require management in accordance with protocols outlined in a site specific occupational health and safety plan and safe work method statement specific to the work activity being conducted.

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

- Parramatta Road, Annandale: The adit connecting the mainline tunnel to the C9 Pyrmont Bridge Road compound passes directly south of the former 7-Eleven service station (see **Figure 4-32**) that is presently under assessment by the NSW EPA under section 60 of the CLM Act. The adit 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 (see **Figure 4-32**). There is potential for asbestos containing materials and lead paint to be present in surface soils
- Darley Road, Leichhardt: The temporary access tunnel to the C4 Darley Road compound passes between historical sites 5 – former manufacturing businesses and 6 - former steel manufacturers and boiler makers (see **Figure 4-13**). 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 C1b Parramatta Road West civil and tunnel site is generally located within the northern portion of the C1b compound and traverses north along Parramatta Road (see **Figure 4-7**). There is potential for asbestos containing materials (from demolition and redevelopment works along Parramatta Road and associated filling) and PAHs (based on data obtained by GHD [2012] and known former car sales yards) to be present in shallow surface soils and/or groundwater
- Rozelle Rail Yards, Rozelle: previously identified LNAPL within the Rozelle civil and tunnel site 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 (see **Figure 4-33**)

- St Peters: The tunnel portal area and construction adit within the former Alexandria landfill at the New M5 St Peters interchange due to leachate and landfill gases (see **Figure 4-29**). The tunnel at this section is shallow and would be exposed to landfill leachate if appropriate mitigation measures (such as the Golder (2016) RAP and LCMP) are not implemented.

The likelihood of encountering plumes with high concentrations of contaminants is low given that, with the exception of the former Alexandria Landfill (assessed as part of the New M5 project), deep contamination (greater than 30 metres below ground surface) has not been identified along the proposed M4-M5 Link alignment. The extracted groundwater however 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 adit at Parramatta Road, Annandale, and the Iron Cove section near and beneath Victoria Road in Rozelle and is discussed further in **Appendix T** (Technical working paper: Groundwater) of the EIS.

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 tunnel construction. The level of treatment would consider the characteristics of the water requiring treatment operational constraints or practicalities and associated environmental impacts, and 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) of the EIS.

6 Assessment of operational impacts

6.1 Operational sites

For the purposes of this contamination assessment, identified operational impacts primarily relate to the potential contamination of soil, surface water and groundwater arising from vehicle accidents, leaks and spills on constructed M4-M5 Link project roadways including tunnels. To manage spills and leaks associated with vehicle accidents during the operation of the project, spill containment facilities would be located in tunnels and where the risk of impact from spills is high. A risk assessment of all project roads would be carried out during detailed design to determine the final locations of these facilities. Typically they would be located on motorway sections where the chance of vehicle accidents is higher. This risk assessment would also take into account proximity to waterways, where the risk of harm to aquatic environments is assessed to be greater.

Potential contamination impacts associated with the presence of roads and permanent operational infrastructure such as motorway operations complexes and associated infrastructure (ventilation facilities, water treatment plants and substations etc.) is presented in **Table 6-1**.

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 6-1 Assessment of operational impacts – operational sites

Operational area	Operation	Potential contamination impacts associated with operation	Likelihood of soil or groundwater contamination to be present as a result of project operation	Consequence (without implementation of appropriate controls)	Risk (refer Table 3-3)
Wattle Street at Haberfield	• Roadway.	• Contamination impacts associated with the operation of the project include leaks and spills on constructed roadways from vehicles and vehicle accidents.	Low likelihood of concentrations above the relevant assessment criteria and limited in extent.	Exposure pathway for human or ecological receptors may be present in the event of leaks and spills associated with vehicle accidents*	Low
Parramatta Road ventilation facility at Haberfield	• Parramatta Road ventilation facility.	• There are historical land uses within the western part of the site that may have caused soil and potentially groundwater contamination (potential former dry cleaners and workshops associated with former car dealerships and mechanics). 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 to be present at concentrations above the relevant assessment criteria and limited in extent.	Exposure pathway for human or ecological receptors may be present and complete as a result of minor spills during operation*	Low

Operational area	Operation	Potential contamination impacts associated with operation	Likelihood of soil or groundwater contamination to be present as a result of project operation	Consequence (without implementation of appropriate controls)	Risk (refer Table 3-3)
Darley Road at Leichhardt	• Permanent water treatment facility and substation on western portion of the site.	• Soil investigations and limited groundwater investigations have been undertaken within the site. The investigations identified that the site was suitable for ongoing commercial/industrial land with the exception of a UST which required decommissioning • Potential contamination impacts from the operation of the permanent water treatment facility could include spills of water treatment chemicals or inadequate water treatment prior to discharge.	Very unlikely to be present at concentrations above the relevant assessment criteria and limited in extent.	Exposure pathway for human or ecological receptors may be present and complete as a result of minor spills during operation*	Low

Operational area	Operation	Potential contamination impacts associated with operation	Likelihood of soil or groundwater contamination to be present as a result of project operation	Consequence (without implementation of appropriate controls)	Risk (refer Table 3-3)
Rozelle Rail Yards at Rozelle	• Roads, entry and exit ramps and tunnel portals • Rozelle ventilation facility • Water treatment plant • Constructed wetland • Substations • Workshop facilities/bulky equipment store • Fire pump room and water tanks • Open space.	• Recent soil investigations have been completed on the site which identified concentrations of metals and PAHs exceeding the land use criteria for open space and commercial/industrial scenarios in fill • Potential contamination impacts from the operation of the permanent water treatment facility could include spills of water treatment chemicals or inadequate water treatment prior to discharge • Minimal soil or groundwater contamination impacts would be expected from the operation of the ventilation facility, substation, workshop, water treatment facility and 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 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.	Potentially present at concentrations above the relevant assessment criteria and widespread, if leaks and spills occur.	Exposure pathway for human or ecological receptors may be present and complete as a result of leaks and spills during operation*	Medium

Operational area	Operation	Potential contamination impacts associated with operation	Likelihood of soil or groundwater contamination to be present as a result of project operation	Consequence (without implementation of appropriate controls)	Risk (refer Table 3-3)
The Crescent	• Road infrastructure • Pedestrian and cycle paths.	• Residual contamination would likely be present in underlying soil, fill, groundwater and sediment • Contamination impacts associated with the operation of the project include leaks and spills on constructed roadways from vehicles and vehicle accidents.	Very unlikely to be present at concentrations above the relevant assessment criteria and limited in extent, if leaks and spills occur.	Exposure pathway for human or ecological receptors may be present in the event of leaks and spills associated with vehicle accidents*	Low
Victoria Road at Rozelle	• Road, pedestrian and cycle paths.	• Contamination impacts associated with the operation of the project include leaks and spills on constructed roadways from vehicles and vehicle accidents.	Very unlikely to be present at concentrations above the relevant assessment criteria and limited in extent.	Exposure pathway for human or ecological receptors may be present in the event of leaks and spills associated with vehicle accidents*	Low

Operational area	Operation	Potential contamination impacts associated with operation	Likelihood of soil or groundwater contamination to be present as a result of project operation	Consequence (without implementation of appropriate controls)	Risk (refer Table 3-3)
Iron Cove Link at Rozelle	• Roads, entry and exit ramps and tunnel portals • Iron Cove Link ventilation facility • Substation (land subject to landscaping).	• There are historical land uses within and surrounding the site which may have caused soil and potentially groundwater contamination • Contamination impacts associated with the operation of the project include leaks and spills on constructed roadways from vehicles and vehicle accidents • Minimal soil or groundwater contamination impacts would be expected from the operation of the substation and 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.	Potentially present at concentrations above the relevant assessment criteria.	Exposure pathway for human or ecological receptors may be present and complete as a result of leaks and spills during operation	Medium

Operational area	Operation	Potential contamination impacts associated with operation	Likelihood of soil or groundwater contamination to be present as a result of project operation	Consequence (without implementation of appropriate controls)	Risk (refer Table 3-3)
Campbell Road at St Peters	• Roads, including dive structures, tunnel portals and entry and exit ramps • Campbell Road ventilation facility • Substation • Workshop facilities/bulky equipment store • Open space (to be delivered in accordance with New M5 conditions of approval).	• There are known soil and groundwater contamination and landfill gas and leachate at the site. The remediation and management of the site would commence as part of the construction of the St Peters interchange for the New M5 project. Minimal soil or groundwater contamination impacts would be expected from the operation of the ventilation facility, substation and workshop for the M4-M5 Link project. 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 • Contamination impacts associated with the operation of the project include leaks and spills on constructed roadways from vehicles and vehicle accidents.	Potentially present at concentrations above the relevant assessment criteria and widespread.	Exposure pathway for human or ecological receptors are unlikely to present during operation assuming appropriate management of historical contamination	Medium

6.2 Tunnel groundwater treatment and discharge

During operation, groundwater seepage would be required to be extracted from the tunnels, treated and discharged to the receiving water bodies. As described in **section 5.2**, 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 **Appendix T** (Technical working paper: Groundwater) of the EIS.

It is noted that some sections of the tunnels would be tanked (see **Table 6-2**). As such, if present, contaminated groundwater would be unable to enter the tunnels at those locations.

Table 6-2 Sections of the tunnels to be tanked

Control line	Start chainage (m)	End chainage (m)	Length (m)	Structure type
Mainline tunnel				
M180	1880	1375	195	Driven tunnel
M190	1175	1390	215	Driven tunnel
Rozelle interchange				
MC4C01	185	335	150	Driven tunnel
MC4D01	1208	1428.8	220.8	Cut and Cover
MC4K01	355	404	49	Trough structure
MC4K01	404	500	96	Cut and Cover
MC4K01	670	760	170	Cut and Cover
MC4M01	2330	2550	220	Cut and Cover
MC4M01	2550	2670	120	Trough structure
MC4M01	2670	2740	70	Trough structure
M4R0 – ventilation adit	0	511	511	Cut and Cover
M4S0 – ventilation adit	0	61	61	Cut and Cover
M4T0 – ventilation adit	0	15	15	Cut and Cover
M4V0 – ventilation adit	500	552	52	Cut and Cover
TOTAL			2144.8	

Impacts associated with the operation of the tunnel would include the following:

- Groundwater ingress
- Stormwater ingress at portals
- Contaminated water ingress events which may occur during the operation of the project including, tunnel wash-down water, fire suppressant deluge or fire main rupture and spillage of flammable and other hazardous materials.

To manage the above operational impacts, separate sumps would be provided at tunnel sags to collect groundwater ingress and 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, with treated flows ultimately discharged to Hawthorne Canal. As the water would be treated prior to discharge, contamination impacts associated with the discharge of treated water to Hawthorne Canal during the operation of the tunnel are considered to be minimal.

Tunnel drainage for Rozelle would be pumped to a water treatment facility and constructed wetland at Rozelle interchange, 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. As for Hawthorne Canal, contamination impacts associated with the discharge of treated water to Rozelle Bay during the operation of the project are considered to be minimal (refer to **Appendix Q** (Technical working paper: Surface water and flooding) of the EIS).

7 Assessment of cumulative impacts

7.1 WestConnex and related projects

The M4-M5 Link project is a component of the WestConnex program of works, which would provide a 33 kilometre motorway linking Sydney's west and southwest with Sydney Airport and the Port Botany precinct. The individual components of WestConnex are:

- M4-M5 Link – Haberfield to St Peters (the subject of this EIS)
- M4 Widening – Pitt Street at Parramatta to Homebush Bay Drive at Homebush (planning approval granted and open to traffic)
- M4 East – Homebush Bay Drive, Homebush to Parramatta Road and City West Link (Wattle Street) at Haberfield (planning approval granted and under construction)
- New M5 – (planning approval granted and under construction)
- King Georges Road Interchange Upgrade (planning approval granted and open to traffic).

Related projects undergoing concept development and subject to separate planning assessment and approval included in this cumulative assessment include:

- Proposed future Western Harbour Tunnel and Beaches Link
- Proposed future Sydney Gateway.

Based on the construction timeframes for the M4-M5 Link project, there is potential for the construction phases of projects to overlap, particularly with respect to the adjacent New M5 and M4 East projects.

Other component projects, such as the M4 Widening and King Georges Road Interchange Upgrade are located further from the project. The likelihood of significant cumulative contamination impacts being generated as a result of the project, the M4 Widening and King Georges Road Interchange Upgrade is therefore considered to be low.

A summary of the key potential contamination impacts, mitigation measures and residual impacts identified through a review of EIS documents associated with the overlapping WestConnex projects are summarised in the following sections. The following WestConnex EIS documents were reviewed:

- M4 East Environmental Impact Statement, Volume 1B, Chapter 16 (GHD 2015)
- M4 East Environmental Impact Statement, Appendix P, Technical working paper: Soil and land contamination assessment (GHD 2015)
- New M5 Environmental Impact Statement, Volume 1C, Chapter 17 (AECOM 2015)
- New M5 Environmental Impact Statement, Appendix O, Technical working paper: Contamination (AECOM 2015)
- New M5 Environmental Impact Statement, Appendix F, Alexandria Landfill closure management plan (AECOM 2015).

7.1.1 M4 East

The M4-M5 Link project would interface directly with the M4 East at the Wattle Street interchange and Parramatta Road West civil and tunnel site at Ashfield. The impacts of the M4 East project on contamination at the Wattle Street interchange were assessed as part of that EIS and subsequent detailed design. Management measures were identified to mitigate impacts on surrounding properties for both the construction and operational phases with the objective of appropriately managing soil and groundwater (including discharge) contamination by working to achieve the requirements of the planning conditions and handover obligations for the M4 East contractor prior to occupation by the M4-M5 Link contractor.

7.1.2 New M5

The M4-M5 Link project would connect directly to the New M5 at the St Peters interchange which is located on a former landfill and adjacent to contaminated lands. The impacts of the New M5 project on remediation and closure of Alexandria Landfill and adjacent contaminated lands at the St Peters interchange were assessed as part of the New M5 EIS.

Management measures were identified to mitigate impacts on surrounding properties for both the construction and operational phases of the New M5 project. The objective was to reduce environmental harm, by working to achieve the requirements of the planning conditions and to implement the landfill closure requirements to mitigate environmental harm.

In accordance with the conditions of the infrastructure approval for the New M5 project, Golder Associates prepared a soil contamination report, RAP and LCMP for St Peters interchange – Alexandria Landfill and Bradshaw Mountain Sites. The objective of the reports was to assess the site condition and document how the Alexandria Landfill site will be closed, remediated and redeveloped for the purpose of road infrastructure and open space land uses as part of the New M5 project. The RAP noted that the preferred remediation option is for on-site isolation and containment of wastes and other contaminated materials. Golder noted that these measures would be complemented by new, improved and/or upgraded environmental controls for leachate, landfill gas, groundwater management and surface water/stormwater management, which will result in an improved environmental condition at this location.

It is understood that any contamination impacts, including odours, arising from works undertaken as part of the New M5 would be managed to minimise impacts on the environment in accordance with the RAP and relevant project conditions of approval by the New M5 contractor.

7.1.3 Western Harbour Tunnel and Beaches Link

The proposed future Western Harbour Tunnel and Beaches Link contractor would inherit a portion of the Rozelle civil and tunnel site near to the Western Harbour Tunnel and Beaches Link entry and exit ramps when this area is no longer required for construction of the M4-M5 Link project, extending the use of this construction site. Notwithstanding that different projects (M4-M5 Link and the proposed future Western Harbour Tunnel and Beaches Link project) would be utilising the Rozelle civil and tunnel site, all construction activities would be undertaken in a staged and coordinated manner to ensure that there are no adverse impacts on human health or the environment as a result of contamination, and that the site is left in a condition suitable for the proposed land use. While no EIS is available for review for the proposed future Western Harbour Tunnel and Beaches Link, it is assumed that construction activities and the operation of the tunnel would be undertaken with appropriate environmental (including reference to contamination) management measures in place in accordance with legislative requirements to prevent adverse impacts on human and/or ecological receptors. No cumulative impacts from contamination are therefore anticipated.

7.2 Other projects

Cumulative contamination impacts associated with other key projects proposed in the vicinity of the M4-M5 Link project footprint have been considered including:

- The Rozelle Rail Yards Site Management Works
- Transport for New South Wales CBD and South East Light Rail (CSLER) – Rozelle maintenance depot
- The Bays Precinct, Sydney Water stormwater channel renewal/naturalisation works
- Western Harbour Tunnel and Beaches Link.

7.2.1 Rozelle Rail Yards – Site Management Works

Roads and Maritime is proposing to carry out a suite of surface and near surface site management works on part of the Rozelle Rail Yards. These works will be undertaken prior to construction of the M4–M5 Link project. The Rozelle Rail Yards – Site Management Works Review of Environmental Factors (Roads and Maritime 2016) indicates that contaminated soil, fill and groundwater will be progressively managed during construction.

Following completion of the works, the ‘finished site’ would be managed and maintained in accordance with the management measures outlined in the REF which would manage soil, water, contamination including asbestos, resource use and waste, and other environmental factors until commencement of the construction of the M4-M5 Link project. Therefore no cumulative impacts resulting from residual contamination are anticipated.

7.2.2 CBD and South East Light Rail (CSELR)

The CBD and South East Light Rail – Rozelle maintenance depot is located immediately to the west of the Rozelle Rail Yards. This development has planning approval and works have commenced. Site clearance activities were undertaken in 2016. The CBD and South East Light Rail Project Environmental Impact Statement (Parsons Brinkerhoff 2013) noted that a large suite of management and mitigation measures are proposed to be implemented to reduce the potential adverse contamination impacts associated with the proposal. It was noted that these measures would be incorporated into the CEMP and sub-plans for the proposal and subsequently if necessary, the future operator’s environmental management system. Therefore no cumulative contamination impacts are anticipated with the M4-M5 Link project.

7.2.3 The Bays Precinct and Sydney Water stormwater channel renewal/naturalisation

The Bays Precinct ad the Sydney Water stormwater channel renewal/naturalisation projects are in their early planning stages, and as such no environmental assessments were available for review at the time of this assessment.

It is assumed that The Bays Precinct project would incorporate environmental management measures during construction and operation in accordance with legislative requirements to prevent adverse impacts on the common receiving receptors of Whites Creek, White Bay and Rozelle Bay and potential environmental impacts from contamination to surrounding properties. Similarly it is assumed that management measures would be implemented by Sydney Water construction contractors during the construction works at Whites Creek and Johnstons Creek for the naturalisation projects to manage potential impacts on the creeks and downstream environment from both a water quality management perspective.

7.2.4 Summary

This report has assessed contamination conditions across the whole of the M4-M5 Link project footprint including the proposed Western Harbour Tunnel and Beaches Link project at Rozelle Rail Yards. Review of EIS documents for the various approved projects located in proximity to the M4-M5 Link project, including M4 East, New M5, M4 Widening and King Georges Road Interchange Upgrade 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. Furthermore, at some locations, the M4-M5 Link project will be utilising land that has been previously investigated and managed in accordance with the conditions of approval for adjacent projects such as M4 East.

With consideration to the management measures proposed to be implemented as part of the M4–M5 Link project (see **section 8**), there are minimal adverse cumulative contamination impacts anticipated to occur as part of the construction or operation of the project. Risks to human health and the environment would be mitigated through implementation of management measures outlined herein (see **section 8**) and also in **Appendix K** (Technical working paper: Human health risk assessment) of the EIS.

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. Additionally, 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 compared with identified contamination conditions at the time of acquisition. 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 surface water and groundwater are discussed in **Appendix Q** (Technical working paper: Surface water and flooding) and **Appendix T** (Technical working paper: Groundwater) of the EIS.

8 Management of impacts

8.1 Management of construction impacts

8.1.1 Ancillary facilities and project footprint

The methods for the management of construction impacts are outlined in the following section and specified for each ancillary facility in **Table 8-2**.

Construction environmental management plan (CEMP)

Procedures and protocols to manage potentially contaminated fill, soil, bedrock and extracted groundwater would be detailed in the CEMP prepared for the project. The CEMP would include procedures and controls applicable to managing contamination related impacts as summarised in **Table 8-1**.

Table 8-1 Construction environmental management plan – contamination component

Management issue	Summary of procedures and controls
Waste	• Waste management plans would include procedures for handling and storing spoil, including potentially or known contaminated soil/fill in accordance with the POEO Act • Protocols for waste classification for off-site disposal or assessment under a resource recovery exemption and waste tracking.
Stockpile management and spoil handling	• Stockpile management procedures for segregating spoil and preventing cross-contamination of clean spoil (VENM or ENM) with contaminated soil • Odour management procedures in the event that odorous material is identified during stockpile management and spoil handling activities.
Surface water runoff erosion of contaminated soils	• Procedures for the prevention of erosion and management of potentially contaminated stormwater runoff would be detailed in the CEMP and soil and water management plan included as an appendix to the CEMP.
Asbestos	• Site specific asbestos management plans would be developed where known or suspected asbestos is present. The plans would be prepared to satisfy the SafeWork Australia Asbestos Codes of Practice and Guidance Notes, NSW legislative requirements and relevant Australian and New Zealand Standards • The AMPs would include procedures for air monitoring and clearance inspections and reports.
Hazardous materials	• A hazardous materials assessment would be undertaken prior to and during the demolition of buildings. Demolition works would be undertaken in accordance with the relevant Australian Standards and relevant SafeWork NSW codes of practice, including the Work, Health and Safety Regulation 2011.
Dangerous goods	• A dangerous goods search of the SafeWork NSW records for licensed dangerous goods would be undertaken for all sites that were former commercial or industrial premises and where subsurface works are planned as part of the project.

Management issue	Summary of procedures and controls
Acid sulfate soil management	• Acid sulfate management plans would be developed in accordance with ASSMAC (1998) guidelines • Acid sulfate soils would be disposed off-site (where required) in accordance with the NSW EPA (2014) Waste Classification Guidelines; Part 4: Acid sulfate soils.
Unexpected finds	• In the event an unexpected find of contamination and/or odorous material is encountered during construction, work in the affected area would cease until an appropriately qualified environmental consultant can inspect the find and provide a recommendation on further investigation, remediation or control measures, as deemed appropriate • Further assessment and management/remediation, where required, would be undertaken in accordance with section 105 of the CLM Act • An unexpected find may include soil discoloration, offensive odours, buried waste or ACM, for example.
Prevention of new/cross-contamination	• Plant and equipment would be maintained and serviced within hardstand areas with adequate spill response kits • Chemicals, oils and fuels would be handled and stored in appropriately bunded areas with adequate spill response kits • Emergency response plans, clean up and reporting procedures would be developed.

Further investigations

Ancillary facilities and areas within the project footprint that have been assessed as low risk do not require further assessment or remediation and would be managed by the implementation of the CEMP. Sites which are assessed as potentially containing soil or groundwater contamination that could pose an unacceptable risk to human or ecological receptors during construction of the project would be further investigated by completing an intrusive site investigation.

Where there is currently insufficient data to prepare a Remedial Action Plan (RAP), sites assessed as either medium or high risk would have a site investigation undertaken prior to commencement of construction.

The site investigation would be designed in accordance with NSW EPA (1995) *Sampling Design Guidelines* and in accordance with the relevant guidelines listed in **section 3**. The consultant would prepare a sampling, analysis and quality plan (SAQP) which would be reviewed by the appointed independent NSW EPA accredited site auditor prior to completion of the site investigation. The final site investigation report prepared would also be reviewed by the appointed independent NSW EPA accredited site auditor.

Remediation

Sites which are assessed as containing soil or groundwater contamination that poses an unacceptable risk to human or ecological receptors would be remediated.

Sites requiring remediation would have a RAP developed prior to the commencement of construction. The RAP would be prepared by a suitably qualified and experienced contaminated lands consultant and independently audited by a NSW EPA accredited site auditor.

Remediation and validation activities would be completed by a contaminated lands consultant, independent to the construction contractor. A validation report would be prepared by the consultant and reviewed by the appointed independent NSW EPA accredited site auditor.

The RAPs would be prepared in accordance with the relevant legislation and guidelines listed in **section 3**.

The need for remediation would be undertaken by considering the risks of undertaking the works. If the risks posed to the environment and human health is greater than the contamination remaining in-situ, then the need for active remediation would be reconsidered and alternative management options such as capping investigated. The RAPs would include the assessment of sustainable remediation options and consideration of the *Waste Avoidance and Resource Recovery Act 2001* (NSW).

Remediation works may need to occur in a staged approach throughout the construction and post construction periods, depending on the final land use following completion of the project.

Table 8-2 Management of construction impacts – ancillary facilities and project footprint

Area	Construction works	Management of construction impacts
C1a – Wattle Street civil and tunnel site at Haberfield	• Stockpiling within cut and cover structure • Excavations and tunnelling for ramp. (It is noted that the ramp and cut-and-cover structure would be built by M4 East contractor). The M4-M5 Link contractor will construct driven tunnel using road headers to connect the ramps with the mainline. In addition, minor civil and finishing [pavement line-marking] ramps and surface lands along Wattle Street [to Parramatta Road] to prepare ramps for use).	• Further contamination investigations are not required for the M4-M5 Link project at this site • CEMP: The potential construction impacts would be managed through the development and implementation of the CEMP, which would include mitigation measures for encountering unexpected contamination and management of spoil.
C2a – Haberfield civil and tunnel site at Haberfield	• No excavations or tunnelling to be completed (construction completed during M4 East) • Works would comprise minor civil construction associated with construction of a substation which would require shallow excavation works • This location would service tunnelling, but no spoil would be removed to the surface at this site • Tunnel spoil from the M4-M5 Link mainline would be transported out via M4 East stubs to the M4 East mainline • Minor civil construction associated with the substation (including shallow excavation) • Deep excavation for vent tunnels, footings etc. would be carried out by M4 East Contractor • Use of existing M4 East facilities (currently under construction).	• CEMP: The potential construction impacts would be managed by the development and implementation of the CEMP, which would include mitigation measures for encountering unexpected contamination and management of spoil.
C3a – Northcote Street civil site at Haberfield	• Minimal excavation/surface disturbance for parking construction.	• CEMP: The potential construction impacts would be managed by the development and implementation of the CEMP, which would include mitigation measures for encountering unexpected contamination and management of spoil.

Area	Construction works	Management of construction impacts
C1b – Parramatta Road West civil and tunnel site at Ashfield	• Demolition of existing buildings and structures • Utility works including protection and/or adjustment of existing utilities, removal of redundant utilities and installation of new utilities • 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 access tunnel • Tunnel excavation of the eastbound and westbound mainline tunnels and the Wattle Street entry and exit ramps using roadheaders, as well as stockpiling of excavated material and spoil haulage • Excavation of benches and cross-passages • Installation of mechanical and electrical services within the tunnels and fitout of the tunnels with additional infrastructure (eg signage) • Finishing works including asphalting, line marking and signage installation • Demobilisation including works to prepare the site for a permissible future use.	• Further contamination investigations are not required for the M4-M5 Link project at this site • CEMP: The potential construction impacts would be managed through the development and implementation of the CEMP, which would include mitigation measures for encountering unexpected contamination and management of spoil.

Area	Construction works	Management of construction impacts
C2b – Haberfield civil site at Haberfield	• No excavations or tunnelling to be completed (construction completed during M4 East) • Works would comprise minor civil construction associated with construction of a substation which would require shallow excavation works • This location would service tunnelling, but no spoil would be removed to the surface at this site. Tunnel spoil from the M4-M5 Link mainline would be transported out via M4 East stubs to the M4 East mainline • Minor civil construction associated with the substation (including shallow excavation) • Deep excavation for vent tunnels, footings etc. would be carried out by M4 East Contractor • Use of existing M4 East facilities (currently under construction).	• CEMP: The potential construction impacts would be managed by the development and implementation of the CEMP, which would include mitigation measures for encountering unexpected contamination and management of spoil.
C3b – Parramatta Road East civil site at Haberfield	• Demolition of existing structures • Establishment of site offices, amenities and temporary infrastructure including temporary noise barriers • Utility works including protection and/or adjustment of existing utilities, removal of redundant utilities and installation of new utilities • Establishment of site offices and workforce amenities • Support for the construction of the mainline tunnels and the Wattle Street interchange entry and exit ramps (no tunnelling would occur from the Parramatta Road East civil site (C3b)) • Landscaping • Demobilisation.	• CEMP: The potential construction impacts would be managed by the development and implementation of the CEMP, which would include mitigation measures for encountering unexpected contamination and management of spoil.

Area	Construction works	Management of construction impacts
C4 – Darley Road civil and tunnel site at Leichhardt	• Demolition and UST decommissioning • Excavation for construction adit • Stockpiling • Road works.	• CEMP: The potential construction impacts would be managed by the development and implementation of the CEMP, with the exception of the existing identified UST • Hazardous materials assessment and management plans would be undertaken for buildings and structures prior to demolition • Waste management: *In situ*/ex-situ waste classification/virgin excavated natural material VENM/ENM assessment of excavated fill, natural soils and rock to evaluate suitability for disposal to landfill or potential reuse • Acid sulfate soils: Management of acid sulfate soils would be undertaken through the development, implementation and adherence to management procedures for acid sulfate soils as part of the CSWMP • RAP: The existing UST would be required to be removed in accordance with a site specific RAP and a validation report prepared.

Area	Construction works	Management of construction impacts
C5 – Rozelle civil and tunnel site at Rozelle	• Demolition of structures, including buildings • Excavations for tunnel portals and cut and cover tunnels • Road construction • Stockpiling in acoustic shed • Construction of temporary carparks, stores, workshops, offices, construction sediment basins, construction water treatment plants and laydown areas • Construction of permanent operational infrastructure including ventilation facility, water treatment facility and substations • Tunnelling (for ventilation/road construction) • Utility installation, relocation and protection • Constructed wetland and other drainage infrastructure including upgraded culvert below City West Link to Rozelle Bay • Upgraded headwall and drainage outfall to Rozelle Bay • Reshaping of Whites Creek and naturalisation works • Construction of new Victoria Road bridge and new The Crescent bridge • Construction of active transport bridges • Earthworks associated with landscaping.	• Site investigations: A grid based *in situ* characterisation of soil and fill materials proposed to be excavated/disturbed as part of future construction activities, where required, to supplement the existing data/fill in data gaps. The lateral extent and depth of intrusive investigation would be determined by the design and location of the ground disturbance and underground infrastructure • Hazardous materials assessment and management plans would be undertaken for buildings and structures prior to demolition • RAP: Based on the investigations, preparation of a RAP for the excavation and off-site disposal of contaminated materials to licensed landfill or on-site treatment/beneficial reuse (if identified and practicable) • Waste management: *In situ* /ex-situ waste classification/virgin excavated natural material (VENM)/excavated natural material (ENM) assessment of excavated fill, natural soils and rock to evaluate suitability for disposal to landfill or potential reuse • Acid sulfate soils: Further investigations to delineate PASS within excavation footprints. Management of acid sulfate soils and sediment would be undertaken through the development, implementation and adherence to management procedures for acid sulfate soils as part of the CSWMP • CEMP: Potential construction impacts including disturbance of surface water and contaminated sediment within Rozelle Bay) would also be managed by the development and implementation of the CEMP.

Area	Construction works	Management of construction impacts
C6 – The Crescent civil site at Annandale	• Utility works including protection and/or adjustment of existing utilities, removal of redundant utilities and installation of new utilities • Temporary stockpiling of fill and pavement materials as well as materials generated from construction activities prior to off-site removal • Realignment of The Crescent including construction of a new bridge over Whites Creek • Construction of the culvert (Easton Park drain) below City West Link • Installation of coffer dam(s) and dewatering works within Rozelle Bay to facilitate the widening of Whites Creek and construction of culvert below City West Link • Widening and improvement works along Whites Creek, including naturalisation of a section of Whites Creek between The Crescent and Rozelle Bay • Excavating, filling and grading of disturbed areas • Landscaping and construction of pedestrian and cycle paths and bridges.	• Waste management: *In situ*/ex-situ waste classification of excavated fill, natural soils and sediment to evaluate suitability for disposal to landfill or potential reuse • Acid sulfate soils: management of acid sulfate soils and sediment by the development and implementation of management procedures for acid sulfate soils as part of the CSWMP • RAP: Based on the investigations, if required, preparation of a RAP for the excavation and off-site disposal of contaminated materials to licensed landfill or on-site treatment/beneficial reuse (if identified and practicable) • CEMP: Potential construction impacts (including disturbance of surface water and contaminated sediment within Rozelle Bay) would also be managed by the development and implementation of the CEMP.
C7 – Victoria Road civil site at Rozelle	• Demolition of existing buildings • Site sheds, laydown areas and/or site offices would be established on site.	• Hazardous materials assessment and management plans would be undertaken for buildings and structures prior to demolition • CEMP: Potential construction impacts would also be managed by the development and implementation of the CEMP.

Area	Construction works	Management of construction impacts
C8 – Iron Cove Link civil site at Rozelle	• Demolition • Bulk excavations for tunnel portals and cut and cover tunnels • Soft ground tunnelling • Road construction works • Bioretention facility and formalised car parking around the sides of the wetland • Utility installation, relocation and protection • Landscaping.	• Site investigation: Targeted site investigations would be undertaken to investigate identified areas of concern including groundwater investigations targeting potential up gradient contamination sources • Hazardous materials assessment and management plans would be undertaken for buildings and structures prior to demolition • RAP: If contamination posing a risk to human or ecological receptors was identified a RAP would be prepared • CEMP: If no risk is found, construction impacts would be managed by the development and implementation of the CEMP.
C9 – Pyrmont Bridge Road tunnel site at Annandale	• Demolition • Excavation for construction adit • Minor road works.	• Site investigation: targeted site investigations would be undertaken to investigate identified areas of concern. If contamination posing a risk to human or ecological receptors was identified a RAP would be prepared • Hazardous materials assessment and management plans would be undertaken for buildings and structures prior to demolition • RAP: An interim management plan may be developed for the construction period and remediation commence prior to redevelopment or sale of the land at the end of the construction period • CEMP: If no risk is identified based on the site investigation, construction impacts would be managed by the development and implementation of the CEMP.

Area	Construction works	Management of construction impacts
C10 – Campbell Road civil and tunnel site at St Peters	• Road construction works • Tunnelling and associated excavation and stockpiling • Excavation for construction adit to provide construction access to mainline • Construction of cut and cover structures • Construction of permanent operational infrastructure including ventilation facility.	• Site investigation: Intrusive investigations within areas of potential concern would have been undertaken for the New M5 project • RAP: RAPs would be prepared as part of the New M5 project based on findings of the Site investigations • Landfill Closure Management Plan (LCMP): Construction for the M4-M5 Link project would be undertaken in accordance with the relevant requirements of the Golder (2016), RAP, LCMP and EPL • CEMP: The potential construction impacts for the M4-M5 Link project would be managed by the development and implementation of the CEMP.

8.1.2 Management of construction impacts – tunnelling

Groundwater and surface water captured as a result of tunnelling activities may be contaminated with suspended solids and increased pH due to tunnel grouting activities. Temporary water treatment plants would be constructed at each construction ancillary facilities where groundwater is extracted during dewatering and tunnelling to mitigate adverse water quality impacts arising from the discharge of untreated construction water.

Groundwater reuse would be undertaken in accordance with the policies of sustainable water use of (DPI-Water). The proposed volumes and management of extracted groundwater during construction is detailed in **Appendix Q** (Technical working paper: Surface water and flooding) of the EIS.

8.2 Management of operational impacts

8.2.1 Operational sites

The methods for the management of operational impacts are specified for each operational area in **Table 8-3**.

Table 8-3 Management of operational impacts – operational sites

Area	Operational activities	Management of operational impacts
Wattle Street site at Haberfield	• Roadway • Residual land at Wattle Street would be developed in accordance with the conditions of approval for M4 East project (Wattle Street and Haberfield surface sites would be landscaped as per M4 East Urban Design and Landscape Plan, Northcote Street as per M4 East Residual Land Management Strategy).	• No further management anticipated to be required in relation to contamination following completion of construction.
Northcote Street site at Haberfield	• Developed in accordance with the conditions of approval for M4 East project (rehabilitated, fenced off with future land use to be determined).	• Land use suitability assessment would be required prior to redevelopment: – Site investigation: an assessment of soil to supplement the existing data/fill in data gaps and assess the land suitability for the future land use (if required based on M4 East investigations) – RAP: Preparation of a RAP to make the land suitable for future land use, if required based on the findings of the site investigation.
Parramatta Road at Ashfield	• No M4-M5 Link project operations are proposed to occur on the site after completion of construction • The site would be rehabilitated in preparation for a future permissible use in accordance with the Residual Land Management Plan to be prepared for the project.	• Land use suitability: – Site investigation: Characterisation of soil and fill materials to supplement the existing data/fill in data gaps and assess the land suitability for the proposed future land use • RAP: Preparation of a RAP to make the land suitable for open space land use, based on the findings of the site Investigation and future land use/design.

Area	Operational activities	Management of operational impacts
Parramatta Road ventilation facility at Haberfield	• Parramatta Road ventilation facility (being built as part of M4 East. Fitout works only as part of the M4-M5 Link project) • Remaining project land to be landscaped in accordance with the M4 East conditions of approval.	• Land use suitability assessment would be required prior to redevelopment: – Site investigation: an assessment of soil to supplement the existing data/fill in data gaps and assess the land suitability for the future land use (if required based on M4 East investigations) • RAP: Preparation of a RAP to make the land suitable for future land use, if required based on the findings of the site investigation.
Parramatta Road site at Haberfield	• No M4-M5 Link project operations are proposed to occur on the site after completion of construction • The site would be rehabilitated in preparation for a future permissible use in accordance with the Residual Land Management Plan to be prepared for the project.	• Land use suitability: – Site investigation: Characterisation of soil and fill materials to supplement the existing data/fill in data gaps and assess the land suitability for the proposed future land use • RAP: Preparation of a RAP to make the land suitable for open space land use, based on the findings of the site Investigation and future land use/design.
Darley Road site at Leichhardt	• Permanent water treatment facility and substation to be built on western portion of the site at the completion of the project. Remainder of the site to be remaining project land, rehabilitated, fenced-off and redeveloped in accordance with existing land use zoning provisions.	• The site would continue as commercial/industrial land use as a water treatment facility. • Operation to be undertaken in accordance with the POEO Act. Management measures include the storage of chemicals and wastes in accordance with NSW regulations in force at the time. Further detail on the operation and management of the operational water treatment facility is provided in **Appendix Q** (Technical working paper: Surface water and flooding) of the EIS • Ongoing maintenance required for remaining project land.

Area	Operational activities	Management of operational impacts
Rozelle Rail Yards at Rozelle	• Water treatment plant • Constructed wetland • Roads and portals • Remaining project land to be redeveloped as open space • Ventilation facility • Substation • Workshop facilities/bulky equipment store • Fire pump room and water tanks • Road verges would be landscaped.	• Land use suitability: – Site Investigation: A grid based in situ characterisation of soil and fill materials to supplement the existing data/fill in data gaps and assess the land suitability for the future open space land use – RAP: Preparation of a RAP to make the land suitable open land use based on the findings of the Site Investigation and future design • Operation to be undertaken in accordance with the POEO Act. Management measures include the storage of chemicals and wastes and if necessary capture, treatment and discharge of surface water in accordance with NSW regulations in force at the time. Further detail on the operation and management of the operational water treatment plant is provided in **Appendix Q** (Technical working paper: Surface water and flooding) of the EIS.
The Crescent	• Road infrastructure, roadway, pedestrian and cycle paths • Remaining project land would be rehabilitated and returned to current owners • Remaining project land along The Crescent/Whites Creek would be stabilised and soft landscaped.	• The site would continue as commercial/industrial land use • Land use suitability: – Site Investigation: Characterisation of soil and fill materials to supplement the existing data/fill in data gaps and assess the land suitability for the future land use – RAP: Preparation of a RAP to make the land suitable for open space land use based on the findings of the site investigation and future design.
Victoria Road site at Rozelle	• Roadway, pedestrian and cycle paths • Road verges to be landscaped • Remaining project land, rehabilitated, fenced-off and redeveloped in accordance with existing land use zoning provisions.	• Land use suitability: – Site investigation: A grid based *in situ* characterisation of soil and fill materials to supplement the existing data/fill in data gaps and assess land suitability for the future land use – RAP: Preparation of a RAP to make the land suitable open land use based on the findings of the site investigation and future design.

Area	Operational activities	Management of operational impacts
Victoria Road at Iron Cove	• Roads and portal • Sewer pump station • Substation • Remaining project land to be redeveloped as open space • Road verges to be landscaped.	• Land use suitability: – Site investigation: Characterisation of soil and fill materials to supplement the existing data/fill in data gaps and assess the land suitability for the future open space land use – RAP: Preparation of a RAP to make the land suitable for open space land use based on the findings of the site investigation and future design • Operations to be undertaken in accordance with the POEO Act. Management measures include the storage of chemicals and wastes in accordance with NSW regulations in force at the time.
Pyrmont Bridge Road site at Annandale	• Remaining project land, rehabilitated, fenced off and redeveloped in accordance with existing land use zoning provisions.	• Land use suitability: – Site investigation: Characterisation of soil and fill materials to supplement the existing data/fill in data gaps and assess the land suitability for the proposed future land use – RAP: Preparation of a RAP to make the land suitable for open space land use, based on the findings of the site Investigation and future land use/design.
Campbell Road site at St Peters	• Roads and portals • Ventilation facility • Ventilation supply facility • Substation • Workshop facilities/bulky equipment store • Portal and roads • Open space (to be delivered in accordance with New M5 conditions of approval).	• Ongoing groundwater, leachate and landfill gas monitoring would be undertaken by the New M5 project for the former Alexandria Landfill during the operational phase of the New M5 project in accordance with the approved Landfill Closure Plan • Land use suitability for areas outside of the EPL premises (former Alexandria Landfill): – Site investigation: Characterisation of soil and fill materials to supplement the existing data/fill in data gaps and assess the land suitability for the future open space land use (if not already completed as part of New M5) – RAP: Preparation of a RAP to make the land suitable for open space land use (if not already completed as part of New M5 project) • Operations to be undertaken in accordance with the POEO Act. Management measures include the storage of chemicals and wastes in accordance with NSW regulations in force at the time.

8.2.2 Management of operational impacts – roadways including tunnels

A risk assessment of all project roads will be carried out during detailed design to evaluate the likelihood of vehicle accidents during the operation of the project. Spill containment facilities would be located where high risk spill/contamination risk areas of roadway are identified.

The tunnel operation water treatment facilities would be designed such that effluent would be of suitable quality for discharge to the receiving environment. The level of treatment would consider the characteristics of the discharge and receiving waterbody, the operational constraints or practicalities and associated environmental impacts, and would be developed in accordance with ANZECC (2000) and with consideration to the relevant NSW Water Quality Objectives.

Treated flows from the Rozelle water treatment plant would be discharged to a constructed wetland within the Rozelle Rail Yards. This would afford some 'polishing' of the effluent, helping to remove residual dissolved constituents such as nitrogen and phosphorus not removed by the operation water treatment plant. The wetland at Rozelle interchange would also be used to treat a portion of stormwater runoff from the project footprint. Opportunities to incorporate other forms of nutrient removal would be investigated during detailed design for the treatment plant at Darley Road, as required.

An OEMP would be developed to manage potential impacts on groundwater and surface water. The OEMP would be a 'live' document with the capacity to be updated if conditions are different to those expected. As part of the OEMP the following plans or protocols would be included:

- Groundwater Management Plan
- Groundwater monitoring program
- Surface water monitoring program
- Drainage system maintenance plan.

8.3 Management of cumulative impacts

An assessment of cumulative impacts associated with other projects in the vicinity of the M4-M5 Link, in particular other WestConnex projects, such as the M4 East and New M5 projects, has been carried out. The assessment also considered other projects such as the CBD and South East Light Rail and potential future Western Harbour Tunnel and Beaches Link projects (see **section 7**). The projects currently under construction all incorporate construction and operation contamination management and mitigation measures to prevent adverse impacts on human health and the environment. Other projects that are still in the planning stages will be required to incorporate similar mitigation measures in accordance with legislative requirements to prevent adverse impacts.

Therefore, with due consideration of the proposed management measures to be implemented as part of the M4-M5 Link project as discussed in **sections 8.1** and **8.2**, there are likely to be minimal adverse cumulative contamination impacts associated with the past, existing and future land uses of these projects.

9 Conclusions

9.1 Key findings

This technical working paper has identified a number of areas and contaminants of concern which require management during the construction and operation of the M4-M5 Link project. Existing identified contamination issues are primarily related to historical land uses which have adversely impacted the quality of soil, fill, groundwater, surface water and sediment within the project footprint.

A number of properties located within the project footprint were identified as having a high risk of contamination which should be investigated during project planning. These properties generally comprise sites that have potentially been the subject of historically contaminating land uses, including:

- Former industrial and transport infrastructure, along with reclamation within the Rozelle Rail Yards
- Commercial/industrial properties present within or adjacent to the project footprint including but not limited to those on the edge of the Rozelle Rail Yards, manufacturing industries, workshops, timber mills and boat yards
- Areas of historical land reclamation (including unregulated filling activities), particularly along the harbour foreshore near Rozelle Bay
- Structures potentially containing hazardous materials that are required to be demolished for the project.

There is also a potential that contamination arising from tunnel construction and associated project works could adversely impact soil, groundwater and surface water if not managed appropriately.

9.2 Construction impacts and mitigation measures

A CEMP would be prepared for the project. The CEMP would include management measures for areas within the project footprint identified as being potentially contaminated.

Ancillary facilities and areas within the project footprint that have been assessed as low risk do not require further assessment or remediation and would be managed through the implementation of the CEMP. Sites which are assessed as potentially containing soil or groundwater contamination that could pose an unacceptable risk to human or ecological receptors during construction of the project would require further intrusive site investigation. The following sites would require the completion of targeted site investigations, waste characterisation and preparation of management procedures for acid sulfate soils and hazardous materials assessment as part of the Construction Soil and Water Management Plan (CSWMP) to inform the appropriate management of contamination during the intrusive construction program:

- Ancillary facilities and associated areas of construction disturbance within the project footprint comprising:
  - Parramatta Road West civil and tunnel site at Ashfield (C1b)
  - The Darley Road civil and tunnel site at Leichhardt (C4)
  - Rozelle civil and tunnel site at Rozelle (C5)
  - The Crescent civil site at Annandale (C6)
  - Iron Cove Link civil site at Rozelle (C8)
  - Pyrmont Bridge Road tunnel site at Annandale (C9)
  - Campbell Road civil and tunnel site at St Peters (C10) (for properties not previously investigated as part of the New M5 project)
- All contamination investigations must be undertaken by a suitably qualified and experienced person in accordance with guidelines made or approved under the CLM Act
- Subject to the outcomes of the additional investigations, Remediation Action Plan (RAPs) may be required and implemented in the event that site remediation is warranted prior to construction

- Intrusive works undertaken within the Campbell Road civil and tunnel site (C10) at St Peters that are within the former Alexandria Landfill Environment Protection Licence (EPL) boundary would be required to comply with the existing Golder (2016) RAP, Landfill Closure Plan, EPL and New M5 conditions of approval
- Groundwater and surface water captured as a result of tunnelling activities or installation of the coffer dam(s) in Rozelle Bay may be contaminated with suspended solids and increased pH due to tunnel grouting or activities associated with installation of the coffer dam(s). Temporary water treatment plants would be constructed at each construction ancillary facility where groundwater is extracted during dewatering and tunnelling. The water encountered during construction and operation would require appropriate monitoring and treatment prior to discharge to receiving water bodies
- The CEMP would incorporate the Roads and Maritime Unexpected Discovery of Contaminated Lands Procedure Roads and an asbestos management plan. The CEMP prepared for implementation during the project and should encompass all construction activities associated with the project. The plan should accurately reflect the conditions likely to be encountered during construction at various locations within the project footprint
- A construction soil and water management plan must be prepared for implementation during construction of the project
- Management procedures for acid sulfate soils as part of the CSWMP would be prepared for implementation during the project which should encompass the management of all potential or actual acid sulfate soils which may be disturbed as part of construction activities associated with the project. The plans should accurately reflect the conditions likely to be encountered during construction at various locations within the project footprint.

9.3 Operation impacts and mitigation measures

Following the completion of construction works, additional site investigations would be required to confirm the suitability of remaining project land proposed to be redeveloped for a more sensitive land use or to meet site handover obligations. In the event that residual contamination is identified, remediation works would be undertaken in accordance with an approved RAP.

The following would be undertaken and implemented prior to the operational phase of the project:

- A NSW EPA Accredited Site Auditor would be engaged to review all contamination reports and evaluate the suitability of a site for a specified use as part of the project
- An Operational Environmental Management Plan (OEMP) must be prepared to manage potential impacts on groundwater and surface water during the operational phases of the project.

9.4 Conclusions

Based on the findings of this technical working paper, there is potential for localised areas of soil, acid sulfate soil, sediment, fill and groundwater contamination associated with historically contaminating land uses to be encountered during construction, and further assessment is warranted in some instances. The discovery of contaminated materials is considered most likely to occur during near surface excavation works associated with road and tunnel construction activities.

Mitigation and management measures for construction and operation have been recommended to ensure risks arising from disturbances of contaminated soils and acid sulfate soil are minimised.

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Appendix S

Technical working paper: Biodiversity

WestConnex

WestConnex M4-M5 Link

Biodiversity Assessment Report

12 August 2017

Prepared for

Roads and Maritime Services

Prepared by

Eco Logical Australia Pty Ltd with support from AECOM and Roads and Maritime Services of NSW

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Executive summary

NSW Roads and Maritime Services (Roads and Maritime) is seeking approval to construct and operate the WestConnex M4-M5 Link (the project), which would comprise a new multi-lane road link between the M4 East Motorway at Haberfield and the New M5 Motorway at St Peters. The project would also include an interchange at Lilyfield and Rozelle (the Rozelle interchange) and a tunnel connection between Anzac Bridge and Victoria Road, east of the Iron Cove Bridge (Iron Cove Link). In addition, construction of tunnels, ramps and associated infrastructure to provide connections to the proposed future Western Harbour Tunnel and Beaches Link project would be carried out at the Rozelle interchange.

Approval is being sought under Part 5.1 of the *Environmental Planning and Assessment Act 1979* (NSW) (EP&A Act). A request has been made for the NSW Minister for Planning to specifically declare the project to be State significant infrastructure and also critical State significant infrastructure. An environmental impact statement (EIS) is therefore required.

This technical report forms the Biodiversity Assessment Report (BAR) to support the EIS. In preparing this report, the Secretary's Environmental Assessment Requirements (SEARs) issued for the project have been addressed as well as comments received by the NSW Department of Planning and Environment (DP&E) from government agencies during the preparation of the SEARs. No additional matters for further consideration were identified by the NSW Office of Environment and Heritage (OEH) in its submission to the SEARs. Where appropriate, considerations identified by the NSW Department of Primary Industries (DPI) have been addressed in this BAR. Accordingly, biodiversity impacts have been assessed under the Framework for Biodiversity Assessment (FBA) (OEH 2014a), as required by the SEARs.

The project would be generally located within the City of Sydney and Inner West local government areas (LGAs). The project is located about two to seven kilometres south, southwest and west of the Sydney central business district (CBD) and would cross the suburbs of Ashfield, Haberfield, Leichhardt, Lilyfield, Rozelle, Annandale, Stanmore, Camperdown, Newtown and St Peters. The assessment included both desktop analysis and field assessments, using the FBA methodology to assess the presence of native vegetation, habitat for threatened species and condition of any ecological communities.

A separate project for the Rozelle Rail Yards site management works was assessed through a review of environmental factors (REF) under Part 5 of the EP&A Act and approved by Roads and Maritime in April 2017. The works will remove rail and rail related infrastructure within the Rozelle Rail Yards site, as well as vegetation, buildings and stockpiles. The REF assessed impacts of these works on threatened species and ecological communities listed under State and Commonwealth legislation, in accordance with the EP&A Act. The Rozelle Rail Yards site management works are not part of the M4-M5 Link project and have therefore been excluded from the EIS and this BAR. However, the cumulative impacts of the site management works and the M4-M5 Link project have been considered in this assessment (see section 9.6).

The study area for the assessment comprises the project footprint and includes all areas likely to be impacted by the project and is shown in Figure 2.3. The project footprint defined in this report is the same as the development footprint defined in the FBA. Sufficient flexibility has been provided to allow for refinement of the project footprint during detailed design or in response to submissions received during the exhibition of the EIS.

No Plant Community Types (PCTs), defined as native vegetation by the FBA were recorded within the project footprint, and thus no remnant native vegetation is considered to be present. Vegetation observed is consistent with urban native and exotic vegetation.

The project is located in a highly urbanised environment and much of the area is entirely modified and disturbed and contains exotic species, weeds and planted native or non-indigenous species. It is characterised by urban parks, landscaped road verges, disused rail infrastructure, compacted soils, introduced fill, existing residential, commercial and light industrial development and other infrastructure. Vegetation in the project footprint is generally considered to be in a poor ecological condition, with little ecological value and unlikely to have any native resilience or recovery potential. As such, there would be no direct impacts to native vegetation from the project. In this regard, potential threatened fauna are limited to those species that utilise urban environments and man-made structures.

Targeted threatened microbat surveys have been completed for those species initially considered as having a potential to occur within the project footprint. Eastern Bentwing-bat (*Miniopterus schreibersii oceanensis*) and Yellow-bellied Sheathtail-bat (*Saccolaimus flaviventris*), both listed as vulnerable under the *Threatened Species Conservation Act 1995* (NSW) (TSC Act) were recorded within the Rozelle Rail Yards. The high number of Eastern Bentwing-bat calls recorded during the targeted surveys suggests that this species may be roosting in the cavities under the Victoria Road bridge, or using the archway under the bridge as a flyway. The Yellow-bellied Sheathtail Bat is a predominantly tree-dwelling bat, and thus, its presence in the project footprint is limited to foraging habitat. The Eastern Bentwing-bat and Yellow-bellied Sheathtail-bat are considered an ecosystem credit species under the FBA in relation to foraging and roosting habitat.

In addition, the Grey-headed Flying Fox (*Pteropus poliocephalus*), listed as vulnerable under the TSC Act and *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth) (EPBC Act) is assumed to be present. It was considered that this species is likely to use some of the vegetation in the project footprint for foraging and has been recorded foraging adjacent to the project footprint. The Grey-headed Flying-fox is considered an ecosystem credit species under the FBA in relation to foraging habitat. No roosting sites or camps occur in proximity to the project footprint, and thus would not be impacted by the works. The closest Grey-headed Flying-fox camps are the Centennial Park and Turrella, approximately five kilometres east and five kilometres southwest respectively.

This BAR assessed the type and number of credits using the FBA methodology. However, no PCTs or threatened species credit species were recorded within the project footprint, and therefore, no offsets are required. The FBA methodology states '*that an assessor is not required to assess areas of land on the development site without native vegetation under Chapter 4 or Chapter 5 (of the methodology), unless the SEARs issued for the project require an assessment of the land in accordance with those chapters'*. It is noted that the Grey-headed Flying-fox, Eastern Bentwing-bat and Yellow-bellied Sheathtail-bat are ecosystem credit species (for foraging and non-breeding habitat) and therefore due to the absence of PCTs within the project footprint, these species do not require an offset.

The project has substantially avoided biodiversity impacts by utilising, as much as possible, already disturbed sites and due to most of the infrastructure being underground. Opportunities to further avoid impacts in the design have been explored, and as a result of investigations for this assessment, the following ecological values have been avoided:

- Native vegetation communities, as defined by the FBA as native PCTs
- Endangered ecological communities such as Coastal Saltmarsh, which is listed under both the TSC Act and EPBC Act.

A number of potential indirect impacts that have been considered in the assessment include:

- Hydrological changes
- Dust, noise, vibration and light impacts (including overshadowing)
- Injury and mortality to flora and fauna
- Spread of weeds.

A number of mitigation measures to minimise direct and indirect ecological impacts would be implemented as part of the project in line with *Biodiversity Guidelines – Protecting and managing biodiversity on RTA projects* (Roads and Traffic Authority 2011). These measures would be detailed in the Construction Flora and Fauna Management Plan for the project which includes: site-specific environmental induction; identification of clearing limits and protective fencing; vegetation clearance procedures; pre-clearance surveys; erosion and sediment controls; weed management and monitoring.

The following matters, while not assessed under the FBA, are also covered in this report:

- Aquatic biodiversity listed under the *Fisheries Management Act 1994* (NSW) (FM Act)
- Groundwater dependent ecosystems (GDEs)
- Matters of national environmental significance (MNES) listed under the EPBC Act, as required by the Bilateral Agreement, made under section 45 of the EPBC Act.

An assessment of the potential impacts on GDEs and aquatic habitats potentially affected by the project concluded there would be no significant impact as a result of the project. No mapped GDEs occur in the study area (see section 4.4). There is likely to be no significant impact to aquatic flora and fauna listed under the FM Act. No protected marine vegetation would be harmed.

Following the desktop assessment and field surveys, one MNES was identified as potentially occurring within the study area and could be adversely affected by the project. The Grey-headed Flying-fox (*Pteropus poliocephalus*) is listed as vulnerable under the EPBC Act, and is known to camp at Centennial Park and Turrella. It is considered that this species is likely to use some of the study area for foraging, such as fig trees and winter flowering street trees.

An assessment of the Commonwealth Significant Impact Criteria (Commonwealth of Australia 2013) was undertaken for the Grey-headed Flying-fox. The assessment concluded that the project would not have a significant impact on this species, and as such, a referral to the Commonwealth was not required. Furthermore, offsets for this species are not required (according to FBA methodology), as impacts are associated with an ecosystem credit species.

Contents

Glossary of terms

Definitions	
Assessment circles	Two circles (the inner and outer assessment circle) in which the percent native vegetation cover in the landscape is assessed, taking into account both cover and condition of vegetation (OEH 2014a)
Biodiversity credit report	The report produced by the Credit Calculator that sets out the number and type of biodiversity credits required to offset the remaining adverse impacts on biodiversity values at a development site, or sets out the number and type of biodiversity credits that are created at an offset site (OEH 2014a)
Campbell Road civil and tunnel site	A construction ancillary facility for the M4-M5 Link project located at St Peters
Concept design	Initial functional layout of a road/road system or other infrastructure. Used to facilitate understanding of a project, establish feasibility and provide basis for estimating and to determine further investigations needed for detailed design
Construction	Includes all physical work required to construct the project
Construction ancillary facilities	Temporary facilities during construction that include, but are not limited to construction sites (civil and tunnel), sediment basins, temporary water treatment plants, pre-cast yards and material stockpiles, laydown areas, workforce parking, maintenance workshops and offices
Critically endangered ecological community (CEEC)	A threatened ecological community with a 'critically endangered' listing status under environmental legislation
Cumulative impact	Impacts that, when considered together, have different and/or more substantial impacts than a single impact assessed on its own
Cut-and-cover	A method of tunnel construction whereby the structure is built in an open excavation and subsequently covered
Darley Road civil and tunnel site	A construction ancillary facility for the M4-M5 Link project located at Leichhardt
Detailed design	The stage of design where project elements are design in detail, suitable for construction
Direct impact	Where a primary action is a substantial cause of a secondary event or circumstance which has an impact on a protected matter (ref http://www.environment.gov.au/system/files/resources/0b0cfb1e-6e28-4b23-9a97-fdadda0f111c/files/environment-assessment-manual.pdf).
Ecological community	An ecological community is a naturally occurring group of native plants, animals and other organisms that are interacting in a unique habitat
Ecosystem credit	A measurement of the value of endangered ecological communities (EECs), critically endangered ecological communities (CEECs) and threatened species habitat for species that can be reliably predicted to occur with a PCT. Ecosystem credits measure the loss in biodiversity values at a development site and the gain in biodiversity values at an offset site (OEH 2014a)

Definitions	
Endangered ecological community	A threatened ecological community with an ‘endangered’ listing status under environmental legislation
Groundwater dependent ecosystem	Refers to communities of plants, animals and other organisms whose extent and life process are dependent on groundwater, such as wetlands and vegetation on coastal sand dunes
Haberfield civil and tunnel site / Haberfield civil site	Construction ancillary facilities for the M4-M5 Link project located at Haberfield
Habitat	An area or areas occupied, or periodically or occasionally occupied, by a species, population or ecological community, including any biotic or abiotic component (OEH 2014a)
Indirect impact	Where an event or circumstance is a direct consequence of the action (ref http://www.environment.gov.au/system/files/resources/0b0cfb1e-6e28-4b23-9a97-fdadda0f111c/files/environment-assessment-manual.pdf)
Iron Cove Link	Around one kilometre of twin tunnels that would connect Victoria Road near the eastern abutment of Iron Cove Bridge and Anzac Bridge
Iron Cove Link civil site	A construction ancillary facility for the M4-M5 Link project south of Victoria Road at Rozelle, near the eastern abutment of Iron Cove Bridge
Matters for further consideration	Impacts that are considered to be complicated or severe that will require further consideration by the consent authority (OEH 2014a). The assessment is based on thresholds detailed in section 9 of the FBA. These can also be included as part of the project SEARs
MNES	A matter of national environmental significance (MNES) protected by a provision of Part 3 of the EPBC Act
Mitchell landscape	Landscapes with relatively homogeneous geomorphology, soils and broad vegetation types, mapped at a scale of 1:250,000 (OEH 2014a)
Mitigation	Action to reduce the severity of an impact (OEH 2014a)
Mitigation measure	Specific measure or management action to mitigate the severity of an impact
Northcote Street civil site	A construction ancillary facility for the M4-M5 Link project located at Haberfield
Parramatta Road East civil site	A construction ancillary facility for the M4-M5 Link project Haberfield
Parramatta Road West civil and tunnel site	A construction ancillary facility for the M4-M5 Link project at Ashfield
Population	All the individuals that interbreed within a given area

Definitions	
Project	A new multi-lane road link between the M4 East Motorway at Haberfield and the New M5 Motorway at St Peters. The project would also include an interchange at Lilyfield and Rozelle (the Rozelle interchange) and a tunnel connection between Anzac Bridge and Victoria Road, east of Iron Cove Bridge (Iron Cove Link). In addition, construction of tunnels, ramps and associated infrastructure to provide connections to the proposed future Western Harbour Tunnel and Beaches Link project would be carried out at the Rozelle interchange
Project footprint	The land required to construct and operate the project. This includes permanent operational infrastructure (including the tunnels), and land required temporarily for construction. For the purposes of this assessment, this term is used instead of 'development footprint' defined in the FBA methodology (OEH 2014a) to describe the area of direct impact: the area of land that is directly impacted on by a proposed Major Project that is under the EP&A Act, including access roads, and areas used to store construction materials (OEH 2014a)
Pyrmont Bridge Road tunnel site	A construction ancillary facility for the M4-M5 Link project located at Annandale
Rozelle civil and tunnel site	A construction ancillary facility for the M4-M5 Link project located at Lilyfield and Rozelle
Rozelle interchange	A new interchange at Lilyfield and Rozelle that would connect the M4-M5 Link mainline tunnels with City West Link, Anzac Bridge, the Iron Cove Link and the proposed future Western Harbour Tunnel and Beaches Link
Rozelle Rail Yards	The Rozelle Rail Yards is bound by City West Link to the south, Lilyfield Road to the north, Balmain Road to the west, and White Bay to the east. Note that the project only occupies part of the Rozelle Rail Yards site
Secretary's Environmental Assessment Requirements	Requirements and specifications for an environmental assessment prepared by the Secretary of the Department of Planning and Environment under section 115Y of the *Environmental Planning and Assessment Act 1979* (NSW)
Species credit species	Threatened species and populations that are assessed according to section 6.4 of the FBA (OEH 2014a)
Species credits	The class of biodiversity credits created or required for the impact on threatened species that cannot be reliably predicted to use an area of land based on habitat surrogates. Species that require species credits are listed in the Threatened Species Profile Database
St Peters interchange	A component of the New M5 project, located at the former Alexandria Landfill site at St Peters. Approved and under construction as part of the New M5 project. Additional construction works proposed as part of the M4-M5 Link project
Study area	The area directly affected by the development and any additional areas likely to be affected by the development, either directly or indirectly (OEH 2014a)
Target species	A species that is the focus of a study or intended beneficiary of a conservation action or connectivity measure
The Crescent civil site	A construction ancillary facility for the M4-M5 Link project located at Annandale

Definitions	
Victoria Road civil site	A construction ancillary facility for the M4-M5 Link project located on the eastern side of Victoria Road at Rozelle, between Lilyfield Road and Quirk Street
Wattle Street civil and tunnel site	A construction ancillary facility for the M4-M5 Link project located at Haberfield
WestConnex program of works	A program of works that includes the following projects: M4 Widening, King Georges Road Interchange Upgrade, M4 East, New M5 and M4-M5 Link projects

Abbreviations	
BAR	Biodiversity Assessment Report
BBCC	BioBanking Credit Calculator
BOPMP	NSW Biodiversity Offsets Policy for Major Projects
BVT	Biometric Vegetation Type
CE	Critically Endangered
CEMP	Construction Environmental Management Plan
CEEC	Critically endangered ecological community
CSSI	Critical State Significant infrastructure
DECC	NSW Department of Environment and Climate Change (former)
DEHWA	Australian Government Department of the Environment, Water, Heritage and the Arts (former)
DotEE	Department of the Environment and Energy
DP	Deposited Plan
DP&E	NSW Department of Planning and Environment
DPI	NSW Department of Primary Industries
E	Endangered
EEC	Endangered ecological community
EIS	Environmental Impact Statement
ELA	Eco Logical Australia
EP	Endangered Population
EP&A Act	*Environmental Planning and Assessment Act 1979* (NSW)
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth)
ESCPs	Erosion Sediment Control Plans
FBA	Framework for Biodiversity Assessment
FM Act	*Fisheries Management Act 1994* (NSW)
GDE	Groundwater dependent ecosystems

Abbreviations	
GIS	Geographic Information Systems
IBRA	Interim Biogeographically Regionalisation of Australia
KFH	Key Fish Habitat
KTP	Key Threatening Process
LGA	Local Government Area
MI	Migratory
MNES	Matters of national environmental significance
NV Act	*Native Vegetation Act 2003* (NSW)
OEH	NSW Office of Environment and Heritage
OZCAM	Online Zoological Collections of Australian Museums
P	Protected
PCT	Plant Community Type
REF	Review of environmental factors
Roads and Maritime	NSW Roads and Maritime Services
SEARs	Secretary's Environmental Assessment Requirements
SEPP	State Environmental Planning Policy
SIS	Species Impact Statement
SMC	Sydney Motorway Corporation
SSD	State Significant Development
SSI	State Significant Infrastructure
TECs	Threatened Ecological Communities
TSPD	Threatened Species Profile Database
TSC Act	*Threatened Species Conservation Act 1995* (NSW)
V	Vulnerable
VIS	Vegetation information system

1 Introduction

1.1 Project background

NSW Roads and Maritime Services (Roads and Maritime) is seeking approval to construct and operate the WestConnex M4-M5 Link (the project), which would comprise a new multi-lane road link between the M4 East Motorway at Haberfield and the New M5 Motorway at St Peters. The project would also include an interchange at Lilyfield and Rozelle (the Rozelle interchange) and a tunnel connection between Anzac Bridge and Victoria Road, east of Iron Cove Bridge (Iron Cove Link). In addition, construction of tunnels, ramps and associated infrastructure to provide connections to the proposed future Western Harbour Tunnel and Beaches Link project would be carried out at the Rozelle interchange.

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.

Approval is being sought under Part 5.1 of the *Environmental Planning and Assessment Act 1979* (NSW) (EP&A Act) for the project. A request has been made for the NSW Minister for Planning to specifically declare the project to be State significant infrastructure and also critical State significant infrastructure. An environmental impact statement (EIS) is therefore required.

1.1.1 Overview of WestConnex and related projects

The M4-M5 Link is part of the WestConnex program of works. Separate planning applications and assessments have been completed for each of the approved WestConnex projects. Roads and Maritime has commissioned Sydney Motorway Corporation (SMC) to deliver WestConnex, on behalf of the NSW Government. However, Roads and Maritime is the proponent for the project.

In addition to linking to other WestConnex projects, the M4-M5 Link would provide connections to the proposed future Western Harbour Tunnel and Beaches Link, the Sydney Gateway (via the St Peters interchange) and the F6 Extension (via the New M5).

The WestConnex program of works, as well as related projects, are shown in Figure 1.1 and described in Table 1.1.

Table 1.1 WestConnex and related projects

Project	Description	Status
WestConnex program of works		
M4 Widening	Widening of the existing M4 Motorway from Parramatta to Homebush.	Planning approval under the 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.

Project	Description	Status
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.
M4-M5 Link (the project)	Tunnels connecting to the M4 East at Haberfield (via the Wattle Street interchange) and the New M5 at St Peters (via the St Peters interchange), a new interchange at Rozelle and a link to Victoria Road (the Iron Cove Link). The Rozelle interchange also includes ramps and tunnels for connections to the proposed future Western Harbour Tunnel and Beaches Link project.	The subject of this EIS.
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.
Western Harbour Tunnel and Beaches Link	The Western Harbour Tunnel component would connect to the M4-M5 Link at the Rozelle interchange, cross underneath Sydney Harbour between the Birchgrove and Waverton areas, and connect with the Warringah Freeway at North Sydney. The Beaches Link component would comprise a tunnel that would connect to the Warringah Freeway, cross underneath Middle Harbour and connect with the Burnt Bridge Creek Deviation at Balgowlah and Wakehurst Parkway at Seaforth. It would also involve the duplication of the Wakehurst Parkway between Seaforth and Frenchs Forest.	Planning underway by Roads and Maritime and subject to separate environmental assessment and approval.
F6 Extension	A proposed 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.

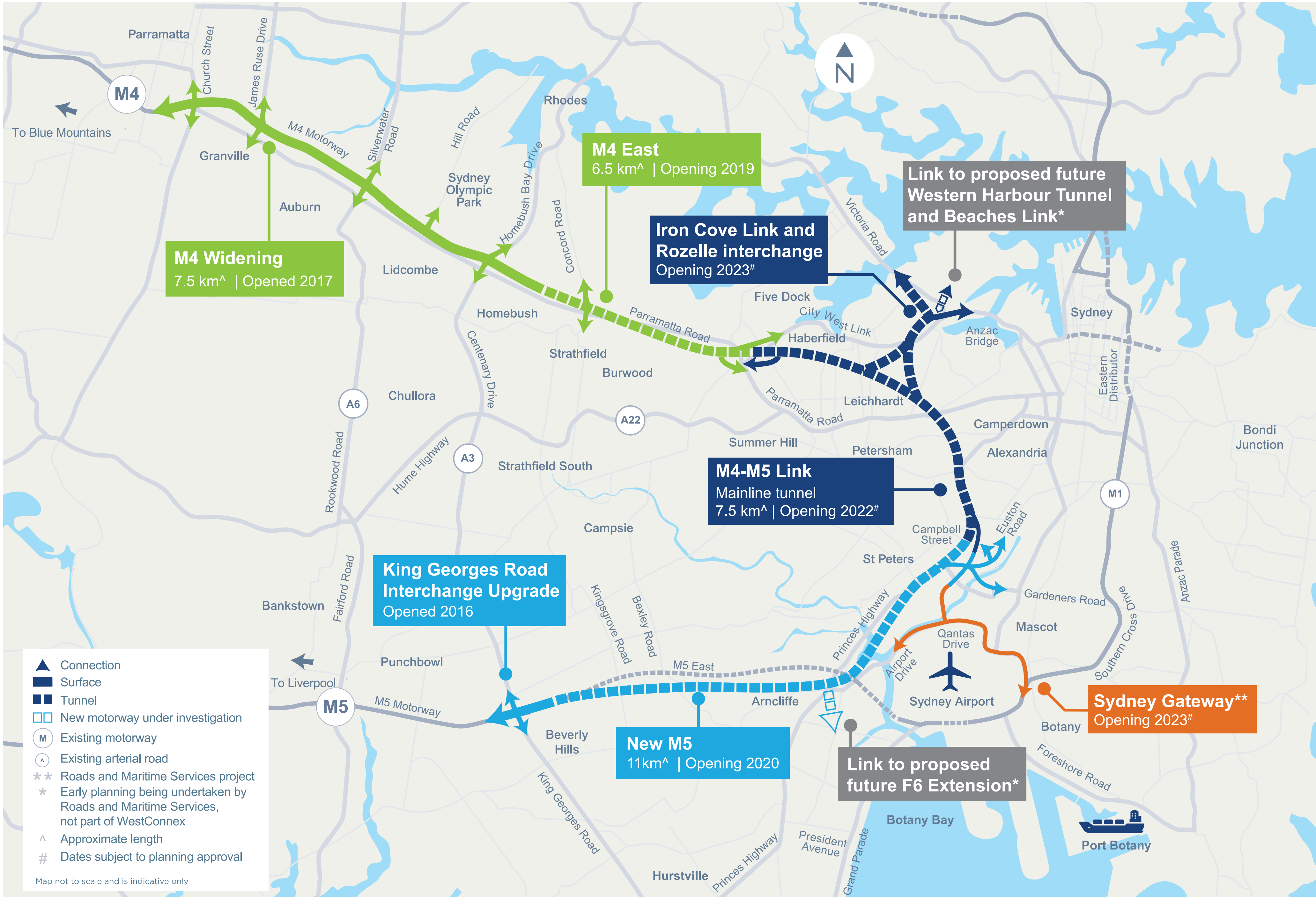

Figure 1-1 Overview of WestConnex and related projects

1.2 Legislative context

EISs are prepared to assess the impacts of major projects, including State significant infrastructure projects, under Part 5.1 of the EP&A Act. This BAR forms part of the EIS being prepared for the M4-M5 Link and assesses the biodiversity impacts of the project.

EISs are subject to a range of legislative and policy requirements as set out in the Secretary's Environmental Assessment Requirements (SEARs). Revised SEARs for the project were issued by the NSW Department of Planning and Environment (DP&E) on 3 May 2017.

The SEARS (outlined in section 1.3 and Annexure C) require that biodiversity impacts are assessed with the current guidelines including the Framework for Biodiversity Assessment (FBA). Any impacts on biodiversity values not covered by the FBA are also required to be addressed. Table 1.2 sets how the biodiversity requirements should be addressed in this BAR.

Table 1.2: Commonwealth and NSW Assessment requirements

Biodiversity assessment	Required by	Section addressed
Inventory		
Identification of the terrestrial biodiversity values, including NSW listed threatened species and endangered ecological communities, in the area proposed for development	Framework for Biodiversity Assessment	Chapter 3 (Landscape features) Chapter 4 (Native vegetation) Chapter 5 (Threatened species)
Identification of aquatic biodiversity values in the area proposed for development	Policy and guidelines for fish habitat conservation and management	Section 5.4
Identification of nationally listed threatened species, endangered ecological communities and migratory species in the area proposed for development	Framework for Biodiversity Assessment	Chapter 6 (Matters of national environmental significance)
Impact assessment		
Description of the direct (related to vegetation clearance) impacts of the project on biodiversity	Framework for Biodiversity Assessment	Chapter 9 (Impact assessment)
Description of the full range of impacts of the project on biodiversity	Secretary's Environmental Assessment Requirements	Chapter 9 (Impact assessment)
Description on the likely significance of impacts of the project on each nationally listed species, EECs and migratory species	Secretary's Environmental Assessment Requirements and Framework for Biodiversity Assessment	Section 9.3
Mitigation measures		
Description of the mitigation measures to be applied	Framework for Biodiversity Assessment	Chapter 8 (Avoid and minimise impacts)
Description of the specific mitigation measures to be applied on each nationally listed species, EEC and migratory species	Framework for Biodiversity Assessment	Chapter 10 (Mitigation)

Biodiversity assessment	Required by	Section addressed
Offset requirements		
Quantification and description of biodiversity offsets required for the unavoidable direct impacts of the project on threatened species and EECs	Framework for Biodiversity Assessment	Chapter 11 (Offsetting required)
Quantification and description of biodiversity offsets required for all direct and indirect significant residual impacts on nationally listed species, EEC and migratory species	EPBC Act Bilateral Agreement	Chapter 11 (Offsetting required)

1.3 SEARs – Biodiversity

The SEARs for biodiversity and where these are addressed in the report are outlined in the table below. This has been extracted from the SEARs for the project (State significant infrastructure (SSI) 16_7485), which are detailed in the EIS. In addition, relevant considerations provided by the NSW Department of Primary Industries (DPI) from the Water and Fisheries sections have been included.

Table 1.3: Secretary's Environmental Assessment Requirements for biodiversity

Key Issue and desired performance outcome	Requirement (specific assessment requirements in addition to the general requirements)	Section addressed
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). 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 OEH. Species specific surveys shall be undertaken for those species and in accordance with the survey requirements specified by the OEH. 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).	FBA is addressed in the form of this BAR No species for further consideration were provided by the NSW Office of Environment and Heritage (OEH)
DPI Water (requirements relating to the BAR). NB: Other requirements from DPI Water, not outlined here are provided elsewhere	**Groundwater Dependent Ecosystems** The EIS must consider the potential impacts on any Groundwater Dependent Ecosystems (GDEs) at the site and in the vicinity of the site and: · Identify any potential impacts on GDEs as a result of the proposal including: o the effect of the proposal on the recharge to groundwater systems; o the potential to adversely affect the water	Section 4.4 Section 9.4.2 Section 10

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    quality of the underlying groundwater system and adjoining groundwater systems in hydraulic connections; and
  o the effect on the function of GDEs (habitat, groundwater levels, connectivity).
· Provide safeguard measures for any GDEs.

Watercourses, Wetlands and Riparian Land
The EIS should address the potential impacts of the project on all watercourses likely to be affected by the project, existing riparian vegetation and the rehabilitation of riparian land. It is recommended the EIS provides details on all watercourses potentially affected by the proposal, including:
· Scaled plans showing the location of:
  o wetlands/swamps, watercourses and top of bank;
  o riparian corridor widths to be established along the creeks;
  o existing riparian vegetation surrounding the watercourses (identify any areas to be protected and any riparian vegetation proposed to be removed);
  o the site boundary, the footprint of the proposal in relation to the watercourses and riparian areas; and
  o proposed location of any asset protection zones.
· Photographs of the watercourses / wetlands and a map showing the point from which the photos were taken.
· A detailed description of all potential impacts on the watercourses/riparian land.
· A detailed description of all potential impacts on the wetlands, including potential impacts to the wetlands hydrologic regime; groundwater recharge; habitat and any species that depend on the wetlands.
· A description of the design features and measures to be incorporated to mitigate potential impacts.
· Geomorphic and hydrological assessment of water courses including details of stream order (Strahler System), river style and energy regimes both in channel and on adjacent floodplains.
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Section 3.1.3
Section 3.1.4
Section 5.4
Section 9.4.1
Section 9.4.3
Section 10

NB: Scaled plans, geomorphic and hydrological assessments and photographs of watercourses, wetlands and riparian land are detailed in Appendix Q (Technical working paper: Surface water and flooding) and Appendix T (Technical working paper: Groundwater) of the EIS.
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DPI Fisheries (requirements relating to the BAR). NB: Other requirements from DPI Fisheries, not outlined here are provided elsewhere in the EIS	**General Requirements** · site address and contact details. · property description (eg Lot and DP numbers). · a clear description of the proposal including details of construction methods and materials. · map(s) of the development area and adjacent areas - this should include nearby waterways, adjacent infrastructure (such as jetties) and land use. · clear photographs of the site (at low and high tide in estuaries), including photographs of any riparian and aquatic vegetation present (including pest species such as *Caulerpa taxifolia*). · a clear description of the physical and hydrological features of the development area (which may extend upstream and downstream of the development site in the case of flowing rivers or tidal waterways). · a clear description of aquatic environments including: o an aquatic and riparian vegetation survey map (where relevant) of the area which shows the location and/or coverage of saltmarsh, mangrove, seagrass, macroalgae, macrophytes, riparian vegetation and snags, · details of the nature, timing, magnitude and duration of the proposed disturbance to the aquatic environment. · assessments of predicted impacts upon any threatened species (fish and marine vegetation) (i.e. completion of a 7-part test and/or species impact statement(s)) and other aquatic flora and fauna. · details of any mitigation measures to limit environmental impacts. · details of the general regional context, any protected areas, other developments in the area, and/or cumulative impacts. · a copy of the land owner's consent where relevant. · notification of any other matters relevant to the particular proposal and of interest to NSW DPI.	Section 3.1.3 Section 3.1.4 Section 5.4 Section 9.4.1 Section 9.4.3 Section 10 Section 11.4

1.4 Context of Biodiversity Assessment Report

The NSW Government has developed a *NSW Biodiversity Offsets Policy for Major Projects* (BOPMP) (OEH 2014), including State significant development (SSD) and SSI. As part of an application for a Major Project under the EP&A Act, a proponent must prepare an EIS that addresses the SEARs provided by the DP&E.

The NSW Biodiversity Offsets Policy for Major Projects 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. Dr Matthew Dowle is an accredited assessor (Table 1.4) and conducted the assessment in accordance with the requirements of the legislation and the FBA.

The FBA applies only to terrestrial impacts. However, assessment of impacts to aquatic biodiversity and requirements for avoiding, minimising and offsetting these impacts is guided by the *Fisheries NSW Policy and guidelines for fish habitat conservation and management (Update 2013)* (Fisheries NSW policy and guidelines) and is provided in this BAR. The BAR is also required to consider impacts to matters of national environmental significance (MNES) under the EPBC Act.

1.4.1 Rozelle Rail Yards site management works

The Rozelle Rail Yards site management works was assessed through a Review of Environmental Factors (REF) under Part 5 of the EP&A Act and EPBC Act. The works would remove all rail and rail related infrastructure, as well as vegetation, buildings and stockpiles, and allow existing issues, such as waste and noxious weeds to be appropriately managed.

The REF included an assessment of potential impacts of these works on threatened species and ecological communities listed under State and Commonwealth legislation, in accordance with the EP&A Act. The biodiversity impact assessment for the REF included a database review, vegetation surveys and targeted threatened fauna surveys for the Green and Golden Bell Frog (*Litoria aurea*), Long-nosed Bandicoot (*Perameles nasuta – endangered population*) and threatened microbats, including the Eastern Bentwing-bat and Yellow-bellied Sheathtail-bat. Assessments of Significance under the TSC and EPBC Act were completed for these species, as well as the Grey-headed Flying-fox. These assessments concluded that a significant impact is not likely to occur as a result of the proposed works.

The Rozelle Rail Yards site management works are not part of the M4-M5 Link project and have been excluded from the EIS and the BAR. No additional impacts are expected following the completion of the Rozelle Rail Yards site management works. However, the cumulative impacts of the site management works and the M4-M5 Link project have been considered in this assessment (see section 9.6).

1.4.2 Assessment guidelines

The assessment presented in this BAR was undertaken in accordance with the survey guidelines specified by the SEARs. Updated versions of the guidelines were used if available and were confirmed with DP&E. These include:

- *NSW Framework for Biodiversity Assessment* (OEH 2014a)
- *NSW offset policy for major projects (State Significant Development and State Significant Infrastructure)* (OEH 2014b)
- *Policy and guidelines for fish habitat conservation and management* (update 2013). This guideline supersedes the *Guidelines for Aquatic Habitat Management and Fish Conservation* (DPI 1999)
- *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)
- *Aquatic Ecology in Environmental Impact Assessment – EIA Guideline* (Marcus Lincoln Smith 2003)
- *NSW Sustainable Design Guidelines Version 3.0* (Transport for NSW, 2013)
- *Commonwealth Survey Guidelines for Australia's Threatened Frog* (Australian Government Department of the Environment, Water, Heritage and the Arts (DEHWA) 2010a)
- *Commonwealth Survey Guidelines for Australia's Threatened Bats* (DEHWA 2010b)
- *Matter 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).

1.4.3 Report structure

This BAR follows the structure as outlined in FBA (OEH 2014a). The report is divided into several chapters, which reflect the requirements of the FBA (refer to Annexure F):

- Executive summary
- Chapter 1 – Project background
- Chapter 2 – The project
- Chapter 3 – Landscape features
- Chapter 4 – Native vegetation
- Chapter 5 – Threatened species
- Chapter 6 – Matters of national environmental significance
- Chapter 7 – Avoidance, mitigation and impacts
- Chapter 7 – Summary of biodiversity issues
- Chapter 8 – Avoid and minimise impacts
- Chapter 9 – Impact assessment
- Chapter 10 – Mitigation
- Chapter 11 – Offsetting required
- Chapter 12 – References
- Annexure A – Habitat assessment table
- Annexure B – Species recorded
- Annexure C – Secretary's Environmental Assessment Requirements for Biodiversity and Department of Primary Industries requirements
- Annexure D – Anabat survey results
- Annexure E – EPBC Act Significant Impact Criteria
- Annexure F – FBA Methodology and where addressed in document
- Annexure G – Arboricultural impact statement.

1.4.4 Personnel

This BAR was carried out by appropriately qualified and experienced environmental professionals, ecologists and accredited Biobanking assessors as demonstrated in Table 1.4.

Table 1.4: Personnel, role and qualifications

Name	Role	Qualifications
Dr Steven Ward	Project Director	Accredited Biodiversity Banking Assessor Doctor of Philosophy, University of Western Sydney, 2002 Bachelor of Science Honours, Wollongong University, 1994 Bachelor of Science, Major in Botany/Zoology, University of Western Australia, 1992
Dr Mathew Dowle	Biodiversity Assessment	Doctor of Philosophy, Macquarie University, Sydney 2012 Bachelor of Advanced Science (Honours), University of NSW 2004 Accredited Biobanking Assessor (#0203)
Dr Meredith Henderson	Quality Assurance	Doctor of Philosophy, Victoria University, Melbourne 2003 Bachelor of Science (Honours), University of Wollongong 1991 Accredited Biobanking Assessor (#0155)
Ian Dixon	Aquatic Assessment	AUSRIVAS Accreditation (Australian River Assessment System), 2011 Master of Tropical Environmental Management, Charles Darwin University, 2006 Graduate Diploma of Tropical Environmental Management, Charles Darwin University, 2001 Bachelor of Landscape Architecture, 1999
Dr Peter Hancock	Groundwater Assessment	Doctor of Philosophy, University of New England, 2004 Bachelor of Natural Resources. University of New England, 1996

Name	Role	Qualifications
Stacey Wilson	Ecology Assessment	Master of Environment, Macquarie University, 2015 Bachelor of Biodiversity and Conservation, Macquarie University, 2013
Vivian Hamilton	GIS Analysis and Mapping	Completion of the BioBanking and Biocertification Assessor Accreditation Training Course (AHCLPW503A), OEH Bachelor of Environmental Management, Macquarie University, 2007
Byron Heffernan	GIS Analysis and Mapping	Bachelor of Science (Biological Sciences), University of Wollongong, 2006

2 The project

2.1 Project location

The project would be generally located within the City of Sydney and Inner West local government areas (LGAs). The project is located about two to seven kilometres south, southwest and west of the Sydney central business district (CBD) and would cross the suburbs of Ashfield, Haberfield, Leichhardt, Lilyfield, Rozelle, Annandale, Stanmore, Camperdown, Newtown and St Peters. The local context of the project is shown in Figure 2.1.

2.2 Overview of the project

Key components of the project are shown in Figure 2.1 and would include:

- Twin mainline motorway tunnels between the M4 East at Haberfield and the New M5 at St Peters. Each tunnel would be around 7.5 kilometres long and would generally accommodate up to four lanes of traffic in each direction
- Connections of the mainline tunnels to the M4 East project, comprising:
  - A tunnel-to-tunnel connection to the M4 East mainline stub tunnels east of Parramatta Road near Alt Street at Haberfield
  - Entry and exit ramp connections between the mainline tunnels and the Wattle Street interchange at Haberfield (which is currently being constructed as part of the M4 East project)
  - Minor physical integration works with the surface road network at the Wattle Street interchange including road pavement and line marking
- Connections of the mainline tunnels to the New M5 project, comprising:
  - A tunnel-to-tunnel connection to the New M5 mainline stub tunnels north of the Princes Highway near the intersection of Mary Street and Bakers Lane at St Peters
  - Entry and exit ramp connections between the mainline tunnels and the St Peters interchange at St Peters (which is currently being constructed as part of the New M5 project)
  - Minor physical integration works with the surface road network at the St Peters interchange including road pavement and line marking
- An underground interchange at Leichhardt and Annandale (the Inner West subsurface interchange) that would link the mainline tunnels with the Rozelle interchange and the Iron Cove Link (see below)
- A new interchange at Lilyfield and Rozelle (the Rozelle interchange) that would connect the M4-M5 Link mainline tunnels with:
  - City West Link
  - Anzac Bridge
  - The Iron Cove Link (see below)
  - The proposed future Western Harbour Tunnel and Beaches Link
- Construction of connections to the proposed future Western Harbour Tunnel and Beaches Link project as part of the Rozelle interchange, including:
  - Tunnels that would allow for underground mainline 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)

  - A dive structure and tunnel portals within the Rozelle Rail Yards, north of the City West Link / The Crescent intersection
  - Entry and exit ramps that would extend north underground from the tunnel portals in the Rozelle Rail Yards to join the mainline connections to the proposed future Western Harbour Tunnel and Beaches Link
  - A ventilation outlet and ancillary facilities as part of the Rozelle ventilation facility (see below)
- Twin tunnels that would connect Victoria Road near the eastern abutment of Iron Cove Bridge and Anzac Bridge (the Iron Cove Link). Underground entry and exit ramps would also provide a tunnel connection between the Iron Cove Link and the New M5 / St Peters interchange (via the M4-M5 Link mainline tunnels)
- The Rozelle surface works, including:
  - Realigning The Crescent at Annandale, including a new bridge over Whites Creek and modifications to the intersection with City West Link
  - A new intersection on City West Link around 300 metres west of the realigned position of The Crescent, which would provide a connection to and from the New M5/St Peters interchange (via the M4-M5 Link mainline tunnels)
  - Widening and improvement works to the channel and bank of Whites Creek between the light rail bridge and Rozelle Bay at Annandale, to manage flooding and drainage for the surface road network
  - Reconstructing the intersection of The Crescent and Victoria Road at Rozelle, including construction of a new bridge at Victoria Road
  - New and upgraded pedestrian and cyclist infrastructure
  - Landscaping, including the provision of new open space within the Rozelle Rail Yards
- The Iron Cove Link surface works, including:
  - Dive structures and tunnel portals between the westbound and eastbound Victoria Road carriageways, to connect Victoria Road east of Iron Cove Bridge with the Iron Cove Link
  - Realignment of the westbound (southern) carriageway of Victoria Road between Springside Street and the eastern abutment of Iron Cove Bridge
  - Modifications to the existing intersections between Victoria Road and Terry, Clubb, Toelle and Callan streets
  - Landscaping and the establishment of pedestrian and cycle infrastructure
- Five motorway operations complexes; one at Leichhardt (MOC1), three at Rozelle (Rozelle West (MOC2), Rozelle East (MOC3) and Iron Cove Link (MOC4)), and one at St Peters (MOC5). The types of facilities that would be contained within the motorway operations complexes would include substations, water treatment plants, ventilation facilities and outlets, offices, on-site storage and parking for employees
- Tunnel ventilation systems, including ventilation supply and exhaust facilities, axial fans, ventilation outlets and ventilation tunnels
- Three new ventilation facilities, including:
  - The Rozelle ventilation facility at Rozelle
  - The Iron Cove Link ventilation facility at Rozelle
  - The Campbell Road ventilation facility at St Peters

- Fitout (mechanical and electrical) of part of the Parramatta Road ventilation facility at Haberfield (which is currently being constructed as part of M4 East project) for use by the M4-M5 Link project
- Drainage infrastructure to collect surface and groundwater for treatment at dedicated facilities. Water treatment would occur at
  - Two operational water treatment facilities (at Leichhardt and Rozelle)
  - The constructed wetland within the Rozelle Rail Yards
  - A bioretention facility for stormwater runoff within the informal car park at King George Park at Rozelle (adjacent to Manning Street). A section of the existing informal car park would also be upgraded, including sealing the car park surface and landscaping
- Treated water would flow back to existing watercourses via new, upgraded and existing infrastructure
- Ancillary infrastructure and operational facilities for electronic tolling and traffic control and signage (including electronic signage)
- Emergency access and evacuation facilities, including pedestrian and vehicular cross and long passages and fire and life safety systems
- Utility works, including protection and/or adjustment of existing utilities, removal of redundant utilities and installation of new utilities. A Utilities Management Strategy has been prepared for the project that identifies management options for utilities, including relocation or adjustment. Refer to **Appendix F** (Utilities Management Strategy) of the EIS.

The project does not include:

- Site management works at the Rozelle Rail Yards. These works were separately assessed and determined by Roads and Maritime through a Review of Environmental Factors under Part 5 of the EP&A Act (refer to **Chapter 2** (Assessment process) of the EIS)
- Ongoing motorway maintenance activities during operation
- Operation of the components of the Rozelle interchange which are the tunnels, ramps and associated infrastructure being constructed to provide connections to the proposed future Western Harbour Tunnel and Beaches Link project.

Temporary construction ancillary facilities and temporary works to facilitate the construction of the project would also be required.

2.2.1 Staged construction and opening of the project

It is anticipated the project would be constructed and opened to traffic in two stages (as shown in Figure 2.1).

Stage 1 would include:

- Construction of the mainline tunnels between the M4 East at Haberfield and the New M5 at St Peters, stub tunnels to the Rozelle interchange (at the Inner West subsurface interchange) and ancillary infrastructure at the Darley Road motorway operations complex (MOC1) and Campbell Road motorway operations complex (MOC5)
- These works are anticipated to commence in 2018 with the mainline tunnels open to traffic in 2022. At the completion of Stage 1, the mainline tunnels would operate with two traffic lanes in each direction. This would increase to generally four lanes at the completion of Stage 2, when the full project is operational.

Stage 2 would include:

- Construction of the Rozelle interchange and Iron Cove Link including:
  - Connections to the stub tunnels at the Inner West subsurface interchange (built during Stage 1)
  - Ancillary infrastructure at the Rozelle West motorway operations complex (MOC2), Rozelle East motorway operations complex (MOC3) and Iron Cove Link motorway operations complex (MOC4)
  - Connections to the surface road network at Lilyfield and Rozelle
  - Construction of tunnels, ramps and associated infrastructure as part of the Rozelle interchange to provide connections to the proposed future Western Harbour Tunnel and Beaches Link project
- Stage 2 works are expected to commence in 2019 with these components of the project open to traffic in 2023.

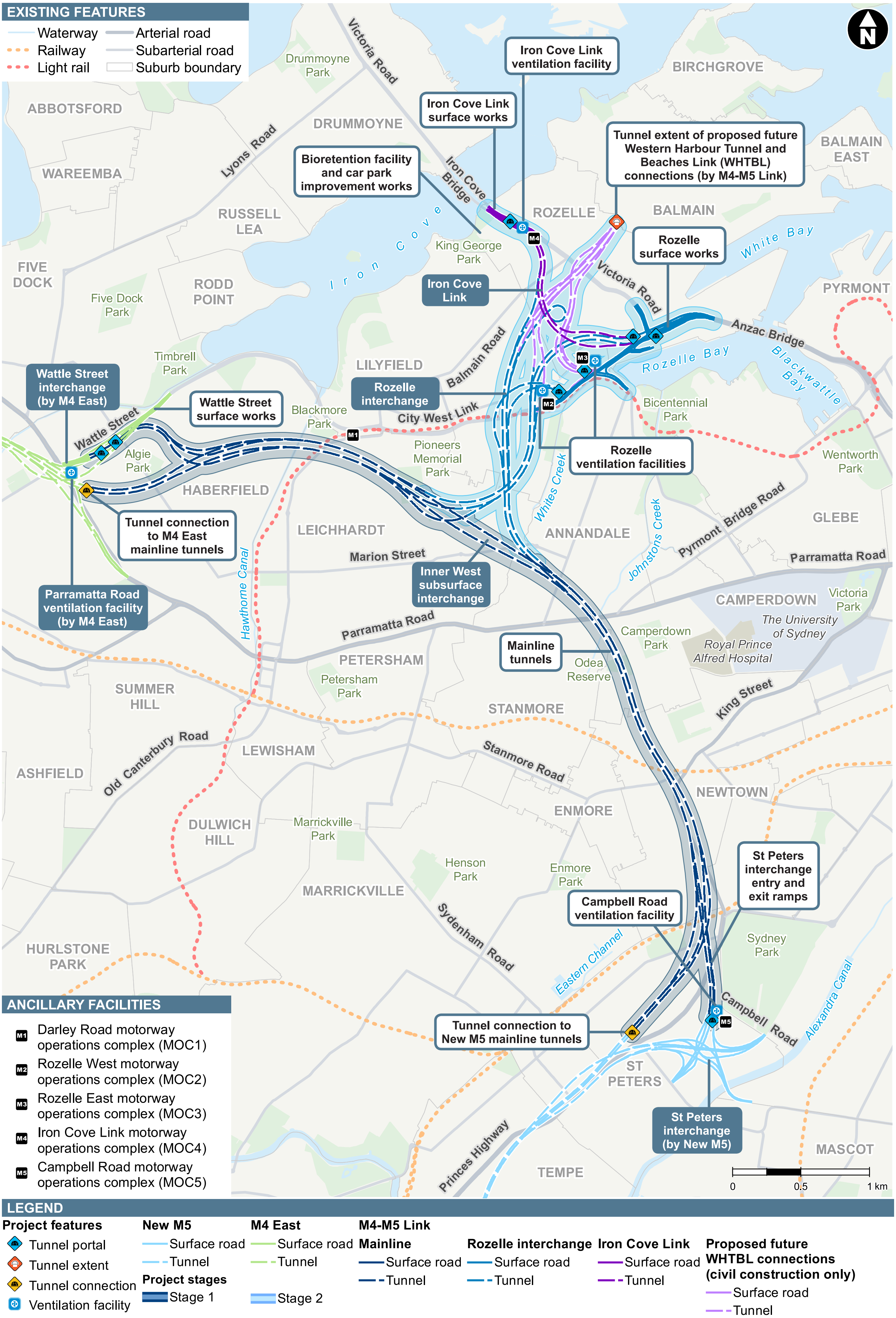


Figure 2-1 Overview of the project

2.3 Construction activities

2.3.1 Overview

An overview of the key construction features of the project is shown in Figure 2.2 and would generally include:

- Enabling and temporary works, including provision of construction power and water supply, ancillary site establishment including establishment of acoustic sheds and construction hoarding, demolition works, property adjustments and public and active 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.

A more detailed overview of construction activities is provided in Table 2.1.

Table 2.1: Overview of construction activities

Component	Typical activities
Site establishment and enabling works	· Vegetation clearing and removal · Utility works · Traffic management measures · Install safety and environmental controls · Install site fencing and hoarding · Establish temporary noise attenuation measures · Demolish buildings and structures · Carry out site clearing · Heritage salvage or conservation works (if required) · Establish construction ancillary facilities and access · Establish acoustic sheds · Supply utilities (including construction power) to construction facilities · Establish temporary pedestrian and cyclist diversions
Tunnelling	· Construct temporary access tunnels · Excavation of mainline tunnels, entry and exit ramps and associated tunnelled infrastructure and install ground support · Spoil management and haulage · Finishing works in tunnel and provision of permanent tunnel services · Test plant and equipment
Surface earthworks and structures	· Vegetation clearing and removal · Topsoil stripping · Excavate new cut and fill areas · Construct dive and cut-and-cover tunnel structures · Install stabilisation and excavation support (retention systems) such as sheet pile walls, diaphragm walls and secant pile walls (where required) · Construct required retaining structures · Excavate new road levels

Bridge works	· Construct piers and abutments · Construct headstock · Construct bridge deck, slab and girders · Demolish and remove redundant bridges
Drainage	· Construct new pits and pipes · Construct new groundwater drainage system · Connect drainage to existing network · Construct sumps in tunnels as required · Construct water quality basins, constructed wetland and bioretention facility and basin · Construct drainage channels · Construct spill containment basin · Construct onsite detention tanks · Adjustments to existing drainage infrastructure where impacted · Carry out widening and naturalisation of a section of Whites Creek · Demolish and remove redundant drainage
Pavement	· Lay select layers and base · Lay road pavement surfacing · Construct pavement drainage
Operational ancillary facilities	· Install ventilation systems and facilities · Construct water treatment facilities · Construct fire pump rooms and install water tanks · Test and commission plant and equipment · Construct electrical substation to supply permanent power to the project
Finishing works	· Line mark to new road surfaces · Erect directional and other signage and other roadside furniture such as street lighting · Erect toll gantries and other control systems · Construct pedestrian and cycle paths · Carry out earthworks at disturbed areas to establish the finished landform · Carry out landscaping · Closure and backfill of temporary access tunnels (except where these are to be used for inspection and/or maintenance purposes) · Site demobilisation and preparation of the site for a future use

Twelve construction ancillary facilities are described in this EIS (as 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).

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 number, location and layout of construction ancillary facilities would be finalised as part of detailed construction planning during detailed design and would meet the environmental performance outcomes stated in the EIS and the Submissions and Preferred Infrastructure Report and satisfy criteria identified in any relevant conditions of approval.

The construction ancillary facilities would be used for a mix of civil surface works, tunnelling support, construction workforce parking and administrative purposes. Wherever possible, construction sites would be co-located with the operational footprint to minimise property acquisition and temporary disruption. The layout and access arrangements for the construction ancillary facilities are based on the concept design only and would be confirmed and refined in response to submissions received during the exhibition of this EIS and during detailed design.

2.3.2 Construction program

The total period of construction works for the project is expected to be around five years, with commissioning occurring concurrently with the final stages of construction. An indicative construction program is shown in Table 2.2.

Table 2.2: Construction program overview

Construction activity	Indicative construction timeframe 2018				2019				2020				2021				2022				2023			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Mainline tunnels																								
Site establishment and establishment of construction ancillary facilities			■	■	■	■	■	■	■	■														
Utility works and connections			■	■	■	■	■	■																
Tunnel construction				■	■	■	■	■	■	■	■	■	■											
Portal construction				■	■	■	■	■																
Construction of permanent operational facilities												■	■	■	■	■								
Mechanical and electrical fitout works														■	■	■								
Establishment of tolling facilities															■	■								
Site rehabilitation and landscaping																■	■	■	■					
Surface road works																	■	■	■					
Demobilisation and rehabilitation																			■	■				
Testing and commissioning																■	■	■	■	■				

Construction activity	Indicative construction timeframe																							
	2018				2019				2020				2021				2022				2023			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Rozelle interchange and Iron Cove Link																								
Site establishment and establishment of construction ancillary facilities				■	■	■	■	■	■															
Utility works and connections and site remediation				■	■	■	■	■																
Tunnel construction									■	■	■	■	■	■	■	■	■							
Portal construction						■	■	■	■															
Construction of surface road works						■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■			
Construction of permanent operational facilities						■	■	■	■	■	■	■	■	■	■	■								
Mechanical and electrical fitout works													■	■	■	■	■	■	■	■				
Establishment of tolling facilities																		■	■					
Site rehabilitation and landscaping																			■	■	■			
Demobilisation and rehabilitation																						■	■	
Testing and commissioning																			■	■	■	■	■	

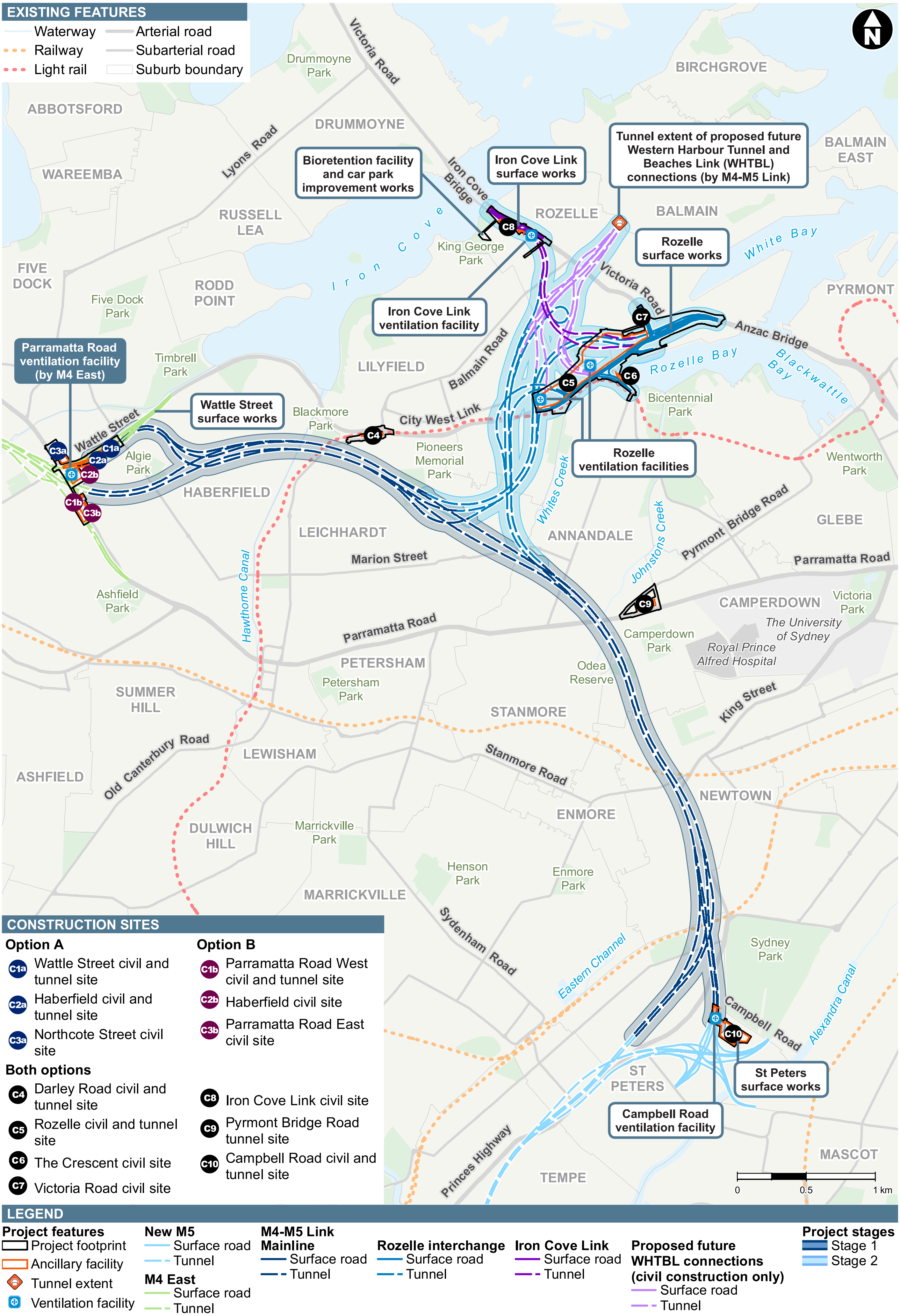


Figure 2-2 Overview of project footprint and ancillary facilities

2.3.3 Study area

The project is located within the Cumberland and Pittwater sub-regions of the Sydney Basin Bioregion. The study area comprises the project footprint and a surrounding 550 metre buffer, as required by the FBA. The project footprint defined in this report is the same as the development footprint defined in the FBA.

The study area includes existing roads, motorways, residential areas, industrial areas, urban landscaped areas, and exotic vegetation and is shown in Figure 2.3. Figure 2.3 also shows the corridor assessed for MNES, groundwater dependant ecosystems (GDEs) and riparian ecosystems.

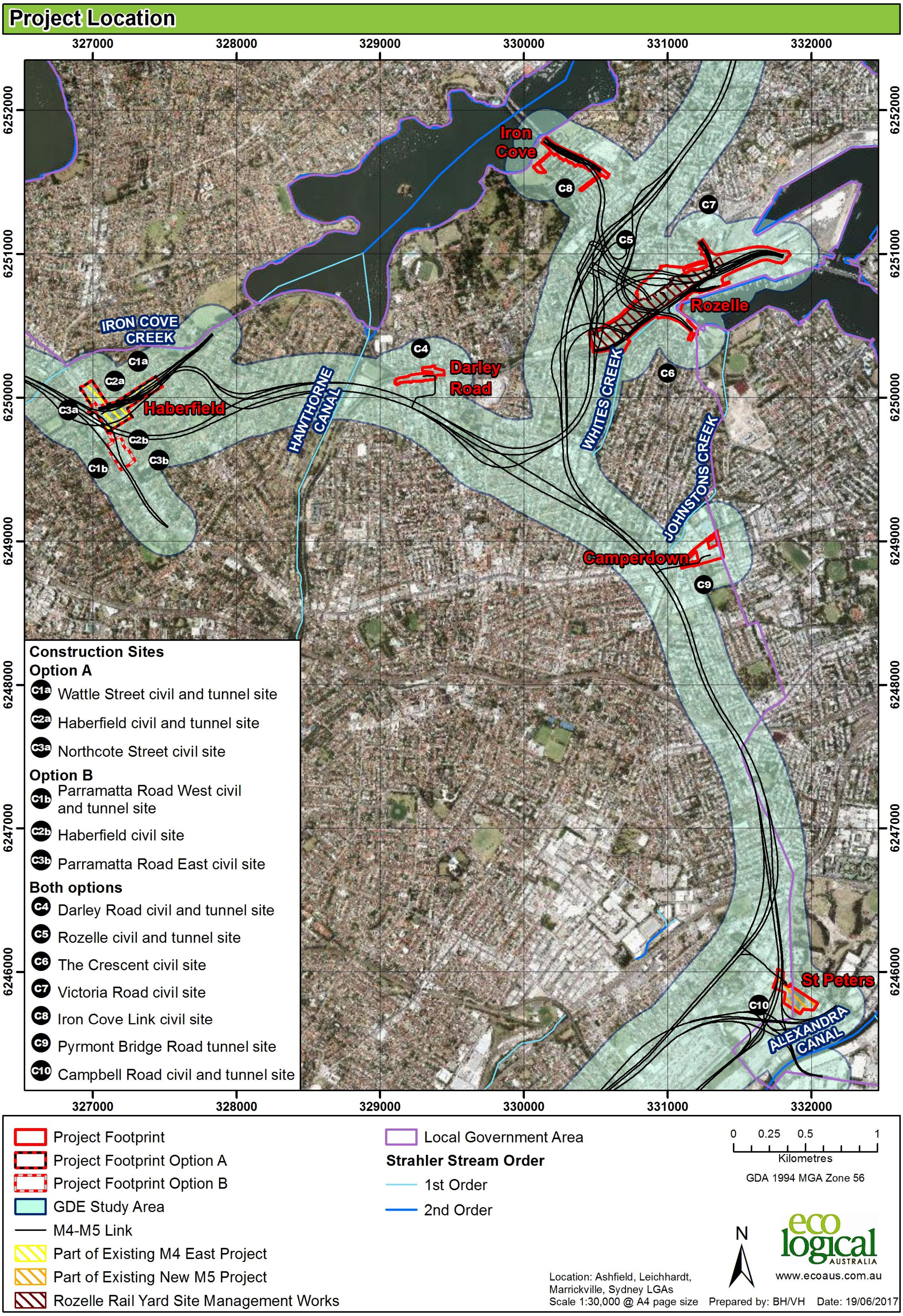


Figure 2.3: Project location and study area (project footprint assessed under the FBA is in red outline)

3 Landscape features

3.1 Identified features

In accordance with Chapter 4 of the FBA, the BAR is required to identify a number of landscape features such as the Interim Biogeographic Regionalisation for Australia (IBRA) region, IBRA sub-region, Mitchell landscape, rivers and streams, extent of native vegetation in the area assessed for the project footprint. The landscape features of the project footprint are shown in this chapter (Chapter 3).

3.1.1 IBRA Bioregions and subregions

The project footprint 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 occurs within a highly urbanised setting surrounded by extensive areas of established urban development to the east, north and south.

The project footprint is located entirely within the Sydney Basin Bioregion and crosses two IBRA subregions, the Cumberland subregion and the Pittwater subregion. They were used for the 550 metre buffer (see section 3.2.1 and Figure 3.1).

3.1.2 NSW landscape regions (Mitchell landscapes)

The project footprint occurs across two Mitchell Landscapes with the majority occurring within Sydney – Port Jackson and Ashfield Plains landscapes (Mitchell 2002) (Figure 3.1). A further Mitchell Landscape; Sydney - Newcastle Barriers and Beaches occurs within the study area.

3.1.3 Rivers and streams

Riparian buffers of three waterways occur within the project footprint: The riparian buffers of Whites Creek (1st Order Stream) and Rozelle Bay (Estuarine Area) are located near the surface works at Rozelle (Figure 3.4); and a small portion of the riparian buffer of Iron Cove (2nd Order Stream) is located near construction at Iron Cove. No other construction compounds or operational areas are within riparian corridors.

Whites Creek has not been mapped as Key Fish Habitat (KFH), as defined in the *Fisheries Policy and Guidelines for Fish Habitat Conservation and Management – update 2013* (Fairfull 2013). Rozelle Bay is mapped as KFH and is located within the project footprint.

Iron Cove has been mapped as KFH and would not be directly impacted by the project. However, it will require protection from indirect impacts associated with drainage flows from works associated with the Iron Cove Link. Waterways in or adjacent to the project footprint are not suitable habitat for threatened fish species.

3.1.4 Wetlands

There are no wetlands identified in State Environmental Planning Policy No 14 – Coastal Wetlands (SEPP 14) in the study area. Artificial waterbodies are scattered across the study area and surrounds as detention basins and ponds.

3.1.5 State or Regionally significant biodiversity links

No formal regional or State biodiversity links recognised by the FBA methodology occur within the study area. Given there were no links crossed, in accordance with the FBA the connectivity value class entered into the calculator was zero.

3.2 Landscape values

The FBA requires the landscape value (landscape attributes defined in Section 4.2 of the FBA) of the study area to be determined. This value contributes to the overall biodiversity value of the project footprint and it is used to inform the required offsets. It is combined with the credits calculated from the ecosystem and species credits which are detailed in Chapters 4 and 5.

3.2.1 Current and future native vegetation cover score

The linear assessment method was selected for this project, as defined in the FBA. An assessment buffer of 550 metres was applied to the project footprint in accordance with Appendix 5 of the FBA. This was used to assess the impact of the project on the surrounding vegetation cover (Figure 3.2 to Figure 3.7).

The amount of existing native vegetation within the study area was calculated using ArcGIS, and the vegetation mapping from the Native Vegetation of the Sydney Metropolitan Area (OEH 2013) (excluding the non-native categories). Where this layer did not cover the whole buffer, the gaps were filled in manually based on interpretation of recent aerial imagery.

To determine the native vegetation cover after the project in the study area, the total amount of clearing was subtracted from the pre-project cover. The project footprint was then used to calculate the amount of vegetation loss. Table 3.1 outlines the vegetation before and after the project, and the average and associated Native Vegetation Cover Class (per cent) to be entered into the online calculator for the assessment.

The assessment for the study area recorded approximately 0.62 hectares of native vegetation cover before the project (Table 3.1). This represents 0.05 per cent native vegetation cover. After the project, the area of native vegetation was 0.62 hectares. This represents 0.05 per cent native vegetation cover.

The area of native vegetation after the project was in the same cover category as before the project (≤ 5 per cent). The native vegetation cover class did not change between before and after the project. Therefore in accordance with Table 16 of the FBA, the score for the per cent native vegetation cover entered into the calculator was 1.25.

Table 3.1: Area of native vegetation in buffer area

Area in 550 metre buffer	Native Vegetation Cover (Before The project)	Native Vegetation Cover (After The project)
1133.38 ha	0.62 ha	0.62 ha

3.2.2 Connectivity value score

A connectivity assessment was conducted using the FBA technique for linear based projects (OEH 2014a). No formal State or regional biodiversity links recognised by the methodology are present within the study area. There is also no native vegetation in moderate to good condition within the study area that meets the definition of a very large, large, or local area biodiversity link.

Given there were no links present, in accordance with the FBA the connectivity value score is zero.

3.2.3 Patch size

The vegetation within the project footprint is limited to patches of urban native and exotic vegetation (as described by the Native Vegetation of the Sydney Metropolitan Area (OEH 2013)), and is surrounded by extensive urbanised areas. These patches of vegetation do not conform to the FBA definition of moderate to good condition native vegetation (refer to the definition of 'vegetation in low condition' on page 60 of the FBA), and as such, do not meet the criteria for assessing patch size. In accordance with Table 18 of the FBA, the patch size score is zero.

3.2.4 Change in area to perimeter ratio

For a linear shaped or multiple fragmented major project such as this project, the FBA requires the change in area to perimeter ratio of impacted patch size areas to be calculated. This represents the area of native vegetation before and after the project. As there are no patch sizes of native vegetation associated with the project, the proportional change in area to perimeter ratio cannot be assessed. In accordance with Table 19 of the FBA, the proportional change in area to perimeter ratio score is zero.

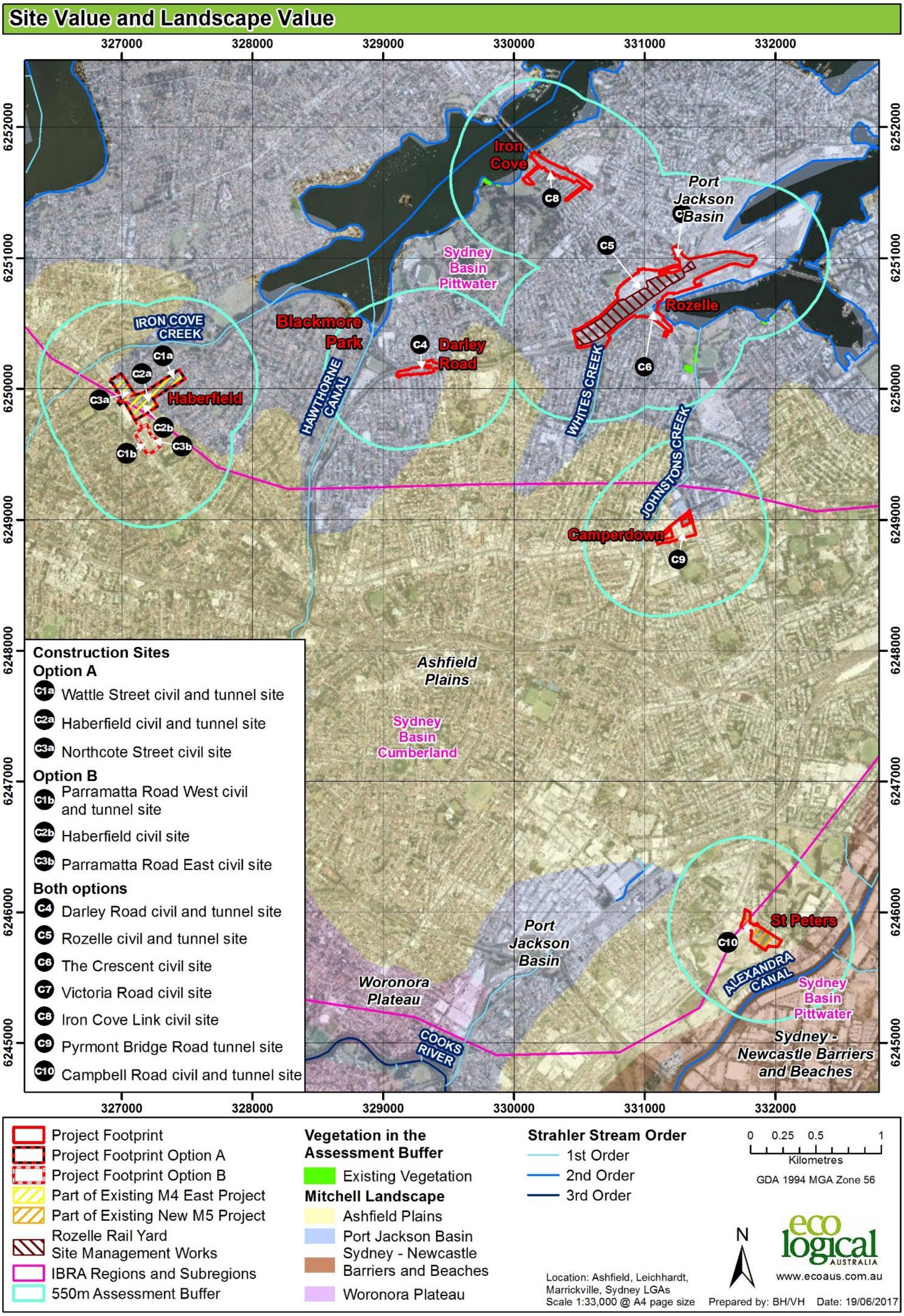


Figure 3.1: Landscape values overview

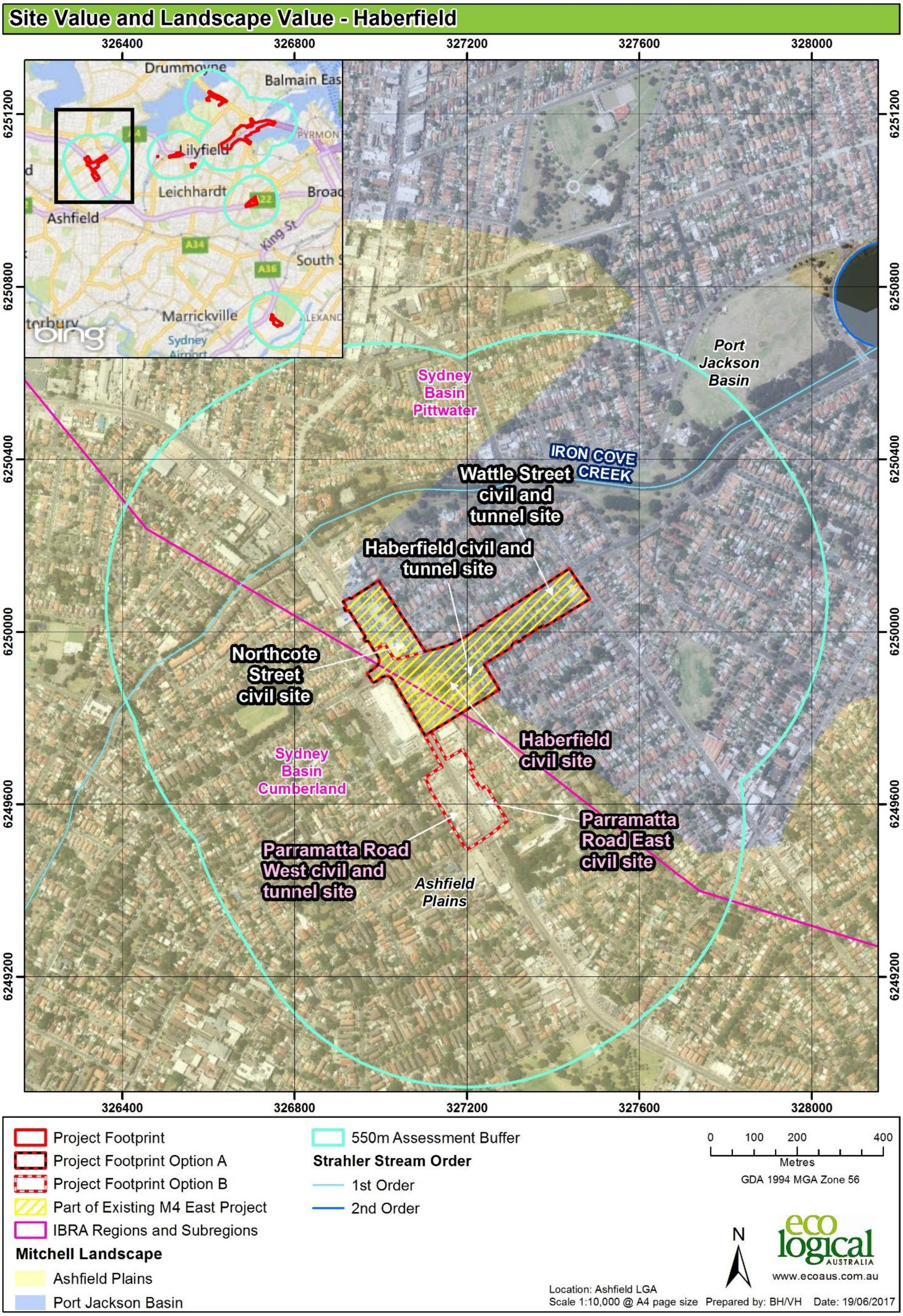


Figure 3.2: Landscape values at Haberfield and Ashfield

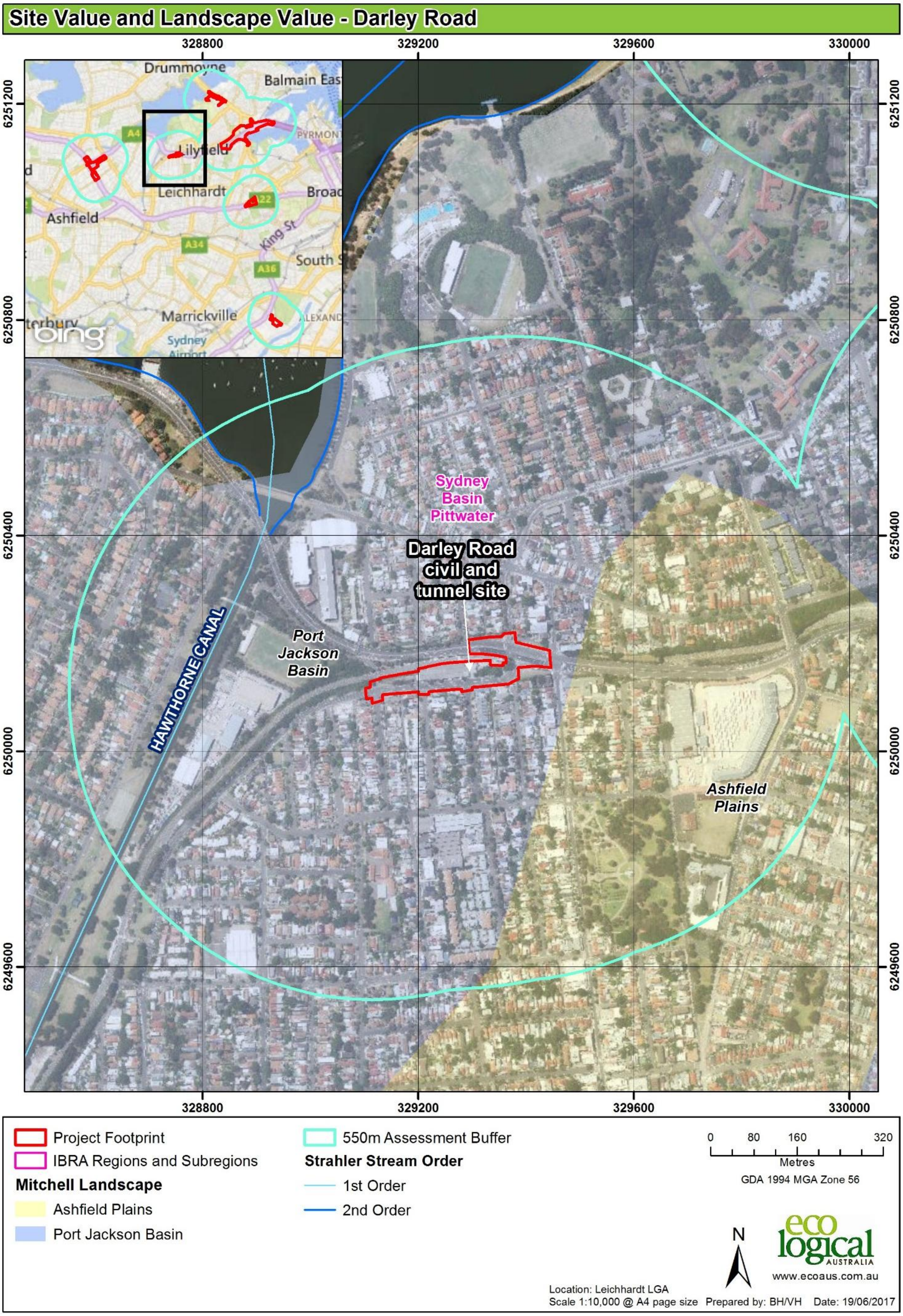


Figure 3.3: Landscape values at the Darley Road civil and tunnel site (C4)

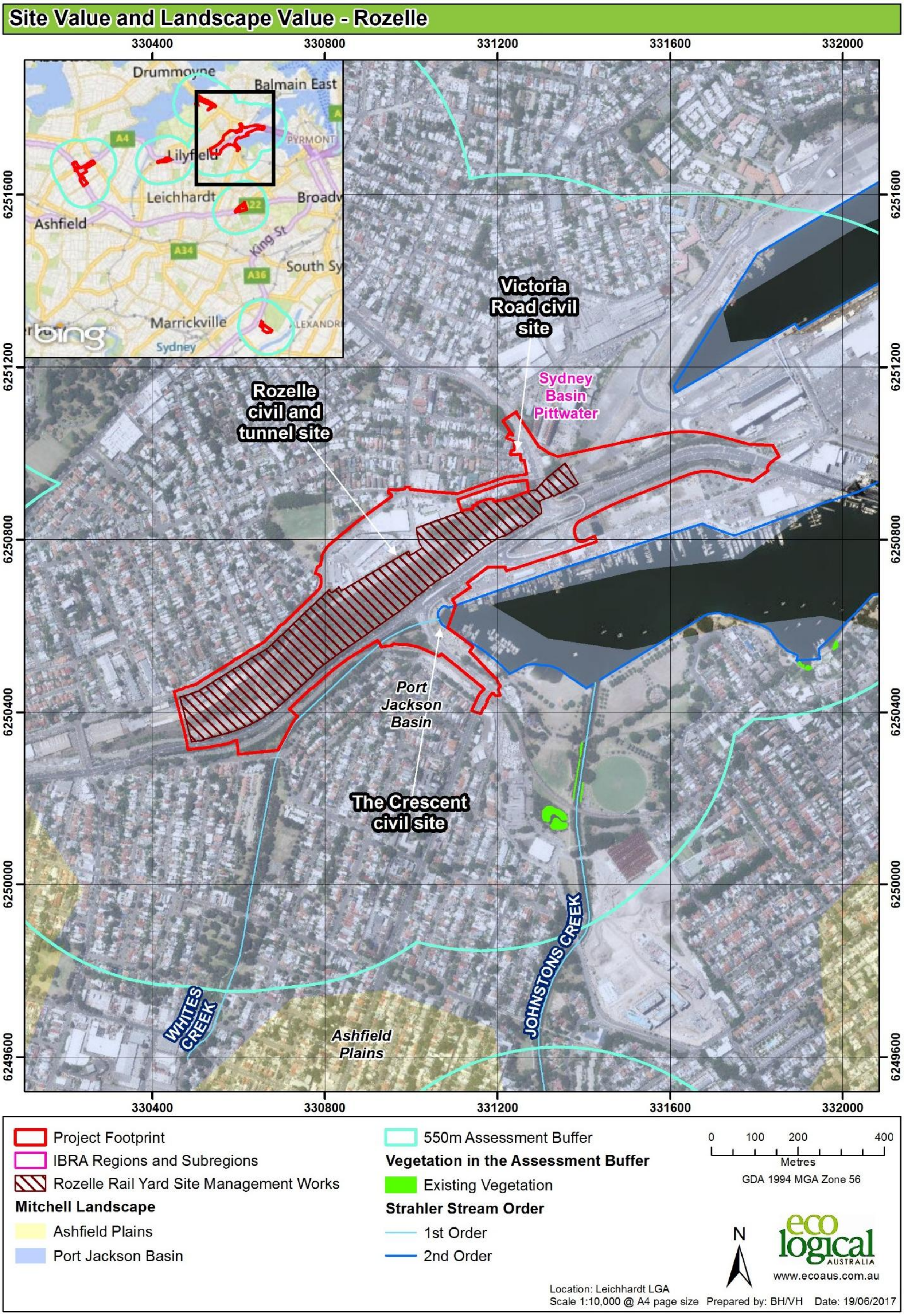


Figure 3.4: Landscape values at the Rozelle civil and tunnel site (C5), The Crescent civil site (C6) and Victoria Road civil site (C7)

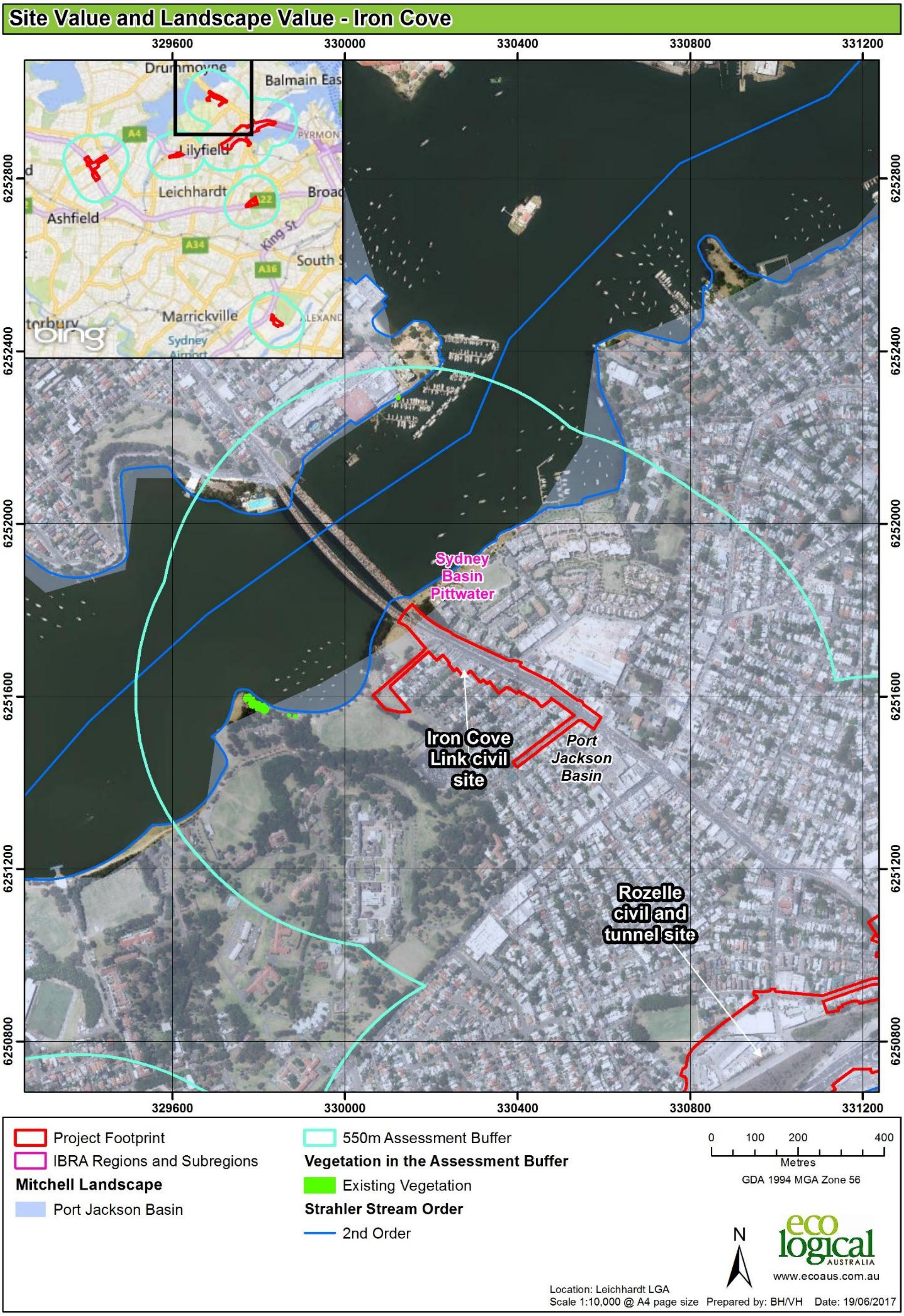


Figure 3.5: Landscape values at Iron Cove Link civil site (C8)

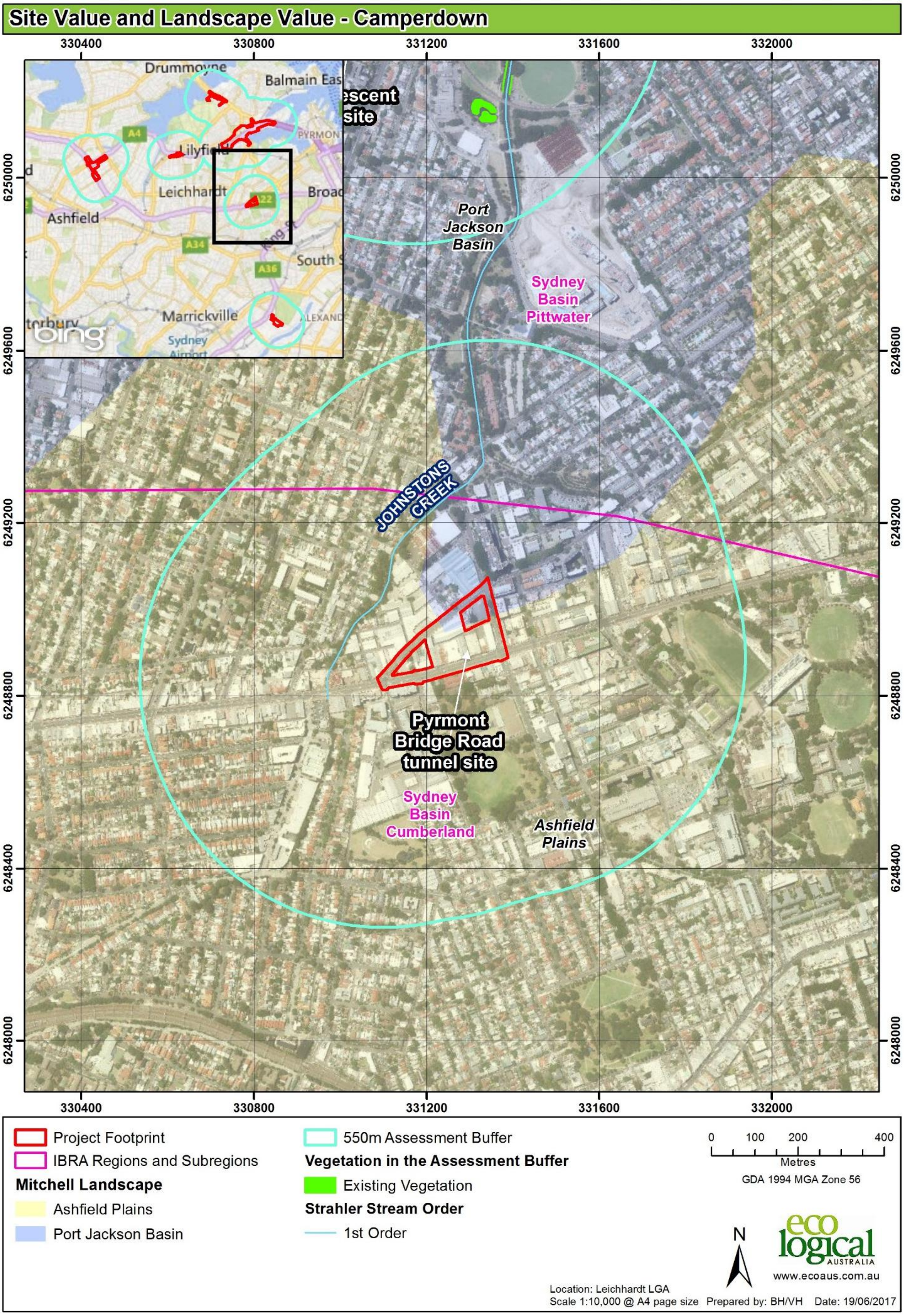


Figure 3.6: Landscape values at Pyrmont Bridge Road tunnel site (C9)

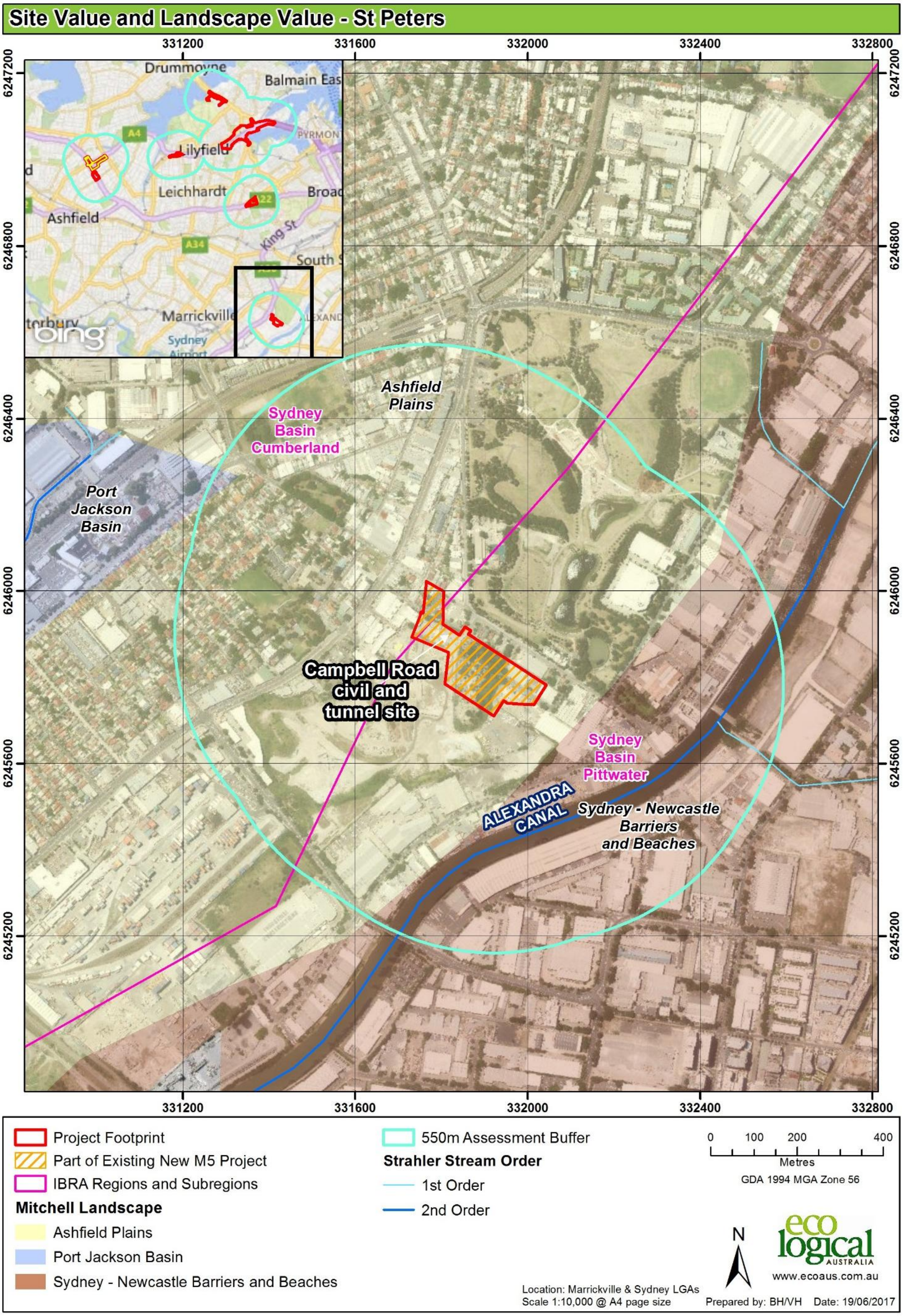


Figure 3.7: Landscape values at Campbell Road civil and tunnel site (C10)

4 Native vegetation

Eco Logical Australia (ELA) employed a series of survey methods to undertake the field assessment of the biodiversity values within the study area. The surveys conducted were consistent with the SEARs, FBA, survey guidelines and relevant impact assessment guidelines. The methods used and rationale behind their selection are described in section 4.1.

4.1 Method

4.1.1 Background research

Data searches

ELA reviewed aerial photography as well as the following vegetation and soil datasets which overlap within the study area:

- Vegetation Information System (VIS) online vegetation classification database (OEH 2016c)
- The Native Vegetation of the Sydney Metropolitan Area (OEH 2013)
- Soil Landscapes of the Sydney 1:100,000 Sheet (Chapman and Murphy 1989).

The following threatened species and predicted species databases were reviewed for the locality:

- OEH Atlas of NSW Wildlife (NSW BioNet) (10 kilometre radius, searched 17 August 2016)
- NSW Threatened Species Profile Database (OEH 2016b)
- EPBC Act Protected Matters Search Tool (10 kilometre radius search) (DotEE 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).

Previous Reports

To understand the context of the study area in relation to previous biodiversity studies, reviews of reports were conducted. ELA reviewed a number of previous reports or documents that may be relevant to the study area, including:

- M4 East EIS - Biodiversity Impact Assessment (GHD Pty Ltd 2015)
- The New M5 EIS – Biodiversity Assessment Report (ELA 2015)
- Rozelle Rail Yards REF – Brief Biodiversity Assessment (ELA 2016)
- WestConnex M4-M5 Link Geotechnical Investigations Flora and Fauna Assessment (Niche 2016)
- CBD Metro Environmental Assessment (SKM 2010)
- 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)
    - Inner West Council Greenway Strategy:
        - Greenway Biodiversity Strategy (2012)
        - Greenway Revegetation and Bushcare Plan (2011)
        - Greenway Flora and Fauna Literature Review (2010)

- Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2011 (Appendix 2).

A cumulative impact assessment has been undertaken that assesses impacts from M4-M5 Link project, Rozelle Rail Yards site management works, New M5 project and the M4 East project (see section 9.6).

M4 East EIS – Biodiversity Impact Assessment

The M4 East project was declared as SSI and will result in the clearing of 15.7 hectares of vegetation, including planted trees along road reserves and urban parklands. This vegetation did not represent threatened ecological communities listed under the TSC or EPBC Acts. In addition, no threatened flora (or its potential habitat) listed under the TSC or EPBC Acts was observed within the project footprint. It is noted that part of the M4 East construction footprint overlaps with the M4-M5 Link project footprint at Haberfield.

The Grey-headed Flying-fox, which is listed as vulnerable under the TSC and EPBC Acts, was recorded foraging within the project footprint. Following the relevant Significant Impact Criteria, the report determined that impacts to this species were not significant. This was due to the large expanses of available habitat in the locality and due to the project not impacting on any roosting sites or camps.

The report also determined that several threatened microbat species, such as the Eastern Bentwing-bat and the Large-footed Myotis (*Myotis macropus*), may also occur within the project footprint on occasion. However, similarly, Assessments of Significance concluded that the project would not have a significant impact as a result of the proposed works.

The report determined that a formal biodiversity offset was not necessary to compensate for the minor and localised residual impacts from the project. However, the planting of Grey-headed Flying-fox food trees in landscaped areas following construction would compensate for the removal of planted vegetation and assist in maintaining foraging habitat for this species in the study area.

It is noted this report did not use the FBA methodology to assess impacts on biodiversity. The impact assessment methodology used was consistent with the original Director General's Requirements (DGRs) for the project issued on 7 January 2014 and also subsequently by the Secretary's Environmental Assessment Requirements (SEARs) issued on 16 June 2015.

The New M5 EIS – Biodiversity Assessment Report

The New M5 project was declared as SSI, and unlike the M4 East, was assessed using the FBA methodology, as outlined in the project's SEARs. Part of the New M5 overlaps with the M4-M5 Link project footprint at St Peters.

The assessment determined that the New M5 would result in 3.31 hectares of direct impacts on native vegetation (ecosystem credits), comprising the following plant community types:

- Broad-leaved Ironbark - *Melaleuca decora* shrubby open forest on clay soils of the Cumberland Plain, Sydney Basin Bioregion
- Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion
- Paperbark swamp forest of the coastal lowlands of the NSW North Coast Bioregion and Sydney Basin Bioregion.

The project would also impact on the Green and Golden Bell Frog, a species credit species, through the removal of potential breeding and known foraging, dispersal and sheltering habitat.

Accordingly, the project BAR assessed the type and number of credits using the FBA methodology. These calculations identified the following offset requirements for the project:

- A total of 58 ecosystem credits consisting of 31 Broad-leaved Ironbark - *Melaleuca decora* shrubby open forest on clay soils of the Cumberland Plain, Sydney Basin Bioregion (PCT 725) credits and 27 Paperbark swamp forest of the coastal lowlands of the NSW North Coast Bioregion and Sydney Basin Bioregion (PCT 1046) credits
- A total of 203 credits for Green and Golden Bell Frog.

Rozelle Rail Yards REF –Biodiversity Assessment

ELA prepared the biodiversity assessment to support a REF for site management works to be undertaken at a part of the former Rozelle Rail Yards. The report assessed the potential impacts of the proposed works on threatened species and ecological communities listed under State and Commonwealth legislation.

The works would remove rail and rail related infrastructure and allow existing issues, such as waste and noxious weeds to be appropriately managed. This would allow Roads and Maritime to manage existing environmental and safety issues and would also improve access to surface conditions which would allow further investigation into the location of utilities and the presence of contamination and waste. The works would benefit future uses of the Rozelle Rail Yards.

A database review and field surveys were conducted to determine the extent of vegetation present (particularly threatened ecological communities) and to inform an impact assessment for threatened species, their habitat and ecological communities. Targeted threatened fauna surveys were completed for those species initially considered as having a potential to occur, including the Green and Golden Bell Frog, Long-nosed Bandicoot and threatened microbats.

The Rozelle Rail Yards is entirely modified and disturbed, and represented primarily by exotic species and weeds. No remnant native vegetation was recorded. It is considered to be in a very poor ecological condition, consisting of compacted soils and introduced fill, and unlikely to have any native resilience or recovery potential. No threatened flora species or listed ecological communities were identified, or are considered as having the potential to occur within the site.

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. Yellow-bellied Sheathtail-bat was also recorded as a possible call from and may be using the site to forage. Several Grey-headed Flying-fox were observed feeding on fig trees immediately adjacent to the site during targeted fauna surveys. The habitat assessment also identified limited foraging habitat for this species. The Grey-headed Flying-fox may therefore be present within the site on occasion. No other threatened fauna species were observed, or have previously been observed within the site. Targeted fauna survey for the Green and Golden Bell Frog and the Long-nosed Bandicoot (endangered population) were conducted as part of the project and confirmed that no habitat for these species was present within the Rozelle Rail Yards.

Assessments of Significance under the TSC and EPBC Act were completed for those threatened fauna species recorded (threatened microbats), as well as the Green and Golden Frog and the Long-nosed bandicoot. These assessments concluded that a significant impact is not likely to occur as a result of the proposed works. This conclusion was due primarily to the disturbed and degraded nature of the habitat present, lack of records of previous sightings (for those species not recorded during the targeted surveys), and lack of known breeding habitat within the study area. In addition, the targeted surveys did not confirm the presence of Green and Golden Frogs or Long-nosed bandicoots. Thus, a Species Impact Statement (SIS) or EPBC Act referral was not considered to be required.

A range of biodiversity safeguards designed to avoid or mitigate potential impacts on ecological values, namely potential threatened fauna and their habitat were provided. The safeguards and mitigation measures are to be incorporated into an Environmental Management Plan. The measures are to include site boundary fencing for protection of off-site trees, a weed management plan, a soil and water management plan and an unexpected finds procedure that outlines the process if a threatened species is observed during the works.

WestConnex M4-M5 Link Geotechnical Investigations Flora and Fauna Assessment

Niche (2016) was commissioned by WestConnex to prepare a flora and fauna assessment for geotechnical investigations at The Crescent and Rozelle Rail Yards. The NSW listed Coastal Saltmarsh endangered ecological community was recorded along the banks of Johnstons

Creek at Bicentennial Park. However, the report determined a significant impact was unlikely given the implementation of avoidance and mitigation measures.

The report determined potential habitat for several threatened fauna may be impacted by the works, including the Grey-headed Flying-fox, Green and Golden Bell Frog, Long-nosed Bandicoot (endangered population) and some migratory bird species. However, assessments of significance concluded that a significant impact on these species was unlikely to occur. It is noted that no suitable potential habitat for microbats was determined to be present.

CBD Metro Environmental Assessment

SKM prepared an environmental assessment for sites associated with the CBD Metro, including part of the Rozelle Rail Yards. No threatened ecological communities or threatened flora were recorded or considered as having a potential to be impacted by the works. The report assessed potential impacts to the Grey-headed Flying-fox and some microbats, due to the presence of potential habitat. The assessment concluded that the project was unlikely to result in a significant impact on local populations of these threatened species.

Local Council Action Plans

The local council action plans from the City of Sydney and Marrickville (now part of Inner West Council) provides a framework for the protection and enhancement of Biodiversity in the LGA's. The plans identify significant ecological values present (flora and fauna, the majority of which represent non-threatened species) within the respective LGAs, and their potential treats. The action plans also identify areas of connectivity and/or priority biodiversity sites that contain relatively high biodiversity values.

It is noted that the project footprint occurs outside of the 'priority sites' identified within the City of Sydney LGA and outside of the 'priority biodiversity sites' identified within the Marrickville LGA.

A number of threatened priority fauna species identified in both plans were considered to have suitable habitat (or were recorded) within the project footprint, including; Grey-headed Flying-fox and Eastern Bentwing-bat (and other microbats). The Green and Golden Bell Frog and Long-nosed Bandicoot are also threatened species identified in the plans, however, suitable habitat for these species is not considered to be present within the project footprint. It is noted that targeted fauna surveys for these species were conducted as part of the Rozelle Rail Yards REF; Biodiversity Assessment. Other species considered to be uncommon in urban areas, but are not listed as threatened under State or Commonwealth legislation may have potential within the project footprint.

4.1.2 Vegetation surveys

Assessment of vegetation mapping

The existing vegetation community mapping (OEH 2013) within the study area was verified to confirm the presence or absence of native vegetation communities, including presence of any threatened ecological communities (TECs). Vegetation communities were identified from a combination of floristic surveys and transect traverses, and checked to see if a PCT could be assigned or as non-native vegetation, by comparing the dominant canopy species, the general description of location, soil type and other attributes as described in the OEH online VIS classification database (OEH 2016c).

Vegetation within the project footprint is shown in Figure 4.1 to Figure 4.6. Where vegetation was present but it could not be classified as any particular PCT, it was combined into the vegetation type 'Urban Exotic and Native Cover' (see section 4.2).

Biometric plots using the methodology described in the FBA

No biometric plots were completed as part of this FBA, as no PCTs are present within the project footprint.

Figure 4.1: Existing vegetation at the Haberfield and Ashfield sites

Figure 4.2: Existing vegetation at Darley Road civil and tunnel site (C4)

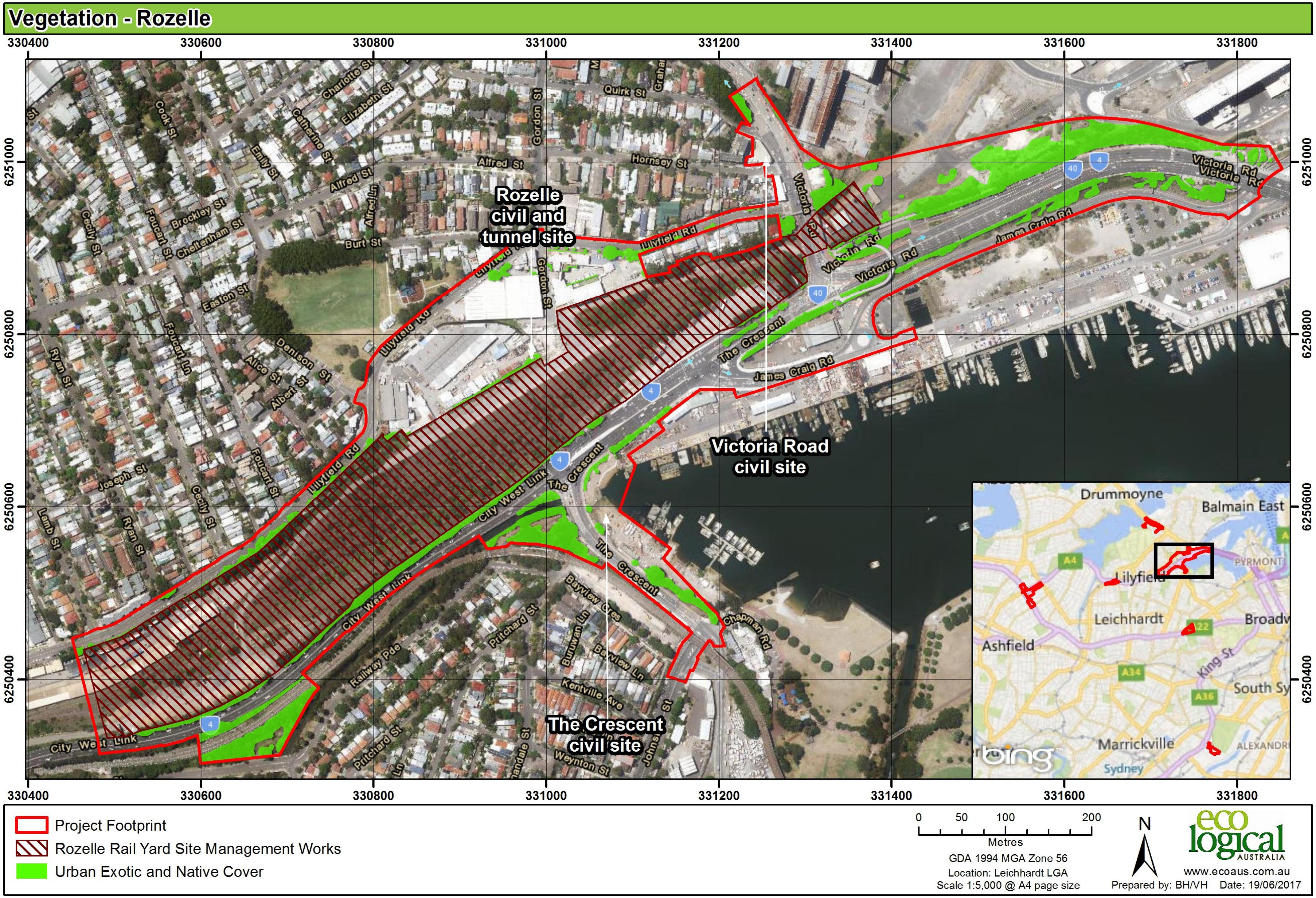


Figure 4.3: Existing vegetation at Rozelle civil and tunnel site (C5), The Crescent civil site (C6) and Victoria Road civil site (C7)

Figure 4.4: Existing vegetation at Iron Cove Link civil site (C8)

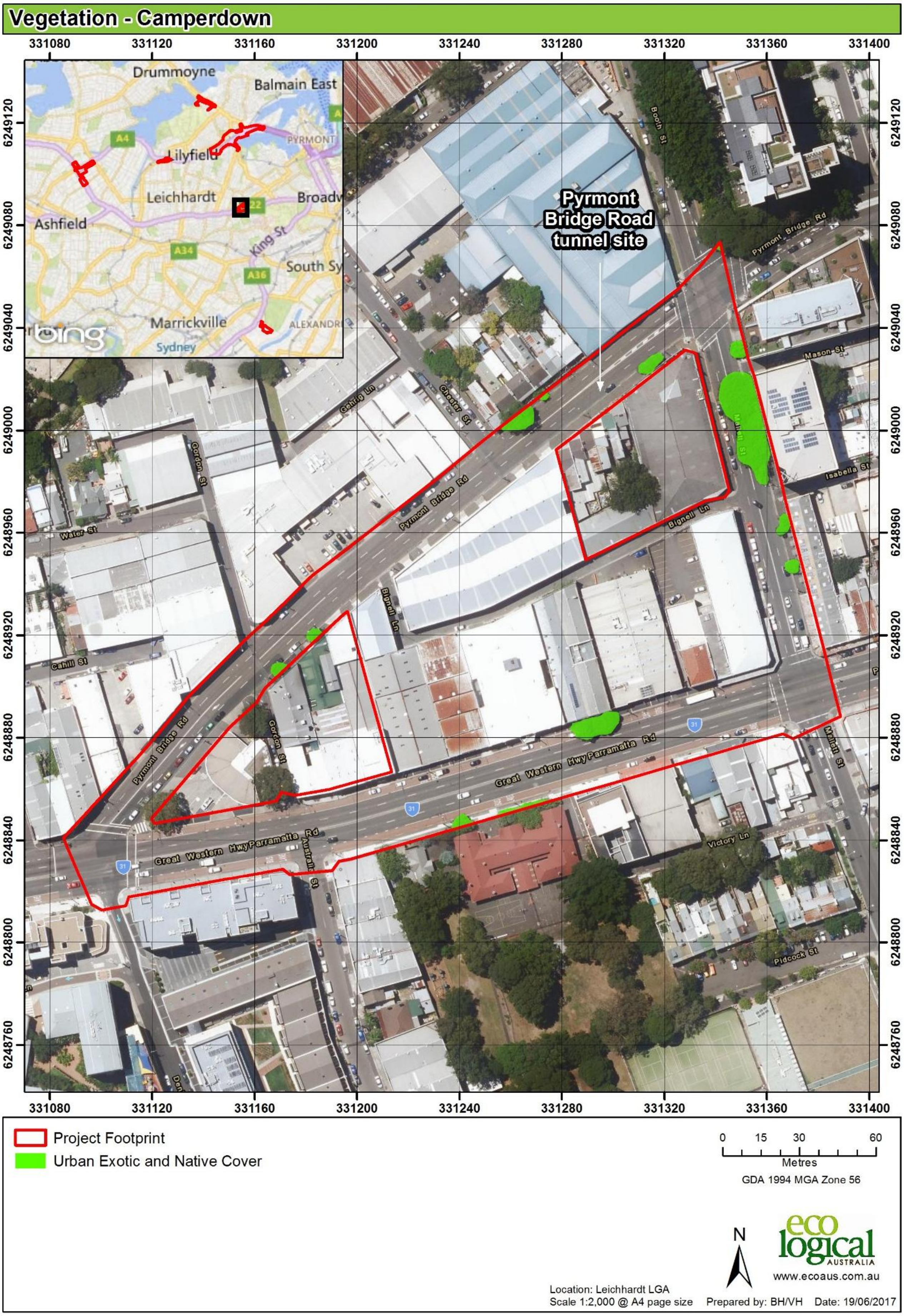


Figure 4.5: Existing vegetation at Pyrmont Bridge Road tunnel site (C9)

Figure 4.6: Cleared site at Campbell Road civil and tunnel site (C10)

4.2 PCT descriptions

The FBA requires that the extent of native vegetation within the project footprint be mapped. This native vegetation is to be classified using PCTs defined in the VIS Classification database (OEH 2016c).

The FBA provides the following definitions:

- *PCT* – a NSW plant community type identified using the PCT classification system, which is the system of classifying native vegetation approved by the NSW Plant Community Type Control Panel and described in the VIS Classification Database
- *Native vegetation* - as the same meaning as in section 6 of the *Native Vegetation Act 2003* (NV Act).

However, no PCTs were recorded within the project footprint, and thus no native vegetation is considered to be present. The project footprint is entirely modified and disturbed, and contains exotic species, weeds and planted native or non-indigenous species. The project footprint is characterised by urban parks, landscaped road verges, disused rail infrastructure, compacted soils, introduced fill, existing dwellings and other infrastructure and considered to be in a poor ecological condition, with little ecological value and unlikely to have any native resilience or recovery potential.

All vegetation present within the project footprint was classified as 'Urban Exotic and Native Cover', as shown by the non-native vegetation mapped by OEH (2013; *Sydney Metropolitan Catchment Management Authority Vegetation Mapping project*) and was considered to be in a low condition, as described by the FBA (Table 4.1). This vegetation type is not required to be further assessed using the FBA methodology, and was thus excluded from any credit or offset calculations.

Table 4.1 Vegetation zones

Veg zone	Veg zone code	Vegetation Type	PCT	TEC?	Site value score	Area (ha)
1	Low	Urban Exotic and Native Cover	No	No	N/A	4.49*

* This number excludes any areas that have been assessed as part of the M4 East and New M5 projects and Rozelle Rail Yards site management works.

The FBA describes vegetation in low condition where:

a) woody native vegetation with native over-storey percent foliage cover less than 25 per cent of the lower value of the over-storey percent foliage cover benchmark for that vegetation type, and where either:

– less than 50 per cent of ground cover vegetation is indigenous species, or
– greater than 90 per cent of ground cover vegetation is cleared OR

b) native grassland, wetland or herbfield where either:

– less than 50 per cent of ground cover vegetation is indigenous species, or
– more than 90 per cent of ground cover vegetation is cleared.

Under the OEH (2013) mapping project, *"non-native vegetation cover comprised two classes: 'weeds and exotics' and 'urban exotics and natives'. The label 'weeds and exotics' was applied to vegetation patches greater than 0.1 hectare in size with a complete cover of exotic species in the upper strata (ie where no visible native species could be discerned). The label 'urban exotics and natives' was applied to polygons greater than 0.1 hectares in size for which urban land use covered more than 70 per cent of the polygon and there was evidence of both exotic and native species in the upper or lower strata. Typically these areas include backyard trees, street trees, gardens, median strips and other small-scale features that are small isolated stands".*

4.2.1 Urban Exotic and Native Cover

Urban exotic and native cover within the project footprint consisted of planted indigenous, non-indigenous native and exotic species within local parklands, urban backyards, riparian vegetation (eg Figure 4.7) and the Rozelle Rail Yards (see description below). These areas often contained large expanses of exotic grasses and other weeds and generally occurred where the soil profile had been extensively modified. Some areas such as parklands only contain large established trees (native and exotic) over exotic grasses, with no shrub layer or evidence of regenerating overstorey species.

A typical area within and adjacent to the Rozelle Rail Yards was dominated by exotic vegetation or non-indigenous and disturbance tolerant species across all vegetation layers, including, *Casuarina glauca* (Swamp Oak), *Phoenix canariensis* (Canary Island Date palm), *Acacia longifolia* subsp. *sophorae* (Coastal Wattle), *Acacia saligna* (Golden Wreath Wattle), *Lantana camara* (Lantana), *Rubus fruticosus* (Blackberry), and *Phyllostachys aurea* (Bamboo) in the mid to upper stratum. The ground layer was dominated by exotic grasses including *Andropogon virginicus* (Whiskey Grass), *Melinis repens* (Red Natal Grass), *Eragrostis curvula* (African Love Grass), *Cortaderia selloana* (Pampas Grass), *Pennisetum* spp. (Swamp Foxtail and Kikuyu) and *Chloris gayana* (Rhodes Grass).

Other key information relating to this vegetation category is summarised in Table 4.2.

Table 4.2: Key information regarding the Urban Exotic and Native Cover vegetation category within the study area Threatened ecological communities within the study area locality

Vegetation formation and class	Not applicable
PCT / BVT	Non-Native Vegetation. Mapped as Urban Exotic and Native Cover
Other mapping sources	Native Vegetation of the Sydney Metropolitan Area (OEH 2013).
Conservation status	Not listed
Condition	Low
Extent in the study area	Around 4.49 hectares

Figure 4.7: Urban exotic and native cover within and adjacent to the Rozelle Rail Yards

4.3 Threatened ecological communities

No threatened ecological communities were recorded within the project footprint.

It is noted that three threatened ecological communities listed under the TSC and/or EPBC Act have been mapped close to the site. However, impacts to these communities will not occur as a result of the works, and therefore have not been assessed further in the report.

Table 4.3: Threatened ecological communities within the study area locality

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 approximately 300 metres south-east of the works associated with the widening of The Crescent and 600 metres south-east of the Rozelle Rail Yards. It 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, 900 metres and 1,800 metres north of the Wattle Street tunnel and civil site.

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 approximately 400 metres west of the Victoria Road and Iron Cove civil site.

4.4 Groundwater dependent ecosystems

Groundwater Dependant 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. The frequency of groundwater influence may range from daily to inter-annually, however it becomes clearly apparent when either the supply of groundwater or its quality (or both) is altered for a sufficient length of time to cause changes in plant function. Groundwater use by an ecological community or individual species does not necessarily imply groundwater dependence.

The assessment process followed the steps outlined in the risk assessment guidelines for groundwater dependent ecosystems (NSW DPI 2012). A search of the National GDE Atlas was conducted for the study area (inclusive of the mainline tunnel alignment and its adjacent areas), and the *Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2011* was reviewed for high priority GDEs. Potential GDEs were assessed by a GDE expert for their type and level of groundwater dependence, as well as their ecological value (where this was known).

The GDE assessment does not estimate the impacts of the project on groundwater, rather it attempts to estimate and assess the impacts of groundwater extraction on the biodiversity values of GDEs.

No field assessments were conducted for the assessment of GDEs. The GDE assessment was based on a desktop assessment only. A map of the GDEs in relation to the project footprint is provided in Figure 4.8. ELA relied on information available at the time to determine the type and intensity of potential impacts. This information was limited to the spatial extent of the proposed road corridor and did not consist of modelled groundwater data or detailed information on the volume and extent of groundwater extraction. To account for any impact that may extend beyond the proposed road corridor, a buffer of approximately 200 metres was included in the assessment.

In Australia, many ecosystems have a dependence on groundwater, although the full 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 resources.

GDEs are generally classified into six categories:

- *Terrestrial vegetation* – forests and woodland which develop a permanent or seasonal dependence on groundwater, often by extending roots into the water table
- *Base flow in streams* – aquatic and riparian ecosystems that exist in or adjacent to streams that are fed by groundwater base flow
- *Aquifer and cave systems* – aquatic ecosystems that occupy caves or aquifers
- *Wetlands* – aquatic communities and fringing vegetation that depend on groundwater fed lakes and wetlands
- *Estuarine and near shore marine ecosystems* – various ecosystems including mangroves, saltmarsh and seagrass, whose ecological function has some dependence on groundwater discharge
- *Terrestrial fauna* – fauna species assemblages reliant on groundwater for drinking water.

A final category is also recognised ‘not apparently dependant’. This category acknowledges that some ecosystems, particularly wetland and riparian vegetation, might superficially appear to be groundwater dependent while in fact they are dependent entirely on surface flows and or rainfall.

The most likely GDE types in the Sydney region are terrestrial vegetation communities with deep roots that use groundwater, wetlands, and river baseflow systems. The project footprint is highly developed. A search of the GDE Atlas (Bureau of Meteorology, accessed 27 September 2016) indicates that there are no ecosystems within the study area that are likely to be dependent on groundwater.

Although not mapped as being groundwater dependent, Johnstons Creek and Whites Creek are associated with palaeochannels and it is possible that fracturing of basement rock may result in draining of the alluvium associated with these channels. Tunnels passing beneath these creeks should be constructed in a way that ensures no draining of the alluvium.

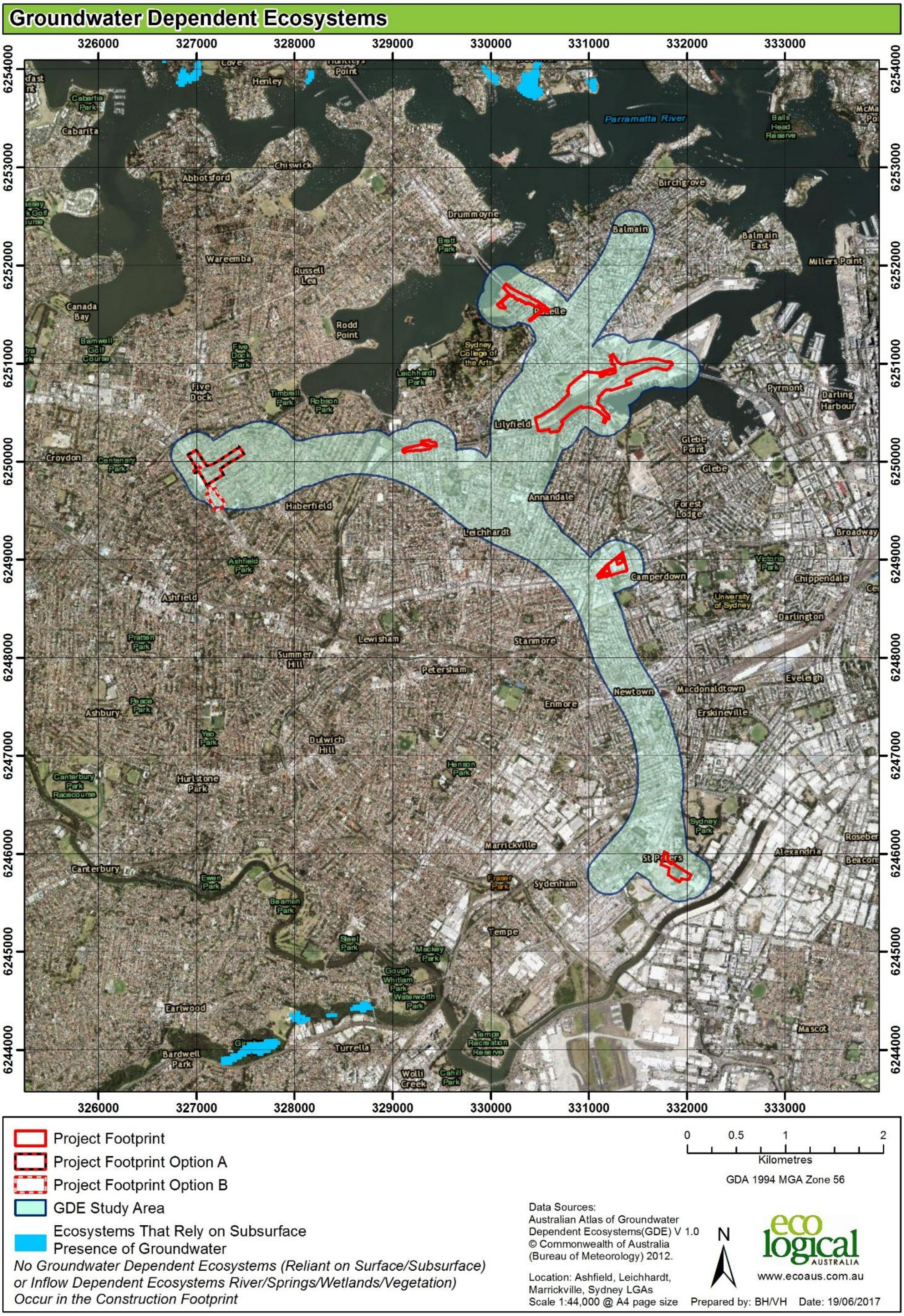


Figure 4.8: GDE assessment area

5 Threatened species

5.1 Candidate species

5.1.1 Ecosystem credit species

The FBA requires that a list of threatened species that can be reliably predicted by habitat surrogates are identified. These species are called ecosystem credit species and they are automatically generated based on the PCT, the IBRA subregion of the project footprint, the condition and patch size of vegetation. The FBA allows an assessor to determine whether any of the habitat components for the predicted threatened species are present or not. If they are not present, an assessor does not need to identify the ecosystem credit species present in the vegetation zone.

However, due to the lack of PCTs within the project footprint, no ecosystem credits species were predicted to occur.

5.1.2 Species credit species

Species credit species are typically predicted by the assessment tool based on the PCTs present within the project footprint, and a series of habitat and geographic location questions formulated by the assessment tool. Once the species credit species are identified, they undergo a second filtering step to determine whether they are filtered into the assessment for consideration as a species credit species.

However, no species credit species were identified from the tool, and therefore no species credit species were considered for further assessment.

5.1.3 Final candidate species

No candidate species were initially predicted by the tool. However, some species have habitat requirements that cannot be predicted by PCTs, and therefore cannot be predicted by the assessment tool. Particularly those species that can utilise man-made or exotic environments. As such, a conservative list of final candidate species was developed (Table 5.1).

This list is based on the species likelihood of occurrence (Annexure A), which was informed from database searches, previous studies, and specific habitat features present within the project footprint. The list of final candidate species is then used to determine whether or not the species requires further assessment in the tool and whether targeted surveys are required. It is noted that this list (Table 5.1) contains both species and ecosystem credit species, and targeted survey was completed for all species, despite the assessment tool not requiring targeted survey for ecosystem credit species.

Furthermore, it is noted that a candidate species is typically not considered present by the FBA where:

- The habitat is substantially degraded
- An expert report states that the species is unlikely to be present
- The species is a vagrant and is unlikely to frequently use habitat in the project footprint
- Records of the species are at least 20 years old or have doubtful authenticity.

Table 5.1: List of candidate species credit species and their initial likelihood of occurrence (Annexure A)

Species	Species or ecosystem credit species	Likelihood of occurrence	Habitat assessment	Targeted survey
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 in close proximity to the site and are common in the locality.	No – assumed presence for foraging
Little Bentwing-bat *(Miniopterus australis)*	Species (breeding sites) and ecosystem (foraging)	Low	Utilises 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 NSW Wildlife Atlas, as the record is well outside the species known range.	Yes
Eastern Bentwing-bat *(Miniopterus schreibersii oceanensis)*	Species (breeding sites) and ecosystem (foraging)	Moderate	Utilises caves, hollows and man-made structures as roost sites. A number of records exists 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 (ten years old), 2.5 km north of the site within Sydney Harbour.	Yes
Eastern Freetail-bat *(Mormopterus norfolkensis)*	Ecosystem	Moderate	Primarily uses hollows as roost sites, but can also use man-made structures. Nearest record is ten years old from Goat Island, 2.5 km north of the site 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 (ten years old) is from Goat Island, 2.5 km north of the site 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

5.2 Threatened species survey

5.2.1 Terrestrial flora surveys

No threatened flora were considered as having the potential to occur within the project footprint, or were recorded opportunistically during the vegetation and fauna surveys. The project footprint is representative of a highly disturbed and degraded environment, dominated by exotic vegetation or disturbance tolerant species.

5.2.2 Terrestrial fauna surveys

All fauna surveys were conducted in accordance with the SEARs and were consistent with the FBA and NSW and Commonwealth guidelines (Table 5.2). Where survey methods differed, an explanation was provided. A summary of the field survey effort for each species is provided in Table 5.3 and a map showing survey locations in Figure 5.1.

Fauna habitat assessments were initially conducted to identify potential habitat, including marking of habitat features, such as hollow-bearing trees, rock habitats, known food trees and foraging substrates, presence of termite mounds, and evidence of fauna usage, for example diggings, chewed plant cones and scats. This habitat assessment was used to inform the requirement for targeted threatened fauna surveys, survey effort and survey location.

Table 5.2: Minimum requirements for candidate fauna species

Species	Minimum survey requirements and survey timing
Microbats	*FBA Tool* = Surveys should be conducted between October and March. *NSW* = Echolocation call survey (such as Anabat recorders) for a minimum of four hours. While not specified as a minimum requirement, it is recommended the recorders operate for the entire night (DEC 2004). *Commonwealth* = Species are not listed under the EPBC Act.
Grey-headed Flying-fox	*FBA* = Surveys are to be conducted between September and May. *NSW* = Spotlight searches combined with listening for audible calls and movements in trees, focussing on fruiting or flowering food trees and known roost sites or camps. For targeted survey near likely food resources, survey effort should involve 2 x 1 hour spotlighting sessions over two nights (DEC 2004). *Commonwealth* = This species occupies most areas in its distribution in highly irregular patterns, and therefore surveys based on animal sightings are unlikely to be reliable. A more effective survey method is to search appropriate databases and other sources for the locations of camps, and to conduct vegetation surveys to identify feeding habitat (DEWHA 2010b).

5.2.3 Summary of fauna survey effort

The fauna surveys for this assessment were conducted over multiple nights between August and October 2016 (Table 5.3). Surveys were only conducted at the Rozelle Rail Yards as potential habitat for these species were not considered to be present at other sites. Survey effort was prioritised according to the habitat features present within the rail yards (Figure 5.1).

Table 5.3 Summary of survey effort

Species	Survey effort	Dates	Survey method
Microbats	102 hours of recording	21/09/16, 22/09/16, 27/09/16, 12/10/16, 14/10/16 & 24/10/16	Four echolocation recording devices were set at separate locations over two consecutive nights (see Figure 5.1). A time delay was programmed into each device such that the calls were recorded from 5:30pm to 6am. Opportunistic follow-up Anabat surveys were conducted on 27 September and 24 October to supplement initial surveys. During these surveys, the Anabat was set for an hour following sunset. Bat calls for the initial Anabat surveys were analysed by Rodney Armistead and assigned to four levels of confidence as per Mills et al. (1996) (refer to Annexure E). An inspection (internal and external) of the Ports Authority building east of the bridge was conducted on 12 October for potential roost sites. An inspection of the cavities of the northern span of Victoria Road bridge was conducted on 14 October, using a burrow-scope and elevated work platform.

5.2.4 Fauna survey conditions

The fauna surveys were conducted during variable temperatures and generally after suitable rainfall (Table 5.4).

Table 5.4: Weather observations during fauna field survey

Date	Temperature °C (Min)	Temperature °C (Max)	Wind Speed km/h (at 9am)	Rainfall (mm) previous 48 hours
21/09/2016	14.0	22.3	15	11.0
22/09/2016	12.8	19.7	20	1.0
27/09/2016	10.6	23.3	28	9.8
12/10/2016	9.7	23.3	22	3.6
14/10/2016	8.4	20.3	11	6.2
24/10/2016	9.9	18.7	20	16.2

*Note: Data taken from Sydney Airport automatic weather station, 066037 (BOM 2016).

5.3 Threatened species results

Two threatened fauna species, the Eastern Bentwing-bat and Yellow-bellied Sheathtail-bat were recorded during the targeted surveys (Table 5.5), within the Rozelle area. Furthermore, the Grey-headed Flying-fox was assumed to be present across the project footprint based on the presence of suitable foraging trees, and known records in close proximity to the Rozelle Rail Yards site.

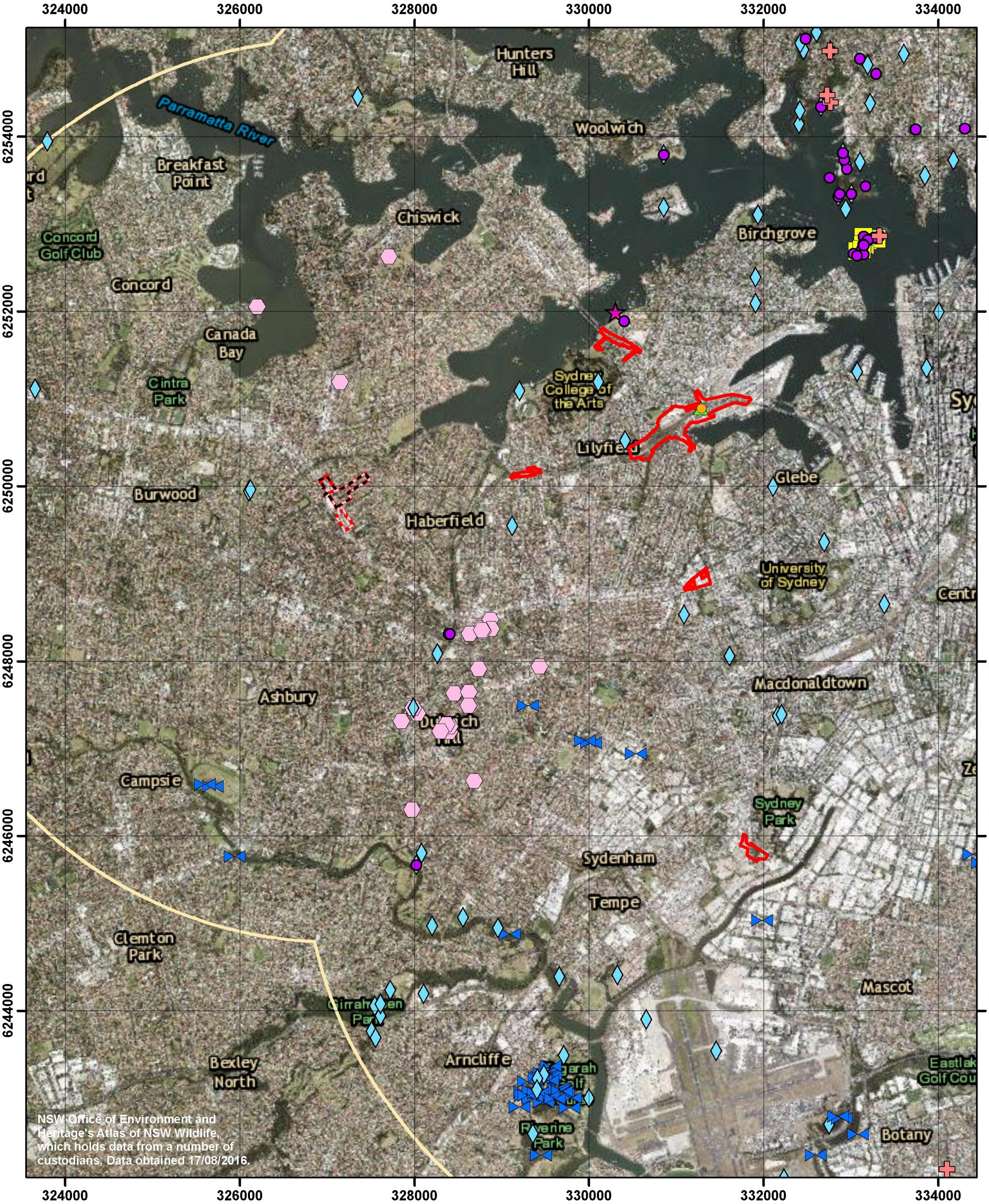
Table 5.5: Threatened species survey results

Species	Ecosystem or species credit species?	Identification method	Can the species withstand further loss?	Habitat feature/ component	Impact
Grey-headed Flying-fox *(Pteropus poliocephalus)*	Ecosystem (foraging habitat)	Assumed	Not applicable for ecosystem credit	Planted and landscaped foraging trees within and adjacent to the site	Limited feed trees within the 4.49 hectares mapped as urban exotic and native cover
Eastern Bentwing-bat* *(Miniopterus schreibersii oceanensis)*	Species (breeding sites)* and ecosystem (foraging)	Recorded (Anabat surveys)	Yes	Non-native foraging habitat and potential roosting cavities under Victoria Road bridge (ecosystem credit components)	Up to 3.78 hectares foraging habitat (mapped urban exotic and native cover at construction sites; C5, C6 & C7) and direct impacts on potential roost sites
Yellow-bellied Sheathtail-bat *(Saccolaimus flaviventris)*	Ecosystem	Recorded (possible call, Anabat survey)	Not applicable for ecosystem credit	Non-native foraging habitat (ecosystem credit component)	Up to 3.78 hectares foraging habitat (mapped urban exotic and native cover)

* No maternity colonies for the Eastern Bentwing-bat are known within the Sydney Metro CMA Area (OEH 2016a). It breeds at maternal roosting sites within karst (limestone) caves (in areas such as the Blue Mountains some distance from the study area) and migrates to Sydney and other areas in the winter, returning to the maternal roost in summer.

Figure 5.1: Threatened species survey locations for the Rozelle Rail Yards site management works (ELA 2016)

Threatened Fauna Records



Project Footprint
Project Footprint Option A
Project Footprint Option B

Threatened Fauna Records (ELA 2016)

Eastern Bentwing-bat
Yellow-bellied Sheathtail bat

NSW Wildlife Atlas Threatened Species

Eastern Bentwing-bat (*Miniopterus schreibersii oceanensis*)

Eastern Freetail-bat (*Mormopterus norfolkensis*)
Green and Golden Bell Frog (*Litoria aurea*)
Grey-headed Flying-fox (*Pteropus poliocephalus*)
Little Bentwing-bat (*Miniopterus australis*)
Long-nosed Bandicoots (*Perameles nasuta*) – Inner West Endangered Population
Southern Myotis (*Myotis macropus*)

Location: Ashfield, Burwood, Canada Bay, Canterbury, Hunters Hill, Lane Cove, Leichhardt, Marrickville, North Sydney, Ryde, Sydney, Willoughby, Woollahra LGAs
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Prepared by: BH/VH Date: 19/06/2017

Figure 5.2: Recorded threatened species (database and survey records)

5.4 Aquatic habitat and threatened species

The aquatic marine environment includes the intertidal and subtidal ecosystem of the harbour and its estuarine tributaries.

5.4.1 Aquatic assessment methodology

A desktop review of threatened species considers a broad context for mobile aquatic species in estuarine waters. Traditionally a 10 kilometre radius search is used, however, a larger search area is suitable where connectivity is possible (eg water or vegetation corridors) or when flora/fauna surveys are historically limited or difficult (eg underwater). The following databases and online researches were searched for an area encompassing all of Sydney Harbour, its major tidal rivers and within 10 kilometre of the shore:

- EPBC Act – Protected Matters Search Tool
- TSC Act – Threatened Species Search Tool (BioNet)
- 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)
- The Sydney Harbour – Foreshores and Waterways Area Development Control Plan: Ecological Communities and Landscape Characters' Map and Wetlands Protection Map.

This desktop assessment determines the likelihood of occurrence for listed species, populations and communities. Strictly terrestrial species were filtered from the results, with focus given to fish, sharks, rays, aquatic mammals, aquatic reptiles, shorebirds, wetland birds, migratory birds and pelagic birds. Other populations filtered out are those with defined geographic boundaries outside of the study area.

Following the desktop assessment, a site visit was conducted of Whites Creek and its confluence with Rozelle Bay on 26 September 2016 and 30 May 2017. Other sites were considered in the desktop assessment but were not visited as part of the aquatic methodology: Iron Cove bridge abutment (reclaimed land with seawall); Iron Cove at Haberfield (footprint beyond riparian buffer); Hawthorne Canal at Darling Road (footprint beyond riparian buffer); Johnstons Creek at Camperdown (footprint beyond riparian buffer); and Alexandra Canal at St Peters (footprint beyond riparian buffer).

5.4.2 Aquatic results

Desktop assessment

The results of the desktop assessment are shown in Figure 5.3.

Threatened fish are either unlikely to occur because there is no suitable habitat (eg freshwater for Macquarie Perch) and no records of occurrence in the catchment (eg Australian Grayling), and no specific habitat is available (eg caves and crevices for Black Rock cod).

Threatened sharks and rays may opportunistically pass through the estuary while exploring or chasing prey, but they would not depend on Whites Creek, or Rozelle Bay, Iron Cove Bay, Alexandra Canal or any other waterway near the sites for habitat. Regular boat traffic may deter large fauna from regularly using the study area.

Threatened aquatic mammals (whales, dolphins, dugongs and seals) are known to occur in the harbour and/or along the coast. Large mammals are unlikely to depend on shallow areas. Dugongs forage on seagrass beds, but there are no records in the harbour, suggesting they prefer more expansive beds such as in Botany Bay. Seals may follow prey into shallow water or explore the adjacent area. It is likely most aquatic mammals avoid human activities, especially in high boat traffic areas.

Threatened aquatic reptiles (turtles) are more common along coastal waters than in the harbour. It is possible they explore the greater area, but would not depend on the project footprint and its immediate surrounds for habitat.

Threatened birds such as shore birds, wetland birds, migratory birds and pelagic birds are unlikely to occur given the minimal/steep intertidal area created by the channel and rock revetment walls. They would also avoid areas with concentrated human activities.

Threatened flora and vegetation communities/populations (saltmarsh and *Posidonia* (Seagrass)) do not occur on or near the project footprint.

Other protected fauna listed under the FM Act are assessed for likelihood of occurrence. Listed marine or estuarine species include one shark, six fishes and a taxonomic order of Syngnathiformes (seahorses, sea dragons, pipefish, pipe horses, ghost pipefish and sea moths):

- The Herbst's Nurse Shark only occurs in deep water (150-600 metres), unlike the shallow study area
- Most listed fishes are known to occur around rocky coastal reefs, which are absent in the study area. One fish (Estuary Cod) occurs in a range of habitats, from turbid shallow estuary waters (juveniles) to the base of drop offs and deeper water (adults). Sydney is the southern extent of Estuary Cod, with no records in the harbour or similar habitats nearby
- Syngnathiformes occur in the harbour, and are known to use a variety of habitats, such as macroalgae, seagrass beds and unvegetated shallows. These species are unlikely to occur in the project footprint due to unsuitable habitat.

It is considered unlikely that there is valuable or specific aquatic habitat for threatened aquatic/estuarine species, populations or communities listed under the FM Act, TSC Act and EPBC Act within the project footprint. It is possible some species may opportunistically pass near the project footprint in estuarine bays given the connectivity to the broader harbour and coastal habitats, but they are unlikely to depend on the habitat within the project footprint.

Existing environment

The foreshore of Rozelle Bay near Whites Creek consists of reclaimed land, vertical seawalls, jetty structures, riprap embankment and gentle sloping intertidal land. At the lower end of Whites Creek, the marine environment is highly modified, consisting of a nine-metre wide concrete lined channel with vertical walls (historic Sydney Water channel). On The Crescent, the existing crossing is a low bridge, 46 metres wide by nine metres long. Sydney Water has a plan to naturalise sections of Whites Creek further upstream of the crossing, which provides an opportunity for the project to extend the Sydney Water naturalisation works to the confluence with Rozelle Bay.

Sessile marine organism have adapted to the concrete walls of Whites Creek, especially *Saccostrea commercialis* (Sydney Rock Oyster) and *Chamaesipho tasmanica* (Honeycomb Barnacle). A low horizontal intertidal zone prevents establishment of mangroves and saltmarsh. The concrete substrate 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 the bay at the discharge point immediately east of the road crossing. No seagrass occurs near the outlet, and no marine alga is attached to the gabion wall. Riparian vegetation upstream is comprised of a row of planted *Casuarina glauca* (Swamp Oak) and *Phoenix canariensis* (Canary Island Date Palm).

The 'Sydney Harbour – Foreshores and Waterways Area Development Control Plan: Ecological Communities and Landscape Characters' map does not identify the site as any notable Aquatic Ecology Community, besides 'Rivers and Creeks' and 'Water'. Likewise, the area is not identified for "Wetland Protection'. The state-wide mapping of estuarine macrophytes (mangrove, saltmarsh and seagrass) by DPI Fisheries, identifies a patch of seagrass (*Halophila*) in the shallow subtidal zone at the opposite end of Rozelle Bay, around two kilometres north-east near Ewenton Park – Balmain; and a small patch of mangroves 800 metres east in Rozelle Bay (Creese et al 2009). A small mangrove/saltmarsh restoration zone is located 250 metres east in Bicentennial Park, Glebe.

Whites Creek is concrete lined and, therefore, is not considered KFH and does not receive a waterway crossing classification for fish passage (see classification system in Fairfull 2013).

Photos of the existing environment at Whites Creek are shown in Figure 5.4 to Figure 5.7.

The foreshore of Rozelle Bay near Whites Creek is highly modified. Banks are either rock revetment batters with twin pipe culverts, gabion baskets, weed-invaded fill or dilapidated seawalls. Two *Casuarina glauca* saplings have colonised the artificial batters, but do not qualify as any native vegetation community. This landscape prevents saltmarsh and mangrove establishment. The exotic *Lampranthus tegans* (Little Noon-flower) occurs at the top of the batter but does not qualify as a saltmarsh community. Few marine molluscs and oysters occupy the intertidal base of the batter. The subtidal substrate is silty-sand covered with organic matter (leaves and branches) discharged from Whites Creek. Decomposition of detritus may result in anoxic conditions close to the sediment, and is unlikely to be suitable for benthic infauna. No seagrass or macroalgae occur within 50 metres of the bank. This area is classed as Type 3 Key Fish Habitat (minimal sensitivity) (Table 1 in Fairfull 2013).

Photos of the existing environment at Rozelle Bay near Whites Creek are shown in Figure 5.8 to Figure 5.13.

Johnstons Creek also flows to Rozelle Bay, and like Whites Creek (Figure 5.3), it is concrete lined and does not have any valuable aquatic habitat mapped by DPI Fisheries and the Sydney in the Sydney Harbour – Foreshores and Waterways Area Development Control Plan: Ecological Communities and Landscape Characters'.

Iron Cove Creek and Hawthorne Canal are 1st Order tributaries of Iron Cove estuary (Figure 5.3). Both waterways are concrete lined channels, transitioning from freshwater to estuarine where they are mapped as KFH. These provide limited value aquatic habitat with limited opportunities for water quality improvement before water reached the bay. The 'Sydney Harbour – Foreshores and Waterways Area Development Control Plan: Ecological Communities and Landscape Characters' map does not identify the creeks near the sites as having any notable Aquatic Ecology Community, besides '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 'Sydney Harbour – Foreshores and Waterways Area Development Control Plan: Ecological Communities and Landscape Characters' 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 400 metres to the west, and a small patch of Zostera 500 metres to the east.

Alexandra Canal 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 KFH, 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.

5.4.3 Riparian vegetation

The riparian vegetation in the project footprint is mapped as urban exotic and native cover, and represents planted and landscaped native and exotic species, such as *Casuarina glauca, Lomandra longifolia* and Palm trees.

The parts of the Whites Creek and Hawthorne Canal riparian corridor that occur in the project footprint are highly modified environments, consisting of a concrete channel with vertical walls and concrete base. These channels for the purposes of the *Water Management Act 2000*, do not meet the definition of a river. Furthermore, the riparian vegetation does not contribute to the ecological functioning of the creek. The vegetation provides low ecological value, and is of limited habitat for fauna species.

However, it is noted that Sydney Water has a plan to naturalise sections of Whites Creek further upstream of the crossing at The Crescent. This provides an opportunity for the project to integrate and build on the Sydney Water naturalisation plan, and continue the naturalisation of the riparian corridor through to the confluence with Rozelle Bay.

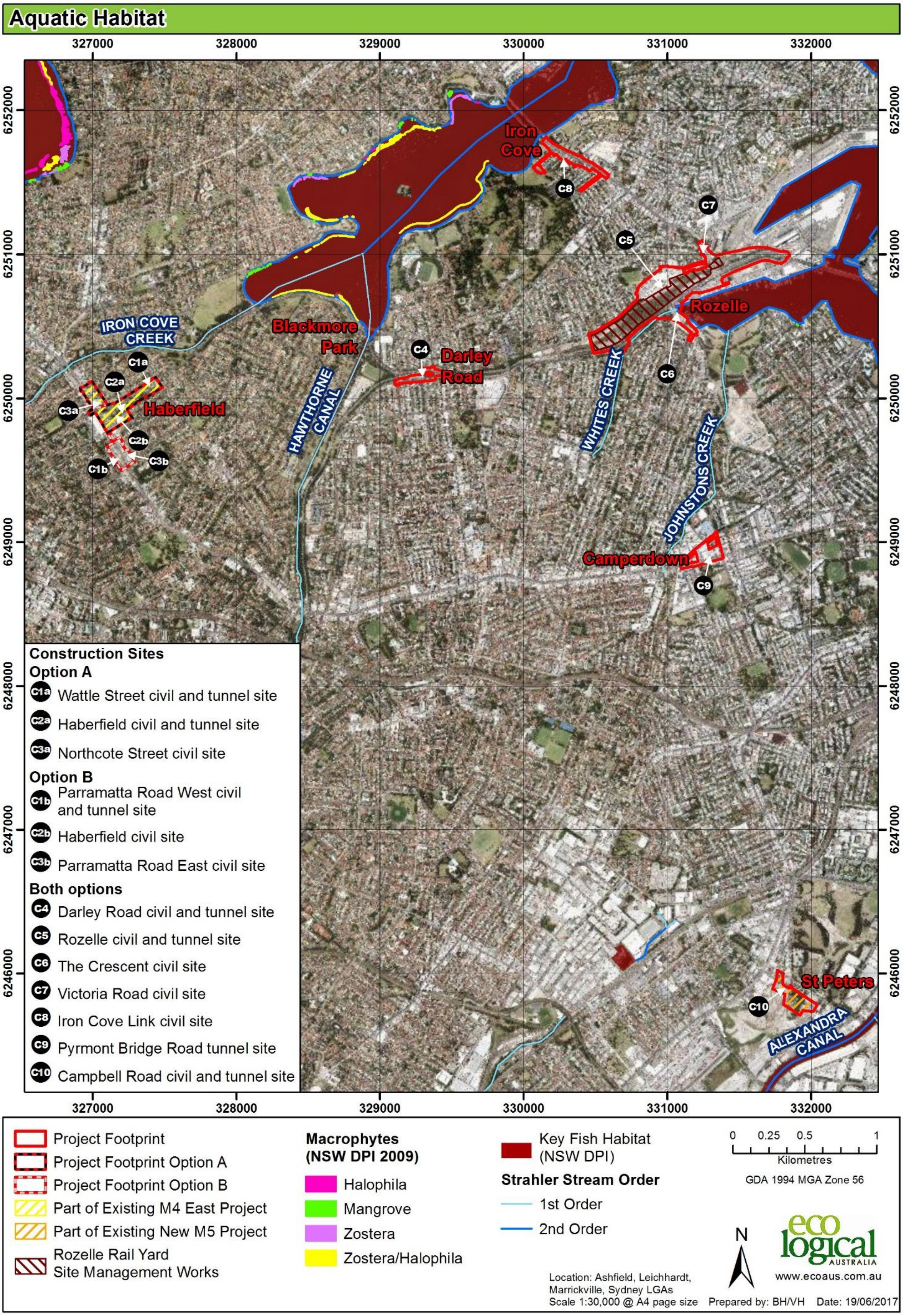

Figure 5.3: Aquatic values and key fish habitat

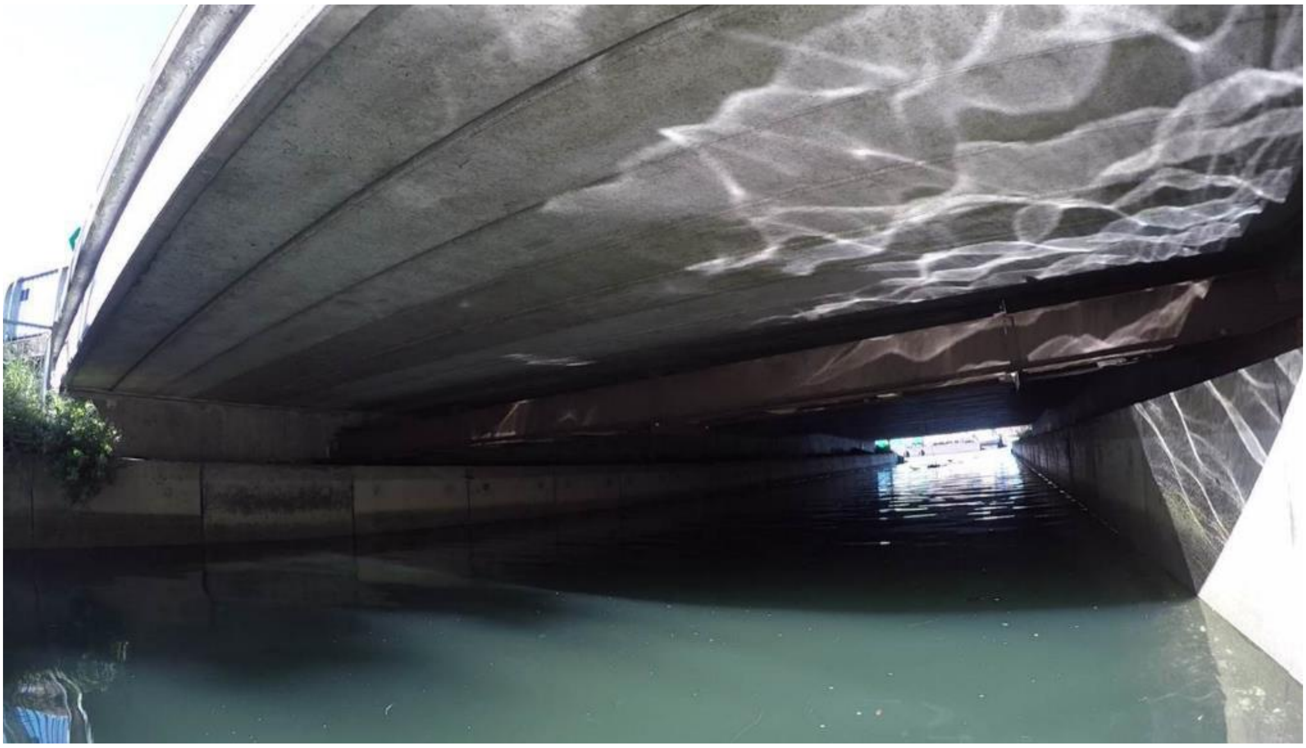

Figure 5.4: The Crescent bridge over Whites Creek; taken from western side facing downstream

Figure 5.5: Whites Creek 50 metres upstream of The Crescent bridge

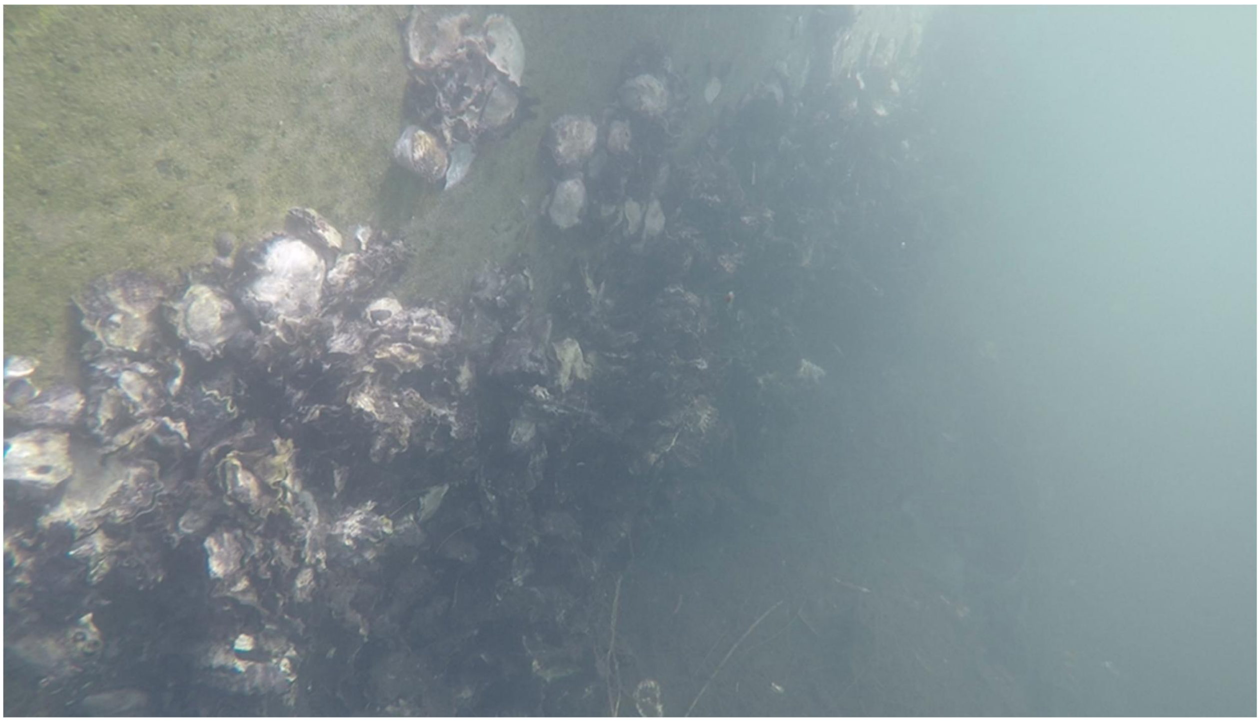

Figure 5.6: Oysters attached to concrete channel walls in Whites Creek

Figure 5.7: Large woody debris and a thin layer of detritus at the outlet of Whites Creek into Rozelle Bay

Figure 5.8: Whites Creek outlet and banks of Rozelle Bay proposed for modification

Figure 5.9: Northern side of Whites Creek outlet where new culverts would discharge across a rock spillway

Figure 5.10: Proposed site of new pipe and box culvert outlet (red line shows approximate disturbance)

Figure 5.11: Location of proposed bank stabilisation works south of Whites Creek outlet (red line shows approximate disturbance)

Figure 5.12: Subtidal benthic habitat in Rozelle Bay near Whites Creek outlet covered with fine woody debris

Figure 5.13: Subtidal benthic habitat in Rozelle Bay comprised of silty sand with no bioturbation from infauna and no marine vegetation (seagrass, macroalgae)

6 Matters of national environmental significance

The following MNES protected under the EPBC Act were considered for their relevance in regards to the project:

- World Heritage Properties (sections 12 and 12A)
- National Heritage Places (sections 15B and 15C)
- wetlands of international importance (sections 16 and 17B)
- listed threatened species and communities (sections 18 and 18A)
- listed migratory species (sections 20 and 20A)
- Commonwealth land (for actions outside Commonwealth Land that may impact on the environment on Commonwealth Land) (section 26 and 27A).

Of these, only listed threatened and migratory species were considered relevant for this report.

6.1 Threatened species

One MNES (threatened species) was presumed to be present within the study area, being the Grey-headed Flying Fox, which is listed as vulnerable under the EPBC Act.

A habitat assessment and likelihood of occurrence (Annexure A) indicated that this species was considered likely to forage on a limited number of feed trees (within the 4.49 hectares of the mapped urban exotic and native cover) within the study area and potentially be impacted by the project. This species was not recorded during the field surveys for the project. However, known records exist for the species within the locality and in close proximity to the project footprint. Further details including level of impacts, project specific mitigation measures and required offsets are discussed in Chapter 9.

An assessment in accordance with the Commonwealth Significant Impact Guidelines (Commonwealth of Australia 2013) for the Grey-headed Flying-fox is provided in Annexure E. This assessment concluded that a significant impact on the Grey-headed Flying-fox is unlikely to occur as a result of the works. Consequently, an EPBC Act referral is not required and the EPBC Act bilateral agreement relating to environmental assessment (2015) does not apply.

Consequently, an assessment in accordance with the Commonwealth Significant Impact Guidelines or referral to the Commonwealth was not required.

6.2 Migratory species

Forty migratory species listed under the EPBC Act were assessed for their likelihood of occurrence, including a number of predominantly marine species (Annexure A). The assessment considered it was unlikely for any species to occur within the project footprint, primarily due to the lack of suitable habitat and the highly urbanised environment of the site.

7 Summary of biodiversity values

7.1 Biodiversity values assessed under the FBA

This section provides a summary of the biodiversity values that occur in the project footprint, and have been assessed under the FBA (Table 7.1). This includes threatened species, populations and communities listed under the TSC Act and EPBC Act.

Table 7.1: Summary of biodiversity values assessed under the FBA

Biodiversity value	Ecosystem or species credit species	Identification method	Area/individuals within project footprint	Assessed in FBA for offsets
Eastern Bentwing-bat	Ecosystem credit species (foraging and roosting habitat)*	Recorded (echolocation recording device). Potential roosting site under Victoria Road bridge.	Potential roosting sites and up to 3.78 hectares of foraging habitat	Not required, as there are no ecosystem credits present and there is no direct impact on species credit species component (breeding habitat)
Grey-headed Flying-fox	Ecosystem credit species (foraging habitat)	Assumed to be present. Known to occur within the locality and in close proximity to the site	Limited feed trees within the 4.49 hectares (mapped as urban exotic and native cover)	Not required, as there are no ecosystem credits present and there is no direct impact on species credit species component (breeding camps)
Yellow-bellied Sheathtail-bat	Ecosystem credit species (foraging and roosting habitat)	Recorded (echolocation recording device)	Up to 3.78 hectares foraging habitat (mapped urban exotic and native cover)	Not required, as there are no ecosystem credits present and there is no direct impact on species credit species component (breeding habitat)

* Ecosystem credit was not assessed under the FBA, as no PCTs present within site. See section 7.2.

7.2 Biodiversity values outside the FBA

All biodiversity values in the project footprint were assessed under the FBA (Table 7.1). There were no matters outside of the FBA methodology unassessed within the project footprint. Therefore, no species, populations or communities listed under the FM Act, migratory species listed under the EPBC Act or groundwater dependent ecosystems were considered to occur, or be impacted by the project.

8 Avoid and minimise impacts

8.1 Avoidance and minimisation

Stage Two of the FBA requires a demonstration of efforts to avoid and minimise impacts on biodiversity, followed by an assessment of direct and indirect impacts and proposed onsite mitigation measures.

This chapter is consistent with Section 8 of the FBA and describes how biodiversity values identified in the study area (Table 7.1), have been avoided and impacts minimised, using reasonable onsite measures.

A detailed description on avoidance, alternate locations and route alignments are provided in the main EIS document. This description incorporates constraints and considerations from all factors such as social, economic, transport, and engineering.

8.1.1 Avoidance

Avoidance measures for biodiversity values were incorporated into the project in order to reduce ecological impacts, and primarily involved:

- Examining alternate locations for surface area works
- Examining route alignment and placement of construction compounds.

The project occurs within a highly urban context, where biodiversity values are limited and restricted in extent. Furthermore, the project is a linking tunnel for the M4 East and New M5 projects, and is therefore predominantly underground. This reduces the overall project footprint and minimises impacts to terrestrial biodiversity values by limiting vegetation clearance and impacts to terrestrial fauna habitats.

The combination of the factors above has resulted in the selection of a project footprint that has avoided all impacts to native vegetation, avoided threatened flora and avoided threatened fauna breeding habitat.

8.1.2 Alternate locations and route alignment

Alternatives to the project to reduce impacts on biodiversity values were considered by Roads and Maritime 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 options were considered:

- 'Do nothing / do minimum'
- Improvements to the freight rail network
- Public and active transport enhancements
- Demand management
- Optimising the performance of existing infrastructure
- The construction of a new motorway (the project).

Alternative locations initially considered for the project include surface works at Blackmore Oval in Leichhardt, Easton Park in Lilyfield and Bicentennial Park in Annandale. Whilst native vegetation (as defined by the FBA) were not present within the proposed footprints at these locations, they did provide a greater potential to provide for threatened fauna habitat than their alternative locations at Leichhardt (C4) and Rozelle (C5, C6 and C7).

9 Impact assessment

9.1 Areas requiring assessment

In accordance with the FBA, areas not requiring assessment must be identified in the BAR, including land without native vegetation (as per the definition under the *Native Vegetation Act 2003*), unless the area of land requires assessment under the SEARs.

Other areas not requiring offsets and further assessment in the BAR include:

- Impacts on PCTs that:
  - Have a site value score <17, or
  - Are not identified as critically endangered ecological communities (CEECs) or endangered ecological communities (EECs)
- Impacts on PCTs that are not associated with threatened species habitat and are not identified as CEECs/EECs
- Impacts on non-threatened species and populations that do not form part of a CEEC or EEC
- Impacts on threatened species habitat associated with a PCT within a vegetation zone with a site value score <17.

These areas cover the project footprint and are mapped as cleared land (associated with tracks, roads, buildings and other infrastructure) and urban exotic and native vegetation within the project footprint (Figure 9.1).

9.1.1 Removal of native vegetation

No areas of native vegetation (ie PCTs under the FBA) were mapped within the project footprint.

9.1.2 Removal of threatened fauna species habitat and habitat features

Direct and indirect impacts are associated with potential foraging habitat of the Grey-headed Flying-fox, Eastern Bentwing-bat and Yellow-bellied Sheathtail-bat. These species are classified as ecosystem credit species in relation to foraging habitat. However, due to the absence of native vegetation (PCTs) within the project footprint, these areas of foraging habitat do not require further assessment or offsets.

Direct impacts are also associated with potential microbat roosting sites (non-breeding / maternal roost), located under Victoria Road bridge. However, no bats were observed within the cavities under the bridge during visual inspections, but were recorded flying around the bridge during the echolocation surveys.

However, these roost sites are not classified as part of the species credit component (breeding / maternal) and therefore, under the FBA they are assessed as part of the ecosystem credits. 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 karst (limestone) caves and migrates to Sydney and other areas in the winter, returning to the maternal roost in summer. Indirect impacts would include noise, dust and light. A description of these impacts is provided in section 9.4.

9.1.3 Removal of threatened plants

No threatened flora were identified during field surveys, or are considered has having a potential to occur.

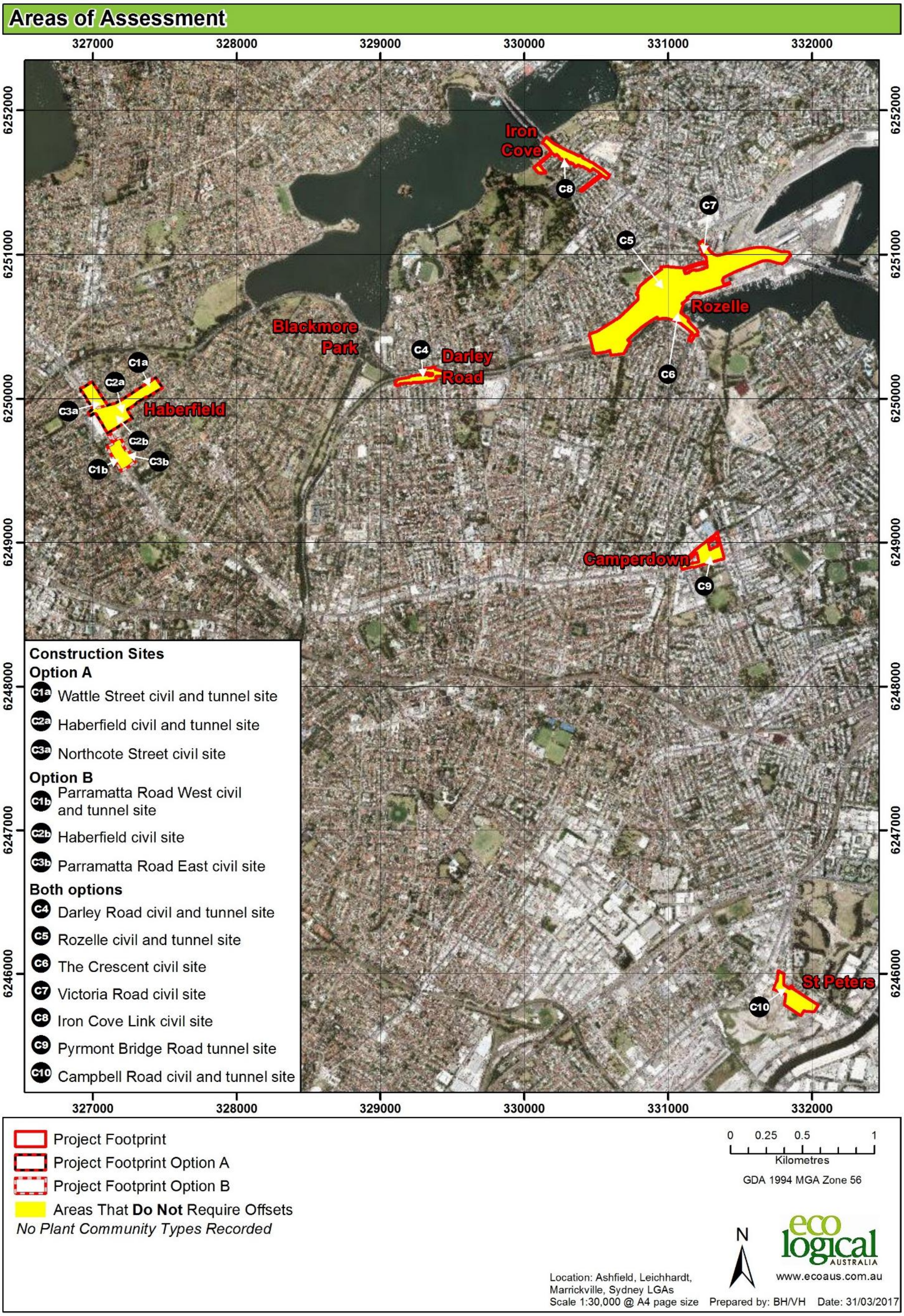

Figure 9.1: Areas not requiring assessment

9.2 Matters for further consideration

No matters for further consideration were provided by OEH or included in the SEARs, and thus no additional matters are required to be assessed.

9.2.1 Landscape features

Landscape features that are matters for further consideration include:

- Impacts that will substantially reduce the width of vegetation in the riparian buffer zone bordering rivers and streams fourth order or greater
- Impacts in state biodiversity links
- Impacts on important wetlands and their buffers
- Impacts in the buffer zone along estuaries.

No matters for further consideration relating to landscape features were present within the study area.

9.2.2 Native vegetation

Native vegetation features that are matters for further consideration include:

- Any impact on a CEEC (unless specifically excluded in the SEARs) because it is likely to:
  - cause the extinction of the CEEC from the IBRA subregion, or
  - significantly reduce the viability of the CEEC
- Any impact on an EEC nominated in the SEARs because it is likely to:
  - cause the extinction of the EEC from the IBRA subregion, or
  - significantly reduce the viability of the EEC.

No matters for further consideration relating to native vegetation were present within the study area.

9.2.3 Species and populations

Species and populations that are matters for further consideration include:

- Impacts on areas of land that the NSW Minister for Environment has declared as critical habitat in accordance with section 46 of the TSC Act and which is listed on the Register of Critical Habitat in NSW
- Any impact on a critically endangered species (unless specifically excluded in the SEARs)
- Any impact on a threatened species or population nominated in the SEARs because it is likely to:
  - cause the extinction of a species or population from an IBRA subregion, or
  - significantly reduce the viability of a species or population
- Any impact on a threatened species or population that has not previously been recorded in the IBRA subregion according to records in the NSW Wildlife Atlas.

No matters for further consideration relating to species and populations were present within the study area.

9.2.4 Critical habitat

No impact of the project on areas of land that the NSW Minister for the Environment has declared ‘critical habitat’ in accordance with section 47 of the TSC Act and that are listed on the Register of Critical Habitat in NSW would occur.

9.3 Matters of national environmental significance

The only MNES that was considered likely to be impacted by the proposed works is the Grey-headed Flying-fox. This species was considered likely to forage on a limited number of feed trees within the project footprint (suitable feed trees within the 4.49 hectares of the mapped urban exotic and native cover) and others adjacent to the site. This species was not recorded during the field surveys. However, known records exist within close proximity to the project footprint. No impacts to a roosting site or camp will occur as a result of the project.

An assessment in accordance with the (Commonwealth of Australia 2013) for this species is provided in Annexure E. This assessment concluded that a significant impact on the Grey-headed Flying-fox is unlikely to occur as a result of the project. The Grey-headed Flying-fox is considered an ecosystem credit species under the FBA in relation to foraging habitat. Therefore, under the FBA and due to the absence of PCTs within the site, this species does not require an offset.

A summary of impacts relating to MNES are provided below in Table 9.1. Specific safeguards and mitigation measures for this species are provided below in Table 10.1 and Chapter 10.

Table 9.1: Summary of impacts relevant to MNES

Impact	MNES	Nature of impact	Scale of impact of proposed action	Intensity of impact of proposed action	Duration	Likely significance of impact	Confidence in assessment
Loss of foraging habitat	Grey-head Flying-fox *(Pteropus poliocephalus)*	Additional	Regional	Minor – the proposed action would remove a total of 4.49 hectares of foraging habitat. However, the loss of foraging habitat is considered negligible in the context of similar available habitat in the locality, and within the foraging range for this species.	Long term	Not significant	High – impacts are predictable.
Future urban growth	All MNES potentially present in Sydney's Inner West	Cumulative and facilitated	Regional	Minor – project increases capacity of existing regional road network and will support economic development across the Sydney region. It does not provide local road infrastructure.	Long term	Not significant	Moderate – impacts are unknown and unpredictable but confined to largely urban environments and the existing road corridor

9.4 Other impacts not covered by the FBA

9.4.1 Aquatic impacts

No impacts on aquatic biodiversity due to water quality are likely to occur as a result of the project. Appendix Q (Technical working paper: Surface water and flooding) of the EIS has concluded that no adverse cumulative surface water quality impacts are anticipated with implementation of appropriate management measures as part of the project and the residual risk to the environment would be low.

The project would not directly harm marine vegetation or habitat of threatened species, communities or populations. The works may require removal of planted riparian vegetation along the edges of the concrete channels for the upgrade of the intersection of The Crescent and City West Link. Following these works, the riparian corridor would be replanted as a continuation of the Sydney Water White's Creek naturalisation works, in consultation with Sydney Water (section 9.6.2).

The upgraded road will shade the aquatic habitat within the concrete channel, 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 appears to have adequate clearance (two to three metres above water), depth (one to two metres) and width (nine metres) to encourage fish movement.

Indirect impacts to aquatic habitat may occur if mitigation measures are not in place and effective during construction. Indirect impacts during construction include turbid water, sediment deposition, and oil and pollutant spills. These impacts can reduce water quality, decrease light penetration through the water column, and smother benthic habitat with sediment. This may alter primary (plant) and secondary (animal) production that supports or regulates the aquatic food web.

Works would temporarily obstruct fish passage if a floating boom and silt curtain is placed near the creek outlet across the bay. This impact would be minimal given the poor creek habitat in Whites Creek and Rozelle Bay intertidal area. Fish passage would be restored during operation.

Upgrade of the Easton Park drain draining the Rozelle Rail Yards would result in the removal of around 27 metres of intertidal rock revetment wall to provide low and high-flow pipe/box culverts. Two large pipe culverts already exist in this location partially below the high tide mark. This intertidal habitat is in poor condition with limited aquatic value. Few oysters or marine molluscs inhabit this area. The adjacent subtidal zone is silty-sand with dense organic debris discharged from Whites Creek. No seagrass or macroalgae is present. As such, this area of Rozelle Bay is classed as Type 3 KFH (minimally sensitive) (from Table 1 in Fairfull 2013). 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 immediate occurrence of marine vegetation that could be affected by changes in salinity due to freshwater discharge. The nearest vegetation is 250 metres east (mangrove/saltmarsh rehabilitation in Bicentennial Park, Glebe), which is unlikely to be unaffected by changes in freshwater discharge due to its distance and mixing with tidal water. Therefore, the proposed works will not result in a net loss of KFH, as required by the Fisheries NSW Policy and guidelines for fish habitat conservation and management (Update 2013).

No direct impacts would occur to Dobroyd Canal (Iron Cove Creek), Hawthorne Canal, Iron Cove estuary, Johnstons Creek and Alexandra Canal as the project footprint either lies outside of the riparian buffer or is on developed land.

Indirect impacts to waterways could occur if adequate controls are not in place, specifically to address sediment runoff during construction, poor water discharged from tunnel dewatering, polluted road runoff during operation, and high velocity runoff/discharge. Uncontrolled runoff or discharge can influence the physico-chemical properties of waterways, such as water temperature, turbidity, pH, salinity and alkalinity. However, the receiving waterways are currently highly disturbed ecosystems, which cannot feasibly be returned to a 'slightly to moderately disturbed' condition (ANZECC, 2000). If the ANZECC (2000) guidelines are followed, the discharge water quality is expected to be typically better than the current water quality of the receiving watercourses.

There would be no net loss of aquatic habitat in the medium to long term. Accordingly, the project could meet the aquatic ecology conservation requirements of the *Sydney Regional Environmental Plan (Sydney Harbour Catchment) 2005* under the EP&A Act.

9.4.2 Groundwater dependent ecosystems

There are no priority GDEs identified within the Greater Metropolitan Water Sharing Plan within five kilometres of the project footprint. Consequently, no GDEs are likely to be impacted by groundwater level decline associated with the long term impacts of the project. Long term dewatering caused by tunnel drainage could lower the water table and potentiometric heads within the Hawkesbury Sandstone, reducing the amount of groundwater available for non-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 and consequently flora is unlikely to be completely dependent on groundwater. This would not change following the construction of the tunnels.

In low lying areas, the low permeability of the clayey soils in combination with frequent rainfall events and higher recharge due to surface water concentration is not expected to change availability of water for plants.

9.4.3 Changes to hydrology

Appendix Q (Technical working paper: Surface water and flooding) of the EIS has concluded that no adverse cumulative surface water quality impacts are anticipated with implementation of appropriate management measures as part of the project and the residual risk to the environment would be low.

Therefore, the project is unlikely to impact on present surface or groundwater hydrology, given the lack of major rivers or streams within the site. Whites Creek is a minor tributary within the southern extent of the Rozelle Rail Yards site, and is a highly modified, consisting of a concrete channel with vertical walls. There is a low potential for impacts to occur on Whites Creek from the project.

9.4.4 Arboriculture impacts

An Arboricultural Impact Assessment report was completed for the project and is included in Annexure G. 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.

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.

A total of about 162 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), and these trees have been recommended for further investigation during detailed design to determine their suitability to be retained.

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

Trees to be retained would be protected in accordance with *Australian Standard (AS) 4970-2009 Protection of trees on development site*s and suitable ground protection measures to protect the tree protection zone.

Trees 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. Management measures have been recommended as per the hierarchy to avoid (retain), minimise (investigate to retain) and mitigate (compensatory planting). 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 is recommended. Replacement trees should be planted within, or close to, the project footprint where feasible.

Compensatory planting should seek to use opportunities presented by the new open space at the Rozelle Rail Yards, including along Lilyfield Road and City West Link and in landscaping at Iron Cove Link in accordance with the Urban Design and Landscaping Plan.

9.4.5 Edge effects on adjacent native vegetation and habitat

No remnant native vegetation occurs within or adjacent to the site. Therefore, edge effects on native vegetation are not considered likely to occur as a result of the project. Habitat for native species includes non-remnant vegetation (such as planted street trees and exotic species), which was recorded adjacent to the site. Edge effects on these areas are likely to occur, but will be limited through the implementation of mitigation measures.

9.4.6 Injury and mortality of fauna

Fauna injury or mortality could occur as a result of the construction and operation of the project.

During the construction of the project, injury or mortality may occur as a result of direct collision with vehicles and equipment within construction compounds. Some mobile species may be able to move away quickly and easily such as some birds. However, other less mobile species, or those which have 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 works at the Rozelle Rail Yards, there is a possibility that the Eastern Bentwing-bat may be injured or stressed due to disturbances associated with noise, dust or light. Direct mortality is also possible during the removal of the Victoria Road bridge, if individuals are roosting in the cavities of the bridge at the time of the construction works. Direct mortality or injury is unlikely to occur to the Grey-headed Flying-fox as result from the works. Individuals are likely to actively avoid the area during works.

Although the project may potentially result in some injury or mortality of fauna species, the project is unlikely to cause a substantial increase in fauna injury or mortality incidents as the majority of the route alignment occurs underground. Where ancillary infrastructure or construction compounds occur, the surrounding land is highly urbanised. Implementation of mitigation measures will reduce the chances or injury or mortality of fauna.

9.4.7 Invasion and spread of weeds

Weeds were common within the study area with some areas supporting weed infestations, particularly the Rozelle Rail Yards. Noxious and environmental weeds recorded within the study area during the survey period are identified in Table 9.2.

Table 9.2: Noxious and environmental weed species recorded in the study area

Scientific Name	Common Name	Class of declared weeds for Inner West LGA	WoNS*
Anredera cordifolia	Madeira Vine	-	Yes
Asparagus asparagoides	Bridal Creeper	5	Yes
Cenchrus echinatus	Spiny Burr Grass	5	-
Cestrum parqui	Green Cestrum	3	-
Cortaderia selloana	Pampas Grass	4	-
Lantana camara	Lantana	4	Yes
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	Yes

* WoNS – Weeds of National Significance
Class 3 – Regionally Controlled Weed; the plant must be fully and continuously suppressed and destroyed and the plant must not be sold, propagated or knowingly distributed.
Class 4 – Locally Controlled Weeds; that pose a threat to primary production, the environment or human health, are widely distributed in an area to which The Noxious Weeds (Weed Control) Order 2014 order applies and are likely to spread in the area or to another area.
Class 5 – The requirements in the *Noxious Weeds Act 1993* (NSW) for a notifiable weed must be complied with.

9.4.8 Invasion and spread of pests

Given the study area is disturbed and within a highly urbanised setting it is highly likely that animal pests would be present within the study area. The following species were recorded during field surveys:

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

The European Red Fox can be found in a range of habitats. They prey on medium-sized ground-dwelling and semi-arboreal mammals and ground-nesting birds. ‘Predation by the European Red Fox *Vulpes vulpes*’ is a KTP listed under both the EPBC Act and the TSC Act. The European Red Fox was recorded within the study area. However, the project is not likely to exacerbate the impacts of the European Red Fox on native fauna, due to its existence within the study area, highly urban context and lack of native fauna present.

The European Rabbit causes a number of environmental problems in the Australian landscape. The rabbit can increase the likelihood of soil erosion by creating numerous burrows, threaten the survival of a number of native animal species by altering habitat, reducing native food sources, displacing small animals from burrows and attracting introduced predators such as foxes. ‘Competition and grazing by the feral European Rabbit (*Oryctolagus cuniculus*)’ is a listed KTP under both the EPBC Act and the TSC Act. The project is unlikely to exacerbate the impacts of the European Rabbit given the existing presence of the species within the study area and the highly degraded condition of the habitats within and adjoining the study area.

Cats can be found in almost all terrestrial environments in Australia. Predation by feral cats is a particular problem affecting small mammals (such as rodents, dasyurids, and burramyids) and ground-nesting birds. ‘Predation by the feral cat (*Felis catus*)’ is a listed KTP under both the EPBC Act and the TSC Act. Feral cats were recorded during the field survey in the Rozelle Rail Yards, however they are also likely to forage throughout other parts of the study area given the surrounding urban development. Given the likely abundance of cats in the locality and study area, the project is unlikely to increase the abundance of cats, introduce them into new areas, or increase predation pressure on native fauna.

9.4.9 Invasion and spread of pathogens and disease

A number of pathogens are of concern in NSW that have the potential to impact on native flora and fauna. Activities that involve movement of equipment over large areas are of particular concern given the high potential for pathogen spread over large areas.

Although no sign of pathogen infection was identified during the field survey or literature search it is important to assess the potential impacts of these pathogens and mitigate against their spread. The main pathogens of concern are:

- Myrtle Rust (*Uredo rangelli*)
- Chytrid Fungus (*Batrachochytrium dendrobatidis*)
- Phytophthora (*Phytophthora cinnamomi*).

Myrtle Rust is an air-borne plant fungus that attacks the young leaves, shoot tips and stems of Myrtaceous plants eventually causing plant death. It is spread by movement of contaminated material such as clothing, infected plants, vehicles and equipment etc. The ‘introduction and establishment of Exotic Rust Fungi of the order Pucciniales pathogenic on plants of the family Myrtaceae’ is a listed KTP under the TSC Act (OEH 2016f).

Chytrid fungus is a water-borne fungus that affects amphibians. It is spread by cross contamination of water bodies and improper handling of frogs. Chytridiomycosis is the infection that causes lethargy, emaciation, skin sloughing and a range of other symptoms that eventually result in death. The infection of frogs by amphibian chytrid fungus causing the disease Chytridiomycosis’ is a listed KTP under both the EPBC Act and the TSC Act (OEH 2016e).

Phytophthora is a soil-borne fungus capable of causing tree death (dieback) by attacking the roots of native plants. Spores can be spread over large areas by water, vehicle and machinery movement as well as human and animal movement. ‘Dieback caused by Phytophthora’ is a listed KTP under both the EPBC Act and the TSC Act (OEH 2016d).

It is unknown if any of these three pathogens are present within the study area. However, considering the highly urban context of the site, it is unlikely that Phytophthora is present and Mrytle rust would be limited to any landscaped or planted Eucalypts. It is possible that the Chytrid fungus could be present at the Rozelle Rail Yards, where non-threatened frogs were recorded.

9.4.10 Noise, light and vibration

The project has the potential to result in indirect impacts on biodiversity caused by noise, vibration, light and dust during construction. This is particularly the case given that construction activities would occur during the day and night and would not be restricted to just daylight hours. Indirect impacts on biodiversity may also result from changes in noise levels or lighting during operation.

The threatened species most at risk from indirect noise, light, dust and vibration is the Eastern Bentwing-bat. The works for the Rozelle interchange would be occurring 24 hours per day during construction and the impacts of noise, dust and vibration are expected to continuously operate during this time. However, it is noted that there would be separation distances from these activities to the Victoria Road bridge where potential roost sites exist, prior to its demolition. Possible impacts may also occur for this species at the new Victoria Road bridge during the operation of the project. These would only occur following construction of the new bridge and any potential new roost sites that may be present.

With the exclusion of the Eastern Bentwing-bat, vibration and light are unlikely to have substantial adverse effects on the diurnal and nocturnal threatened birds and mammals that may occur within the study area from time to time, such as the Grey-headed Flying-fox. These types of indirect impacts are already widespread within the highly urbanised study area, and any exacerbation of these impacts would be limited by the proposed mitigation measures. Furthermore, night construction works would likely deter Grey-headed Flying-fox individuals from foraging within or immediately adjacent to the project footprint. In addition, construction noise and vibration impacts would be temporary. Works are expected to be conducted between 2018 and completed by 2023.

9.4.11 Impact on Key Threatening Processes

A number of KTPs have been identified as being relevant to the project. The activities associated with the project would either contribute to the KTP (known) or may potentially contribute to the KTP (potential). These are listed in Table 9.3.

Table 9.3: Known and potential KTPs and impacts on biodiversity

KTP	Relevance to the project	Potential or known
Infection of native plants by *Phytophthora cinnamomi* (TSC Act) Dieback caused by the root-rot fungus[1] *Phytophthora cinnamomi* (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. With the implementation of appropriate mitigation measures listed in Section 10 the risk of exacerbating this KTP is considered to be low.	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. With the implementation of appropriate mitigation measures listed in Section 10 the risk of exacerbating this KTP is considered to be low.	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. Appropriate mitigation measures would be implemented to limit the spread of weeds and reduce the risk of exacerbating weed infestations to areas adjoining the study area. With the implementation of appropriate mitigation measures listed in Section 10, the risk of exacerbating this KTP is considered to be low.	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. Appropriate mitigation measures will be implemented to limit the spread of weeds and reduce the risk of exacerbating weed infestations within and adjoining the study area as a result of the project. With the implementation of appropriate mitigation measures listed in Section 10 the risk of exacerbating this KTP is considered to be low.	Known
Human-caused climate change (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 can be found in Chapter 22 (Greenhouse gas) of the EIS for the project. The risk of the proposal exacerbating this KTP are considered to be low.	Known

[1] It is now understood that *P. cinnamomi* is not a fungus. This was the name of the KTP when it was registered under the EPBC Act.

9.5 Impact summary

The potential direct and indirect impacts of the proposal on biodiversity are summarised below in accordance with Section 8 of the FBA. Consideration of biodiversity constraints during the design process has enabled the potential impacts of the proposal to be substantially reduced. Notwithstanding the level to which biodiversity impacts have been avoided or minimised, the project would have both direct and indirect impacts on a limited number of biodiversity values during both the construction and operational phases. Impacts are primarily associated with the construction compound infrastructure.

The potential indirect impacts on biodiversity values are considered to be minimal given the highly modified and urbanised condition of the habitats to be affected and the proposed mitigation measures (Chapter 10).

This biodiversity assessment considered both construction and operational impacts to biodiversity and includes:

- Grey-headed Flying-fox foraging habitat
- Eastern Bentwing-bat (foraging and potential roosting habitat)
- Yellow-bellied Sheathtail-bat (foraging habitat).

Impacts of the project on MNES are summarised in Table 9.1 and in sections 9.3 to 9.4. The aim of Table 9.1 is to provide an overview of the impacts and requirements for assessment under the EPBC Act.

A summary of impacts to biodiversity values are provided section 9.5, including impacts required and not required to be assessed under the FBA.

Table 9.4: Summary of impacts

Impact	Biodiversity values	Nature of impact Direct, indirect, consequential, cumulative	Extent of impact Site based, Local, Regional, State, National	Duration Short term/ Long term, pre, during or post construction	Does the project constitute or exacerbate a KTP?
Removal of native vegetation	None	N/A	N/A	N/A	N/A
Removal of threatened ecological communities	None	N/A	N/A	N/A	N/A
Removal of threatened fauna species habitat and habitat features	Grey-headed Flying-fox	Direct	Site based. Removal of up to 4.49 hectares potential foraging habitat	Long term	No
	Eastern Bentwing-bat	Direct and indirect	Site based. Direct impact on potential roost sites and removal of up to 3.78 hectares non-native vegetation (foraging habitat)	Long term	No
	Yellow-bellied Sheathtail-bat	Direct	Site based. Removal of up to 3.78 ha non-native vegetation (foraging habitat)	Long-term	No
Removal of threatened plants	None	N/A	N/A	N/A	N/A
Aquatic impacts	Potential for non-threatened values	Indirect	Local	Long-term	No
Groundwater dependent ecosystems	None	N/A	N/A	N/A	N/A
Changes to hydrology	Potential for non-threatened values	Indirect	Local	Long-term	No
Fragmentation of identified biodiversity links and habitat corridors	None	N/A	N/A	N/A	N/A
Edge effects on adjacent native vegetation and habitat	None – no adjacent native vegetation	N/A	N/A	N/A	N/A
Injury and mortality of fauna	Potential for non-threatened, native	Direct	Site based	Short-term	No

Impact	Biodiversity values	Nature of impact Direct, indirect, consequential, cumulative	Extent of impact Site based, Local, Regional, State, National	Duration Short term/ Long term, pre, during or post construction	Does the project constitute or exacerbate a KTP?
	species to be present				
Invasion and spread of weeds	None	Indirect	Site based	Short-term	· Invasion, establishment and spread of *Lantana camara* · Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants
Invasion and spread of pests	None	Indirect	Site based	Short-term	· Competition and grazing by the feral European rabbit (Oryctolagus cuniculus) · Predation and hybridisation of feral dogs (*Canis lupus familiaris*) · Predation by the European red fox (*Vulpes vulpes*) · Predation by the feral cat (*Felis catus*) · Predation by Plague Minnow or Mosquito Fish *(Gambusia holbrooki*)
Invasion and spread of pathogens and disease	None	Indirect	Site based	Short-term	· Infection of native plants by *Phytophthora cinnamomi* · Introduction and establishment of Exotic Rust Fungi of the order Pucciniales pathogenic on plants of the family Myrtaceae
Noise, light and vibration	Grey-headed Flying-fox and Eastern Bentwing-bat	Indirect	Site based	During construction	No

9.6 Cumulative impacts

Cumulative impacts have been summarised below for the WestConnex projects and other known or potential projects in the area.

Mitigation measures for biodiversity values impacted by the M4-M5 Link project (Grey-headed Flying-fox, Eastern Bentwing-bat and Yellow-bellied Sheathtail-bat) are also part of other projects mitigation measures. Where possible, these mitigation measures are consistent across the WestConnex projects.

These measures are detailed in the project reports and form a condition of approval, including but not limited to:

- Unexpected finds procedure
- Bat management procedures (when required)
- Replacement tree planting
- Tree removal procedure

9.6.1 Other WestConnex projects

M4 East

The M4 East project involves upgrade and extension of the M4 Motorway from Homebush Bay Drive at Homebush to Parramatta Road and City West Link (Wattle Street) at Haberfield. This includes twin tunnels about 5.5 kilometres long and associated surface works to connect to the existing road network.

The biodiversity assessment undertaken for M4 East involved a desktop assessment and detailed field investigations. No remnant native or threatened ecological communities were recorded. The assessment determined that a formal biodiversity offset was not necessary to compensate for the minor and localised residual impacts from the project. Furthermore, significant impacts to threatened ecological communities, or threatened flora or fauna would not result from the project.

However, approximately 15.7 hectares of exotic and planted vegetation equivalent to the mapped 'urban exotic and native cover' would be impacted, and represents a minor impact to potential foraging habitat for the Grey-headed Flying-fox, Eastern Bentwing-bat and Yellow-bellied Sheathtail-bat. The assessment is summarised at Section 4.4.1 of this BAR.

The M4-M5 Link project overlaps with the M4 East project at Haberfield, with the M4-M5 Link project utilising existing civil and tunnel sites. The M4-M5 Link would therefore not impact any of the previously identified biodiversity values assessed and managed as part of the M4 East project under Option A. However, under Option B, a few additional Grey-headed Flying-fox trees will be impacted.

Management measures proposed by M4-M5 Link for Biodiversity values are consistent with those adopted for the M4 East project.

The M4-M5 Link would remove up to 4.49 hectares of foraging habitat for the Grey-headed Flying-fox and up to 3.78 hectares of foraging habitat for the Eastern Bentwing-bat in the form of planted native or exotic vegetation, contributing to a minor cumulative impact to these species.

M4 Widening

The project involved widening the existing M4 Motorway from three to four lanes in each direction for approximately 7.5 kilometres between Pitt Street, Parramatta and Homebush Bay Drive, Homebush. The biodiversity assessment for the project formed part of an EIS and included desktop and detailed field investigations.

The assessment for the M4 Widening concluded up to 0.54 hectares of remnant native vegetation, representing threatened ecological communities listed under the TSC Act may be impacted as a result of the works. These vegetation communities occur as highly disturbed remnants in an urban landscape and included:

- Up to 0.08 hectares of Swamp Oak Floodplain Forest
- Up to 0.38 hectares of Freshwater Wetland
- Up to 0.08 hectares of Shale-Gravel Transition Forest

No cumulative impacts to these vegetation communities will occur as a result of the M4-M5 Link project.

Impacts from the M4 Widening may also occur to the following native biodiversity values:

- Four different threatened flora; *Hypsela sessiflora, Marsdenia viridiflora* subsp. *viridiflora* (endangered population), *Wahlenbergia multicaulis* and *Wilsonia backhousei*.
- Up to 8.84 hectares of potential non-native foraging habitat (mapped equivalent as urban exotic and native cover) for the long-nosed bandicoot (endangered population) woodland birds and microbats, including but not limited to the Swift Parrot, Little Lorikeet, Grey-headed Flying-fox, Eastern Bentwing-bat and Yellow-bellied Sheathtail-bat

No cumulative impacts to the threatened flora or woodland birds will occur as a result of the M4-M5 Link project. However, the M4-M5 Link would remove up to 4.49 hectares of foraging habitat (suitable feed trees) for the Grey-headed Flying-fox and up to 3.78 hectares of foraging habitat for the Eastern Bentwing-bat and Yellow-bellied Sheathtail-bat in the form of planted native or exotic vegetation, contributing to a minor cumulative impact to these species.

New M5

The New M5 project involves construction and operation of a new, tolled multi-lane road link between the existing M5 East Motorway, east of King Georges Road, and St Peters. The project also includes an interchange at St Peters and connections to the existing road network. Part of the New M5 overlaps with the construction area at the St Peters site for the project.

The New M5 project was assessed as a Major Project using the FBA methodology, which differed from the assessment methodology for the M4 East. The assessment is summarised at Section 4.4.1 of this BAR.

The New M5 would result in 3.31 hectares of direct impacts on native vegetation. Accordingly, the project BAR assessed the type and number of credits using the FBA methodology. These calculations identified the following offset requirements for the project:

- A total of 58 ecosystem credits consisting of 31 Broad-leaved Ironbark - Melaleuca decora shrubby open forest on clay soils of the Cumberland Plain, Sydney Basin Bioregion (PCT 725) credits and 27 Paperbark swamp forest of the coastal lowlands of the NSW North Coast Bioregion and Sydney Basin Bioregion (PCT 1046) credits
- A total of 203 credits for Green and Golden Bell Frog habitat.

No cumulative impacts to these biodiversity values will occur as a result of the M4-M5 Link project. In addition to the above impacts, 10.80 hectares of planted exotic and native vegetation would be impacted, which may represent potential foraging habitat for the Grey-headed Flying-fox.

The M4-M5 Link project overlaps with the New M5 project at St Peters only (St Peters Interchange), with the M4-M5 Link project utilising existing civil and tunnel sites, and building a new ventilation outlet within the existing footprint. None of the areas identified in the New M5 Project as having potential biodiversity values are within the M4-M5 Link project footprint and would therefore not be impacted by this project.

Management measures proposed by M4-M5 Link for biodiversity values are consistent with those adopted for the New M5 project. The M4-M5 Link would remove a small amount of foraging habitat (suitable feed trees; up to 4.49 hectares) for the Grey-headed Flying-fox in the form of planted native or exotic vegetation, contributing to a minor cumulative impact to this species. The Eastern Bentwing-bat and Yellow-bellied Sheathtail-bat were not identified as being impacted by the New M5 project.

King Georges Road Interchange Upgrade

The King Georges Road Interchange Upgrade involves construction works to increase capacity on the King Georges Road on and off ramps to the M5 Motorway. The biodiversity assessment for the project formed part of an EIS and included desktop and detailed field investigations.

The assessment concluded that impacts to native biodiversity values may occur and include:

- Up to 0.01 hectares of remnant Cooks River/Castlereagh Ironbark Forest, an ECC under the TSC Act and CEEC under the EPBC Act.
- Up to nine *Acacia pubescens* (Downy Wattle), listed as Vulnerable under the TSC and EPBC Acts.
- Up to 3.23 hectares of potential non-native foraging habitat (mapped equivalent as urban exotic and native cover) for woodland birds and microbats, including but not limited to the Swift Parrot, Little Lorikeet, Grey-headed Flying-fox, Eastern Bentwing-bat and Yellow-bellied Sheathtail-bat.

No cumulative impacts to Cooks River/Castlereagh Ironbark Forest, Acacia pubescens or woodland birds will occur as a result of the M4-M5 Link project. However, the M4-M5 Link would remove up to 4.49 hectares of foraging habitat (suitable feed trees) for the Grey-headed Flying-fox and up to 3.78 hectares of foraging habitat for the Eastern Bentwing-bat and Yellow-bellied Sheathtail-bat in the form of planted native or exotic vegetation, contributing to a minor cumulative impact to these species.

9.6.2 Other projects

Rozelle Rail Yards site management works

The Rozelle Rail Yards site management works involves the remove rail and rail related infrastructure within the Rozelle Rail Yards site, as well as vegetation, buildings and stockpiles. The biodiversity assessment for the Rozelle Rail Yards site management works involved a desktop assessment and detailed field investigations. The assessment is summarised at Section 4.1.1 of this BAR.

No threatened flora species or listed ecological communities were identified, or are considered as having potential to occur within the site. However, the Eastern Bentwing-bat and Yellow-bellied Sheathtail-bat were recorded within the site and several Grey-headed Flying-fox were observed feeding immediately adjacent to the site. Assessments of Significance under the TSC and EPBC Act were completed as part of the biodiversity assessment and concluded that a significant impact to values under the TSC and EPBC Acts is not likely to occur.

Subject to planning approval, the M4-M5 Link project would be constructed after the site management works are completed within the Rozelle Rail Yards. This area would serve as a construction site for the Rozelle civil and tunnel site and as an operational ventilation facility. The M4-M5 Link would therefore not impact any of the previously identified biodiversity values assessed and managed as part of the Rozelle Rail Yards site management works.

The M4-M5 Link would remove up to 4.49 hectares of foraging habitat (suitable feed trees) for the Grey-headed Flying-fox and up to 3.78 hectares of foraging habitat for the Eastern Bentwing-bat and Yellow-bellied Sheathtail-bat in the form of planted native or exotic vegetation, contributing to a minor cumulative impact to these species.

CBD and South East Light Rail Project – Rozelle maintenance depot

The CBD and South East Light Rail EIS (Transport for NSW 2013) indicated that the project is likely to have significant benefits for transport and access within and from/to the inner west of Sydney, as well as wider social, economic and environmental benefits. The Rozelle maintenance depot occurs along Lilyfield Road, and is approximately 370 metres long and 120 metres wide. It is a former goods yard with some residential and commercial premises nearby. The key environmental impacts from the Rozelle maintenance depot include, construction impacts, land use and transport integration, operational noise and vibration, historic heritage, ecology and design, sustainability and amenity.

Whites Creek naturalisation

Sydney Water are currently investigating options to rehabilitate an approximately 420 metre section of concrete channel in Whites Creek. This project is currently at a concept design phase, with limited information available. An environmental assessment for the naturalisation works are yet to be completed. The relevant section occurs approximately 200 metres from the outlet at Rozelle Bay in Annandale, to the west of Brenan Street. The project is looking at sections that need to be repaired, and whether this can be achieved through naturalisation, by replacing the concrete banks with ones made of native plants and rocks.

The Whites Creek naturalisation may require some tree removal for the works, which will occur in close proximity to the M4-M5 Link project footprint. However, in the long-term, the naturalisation is likely to provide a riparian corridor consisting of planted native species.

The M4-M5 Link project will extend the Whites Creek naturalisation in consultation with Sydney Water through a complementary planting regime along a section of the riparian corridor between Rozelle Bay and the light rail. The landscape plantings will occur following the widening and improvement works to the channel and bank of Whites Creek at Annandale, to manage flooding and drainage for the surface road network.

Other metropolitan roads projects

Roads and Maritime is currently investigating a number of motorway options in the Sydney metropolitan area, including the Western Harbour Tunnel crossing Sydney Harbour, a connection to the Northern Beaches and the F6 Extension to the Illawarra. These potential projects are in the very early phases of planning. If they were to progress beyond the scoping or business case, they would be subject to environmental impact assessments. These projects would be likely to have some biodiversity impact. However, the nature, extent and intensity of these impacts cannot be predicted at this early stage. There is insufficient information currently available to make any informed assessment about the potential impacts of any of these potential projects.

9.6.3 Summary of Cumulative impacts

The impacts of the WestConnex program of works have been assessed and consistent management measures have been identified. A summary of the cumulative impacts are provided in Table 9.5. In total, approximately 3.86 hectares of native vegetation would be impacted by WestConnex, which is not significant in the context of existing native vegetation across the Sydney Basin. A further 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 (total 53.49 hectares). Of this, up to 38.67 hectares has been identified as potential foraging habitat for the Eastern Bentwing-bat and Yellow-bellied Sheathtail-bat. 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.

The cumulative impacts to Grey-headed Flying-fox and the threatened microbats will not result in a significant impact. No camps or breeding sites will be impacted and the removal of potential feed trees and foraging habitat is negligible in the context of existing available foraging habitat for these species.

Table 9.5: 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*
WestConnex Subtotal	***3.86***	***43.06***	***Up to 46.37***	***Up to 31.55***
Rozelle Rail Yards site management works	-	7.12^	7.12^	7.12^
Total	**3.86**	**50.18**	***Up to* 53.49**	**Up to 38.67**

* Habitat for the microbats was only considered to be present within the vicinity of the Rozelle Rail Yards and not across the whole project.
^ This area was not present in the Rozelle Rail Yards site management works REF.

10 Mitigation

Mitigation measures aim to avoid and minimise direct and indirect impacts of the project. The relevant ecological impacts and associated mitigation measures and protocols (standard and project specific) are identified in Table 10.1. It is anticipated that the standard control measures (ie inductions etc.) would be incorporated in a Construction Flora and Fauna Management Plan, which would be prepared as part of the Construction Environmental Management Plan.

Environmental management measures relating to biodiversity during construction and operation are provided in Table 10.1. All measures would be consistent with the Roads and Maritime *Biodiversity Guidelines – Protecting and Managing Biodiversity on Roads and Maritime Projects* (the Biodiversity Guidelines) (Roads and Traffic Authority 2011) Additional mitigation and management measures relevant to biodiversity are also described in the following sections of the EIS:

- Noise and vibration management measures in Chapter 10 of the EIS (Noise and vibration) to minimise fauna impacts including microbats
- Lighting management measures in Chapter 13 of the EIS (Urban design and visual amenity) to minimise fauna impacts including microbats
- Erosion and sediment control management measures in Chapter 15 of the EIS (Soil and water quality) to minimise the spread of weeds and to minimise impacts to aquatic habitat in particular at Whites Creek and Rozelle Bay
- Flooding and drainage management measures in Chapter 17 of the EIS (Flooding and drainage) to minimise impacts to aquatic habitat in particular at Whites Creek.

Table 10.1 Impacts and mitigation measures

Impact	No.	Environmental Management Measure	Timing
Impact to 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 NSW) 2013) - Tree assessment and management protocols consistent with *AS 4970-2009 Protection of trees on development sites* - Weed management protocols.	Construction
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 CFFMP will include management measures outlined in the Biodiversity Assessment Report (BAR) 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, 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 CSSI as soon as possible following the disturbance to prevent erosion and to minimise sedimentation in adjacent aquatic environments.	Construction

Impact	No.	Environmental Management Measure	Timing
Loss of trees	B5	The CFFMP will include measures to manage potential impacts to 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
	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
Loss of trees	B9	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 construction footprint.	Operation
Loss of aquatic habitat	B10	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 project* (RTA 2011).	Operation

11 Offsetting required

Although avoidance and mitigation measures have been considered and will be implemented during the design of the project, impacts on biodiversity, may occur in association with the project. In accordance with the FBA and the Guideline for Biodiversity Offsets (Roads and Maritime 2011), these impacts must be offset.

In accordance with the FBA, this chapter identifies areas not requiring assessment, areas not requiring offset, identification of any ecosystem or species credits requiring offset and identification of matters requiring further consideration, such as potential aquatic or landscape offsets.

11.1 Areas not requiring assessment offsets

Areas not requiring assessment or offset were:

- Cleared areas – associated with tracks, roads, buildings, and other infrastructure
- Areas dominated by exotics - classified in this assessment as urban native and exotic vegetation.

11.2 Ecosystems requiring offsets

No ecosystem offsets are required.

11.3 Species requiring offsets

No species offsets are required.

11.4 Aquatic biodiversity offsets

This section refers to aquatic habitats that are not considered under the FBA. No saline wetland vegetation or protected marine vegetation would be impacted by the project.

All other non-saline wetlands and riparian vegetation are assessed under the FBA. Loss of riparian vegetation applies to any associated PCT. Loss of freshwater aquatic habitat is not calculated in the FBA or the Fisheries Policy and Guidelines, but is assessed on a case-by-case basis for major projects when impacting KFH. As there were no aquatic biodiversity values impacted by the project, and 'no net loss' of KFH, there is no requirement to provide compensatory habitat.

11.5 Compensatory planting recommendations

Opportunities to retain high retention value trees should be explored where practical during detailed design and tree sensitive construction techniques should be considered. Compensatory planting is recommended for trees that cannot be retained as a result of the works. Replacement trees should be planted within, or in close proximity to the project footprint.

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Annexure A – Habitat assessment table

An assessment of likelihood of occurrence was made for threatened ecological communities and species identified from the desktop review. This was based on database records, habitat features of the site, results of the field surveys and professional judgement. Some Migratory or Marine species from the Commonwealth database search have been excluded from the assessment, due to lack of habitat. The terms for likelihood of occurrence are defined in Table A.1.

Table A.1: Likelihood of occurrence criteria

Likelihood	Criteria
Recorded	The species was observed in the study area during the current survey.
High	It is highly likely that a species inhabits the study area and is dependent on identified suitable habitat (ie. for breeding or important life cycle periods such as winter flowering resources), has been recorded recently in the locality and is known or likely to maintain resident populations in the study area. Also includes species known or likely to visit the study area during regular seasonal movements or migration.
Moderate	Potential habitat is present in the study area. Species unlikely to maintain sedentary populations, however may seasonally use resources within the study area opportunistically or during migration. The species is unlikely to be dependent (ie. for breeding or important life cycle periods such as winter flowering resources) on habitat within the study area, or habitat is in a modified or degraded state. Includes cryptic flowering flora species that were not seasonally targeted by surveys and that have not been recorded.
Low	It is unlikely that the species inhabits the study area and has not been recorded recently in the locality. It may be an occasional visitor, but habitat similar to the study area is widely distributed in the local area, meaning that the species is not dependent (ie. for breeding or important life cycle periods such as winter flowering resources) on available habitat. Specific habitat is not present in the study area or the species are a non-cryptic perennial flora species that were specifically targeted by surveys and not recorded.
None	Suitable habitat is absent from the study area.

Note; assessments of occurrence were made both prior to field survey and following field survey. The pre-survey assessments were performed to determine which species were “affected species”, and hence determine which sorts of habitat to look for during field survey. The post-survey assessments to determine “final affected species” were made after observing the available habitat in the study area and are depicted in the table below.

It is noted that some threatened fauna that are highly mobile, wide ranging and vagrant may use portions of the study area intermittently for foraging. For these species, potential habitat impacted is not considered important for the long-term survival of a local occurrence of the species, particularly in relation to similar habitat remaining in the locality.

The records column refers to the number of records occurring within 5 km of the site (locality), as provided by the NSW Wildlife Atlas (BioNet) database search (OEH 2016a). Information provided for the habitat associations has primarily been extracted (and modified) from the Commonwealth Species Profile and Threats Database (DotEE 2016a), the NSW Threatened Species Profiles (OEH. 2016b) and NSW Department of Primary Industries (DPI 2016).

Key to the tables below:

- CE = Critically Endangered
- E = Endangered (EPBC Act, TSC Act and FM Act)
- EP = Endangered Population (TSC Act and FM Act)
- V = Vulnerable
- Mi = Migratory (EPBC Act)
- P = Protected (FM Act)

Table A.2: Threatened ecological communities – habitat assessment table

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat Associations	Likelihood of occurrence
Blue Gum High Forest	CE	Ce	A moist, tall open forest community, with dominant canopy trees of *Eucalyptus saligna* (Sydney Blue Gum) and *Eucalyptus pilularis* (Blackbutt). *Allocasuarina torulosa* (Forest Oak) and *Angophora costata* (Sydney Red Gum) also occur. Species adapted to moist habitat such as *Acmena smithii* (Lilly Pilly), *Ficus coronata* (Sandpaper Fig), *Calochlaena dubia* (Soft Bracken) and *Adiantum aethiopicum* (Maiden Hair) may also occur. Originally restricted to the ridgelines in Sydney's north from Crow's Nest to Hornsby, and extending west along the ridges between Castle Hill and Eastwood. Occurs only in areas where rainfall is high (above 1100 millimetres per year) and the soils are relatively fertile and derived from Wianamatta shale. In lower rainfall areas, it grades into Sydney Turpentine-Ironbark Forest.	None
Castlereagh Scribbly Gum and Agnes Banks Woodlands	V	E	Castlereagh Scribbly Gum Woodland in the Sydney Basin Bioregion mainly occurs within the local government areas of Bankstown, Blacktown, Campbelltown, Hawkesbury, Liverpool and Penrith. It is almost exclusively found on soils derived from Tertiary alluvium, or on sites located on adjoining shale or Holocene alluvium. It is dominated by *Eucalyptus parramattensis*, *Angophora bakeri* and *Eucalyptus sclerophylla*. A small tree stratum of *Melaleuca decora* is sometimes present, generally in areas with poorer drainage. It has a well-developed shrub stratum consisting of sclerophyllous and the ground stratum consists of a diverse range of forbs.	None
Castlereagh Swamp Woodland	E	-	Occurs in western Sydney in the Castlereagh and Holsworthy areas, on deposits from ancient river systems along todays intermittent creek lines, often in poorly drained depressions. A low woodland, often having dense stands of *Melaleuca decora* along with other canopy trees, such as *Eucalyptus parramattensis*. The shrub layer is not well developed and is mostly made up of young paperbark trees. The ground layer has a diversity of plants that tolerate waterlogged conditions, such as *Centella asiatica, Juncus usitatus* and *Goodenia paniculata*.	None
Coastal Upland Swamps	E	E	Coastal Upland Swamps includes open heath, sedge land and tall scrub associated with periodically waterlogged soils on the Hawkesbury sandstone plateau. The Coastal Upland Swamp is endemic to NSW and confined to the Sydney Basin Bioregion. It occurs in the eastern Sydney Basin from the Somersby district in the north to the Robertson district in the south. In the north it occurs on the Somersby-Hornsby plateau, in the south it occurs on the Worora plateau. It occurs in elevations from 20 m to over 600 m above sea level, with the majority of swamps occurring within 200 m and 450 m elevation. Coastal Upland Swamps occur primarily on impermeable sandstone plateau with shallow groundwater aquifers in the headwaters and impeded drainage lines of streams, and on sandstone benches with abundant seepage moisture.	None
Cooks River/Castlereagh Ironbark Forest	E	CE	Occurs in western Sydney, with the most extensive stands occurring in the Castlereagh and Holsworthy areas. Ranges from open forest to low woodland, with a canopy dominated by *Eucalyptus fibrosa* and *Melaleuca decora*. The canopy may also include other eucalypts such as *Eucalyptus longifolia*. The dense shrubby understorey consists of *Melaleuca nodosa* and *Lissanthe strigosa*, with a range of 'pea' flower shrubs, such as *Dillwynia tenuifolia*, *Pultenaea villosa* and *Daviesia ulicifolia* can be locally abundant. The sparse ground layer contains a range of grasses and herbs.	None

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat Associations	Likelihood of occurrence
Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest	CE	CE	Occurs on soils derived from Wianamatta Shale, and throughout the driest part of the Sydney Basin. Good examples can be seen at Scheyville National Park and Mulgoa Nature Reserve. The dominant canopy trees of Cumberland Plain Woodland are *Eucalyptus moluccana* (Grey Box) and *Eucalyptus tereticornis* (Forest Red Gum), with *Eucalyptus crebra* (Narrow-leaved Ironbark), *Corymbia maculata* (Spotted Gum) and *Eucalyptus eugenioides* (Thin-leaved Stringybark) occurring less frequently. The shrub layer is dominated by *Bursaria spinosa* (Blackthorn), and it is common to find abundant grasses such as *Themeda australis* (Kangaroo Grass) and *Microlaena stipoides* var. *stipoides* (Weeping Meadow Grass).	None
Eastern Suburbs Banksia Scrub	E	E	Once occupied around 5,300 hectares of land between North Head and Botany Bay in Sydney's eastern suburbs. Surviving stands total approximately 146 hectares have been recorded from the LGAs of Botany, Randwick, Waverley, and Manly. Predominantly a sclerophyllous heath or scrub community although, depending on site topography and hydrology, some remnants contain small patches of woodland, low forest or limited wetter areas. Common species include *Banksia aemula*, *Banksia ericifolia*, *Banksia serrata*, *Eriostemon australasius*, *Lepidosperma laterale*, *Leptospermum laevigatum*, *Monotoca elliptica* and *Xanthorrhoea resinifera*.	None
Freshwater Wetlands on Coastal Floodplains	E	-	Known from along the majority of the NSW coast. It is associated with coastal areas subject to periodic flooding and where standing freshwater persists for at least part of the year in most years. Typically occurs on silts, muds or humic loams in low-lying parts of floodplains, alluvial flats, depressions, drainage lines, back swamps, lagoons and lakes, but may also occur in back barrier landforms where floodplains adjoin coastal sandplains. They are dominated by herbaceous plants with very few woody species. The structure and composition varies both spatially and temporally depending on the water regime. Those that lack standing water most of the time are usually dominated by dense grassland or sedge land vegetation, such as *Paspalum distichum, Leersia hexandra, Pseudoraphis spinescens* and *Carex appressa*.	None
Freshwater Wetlands of the Sydney Basin Bioregion	E	-	Occurs on sand dunes and low-nutrient sandplains along coastal areas in the Sydney Basin bioregion. It is known from the Lake Macquarie, Wyong, Gosford, Pittwater, Warringah, Woollahra, Waverley, Botany, Rockdale, Randwick, Sutherland and Wollongong local government areas, but is likely to occur elsewhere within the bioregion. Characteristic species include sedges and aquatic plants such as *Baumea* species, *Eleocharis sphacelata, Gahnia species, Ludwigia peploides* subsp. *montevidensis* and *Persicaria* species.	None
River-Flat Eucalypt Forests (previously known as Alluvial Woodland)	E	-	Occurs on the river flats of the coastal floodplains. It has a tall open tree layer of eucalypts, but can be considerably shorter in regrowth stands or lower site quality. The typical dominant trees include *Eucalyptus tereticornis* (Forest red gum), *Eucalyptus amplifolia* (Cabbage gum), *Angophora floribunda* (Rough-barked Apple) and *Angophora subvelutina* (Broad-leaved Apple). A layer of small trees may be present, including *Melaleuca decora, Melaleuca styphelioides* (Prickly-leaved Teatree), *Backhousia myrtifolia* (Grey Myrtle), *Melia azedarach* (White Cedar), *Casuarina cunninghamiana* (River Oak) and *Casuarina glauca* (Swamp Oak). Scattered shrubs include *Bursaria spinosa, Solanum prinophyllum, Rubus parvifolius, Breynia oblongifolia, Ozothamnus diosmifolius, Hymenanthera dentata, Acacia floribunda* and *Phyllanthus gunnii*. The groundcover is composed of abundant forbs, scramblers and grasses including *Microlaena stipoides, Dichondra repens, Glycine clandestina, Oplismenus aemulus, Desmodium gunnii, Pratia purpurascens, Entolasia marginata, Oxalis perennans* and *Veronica plebeia*. The composition and structure of the understorey is influenced by grazing and fire history, changes to hydrology and soil salinity and other disturbances, and may be dominated by exotic shrubs, grasses, vines and forbs.	None

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat Associations	Likelihood of occurrence
Shale Sandstone Transition Forest	CE	CE	Occurs at the edges of the Cumberland Plain, where clay soils from the shale rock intergrade with soils from sandstone, or where shale caps overlay sandstone. The main tree species include *Eucalyptus tereticornis* (Forest Red Gum), *Eucalyptus punctata* (Grey Gum), *Eucalyptus globoidea, Eucalyptus eugenioides* (Thin-leaved Stringybark) and *Eucalyptus fibrosa* (Broad-leaved Ironbark) and *Eucalyptus crebra* (Narrow-leaved Ironbark). Areas of low sandstone influence have an understorey that is closer to Cumberland Plain Woodland. High sandstone influence have poor rocky soils.	None
Subtropical and Temperate Coastal Saltmarsh	E	V	Found on the river flats of the coastal floodplains. Associated with silts, clay-loams and sandy loams, on periodically inundated alluvial flats, drainage lines and river terraces associated with coastal floodplains. The structure of the community may vary from tall open forests (>40 m) to woodlands. The most widespread and abundant dominant trees include *Eucalyptus tereticornis* (Forest Red Gum), *Eucalyptus amplifolia* (Cabbage Gum), *Angophora floribunda* (Rough-barked Apple) and *Angophora subvelutina* (Broad-leaved Apple).	None
Swamp Oak Floodplain Forest	E	-	It is known from a number of LGA's in Sydney and along the coast of NSW occurring on coastal floodplains. It has a dense to sparse tree layer in which *Casuarina glauca* (Swamp Oak) is the dominant species. Other trees including *Acmena smithii* (Lilly Pilly), *Glochidion* spp. (Cheese Tree) and *Melaleuca* spp. (Paperbarks) may be present as subordinate species. The understorey is characterised by frequent occurrences of vines, a sparse cover of shrubs, and a continuous groundcover of forbs, sedges, grasses and leaf litter.	None
Swamp Sclerophyll Forest	E	-	It is known from a number of LGAs in Sydney and along the coast of NSW. It has an open to dense tree layer of eucalypts and paperbarks although some remnants now only have scattered trees as a result of partial clearing. The most widespread and abundant dominant trees include *Eucalyptus robusta* (Swamp Mahogany), *Melaleuca quinquenervia* (Paperbark) and, south from Sydney*, Eucalyptus botryoides* (Bangalay) and *Eucalyptus longifolia* (Woollybutt). A layer of small trees may also be present. Shrubs include *Acacia longifolia, Dodonaea triquetra, Ficus coronata, Leptospermum polygalifolium* subsp. *polygalifolium* and *Melaleuca* spp. The groundcover is composed of abundant sedges, ferns, forbs, and grasses.	None
Turpentine-Ironbark Forest	E	CE	Open forest, with dominant canopy trees including *Syncarpia glomulifera* (Turpentine), *Eucalyptus punctata* (Grey Gum), *Eucalyptus paniculata* (Grey Ironbark) and *Eucalyptus eugenioides* (Thin-leaved Stringybark). In areas of high rainfall *Eucalyptus saligna* (Sydney Blue Gum) is more dominant. The shrub stratum is usually sparse and may contain mesic species such as *Pittosporum undulatum* (Sweet Pittosporum) and *Polyscias sambucifolia* (Elderberry). Occurs close to the Shale/Sandstone boundary on the more fertile shale influenced soils, in higher rainfall areas on the higher altitude margins of the Cumberland Plain, and on the shale ridge caps of sandstone plateaux.	None
Upland Basalt Eucalypt Forests	-	E	The Upland Basalt Eucalypt Forests of the Sydney Basin Bioregion is typically tall open eucalypt forests found on basalt and basalt-like substrates in, or adjacent to, the Sydney Basin Bioregion. The ecological community usually occurs at elevations between 650 m and 1050 m above sea level although outliers may occur at elevations as low as 350 m (eg closer to the coast) or as high as 1200 m (eg on higher plateau). The ecological community occurs in areas of high rainfall, generally ranging from 1000 to 1800 mm/year.	None
Western Sydney Dry Rainforest and Moist Woodland on Shale	E	CE	This community represents certain occurrences of dry rainforest and moist woodland generally found on shale soil in the Cumberland Plain Sub-region of the Sydney Basin Bioregion. It occurs generally in gullies, sheltered slopes and rugged terrain in isolated patches, largely on the edges of the Cumberland Plain in NSW, with some patches on undulating terrain in the central parts of the Cumberland Plain.	None

Table A.3: Threatened flora – habitat assessment table

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat requirements	Number of records	Likelihood of occurrence	Ecosystem or species credit?
FLORA						
Bynoe's Wattle *(Acacia bynoeana)*	E	V	*Acacia bynoeana* is found in central eastern NSW, from the Hunter District (Morisset) south to the Southern Highlands and west to the Blue Mountains, and has recently been found in the Colymea and Parma Creek areas west of Nowra. It is found in heath and dry sclerophyll forest, typically on a sand or sandy clay substrate, often with ironstone gravels.	2	None – suitable habitat not present	Species
(Acacia gordonii)	E	E	*Acacia gordonii* is restricted to the north-west of Sydney, occurring in the lower Blue Mountains in the west, and in the Maroota/Glenorie area in the east, within the Hawkesbury, Blue Mountains and Baulkham Hills LGAs. Grows in dry sclerophyll forest and heathlands amongst or within rock platforms on sandstone outcrops.	1	None – suitable habitat not present	Species
Downy Wattle *(Acacia pubescens)*	V	V	It occurs mainly around the Bankstown-Fairfield-Rookwood area and the Pitt Town area, with outliers occurring at Barden Ridge, Oakdale and Mountain Lagoon. Occurs on alluviums, shales and at the intergrade between shales and sandstones. The soils are characteristically gravely soils, often with ironstone. Grows in open woodland and forest, in a variety of plant communities, including Cooks River-Castlereagh Ironbark forest, Shale-Gravel Transition Forest and Cumberland Plain woodland.	-	None – suitable habitat not present. No records in locality	Species
Sunshine Wattle *(Acacia terminalis* subsp. *terminalis)*	E	E	This species has a very limited distribution, mainly in near-coastal areas from the northern shores of Sydney Harbour south to Botany Bay, with most records from the Port Jackson area and the eastern suburbs of Sydney. It occurs in coastal scrub and dry sclerophyll woodland on sandy soils.	11	None – suitable habitat not present	Species
(Allocasuarina glareicola)	E	E	*Allocasuarina glareicola* is primarily restricted to the Richmond district on the north-west Cumberland Plain, with an outlier population found at Voyager Point. It grows in Castlereagh woodland on lateritic soil.	-	None – suitable habitat not present. No records in locality	Species
Nielsen Park She-oak *(Allocasuarina portuensis)*	E	E	*Allocasuarina portuensis* was originally recorded at Nielson Park in the Woollahra LGA. None of the original individuals are left within the area it was discovered and the species presently only persists from propagation material. This species once grew in tall closed woodlands on shallow sandy siliceous, coarsely textured soils.	-	None – suitable habitat not present. No records in locality	Species
(Asterolasia elegans)	E	E	It is restricted to a few localities on the NSW Central Coast north of Sydney, in the Baulkham Hills, Hawkesbury and Hornsby LGAs. It is found in sheltered forests on mid- to lower slopes and valleys, in or adjacent to gullies.	-	None – suitable habitat not present. No records in locality	Species

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat requirements	Number of records	Likelihood of occurrence	Ecosystem or species credit?
Thick Lip Spider Orchid *(Caladenia tessellata)*	E	V	*Caladenia tessellata* occurs in grassy sclerophyll woodland, often growing in well-structured clay loams or sandy soils south from Swansea, usually in sheltered moist places and in areas of increased sunlight. It flowers from September to November.	2	None – suitable habitat not present	Species
(Callistemon linearifolius)	V	-	Recorded from the Georges River to Hawkesbury River in the Sydney area, and north to the Nelson Bay area of NSW. For the Sydney area, recent records are limited to the Hornsby Plateau area near the Hawkesbury River. Grows in dry sclerophyll forest on the coast and adjacent ranges.	-	None – suitable habitat not present. No records in locality	Species
Leafless Tongue-orchid *(Cryptostylis hunteriana)*	V	V	Known from a range of vegetation communities including swamp-heath and woodland. The larger populations typically occur in woodland dominated by *Eucalyptus sclerophylla* (Scribbly Gum), *E. sieberi* (Silvertop Ash), *Corymbia gummifera* (Red Bloodwood) and *Allocasuarina littoralis* (Black Sheoak); where it appears to prefer open areas in the understorey and is often found in association with *Cryptostylis subulata) Cryptostylis erecta.*	-	None – suitable habitat not present. No records in locality	Species
(Darwinia biflora)	V	V	*Darwinia biflora* is an erect or spreading shrub to 80 cm high associated with habitats where weathered shale capped ridges intergrade with Hawkesbury Sandstone, where soils have a high clay content.	1	None – suitable habitat not present	Species
(Deyeuxia appressa)	E	E	Little is known of the habitat and ecology of this highly restricted NSW endemic known only from two records in the Sydney area; first collected in 1930 at Herne Bay, Saltpan Creek, off the Georges River, south of Bankstown; then collected in 1941 from Killara, near Hornsby. Grows in moist conditions.	-	None – suitable habitat not present. No records in locality	Species
(Dillwynia tenuifolia)	V	-	The core distribution is the Cumberland Plain from Windsor and Penrith east to Dean Park near Colebee. In western Sydney, may be locally abundant particularly within scrubby/dry heath areas within Castlereagh Ironbark Forest and Shale Gravel Transition Forest on tertiary alluvium or laterised clays. May also be common in transitional areas where these communities adjoin Castlereagh Scribbly Gum Woodland. At Yengo, is reported to occur in disturbed escarpment woodland on Narrabeen sandstone.	-	None – suitable habitat not present. No records in locality	Species
(Epacris purpurascens var. *purpurascens)*	V	-	*Epacris purpurascens* var. *purpurascens* has been recorded between Gosford in the north to Avon Dam in the south, in a range of habitats, but most have a strong shale soil influence.	1	None – suitable habitat not present	Species
Camfield's Stringybark *(Eucalyptus camfieldii)*	V	V	*Eucalyptus camfieldii* is associated with shallow sandy soils bordering coastal heath with other stunted or mallee eucalypts, often in areas with restricted drainage and in areas with laterite influenced soils, thought to be associated with proximity to shale.	-	None – suitable habitat not present. No records in locality	Species

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat requirements	Number of records	Likelihood of occurrence	Ecosystem or species credit?
Narrow-leaved Black Peppermint *(Eucalyptus nicholii)*	V	V	*Eucalyptus nicholii* naturally occurs in the New England Tablelands of NSW, where it occurs from Nundle to north of Tenterfield. Grows in dry grassy woodland, on shallow and infertile soils, mainly on granite. This species is widely planted as an urban street tree and in gardens but is quite rare in the wild. Plantings undertaken for horticultural and aesthetic purposes are not considered threatened species under the TSC Act.	6	None – suitable habitat not present. Records are landscaped plantings	Species
Bauer's Midge Orchid *(Genoplesium baueri)*	E	E	Known from coastal areas from northern Sydney south to the Nowra district. Previous records from the Hunter Valley and Nelson Bay are now thought to be erroneous. Grows in shrubby woodland in open forest on shallow sandy soils.	6	None – suitable habitat not present	Species
(Grammitis stenophylla	E	-	Occurs in moist places usually near streams, on rocks or in trees, within rainforest and moist eucalypt forest.	-	None – suitable habitat not present. No records in locality	Species
Caley's Grevillea *(Grevillea caleyi)*	E	E	Restricted to an 8 km square area around Terrey Hills, approximately 20 km north of Sydney. Occurs in three major areas of suitable habitat, namely Belrose, Ingleside and Terrey Hills/Duffys Forest within the Ku-ring-gai, Pittwater and Warringah LGAs. Sites occur on the ridgetops in association with laterite soils and a vegetation community of open forest, generally dominated by *Eucalyptus sieberi* and *E. gummifera*. Commonly found in the endangered Duffys Forest ecological community.	-	None – suitable habitat not present. No records in locality	Species
(Hibbertia puberula)	CE	CE	*Hibbertia puberula* is currently only known from near Warrimoo in Blue Mountains National Park on the Central Coast. There also several old records from a number of localities in the Sydney basin. It grows in heathy open forest in thin rocky/sandy light brown soil over sandstone.	1	None – suitable habitat not present	Species
(Lasiopetalum joyceae)	V	V	Has a restricted range occurring on lateritic to shaley ridgetops on the Hornsby Plateau south of the Hawkesbury River. It is currently known from 34 sites between Berrilee and Duffys Forest. Seventeen of these are on reserved lands. Grows in heath on sandstone.	-	None – suitable habitat not present. No records in locality	Species
(Leptospermum deanei)	V	V	Limited distribution in the north-west suburbs of Sydney with records between Port Jackson and Broken Bay. Found in riparian shrubland, woodland and open forest on sandy alluvial soil or sand on lower hillsides and along permanent freshwater creeks in Hawkesbury Sandstone areas below 100 m above sea level.	-	None – suitable habitat not present. No records in locality	Species
Deane's Paperbark *(Melaleuca deanei)*	V	V	Found in heath on sandstone, and also associated with woodland on broad ridge tops and slopes on sandy loam and lateritic soils.	10	None – suitable habitat not present	Species

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat requirements	Number of records	Likelihood of occurrence	Ecosystem or species credit?
Hairy Geebung *(Persoonia hirsuta)*	E	E	*Persoonia hirsuta* occurs from Singleton in the north, south to Bargo and the Blue Mountains to the west. It grows in dry sclerophyll eucalypt woodland and forest on sandstone.	4	None – suitable habitat not present	Species
Nodding Geebung *(Persoonia nutans)*	E	E	Nodding Geebung is restricted to the Cumberland Plain region of western Sydney, NSW. The species is confined to Aeolian and alluvial sediments, below 60 m above sea level. Vegetation communities in which the species has been found include Agnes Banks Woodland, Castlereagh Scribbly Gum Woodland, Cooks River/Castlereagh Ironbark Forest and Shale Sandstone Transition Forest.		None – suitable habitat not present. No records in locality	Species
Omeo Stork's-bill *(Pelargonium* sp. *Striatellum)*	E	E	It is known to occur in habitat usually located just above the high water level of irregularly inundated or ephemeral lakes. During dry periods, the species is known to colonise exposed lake beds. It is not known if the species' rhizomes and/or soil seedbank persist through prolonged inundation or drought.	-	None – suitable habitat not present. No records in locality	Species
(Pimelea curviflora var. *curviflora)*	V	V	*Pimelea curviflora* var. *curviflora* is confined to the coastal area of Sydney between northern Sydney in the south and Maroota in the north-west. It grows on shale/lateritic soils over sandstone and shale/sandstone transition soils on ridgetops and upper slopes amongst woodlands. Associated with the Duffys Forest Community, shale lenses on ridges in Hawkesbury sandstone geology.	1	None – suitable habitat not present	Species
Spiked Rice-flower *(Pimelea spicata)*	E	E	In western Sydney, *Pimelea spicata* occurs on an undulating topography of well-structured clay soils, derived from Wianamatta shale. It is associated with Cumberland Plains Woodland, in open woodland and grassland often in moist depressions or near creek lines. Has been located in disturbed areas that would have previously supported.	-	None – suitable habitat not present. No records in locality	Species
Seaforth Mintbush *(Prostanthera marifolia)*	E	CE	*Prostanthera marifolia* is currently only known from the northern Sydney suburb of Seaforth and has a very highly restricted distribution. It occurs in localised patches in or in close proximity to the Duffys Forest ecological community. It grows on deeply weathered clay-loam soils associated with ironstone and scattered shale lenses.	4	None – suitable habitat not present	Species
Sydney Plains Greenhood *(Pterostylis saxicola)*	E	E	Terrestrial orchid predominantly found in Hawkesbury Sandstone Gully Forest growing in small pockets of soil that have formed in depressions in sandstone rock shelves. Known from Georges River National Park, Ingleburn, Holsworthy, Peter Meadows Creek and St. Marys Tower.	-	None – suitable habitat not present. No records in locality	Species
(Pultenaea parviflora)	E	V	Endemic to the Cumberland Plain. Core distribution is from Windsor to Penrith and east to Dean Park. May be locally abundant, particularly within scrubby/dry heath areas within Castlereagh Ironbark Forest and Shale Gravel Transition Forest on tertiary alluvium or laterised clays. May also be common in transitional areas where these communities adjoin Castlereagh Scribbly Gum Woodland.	-	None – suitable habitat not present. No records in locality	Species

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat requirements	Number of records	Likelihood of occurrence	Ecosystem or species credit?
Magenta Lilly Pilly *(Syzygium paniculatum)*	E	V	This species occupies a narrow coastal area between Bulahdelah and Conjola State Forests in NSW. On the Central Coast, it occurs on Quaternary gravels, sands, silts and clays, in riparian gallery rainforests and remnant littoral rainforest communities. Plantings undertaken for horticultural and aesthetic purposes are not considered threatened species under the TSC Act.	16	None – suitable habitat not present	Species
(Tetratheca glandulosa)	V	-	Associated with ridgetop woodland habits on yellow earths also in sandy or rocky heath and scrub. Often associated with sandstone / shale interface where soils have a stronger clay influence. Flowers July to November.	1	None – suitable habitat not present	Species
Black-eyed Susan *(Tetratheca juncea)*	V	V	Occurs on predominantly low nutrient soils with a dense grassy understorey of grasses although it has been recorded in heathland and moist forest. It is associated with dry open forest or woodland habitats dominated by *Corymbia gummifera, Eucalyptus capitellata, E. haemastoma* and *Angophora costata*. *Themeda australis* is generally the dominant ground cover. *Tetratheca juncea* also displays a preference for southern aspect slopes, although is slopes with different aspects. Flowers July to December.	13	None – suitable habitat not present	Species
Austral Toadflax *(Thesium australe)*	V	V	Widespread throughout the eastern third of NSW but most common on the North Western Slopes, Northern Tablelands and North Coast. Occurs in grassland or grassy woodland. Often found in damp sites in association with *Themeda australis*. The preferred soil type is a fertile loam derived from basalt although it occasionally occurs on metasediments and granite.	-	None – suitable habitat not present. No records in locality	Species
(*Zannichellia palustris)*	E	-	In NSW, known from the lower Hunter and in Sydney Olympic Park. Grows in fresh or slightly saline stationary or slowly flowing water. Flowers during warmer months. NSW populations behave as annuals, dying back completely every summer.	-	None – suitable habitat not present. No records in locality	Species
FUNGI						
An agaric fungus *(Hygrocybe collucera)*	E	-	Occurs in warm temperate forests dominated by Lilly Pilly (*Acmena smithii*), Grey Myrtle (*Backhousia myrtifolia*), Cheese Tree (*Glochidion ferdinandi*) and Sweet Pittosporum (*Pittosporum undulatum*). Associated with alluvial sandy soils of the Hawkesbury Soil Landscapes with naturally low fertility and erodible. Occur as individuals or in groups, terrestrial rarely on wood and only if extremely rotten; substrates include soil, humus, or moss.	1	None – suitable habitat not present	Species
An agaric fungus *(Hygrocybe grieoramosa)*	E	-	Occurs in warm temperate forests dominated by Lilly Pilly (Acmena smithii), Grey Myrtle (*Backhousia myrtifolia*), Cheese Tree (*Glochidion ferdinandi*) and Sweet Pittosporum (*Pittosporum undulatum*). Associated with alluvial sandy soils of the Hawkesbury Soil Landscapes with naturally low fertility and erodible. Occur as individuals or in groups, terrestrial rarely on wood and only if extremely rotten; substrates include soil, humus, or moss.	1	None – suitable habitat not present	Species

Table A.4: Threatened fauna likelihood of occurrence

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat requirements	Number of records	Likelihood of occurrence	Ecosystem or species credit?
AMPHIBIA						
Giant Burrowing Frog *(Heleioporus australiacus)*	V	V	Forages in woodlands, wet heath, dry and wet sclerophyll forest. Associated with semi-permanent to ephemeral sand or rock based streams, where the soil is soft and sandy so that burrows can be constructed.	-	None – suitable habitat not present. No records in locality	Species (land within 40 m of heath, woodland or forest)
Green and Golden Bell Frog *(Litoria aurea)*	E	V	Utilises natural and man-made waterbodies such as coastal swamps, marshes, dune swales, lagoons, lakes, other estuary wetlands, riverine floodplain wetlands, stormwater basins, farm dams, bunded areas, drains, ditches and other structures capable of storing water. Preferable habitat includes shallow, still or slow flowing, permanent and/or widely fluctuating water bodies that are unpolluted and without heavy shading. Large permanent swamps and ponds exhibiting well-established fringing vegetation, adjacent to open grassland areas for foraging are preferable.	213	None – suitable habitat not present. Not recorded during targeted surveys as part of the Rozelle Rail Yards REF Biodiversity Assessment	Species (land within 100 m of emergent aquatic or riparian vegetation)
Growling Grass Frog, *(Litoria raniformis)*	E	V	Relatively still or slow-flowing sites such as billabongs, ponds, lakes or farm dams, especially where *Typha* sp., *Eleocharis* sp. and *Phragmites* sp. (Bulrushes) are present. This species is common in lignum shrub lands, black box and River Red Gum woodlands, irrigation channels and at the periphery of rivers in the southern parts of NSW. This species occurs in vegetation types such as open grassland, open forest and ephemeral and permanent non-saline marshes and swamps. Open grassland and ephemeral permanent non-saline marshes and swamps have also been associated with this species.	-	None – suitable habitat not present. No records in locality	Species (land within 100 m of emergent aquatic or riparian vegetation)
Stuttering Frog *(Mixophyes balbus)*	E	V	Occurs in a variety of forest habitats from rainforest through wet and moist sclerophyll forest to riparian habitat in dry sclerophyll forest that are generally characterised by deep leaf litter or thick cover from understorey vegetation. Breeding habitats are streams and occasionally springs. Not known from streams disturbed by humans or still water environments.	-	None – suitable habitat not present. No records in locality	Species (rainforest or tall open wet forest with understorey and/or leaf litter and within 100 m of streams)
Wallum Froglet *(Crinia tinnula)*	V	-	The Wallum Frog is restricted to the Wallum swamps and associated low land meandering watercourses on coastal plains. Occurs in elevations up to around 50 m and is closely related to freshwater habitats in the coastal zone. Found most commonly in Wallum wetlands characterised by low nutrients, highly acidic, tannin-stained waters that are typically dominated by paperbarks and tea-trees. Also found in sedge land and wet heathland habitats.	1	None – suitable habitat not present	Species (land within 40m of coastal swamps and wet heaths)

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat requirements	Number of records	Likelihood of occurrence	Ecosystem or species credit?
FISH						
Sydney Hawk Dragonfly *(Austrocordulia leonardi)*	E (FM Act)	-	The known distribution of the species includes three locations in a small area south of Sydney, from Audley to Picton. The species is also known from the Hawkesbury-Nepean, Georges River and Port Hacking drainages. The Sydney Hawk Dragonfly has specific habitat requirements, and has only ever been collected from deep and shady riverine pools with cooler water. Larvae are found under rocks where they co-exist with *Austrocordulia refracta*.	-	None – suitable habitat not present. No records in locality	Not Applicable – FM Act species only
Adam's Emerald Dragonfly (*Archaeophya adamsi)*	E (FM Act)	-	Adam's Emerald Dragonflies are one of Australia's rarest dragonflies. The species is only known from a few sites in the greater Sydney region. Larvae have been found in small creeks with gravel or sandy bottoms, in narrow, shaded riffle zones with moss and rich riparian.	-	None – suitable habitat not present. No records in locality	Not Applicable – FM Act species only
Black Rockcod *(Epinephelus daemelii)*	V (FM Act)	V	They are found in warm temperate and subtropical parts of the south-western Pacific, and naturally occurred along the entire NSW coast including Lord Howe Island. Adult black cod are usually found in caves, gutters and beneath bomboras on rocky reefs. They are territorial and often occupy a particular cave for life. Small juveniles are often found in coastal rock pools, and larger juveniles around rocky shores in estuaries.	-	None – suitable habitat not present. No records in locality	Not Applicable – FM Act species only
Australian Grayling *(Prototroctes maraena)*	P (FM Act)	V	Australian grayling occurs in freshwater streams and rivers, especially clear gravelly streams with a moderate flow, as well as estuarine areas. Australian grayling need to migrate to and from the sea to complete their life cycle (catadromous), and the construction of barriers such as dams and weirs has had a major impact on populations in some river systems.	-	None – suitable habitat not present. No records in locality	Not Applicable – FM Act species only
REPTILIA						
Broad-headed Snake *(Hoplocephalus bungaroides)*	E	V	Typical sites consist of exposed sandstone outcrops and benching where the vegetation is predominantly woodland, open woodland and/or heath on Triassic sandstone of the Sydney Basin. They utilise rock crevices and exfoliating sheets of weathered sandstone during the cooler months and tree hollows during summer.	-	None – suitable habitat not present. No records in locality	Species (land within 500 m of sandstone escarpments with hollow-bearing trees, rock crevices or flat sandstone rocks on exposed cliff edges and sandstone outcropping)

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat requirements	Number of records	Likelihood of occurrence	Ecosystem or species credit?
DIURNAL BIRDS						
Magpie Goose *(Anseranas semipalmata)*	V	-	Mainly found in shallow wetlands less than 1 m deep, with a dense growth of rushes or sedges.	9	None – suitable habitat not present	Ecosystem
Dusky Woodswallow *(Artamus cyanopterus cyanopterus)*	V	-	The Dusky Woodswallow is often reported in woodlands and dry open sclerophyll forests, usually dominated by eucalypts, including mallee associations. It has also been recorded in shrublands and heathlands and various modified habitats, including regenerating forests; very occasionally in moist forests or rainforests.	6	None – suitable habitat not present	Not provided in Bionet (recently listed threatened species)
Regent Honeyeater *(Anthochaera phrygia)*	E	CE	Mostly occur in dry box-ironbark eucalypt woodland and dry sclerophyll forest associations, wherein they prefer the most fertile sites available, eg along creek flats, or in broad river valleys and foothills. In NSW, riparian forests containing *Casuarina cunninghamiana* (River Oak), and with *Amyema cambagei* (Needle-leaf Mistletoe) are also important for feeding and breeding. At times of food shortage (eg when flowering fails in preferred habitats), they also use other woodland types and wet lowland coastal forest dominated by *Eucalyptus robusta* (Swamp Mahogany) or *Eucalyptus maculata* (Spotted Gum).	1	None – suitable habitat not present	Species
Australasian Bittern *(Botaurus poiciloptilus)*	E	E	Terrestrial wetlands with tall dense vegetation, occasionally estuarine habitats. Found along the east coast and in the Murray-Darling Basin, notably in floodplain wetlands of the Murrumbidgee, Lachlan, Macquarie and Gwydir Rivers. Favours permanent shallow waters, edges of pools and waterways, with tall, dense vegetation such as sedges, rushes and reeds on muddy or peaty substrate. Also occurs in *Muehlenbeckia florulenta* (Lignum) and *Eragrostis australasica* (Canegrass) on inland wetlands.	2	None – suitable habitat not present	Species (land containing brackish or freshwater wetlands)
Bush Stone-curlew *(Burhinus grallarius)*	E	-	Associated with dry open woodland with grassy areas, dune scrubs, in savanna areas, the fringes of mangroves, golf courses and open forest / farmland. Forages in areas with fallen timber, leaf litter, little undergrowth and where grass is short and patchy. Is thought to require large tracts of habitat to support breeding, in which there is a preference for a sparely vegetated understorey.	5	None – suitable habitat not present. No records in locality	Ecosystem
Curlew Sandpiper *(Calidris ferruginea)*	E	CE	Occurs in intertidal mudflats of estuaries, lagoons, mangrove channels; around lakes, dams, floodwaters, flooded saltbush surrounds of inland lakes.	168	None – suitable habitat not present. No records in locality	Ecosystem

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat requirements	Number of records	Likelihood of occurrence	Ecosystem or species credit?
Great Knot *(Calidris tenuirostris)*		CE; Mi	Sheltered coastal habitats containing large intertidal mudflats or sandflats, including inlets, bays, harbours, estuaries and lagoons. Often recorded on sandy beaches with mudflats nearby, sandy spits and inlets, or exposed reefs or rock platforms.	5	None – suitable habitat not present. No records in locality	Ecosystem
Glossy Black-Cockatoo *(Calyptorhynchus lathami)*	V	-	Associated with a variety of forest types containing Allocasuarina species, usually reflecting the poor nutrient status of underlying soils. Intact drier forest types with less rugged landscapes are preferred. Nests in large trees with large hollows.	1	Low – suitable habitat not present	Ecosystem
Eastern Bristlebird *(Dasyornis brachypterus)*	E	E	Habitat is characterised by dense, low vegetation and includes sedgeland, heathland, swampland, shrubland, sclerophyll forest and woodland, and rainforest, as well as open woodland with a heathy understorey. In northern NSW, it occurs in open forest with tussocky grass understorey. All of these vegetation types are fire prone, aside from the rainforest habitats utilised by the northern population as fire refuge.	-	None – suitable habitat not present. No records in locality	Species Dense (>80% projected cover) heath/sedgeland or woodland with dense heath understorey
White-fronted Chat *(Epthianura albifrons)*	V	-	Endemic to Australia, in particular southern regions of Australia. In NSW it occupies temperate to arid habitats from foothills to 1000 m altitude In NSW the White-fronted Chat occurs in open habitats near the coast in close proximity to waterways including estuaries, saltmarsh or marshy wetlands.	4	None – suitable habitat not present. No records in locality	Ecosystem
Red Goshawk *(Erythrotriorchis radiatus)*	E	V	Associated with forests and woodlands with a mosaic of vegetation types, an abundance of birds and permanent water. In NSW, this species is thought to favour mixed subtropical rainforest, Melaleuca Swamp Forest, and open eucalypt forest along rivers, often in rugged terrain. The Red Goshawk nests in large trees, frequently the tallest and most massive in a tall stand, and nest trees are invariably within 1 km of permanent water.	1	None – suitable habitat not present	Not provided for Sydney Metro CMA
Black Falcon *(Falco subniger)*	V	-	Has broad range across inland regions New South Wales, where it has a sparse distributed. However, there are reports of 'Black Falcons' occurring on the tablelands and along the NSW coast. These reports are likely to represent Brown Falcons. In New South Wales there is assumed to be a single population that is continuous with a broader continental population, given that falcons are highly mobile, commonly travelling over hundreds of kilometres.	1	None – suitable habitat not present	Not provided in BioNet

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat requirements	Number of records	Likelihood of occurrence	Ecosystem or species credit?
Little Lorikeet *(Glossopsitta pusilla)*	V	-	In New South Wales they are distributed in forests and woodlands from the coast to the western slopes of the Great Dividing Range, extending westwards to Albury, Parkes, Dubbo and Narrabri. Little Lorikeets mostly occur in dry, open eucalypt forests and woodlands. They have been recorded from both old-growth and logged forests in the eastern part of their range, and in remnant woodland patches and roadside vegetation on the western slopes. They feed primarily on nectar and pollen in the tree canopy, particularly on profusely-flowering eucalypts, but also on a variety of other species including melaleucas and mistletoes. On the western slopes and tablelands *Eucalyptus albens* (White Box) and *Eucalyptus melliodora* (Yellow Box) are particularly important food sources for pollen and nectar respectively.	1	None – suitable habitat not present. No records in locality	Ecosystem
Painted Honeyeater *(Grantiella picta)*	V	V	A nomadic species that typically inhabits Boree, Brigalow and Box-Gum Woodlands and Box-Ironbark Forests with abundant mistletoe. It is a specialist feeder on the fruits of mistletoes growing on woodland eucalypts and acacias, preferring *Amyema* sp. (Mistletoe).	-	None – suitable habitat not present. No records in locality	Ecosystem
Little Eagle *(Hieraaetus morphnoides)*	V	-	The Little Eagle is widespread in mainland Australia, central and eastern New Guinea. The Little Eagle is seen over woodland and forested The population of Little Eagle in NSW is considered to be a single population. This species was recently listed as vulnerable due to a moderate reduction in population size based on geographic distribution and habitat quality lands and open country, extending into the arid zone. It tends to avoid rainforest and heavy forest.	1	Low – suitable habitat not present	Ecosystem
Black Bittern *(Ixobrychus flavicollis)*	V	-	Occurs in both terrestrial and estuarine wetlands generally in areas of permanent water and dense vegetation. In areas with permanent water it may occur in flooded grassland, forest, woodland, rainforest and mangroves.	1	None – suitable habitat not present	Species (land within 40 m of freshwater and estuarine wetlands, in areas of permanent water and dense vegetation or emergent aquatic vegetation)

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat requirements	Number of records	Likelihood of occurrence	Ecosystem or species credit?
Swift Parrot *(Lathamus discolor)*	E	CE	Breeds in Tasmania between September and January. Feeds mostly on nectar, mainly from eucalypts, but also eats psyllid insects and lerps, seeds and fruit. Migrates to mainland in autumn, where it forages on profuse flowering Eucalypts. Favoured feed trees include winter flowering species such as *Eucalyptus robusta*, *Corymbia maculata, Corymbia gummifera, Eucalyptus sideroxylon, Eucalyptus albens* and *Eucalyptus tereticornis.* Box-ironbark habitat in drainage lines, and coastal forest in NSW is thought to provide food resources during periods of drought or low food abundance elsewhere.	1	None – suitable habitat not present	Ecosystem
Turquoise Parrot *(Neophema pulchella)*	V	-	Steep rocky ridges and gullies, rolling hills, valleys and river flats and the plains of the Great Dividing Range compromise the topography inhabited by this species. Spends much of the time on the ground foraging on seed and grasses. It is associated with coastal scrubland, open forest and timbered grassland, especially low shrub ecotones between dry hardwood forests and grasslands with high proportion of native grasses and forbs.	1	None – suitable habitat not present	Ecosystem
Scarlet Robin *(Petroica boodang)*	V	-	Found in south-eastern and south-western Australia, as well as on Norfolk Island, from south of latitude 25°S from south-eastern Queensland along the coast of New South Wales (and inland to western slopes of Great Dividing Range) to Victoria and Tasmania, and west to Eyre Peninsula, South Australia. It lives in open forests and woodlands, but prefers rainforest habitats on Norfolk Island. During winter, it will visit more open habitats such as grasslands and will be seen in farmland and urban parks and gardens at this time.	1	None – suitable habitat not present	Ecosystem
Flame Robin *(Petroica phoenicea)*	V	-	Flame Robins are found in a broad coastal band around the south-east corner of the Australian mainland, from southern Queensland to just west of the South Australian border. The species is also found in Tasmania. Flame Robins prefer forests and woodlands up to about 1800 m above sea level.	1	None – suitable habitat not present	Ecosystem
Superb Fruit-Dove *(Ptilinopus superbus)*	V	-	Inhabits rainforest and similar closed forests where it forages high in the canopy, eating the fruits of many tree species such as figs and palms. It may also forage in eucalypt or acacia woodland where there are fruit-bearing trees. Part of the population is migratory or nomadic. At least some of the population, particularly young birds, moves south through Sydney, especially in autumn. Breeding takes place from September to January.	7	Low – suitable habitat not present	Ecosystem
Diamond Firetail *(Stagonopleura guttata)*	V	-	Typically found in grassy eucalypt woodlands, but also occurs in open forest, mallee, Natural Temperate Grassland, and in secondary grassland derived from other communities. It is often found in riparian areas and sometimes in lightly wooded farmland. Appears to be sedentary, though some populations move locally, especially those in the south.	1	None – suitable habitat not present. No records in locality	Ecosystem
Freckled Duck *(Stictonetta naevosa)*	V	-	Associated with a variety of plankton-rich wetlands, such as heavily vegetated, large open lakes and their shores, creeks, farm dams, sewerage ponds and floodwaters.	1	None – suitable habitat not present	Ecosystem

Common Name (Scientific Name)	TSC Act	EPBC Act	Habitat requirements	Number of records	Likelihood of occurrence	Ecosystem or species credit?
AVES (NOCTURNAL)						
Powerful Owl *(Ninox strenua)*	V	-	Powerful Owls are associated with a wide range of wet and dry forest types with a high density of prey, such as arboreal mammals, large birds and flying foxes. Large trees with hollows at least 0.5 m deep are required for shelter and breeding.	102	Low – suitable roosting habitat not present. Marginal foraging habitat may be present within site	Ecosystem
Masked Owl *(Tyto novaehollandiae)*	V	-	Associated with forest with sparse, open, understorey, typically dry sclerophyll forest and woodland and especially the ecotone between wet and dry forest, and non-forest habitat. Known to utilise forest margins and isolated stands of trees within agricultural land and heavily disturbed forest where its prey of small and medium sized mammals can be readily obtained.	1	None – suitable roosting habitat not present	Ecosystem
Sooty Owl *(Tyto tenebricosa)*	V	-	Associated with tall wet old growth forest on fertile soil with a dense under-storey and emergent tall Eucalyptus. Pairs roost in the daytime amongst dense vegetation, in tree hollows and sometimes caves. Typically associated with an abundant and diverse supply of prey and a selection of large tree hollows.	1	None – suitable roosting habitat not present	Ecosystem
MAMMALS (BATS)						
Large-eared Pied Bat *(Chalinolobus dwyeri)*	V	V	The Large-eared Pied Bat has been recorded in a variety of habitats, including dry sclerophyll forests, woodland, sub-alpine woodland, edges of rainforests and wet sclerophyll forests. This species roosts in caves, rock overhangs and disused mine shafts and as such is usually associated with rock outcrops and cliff faces.	-	None – suitable habitat not present. No records in locality	Ecosystem and Species (land containing escarpments, cliffs, caves, deep crevices, old mine shafts or tunnels)
Little Bentwing-bat *(Miniopterus australis)*	V	-	Moist eucalypt forest, rainforest, vine thicket, wet and dry sclerophyll forest, Melaleuca swamps, dense coastal forests and banksia scrub. Generally found in well-timbered areas. It known to roost in caves, hollows and structures.	1	None – targeted surveys did not record this species. Suitable habitat not present	Ecosystem and Species
Eastern Bentwing-bat *(Miniopterus schreibersii oceanensis)*	V	-	Associated with a range of habitats such as rainforest, wet and dry sclerophyll forest, monsoon forest, open woodland, paperbark forests and open grassland. It forages above and below the tree canopy on small insects. Will utilise caves, old mines, and stormwater channels, under bridges and occasionally buildings for shelter. Returns to known limestone cave maternal breeding sites in winter.	53	Recorded – targeted surveys	Ecosystem and Species (land containing caves or similar structures)

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat requirements	Number of records	Likelihood of occurrence	Ecosystem or species credit?
Eastern Freetail-bat *(Mormopterus norfolkensis)*	V	-	Most records of this species are from dry eucalypt forest and woodland east of the Great Dividing Range. Individuals have, however, been recorded flying low over a rocky river in rainforest and wet sclerophyll forest and foraging in clearings at forest edges. Primarily roosts in hollows or behind loose bark in mature eucalypts, but have been observed roosting in the roof of a hut.	10	None – targeted surveys did not record this species. Suitable breeding habitat not present	Ecosystem
Southern Myotis *(Myotis macropus)*	V	-	Occupies moist habitat types such as mangroves, paperbark swamps, riverine monsoon forest, rainforest, wet and dry sclerophyll forest, open woodland and River Red Gum woodland, as long as they are close to water. While roosting it is most commonly associated with caves, but has been observed to roost in tree hollows, amongst vegetation, in clumps of Pandanus, under bridges, in mines, tunnels and stormwater drains. Species apparently has specific roost requirements, and only a small percentage of available caves, mines, tunnels and culverts are used.	9	None – targeted surveys did not record this species. Suitable breeding habitat not present	Ecosystem and Species (hollow-bearing trees, bridges, caves or artificial structures within 200 m of riparian zone)
Yellow-bellied Sheathtail-bat *(Saccolaimus flaviventris)*	V	-	Found in almost all habitats, from wet and dry sclerophyll forest, open woodland, open country, mallee, rainforests, heathland and waterbodies. Roosts in tree hollows, but may also use caves; and has also been recorded in abandoned sugar glider nests. Dependent on hollows to provide roosts, which may be a limiting factor on populations in cleared or fragmented habitats.	-	Recorded Possible call from targeted surveys - foraging activity.	Ecosystem
Grey-headed Flying-fox *(Pteropus poliocephalus)*	V	V	Inhabits a wide range of habitats including rainforest, mangroves, paperbark forests, wet and dry sclerophyll forests and cultivated areas. Camps are often located in gullies, typically close to water, in vegetation with a dense canopy.	275	High – suitable foraging habitat only. No camps or roost sites within the site	Ecosystem and Species (Species credit species only if impacts occur to known camps or roost sites)
MAMMALS						
Long-nosed Bandicoot population in inner western Sydney *(Perameles nasuta)*	EP	-	The Long-nosed Bandicoot is a medium sized marsupial with an extensive distribution throughout eastern Australia. The inner western Sydney population is restricted to the inner city suburbs within the Marrickville and Canada Bay LGAs where it shelters beneath older houses and buildings and forages in parks and back yards. The full distribution of this species is unknown and may occur over a broader region.	25	Low – potential habitat limited. Not recorded during targeted surveys as part of the Rozelle Rail Yards REF Biodiversity Assessment.	Species
Eastern Quoll *(Dasyurus viverrinus)*	E	CE	Associated with a variety of habitats, including dry sclerophyll forest, shrub, heath land, riparian forests and agricultural areas. Requires features such as hollow logs and rock piles for shelter.	1	None – suitable habitat not present	Not provided in BioNet

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat requirements	Number of records	Likelihood of occurrence	Ecosystem or species credit?
Spotted-tailed Quoll SE mainland population) *(Dasyurus maculatus maculatus)*	V	E	It inhabits a range of forest communities including wet and dry sclerophyll forests, coastal heathlands and rainforests, more frequently recorded near the ecotones of closed and open forest. This species requires habitat features such as maternal den sites, an abundance of food (birds and small mammals) and large areas of relatively intact vegetation to forage in. Maternal den sites are logs with cryptic entrances; rock outcrops; windrows; burrows.	-	None – suitable habitat not present. No records in locality	Ecosystem
Greater Glider *(Petauroides volans)*	-	V	The greater glider is an arboreal nocturnal marsupial, largely restricted to eucalypt forests and Woodlands. It is typically found in highest abundance in taller, montane, moist eucalypt forests with relatively old trees and abundant hollows.	-	None – suitable habitat not present. No records in locality	Not provided in BioNet
Brush-tailed Rock-wallaby *(Petrogale penicillata)*	E	V	Rocky areas in a variety of habitats, typically north facing sites with numerous ledges, caves and crevices.	-	None – suitable habitat not present. No records in locality	Species (land within 1km of rocky escarpments, gorges, steep slopes, boulder piles, rock outcrops or cliff lines)
Koala (Combined populations of Qld, NSW and the ACT). *(Phascolarctos cinereus)*	V	V	Associated with both wet and dry Eucalypt forest and woodland that contains a canopy cover of approximately 10 to 70 per cent, with acceptable Eucalypt food trees. Some preferred Eucalyptus species are: *Eucalyptus tereticornis, Eucalyptus punctata, Eucalyptus cypellocarpa* and *Eucalyptus viminalis.*	-	None – suitable habitat not present. No records in locality	Species
Southern Brown Bandicoot (Eastern) *(Isoodon obesulus obesulus)*	E	E	Associated with heath, coastal scrub, sedgeland, heathy forests, shrubland and woodland on well drained, infertile soils, within which they are typically found in areas of dense ground cover. Suitable habitat includes patches of native or exotic vegetation which contain understorey vegetation structure with 50–80 per cent average foliage density in the 0.2–1 m height range. Is thought to display a preference for newly regenerating heathland and other areas prone to fire, but requires a mosaic of burnt and unburnt areas for survival.	-	None – suitable habitat not present. No records in locality	Species
New Holland Mouse *(Pseudomys novaehollandiae)*	-	V	A small burrowing native rodent with a fragmented distribution across Tasmania, Victoria, New South Wales and Queensland. Inhabits open heathlands, open woodlands with a heathland understorey and vegetated sand dunes. A social animal, living predominantly in burrows shared with other individuals. The home range of the New Holland Mouse ranges from 0.44 ha to 1.4 ha and the species peaks in abundance during early to mid-stages of vegetation succession typically induced by fire.	-	None – suitable habitat not present. No records in locality	Ecosystem

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat requirements	Number of records	Likelihood of occurrence	Ecosystem or species credit?
MIGRATORY SPECIES						
Common Sandpipe *(Actitis hypoleucos)*		Mi	In Australia, it is found in coastal or inland wetlands, both saline and fresh. It is found mainly on muddy edges or rocky shores. During the breeding season in the northern hemisphere, it prefers freshwater lakes and shallow rivers.	5	None – suitable habitat not present	Not applicable
Fork-tailed Swift *(Apus pacificus)*	-	Mi	Sometimes travels with Needletails. Varied habitat with a possible tendency to more arid areas but also over coasts and urban areas.	6	None – suitable habitat not present	Not applicable
Wedge-tailed Shearwater *(Ardenna pacificus)*	-	Mi	The Wedge-tailed Shearwater is a pelagic, marine bird known from tropical and subtropical waters. The species tolerates a range of surface-temperatures and salinities, but is most abundant where temperatures are greater than 21 °C and salinity is greater than 34.6 %.	4	None – suitable habitat not present	Not applicable
Ruddy Turnstone *(Arenaria interpres)*	-	Mi	Frequents beaches along the coast of NSW. Flies from Siberia or Alaska to Australia in August - September each year (ibid).	5	None – suitable habitat not present	Not applicable
Sharp-tailed Sandpiper *(Calidris acuminata)*	-	Mi	It prefers the grassy edges of shallow inland freshwater wetlands. It is also found around sewerage treatment ponds, flooded grasslands, mudflats, mangroves, rocky shores and beaches.	69	None – suitable habitat not present	Not applicable
Sanderling *(Calidris alba)*	-	Mi	Occurs in coastal areas on low beaches, near reefs and inlets along tidal mudflats and bare open coastal lagoons. Rarely seen in near-coastal wetlands such as lagoons, hypersaline lakes, salt ponds and samphire flats.	2	None – suitable habitat not present	Not applicable
Red Knot *(Calidris canutus)*	-	Mi	Red Knots are widespread around the Australian coast, less in the south and with few inland records. Small numbers visit Tasmania and off-shore islands. It is widespread but scattered in New Zealand. They breed in North America, Russia, Greenland and Spitsbergen. Red Knots are a non-breeding visitor to most continents.	8	None – suitable habitat not present.	Not applicable
Pectoral Sandpiper *(Calidris melanotos)*	-	Mi	Prefers shallow fresh to saline wetlands, found at coastal lagoons, estuaries, bays, swamps, inundated grasslands, saltmarshes and artificial wetlands. This species breeds in the Northern Hemisphere.	9	None – suitable habitat not present	Not applicable
Red-necked Stint *(Calidris ruficollis)*	-	Mi	The Red-necked Stint breeds in north-eastern Siberia and northern and western Alaska. It follows the East Asian-Australasian Flyway to spend the southern summer months in Australia. It is found widely in Australia, except in the arid inland. In Australia, Red-necked Stints are found on the coast, in sheltered inlets, bays, lagoons, estuaries, intertidal mudflats and protected sandy or coralline shores. They may also be seen in salt works, sewage farms, saltmarsh, shallow wetlands including lakes, swamps, riverbanks, waterholes, bore drains, dams, soaks and pools in salt flats, flooded paddocks or damp grasslands. They are often in dense flocks, feeding or roosting.	141	None – suitable habitat not present	Not applicable

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat requirements	Number of records	Likelihood of occurrence	Ecosystem or species credit?
Greater Sand-plover *(Charadrius leschenaultii)*	-	Mi	Entirely coastal in NSW, foraging on intertidal sand and mudflats in estuaries, roosting during high tide on sandy beaches or rocky shores.	4	None – suitable habitat not present	Not applicable
Lesser Sand-plover *(Charadrius mongolus)*	-	Mi	Favours coastal areas including beaches, mudflats and mangroves where they forage. They may be seen roosting during high tide on sandy beaches or rocky shores.	4	None – suitable habitat not present	Not applicable
Oriental Cuckoo *(Cuculus optatus)*	-	Mi	It mainly inhabits forests, occurring in coniferous, deciduous and mixed forest. It feeds mainly on insects and their larvae, foraging for them in trees and bushes as well as on the ground.	-	None – suitable habitat not present. No records in locality	Not applicable
Latham's Snipe *(Gallinago hardwickii)*	-	Mi	A variety of permanent and ephemeral wetlands, preferring open fresh water wetlands with nearby cover. Occupies a variety of vegetation around wetlands including wetland grasses and open wooded swamps.	9	None – suitable habitat not present	Not applicable
Sooty Oystercatcher *(Haematopus fuliginosus)*	-	Mi	A coastal species that inhabits rock coastlines, coral cays, reefs and occasionally sandy beaches.	1	None – suitable habitat not present	Not applicable
Pied Oystercatcher *(Haematopus longirostris)*	-	Mi	Roosts and forages on sandy beaches, sand banks, mudflats and estuaries.	4	None – suitable habitat not present	Not applicable
White-bellied Sea-Eagle *(Haliaeetus leucogaster)*	-	Mi	Forages over large open fresh or saline waterbodies, coastal seas and open terrestrial areas. Breeding habitat consists of tall trees, mangroves, cliffs, rocky outcrops, silts, caves and crevices and is located along the coast or major rivers. Breeding habitat is usually in or close to water, but may occur up to a kilometre away.	25	None – suitable habitat not present	Not applicable
White-throated Needletail *(Hirundapus caudacutus)*	-	Mi	Forages aerially over a variety of habitats usually over coastal and mountain areas, most likely with a preference for wooded areas. Has been observed roosting in dense foliage of canopy trees, and may seek refuge in tree hollows in inclement weather.	4	None – suitable habitat not present	Not applicable
Caspian tern *(Hydrophone caspia)*	-	Mi	The Caspian Tern is mostly found in sheltered coastal embayment's (harbours, lagoons, inlets, bays, estuaries and river deltas) and those with sandy or muddy margins are preferred. They also occur on near-coastal or inland terrestrial wetlands that are either fresh or saline, especially lakes (including ephemeral lakes), waterholes, reservoirs, rivers and creeks. They also use artificial wetlands, including reservoirs, sewage ponds and salt works.	3	None – suitable habitat not present	Not applicable

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat requirements	Number of records	Likelihood of occurrence	Ecosystem or species credit?
Broad-billed Sandpipe *(Limicola falcinellus)*	V	Mi	It breeds in northern Siberia before migrating southwards in winter to Australia on the northern coast, particularly in the north-west, with birds located occasionally on the southern coast. In NSW, the main site for the species is the Hunter River estuary, with birds occasionally reaching the Shoalhaven estuary. Broad-billed Sandpipers favour sheltered parts of the coast such as estuarine sandflats and mudflats, harbours, embayment's, lagoons, saltmarshes and reefs as feeding and roosting habitat.	2	None – suitable habitat not present	Not applicable
Bar-tailed Godwit *(Limosa lapponica)*	-	Mi	Mainly coastal, usually sheltered bays, estuaries and lagoons with large intertidal mudflats or sandflats. Breeds in Northern Russia, Scandinavia, NW Alaska.	165	None – suitable habitat not present	Not applicable
Black-tailed Godwit *(Limosa limosa)*	-	Mi	Primarily found along the coast on sand spits, lagoons and mudflats. The species has also been found to occur inland on mudflats or shallow receding waters of portions of large muddy swamps or lakes.	6	None – suitable habitat not present	Not applicable
Rainbow Bee-eater *(Merops ornatus)*	-	Mi	Resident in coastal and subcoastal northern Australia; regular breeding migrant in southern Australia, arriving September to October, departing February to March. Occurs in open country, chiefly at suitable breeding places in areas of sandy or loamy soil: sand-ridges, riverbanks, road-cuttings, sand-pits, occasionally coastal cliffs.	-	None – suitable habitat not present. No records in locality	Not applicable
Black-faced Monarch *(Monarcha melanopsis)*	-	Mi	Occurs in rainforest and eucalypt forests, feeding in tangled understorey.	-	None – suitable habitat not present. No records in locality	Not applicable
Spectacled Monarch *(Monarcha melanopsis)*	-	Mi	Occurs in rainforest and eucalypt forests, feeding in tangled understorey.	-	None – suitable habitat not present. No records in locality	Not applicable
Yellow Wagtail *(Motacilla flava)*	-	Mi	An insectivorous bird, inhabiting open country near water, such as wet meadows. It nests in tussocks.	-	None – suitable habitat not present. No records in locality	Not applicable
Satin Flycatcher *(Myiagra cyanoleuca)*	-	Mi	Occurs in wet, dense forest, often at high elevations.	-	None – suitable habitat not present. No records in locality	Not applicable
Eastern Curlew *(Numenius madagascariensis)*	-	CE	Intertidal coastal mudflats, coastal lagoons, sandy spits. Breeds in Russia and north-east China.	3	None – suitable habitat not present	Not applicable

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat requirements	Number of records	Likelihood of occurrence	Ecosystem or species credit?
Little Curlew *(Numenius minutus)*	-	Mi	The Little Curlew is known to breed in Siberia, with migrants arriving after early April. Southern migration begins in September following the Chinese coast and, after a staging in Mongolia, continues to Northern Australia and New Guinea. Outside of the breeding season, the species inhabits grasslands, open plains, parklands and mud-flats of Northern Australia.	2	None – suitable habitat not present	Not applicable
Whimbrel *(Numenius phaeopus)*	-	Mi	Known to occur in intertidal coastal mudflats, river deltas and mangrove and occasionally at sandy beaches. It breeds in Siberia and Alaska.	1	None – suitable habitat not present	Not applicable
Pacific Golden Plover *(Pluvialis fulva)*	-	Mi	The Pacific Golden Plover breeds in North Siberia and Alaska. It occurs mainly in coastal areas, at beaches, mudflats, sandflats and other open areas such as recreational playing fields in Australia.	38	None – suitable habitat not present	Not applicable
Rufous Fantail *(Rhipidura rufifrons)*	-	Mi	Summer breeding migrant to south-eastern Australia. The Rufous Fantail is found in rainforest, dense wet eucalypt and monsoon forests, paperbark and mangrove swamps and riverside vegetation. Open country may be used by the Rufous Fantail during migration.	-	None – suitable habitat not present. No records in locality	Not applicable
Common Tern *(Sterna hirundo)*	-	Mi	Common Terns are marine, pelagic and coastal. In Australia, they are recorded in all marine zones, but are commonly observed in near-coastal waters, both on ocean beaches, platforms and headlands and in sheltered waters, such as bays, harbours and estuaries with muddy, sandy or rocky shores.	15	None – suitable habitat not present	Not applicable
Little Tern *(Sternula albifrons)*	E	Mi	The Little Tern is almost exclusively coastal, preferring sheltered areas. However, it may occur several kilometres inland in harbours, inlets and rivers. Australian birds breed on sandy beaches and sand spits.	30	None – suitable habitat not present	Species Land within 40 m of inshore coastal waters or shallow waters of estuaries, coastal lagoons and/or lakes)
Grey-tailed Tattler *(Tringa brevipes)*	-	Mi	The Grey-tailed Tattler is found on sheltered coasts with reefs and rock platforms or with intertidal mudflats. It can also be found at intertidal rocky, coral or stony reefs as well as platforms and islets that are exposed at low tide.	3	None – suitable habitat not present	Not applicable
Wood Sandpiper *(Tringa glareola)*	-	Mi	The Wood Sandpiper uses well-vegetated, shallow, freshwater wetlands, such as swamps, billabongs, lakes, pools and waterholes. They are typically associated with emergent, aquatic plants or grass, and dominated by taller fringing vegetation, such as dense stands of rushes or reeds, shrubs, or dead or live trees, especially Melaleuca and River Red Gums.	2	None – suitable habitat not present	Not applicable

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat requirements	Number of records	Likelihood of occurrence	Ecosystem or species credit?
Common Greenshank *(Tringa nebularia)*	-	Mi	Found in a wide variety of inland wetlands and sheltered coastal habitats of varying salinity. It occurs in sheltered coastal habitats, typically with large mudflats and saltmarsh, mangroves or seagrass. Habitats include embayment's, harbours, river estuaries, deltas and lagoons and are recorded less often in round tidal pools, rock-flats and rock platforms.	2	None – suitable habitat not present	Not applicable
Marsh Sandpiper *(Tringa stagnatilis)*	-	Mi	The Marsh Sandpiper occurs in coastal areas, in permanent or ephemeral wetlands of varying degrees of salinity, commonly inland. It breeds in Eastern Europe to Eastern Siberia and migrates to Australia during the northern hemisphere winter months.	2	None – suitable habitat not present	Not applicable
Terek Sandpiper *Xenus cinereus*	V	Mi	In Australia, it has been recorded on coastal mudflats, lagoons, creeks and estuaries. Favours mudbanks and sandbanks located near mangroves, but may also be observed on rocky pools and reefs, and occasionally up to 10 km inland around brackish pools.	4	None – suitable habitat not present	Ecosystem

Annexure B – Species recorded

Table B.1: Flora species recorded during the field surveys.

Species Name	**Common Name**	**Noxious Weed Status**
Native		
^*Acacia baileyana*	Cootamundra Wattle	
^*Acacia longifolia* subsp. *sophorae*	Coastal Wattle	
^*Acacia saligna*	Golden Wreath Wattle	
Alisma plantago-aquatica	Water Plantain	
Angophora costata	Smooth-bark Apple	
Banksia integrifolia	Coast Banksia	
^*Callistemon citrinus*	Crimson Bottlebrush	
Casuarina glauca	Swamp Oak	
^*Corymbia maculata*	Spotted Gum	
Cyathea cooperi	Australian Tree Fern	
^*Cynodon dactylon*	Couch	
Dianella sp.	Blue Flax Lily	
^*Eucalyptus pilularis*	Blackbutt	
Eucalyptus resinifera?	Red Mahogany	
Eucalyptus sp.	Eucalypt	
^*Eucalyptus* spp. *(planted)*	Eucalypt	
^*Ficus* sp.	Fig Tree	
^*Grevillea robusta*	Southern Silky Oak	
Juncus usitatus	Common Rush	
Lomandra longifolia	Spiny-headed Mat-rush	
^*Melaleuca quinquenervia*	Broad-leaved Paperbark	
Pittosporum undulatum	Sweet Pittosporum	
Psilotum nudum	Skeleton Fork-Fern	
Pteridium esculentum	Bracken	
^*Typha orientalis*	Cumbungi	
Exotic		
**Acetosa sagittata*	Turkey Rhubarb	
**Ageratina adenophora*	Crofton Weed	
**Andropogon virginicus*	Whiskey Grass	
**Anredera cordifolia*	Madeira Vine	WoNS
**Asparagus asparagoides*	Bridal Creeper	Class 5. WoNS

Species Name	Common Name	Noxious Weed Status
**Axonopus fissifolius*	Common Carpetgrass	
**Bidens pilosa*	Cobblers Peg	
**Briza maxima*	Quaking Grass	
**Celtis occidentalis*	Hackberry	
**Cenchrus echinatus*	Spiny Burr Grass	Class 5
**Cestrum parqui*	Green Cestrum	Class 3
**Chenopodium ambrosioides*	Wormseed	
**Chloris gayana*	Rhodes Grass	
**Cinnamomum camphora*	Camphor Laurel	
**Conyza* sp.	Fuzzweed	
**Cortaderia selloana*	Pampas Grass	Class 4
**Cotoneaster glaucophyllus*	Cotoneaster	
**Cyperus eragrostis*	Umbrella Sedge	
**Digitaria* sp.		
**Ehrharta erecta*	Panic Veldtgrass	
**Eragrostis curvula*	African Love Grass	
**Foeniculum vulgare*	Fennel	
**Fumaria* sp.	Common Fumitory	
**Gleditsia triacanthos*	Honey Locus	
**Gomphocarpus fruticosus*	Narrow-leaved Cotton Bush	
**Hypochaeris radicata*	Catsear	
**Ipomoea indica*	Morning Glory	
**Lantana camara*	Lantana	WoNS
**Ligustrum lucidum*	Large-leaved Privet	Class 4
**Ligustrum sinense*	Small-leaved Privet	Class 4
**Lolium* sp.	Rye Grass	
**Medicago* sp.	Medic	
**Melinis repens*	Red Natal Grass	
**Modiola caroliniana*	Red-flowered Mallow	
**Olea europaea*	African Olive	
**Oxalis* sp.	Oxalis	Class 5
**Panicum maximum*	Guinea Grass	
**Parietaria judaica*	Pellitory	Class 4
**Paspalum dilatatum*	Paspalum	
**Pennisetum clandestinum*	Kikuyu	

Species Name	Common Name	Noxious Weed Status
**Pennisetum alopecuroides*	Swamp Foxtail	
**Phoenix canariensis*	Canary Island Date Palm	
**Phyllostachys aurea*	Bamboo	
**Plantago lanceolata*	Ribwort	
**Ricinus communis*	Castor Oil Plant	Class 4
**Rubus fruticosus* agg.	Blackberry	Class 4. WoNS
**Sechium edule*	Choko	
**Senna pendula*	Cassia	
**Setaria* spp.	Pigeon Grass	
**Sida rhombifolia*	Paddy's Lucerne	
**Solanum nigrum*	Blackberry Nightshade	
**Solanum* sp.		
**Sonchus oleraceus*	Common Sowthistle	
**Stellaria media*	Common Chickweed	
**Triadica sebifera*	Chinese Tallow	
**Trifolium repens*	White clover	
**Trifolium* spp.	Clover	
**Ulmus parvifolia*	Chinese Elm	
**Verbascum virgatum*	Twiggy Mullein	
**Verbena bonariensis*	Purple Tops	
**Vicia sativa* subsp. *sativa*	Common Vetch	

^ denotes a non-indigenous or planted native species

Noxious weed class for the Inner West LGA:

- Class 3 – Regionally Controlled Weed; the plant must be fully and continuously suppressed and destroyed and the plant must not be sold, propagated or knowingly distributed.
- Class 4 – Locally Controlled Weeds; that pose a threat to primary production, the environment or human health, are widely distributed in an area to which The Noxious Weeds (Weed Control) Order 2014 applies and are likely to spread in the area or to another area.
- Class 5 – The requirements in the *Noxious Weeds Act 1993* (NSW) for a notifiable weed must be complied with.
- WoNs – Weed of National Significance.

Annexure C – Secretary's Environmental Assessment Requirements for Biodiversity and Department of Primary Industries requirements

Table 12.1 The Secretary's Environmental Assessment Requirements (SEARs) for biodiversity. Extracted from the SEARs for the project (SSI 16_7485) and are detailed in the EIS.

Key Issue and desired performance outcome	Requirement (specific assessment requirements in addition to the general requirements)	Current guidelines
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*. 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 OEH. Species specific surveys shall be undertaken for those species and in accordance with the survey requirements specified by the OEH. 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 *Environmental Protection and Biodiversity Conservation Act 2000* (EPBC Act).	NSW Biodiversity Offsets Policy for Major Projects (OEH, 2014) Framework for Biodiversity Assessment (OEH, 2014) Policy and Guidelines for Fish Habitat Conservation and Management – Update 2013 (DPI, 2013) Threatened Species Survey and Assessment Guidelines (DEC 2004) Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings (NSW Fisheries, 2003) NSW Sustainable Design Guidelines Version 3.0 (Transport for NSW, 2013) Aquatic Ecology in Environmental Impact Assessment – EIA Guideline (Marcus Lincoln Smith 2003)

Table 12.2 Department of Primary Industries (DPI) (Water and Fisheries) requirements for the SEARs in relation to biodiversity. Extracted from the DPI request for SEARs requirements.

Key Issue and desired performance outcome	Requirement (specific assessment requirements in addition to the general requirements)	Current guidelines
DPI Water (requirements relating to the BAR). NB: Other requirements from DPI Water, not outlined here are provided elsewhere in the EIS	**Groundwater Dependent Ecosystems** The EIS must consider the potential impacts on any Groundwater Dependent Ecosystems (GDEs) at the site and in the vicinity of the site and: · Identify any potential impacts on GDEs as a result of the proposal including: o the effect of the proposal on the recharge to groundwater systems; o the potential to adversely affect the water quality of the underlying groundwater system and adjoining groundwater systems in hydraulic connections; and o the effect on the function of GDEs (habitat, groundwater levels, connectivity) · Provide safeguard measures for any GDEs. **Watercourses, Wetlands and Riparian Land** The EIS should address the potential impacts of the project on all watercourses likely to be affected by the project, existing riparian vegetation and the rehabilitation of riparian land. It is recommended the EIS provides details on all watercourses potentially affected by the proposal, including: · Scaled plans showing the location of: o wetlands/swamps, watercourses and top of bank; o riparian corridor widths to be established along the creeks; o existing riparian vegetation surrounding the watercourses (identify any areas to be protected and any riparian vegetation proposed to be removed); o the site boundary, the footprint of the proposal in relation to the watercourses and riparian areas; and o proposed location of any asset protection zones. · Photographs of the watercourses / wetlands and a map showing the point from which the photos were taken. · A detailed description of all potential impacts on the watercourses/riparian land. · A detailed description of all potential impacts on the wetlands, including potential impacts to the wetlands hydrologic regime; groundwater recharge; habitat and any species that depend on the wetlands. · A description of the design features & measures to be incorporated to mitigate potential impacts. · Geomorphic and hydrological assessment of water courses including details of stream order (Strahler System), river style and energy regimes both in channel and on adjacent floodplains.	NSW Guidelines for Controlled Activities on Waterfront Land (NOW, 2012) NSW Aquifer Interference Policy (NOW, 2012) Risk Assessment Guidelines for Groundwater Dependent Ecosystems (NOW, 2012) Australian Groundwater Modelling Guidelines (NWC, 2012) The NSW State Rivers and Estuaries Policy (1993) NSW Wetlands Policy (2010) NSW State Groundwater Policy Framework Document (1997) NSW State Groundwater Quality Protection Policy (1998) NSW State Groundwater Dependent Ecosystems Policy (2002) NSW Water Extraction Monitoring Policy (2007)

DPI Fisheries (requirements relating to the BAR). **NB: Other requirements from DPI Fisheries, not outlined here are provided elsewhere in the EIS**	**General Requirements** · Site address and contact details. · Property description (eg Lot and DP numbers). · A clear description of the proposal including details of construction methods and materials. · Map(s) of the development area and adjacent areas - this should include nearby waterways, adjacent infrastructure (such as jetties) and land use. · Clear photographs of the site (at low and high tide in estuaries), including photographs of any riparian and aquatic vegetation present (including pest species such as *Caulerpa taxifolia*). · A clear description of the physical and hydrological features of the development area (which may extend upstream and downstream of the development site in the case of flowing rivers or tidal waterways). · A clear description of aquatic environments including: o an aquatic and riparian vegetation survey map (where relevant) of the area which shows the location and/or coverage of saltmarsh, mangrove, seagrass, macroalgae, macrophytes, riparian vegetation and snags, · Details of the nature, timing, magnitude and duration of the proposed disturbance to the aquatic environment. · Assessments of predicted impacts upon any threatened species (fish and marine vegetation) (i.e. completion of a 7-part test and/or species impact statement(s)) and other aquatic flora and fauna. · Details of any mitigation measures to limit environmental impacts. · Details of the general regional context, any protected areas, other developments in the area, and/or cumulative impacts. · A copy of the land owner's consent where relevant. · Notification of any other matters relevant to the particular proposal and of interest to NSW DPI.	

Annexure D – Anabat survey results

METHODS

Two anabats ultrasonic call recorders (anabat) were set over two consecutive nights between the 21 and 22 September 2016. Each anabat was programed to record microbat calls across the entire night beginning at 5.30 pm and ceasing at 6.00 am the next morning. The overall survey effort was four anabat-survey nights. Each anabat was set to survey a particular habitat type as described below:

- B32RRG – Vegetated rock wall and vegetated drainage line.
- SN81147 –Victoria Road bridge.
- SN81997 – Mostly un-vegetated rock wall, well-lit area near large shed and crib rooms.
- SN81781 – Underground cement culvert that water flowing in the vegetation drainage line flows into.

Additional early evening surveys were undertaken to confirm that the high levels of activity among *Miniopterus schreibersii oceanensis* (Eastern Bentwing-bat) obtained during the initial anabat survey, was not a random event. This involved anabat units being set to record beneath the Victoria Road bridge between 6.30pm and 7.45am on 27 September 2016. A visual assessment of the structures below the bridge was undertaken during the day and at night to determine the likelihood of microbats (in particular the cave and culvert dwelling Eastern Bentwing-bat) roosting there and to watch for bats as they enter or leave these potential roosts.

Data analysis

Bat calls were analysed by Dr Rodney Armistead using the program AnalookW (Version 3.8 25 October 2012, written by Chris Corben, www.hoarybat.com). Call identifications were made using regional based guides to the echolocation calls of microbats in New South Wales (Pennay et al. 2004); and south-east Queensland and north-east New South Wales (Reinhold et al. 2001) and the accompanying reference library of over 200 calls from north-eastern NSW. Available at http://www.forest.nsw.gov.au/research/bats/default.asp.

Bat calls are analysed using species-specific parameters of the call profile such as call shape, characteristic frequency, initial slope and time between calls (Rinehold et al. 2001). To ensure reliable and accurate results the following protocols (adapted from Lloyd et. al. 2006) were followed:

- Search phase calls were used in the analysis, rather than cruise phase calls or feeding buzzes (McKenzie et al. 2002).
- Recordings containing less than three pulses were not analysed and these sequences were labelled as short (Law et al. 1999).
- Four categories of confidence in species identification were used (Mills et al. 1996):
  - definite – identity not in doubt
  - probable – low probability of confusion with species of similar calls
  - possible – medium to high probability of confusion with species with similar calls
  - unidentifiable – calls made by bats which cannot be identified to even a species group.
- *Nyctophilus* spp. are difficult to identify confidently from their calls and no attempt was made to identify this genus to species level (Pennay et al. 2004).
- Sequences not attributed to microbat echolocation calls were labelled as junk or non-bat calls and don't represent microbat activity at the site.
- Sequences labelled as low were of poor quality and therefore not able to be identified to any microbat species, they can however be used as an indicator of microbat activity at the site.

RESULTS

There were 210 sequences recorded on the four anabat detectors. Of these, 160 (76.19%) were of sufficient quality or length to enable positive identified to genus or species. The remaining sequence were either to short or of low quality, thus preventing positive identification.

There were at least five microbat species identified in this survey, including two species listed as vulnerable under the *Threatened Species Conservation Act 1995* (TSC Act) (Table D.1 – Table D.7). The two threatened species that were recorded during this survey:

- Miniopterus schreibersii oceanensis (Eastern Bentwing-bat)
- Saccolaimus flaviventris (Yellow-bellied Sheathtail Bat)

The species diversity was similar across all survey sites, with at least two species being recorded at each site (Table D.1). The most commonly recorded species was the threatened Eastern Bentwing-bat (Table D.2 – Table D.7). This species was recorded at three of the four survey sites. Very high levels of activity among Eastern Bentwing-bats was recorded at the Victoria Road bridge (Table D.3, Table D.6 and Table D.7).

The high levels of activity among Eastern Bentwing-bats witnessed during the initial surveys were supported during the early evening surveys conducted on the 27 September 2016. The high level of activity will be confirmed over subsequent surveys. Roosting among Eastern Bentwing-bats primarily occurs in caves, mines, culverts, stormwater channels, buildings, and occasionally tree-hollows (Hall et al. 2008). According to the anabat data recorded over the three survey periods undertaken at the bridge, activity among this species begun at dusk, continued throughout the evening and into the early morning. This does not provide conclusive evidence that this species is roosting in the bridge, but strongly suggest that it is likely. Indeed, the visual assessment of the bridge identified several small openings of suitable diameter (approximately 200 mm across) to allow Eastern Bentwing-bats to enter, roost and leave. The depth of these structures could not be determined. Further surveys involving an internal investigation (eg burrow-scope) of these structures will be required to provide conclusive evidence that bats are roosting beneath the bridge.

Further, whilst conducting this visual assessment, several Eastern Bentwing-bats were observed flying rapidly beneath the bridge and among the nearby vegetation. Identification of the flying microbats was made after analysing calls recorded on a hand held anabat. It is possible that, in addition to these microbats roosting below the bridge, they are using it as a fly-way to avoid the well-lit road and pedestrian footpath above the bridge. Previous research has shown that microbat could avoid areas lit by artificial street lights because of the following reasons:

- Artificial light could reduce a microbats ability to capture prey because it interferes with their ultrasonic-navigation systems.
- Artificial light increases the ambient temperatures surrounding the light source, that could enhance insect activity (movement and manoeuvrability, rather than densities), making them more difficult for the microbats to capture them.
- Artificial light could affect a microbats perception of being predated upon.

These reasons, in isolation and collectively, could encourage microbats to forage elsewhere in the landscape, away from the artificial lighting, such as the area below the Victoria Road bridge (Linley 2015).

Activity

Activity levels were spread across the night with the majority of the bat activity occurring in the evening and early mornings. Generally, single bat calls were recorded every five minutes across the three sites. The greatest level of activity was recorded at Victoria Road bridge with the numerous Eastern Bentwing-bat calls previously discussed (Table D.3).

Most of the bat calls that were recorded during this survey were clear, often long and easily interpreted. A few feeding buzzes were observed in the data set, indicating that bats were also likely to be actively foraging at the site.

Survey Limitations

Calls were only positively identified when defining characteristics were present such as call shape and when the characteristic frequency allowed discrimination of a species. In this survey, there were only a small number of species with similar call profile that could not be positively identify to species level. Where this was apparent, species with similar call profiles were lumped together into groups of two or three potential species depending on the recorded, and defining all call characteristics. When this occurred these calls were assigned to the lowest certainty level of 'possible' (Table D.1 – Table D.3).

The calls of and Eastern Bentwing-bat and *Vespadelus regulus* (Southern Forest Bat) can be difficult to separate in the range 43.5 – 46 kHz. Alternatively, calls with curved, often down sweeping tails were generally identified as Eastern Bentwing-bat. Alternatively, those calls with even consecutive pulses were identified as being from Southern Forest Bat (Penny et al. 2004). When no distinguishing characteristics were present within the calls, they were assigned as Southern Forest Bat / Eastern Bentwing-bat.

No Southern Forest Bat were recorded, all of these calls were identified as Eastern Bentwing-bat
The call profiles that were difficult to separate are not shown in this document as all of the species discussed were positively identified.

Table D.1: Microbat species diversity recorded during the Rozelle survey between 30 March and 10 April 2016

Species Name	Common Name	B3266RG Rock wall		SN81147 Victoria Road bridge		SN81997 Rock wall		SN81781 Culvert	
		Positive	Possibly	Positive	Possibly	Positive	Possibly	Positive	Possibly
Austronomus australis	White-striped Freetail Bat	X		X					
Chalinolobus gouldii	Gould's Wattled Bat						X		X
*Miniopterus schreibersii (orianae) oceanensis**	Eastern Bentwing-bat			X		X			X
Rhinolophus megaphyllus	Eastern Horseshoe Bat				X				
*Saccolaimus flaviventris**	Yellow-bellied Sheathtail Bat		X		X				X
Species Diversity (Positive identification)		**1**		**2**		**1**		**1**	
Species Diversity (Possible)			**1**		**2**		**1**		**2**
Total (at least) number of species		**2**		**4**		**2**		**3**	

* Threatened species listed under TSC Act

[1] Threatened species listed under the EPBC Act

Table D.2: Anabat results for B3266RG located near rock wall across the 21 and 22 September 2016 (two survey nights)

Species Name	Common name	Positive	Potential	Possible	Total
Austronomus australis	White-striped Free-tailed Bat	2	2	0	4
Saccolaimus flaviventris	Yellow-bellied Sheathtailbat	0	4	0	4
Low					**2**
Short					**0**
Useable calls					**8**
Total Calls					**9**
Percentage usable calls					**88.89**

* Threatened species

Table D.3: Anabat results for SN81147 located near Victoria Road bridge between 21 and 22 September 2016 (two survey nights)

Species Name	Common name	Positive	Potential	Possible	Total
Austronomus australis	White-striped Free-tailed Bat	1	6	3	10
Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	102	2	0	104
Rhinolophus megaphyllus	Eastern Horseshoe Bat	0	1	0	1
Saccolaimus flaviventris	Yellow-bellied Sheathtail-bat	0	4	0	4
Low					**23**
Short					**13**
Useable calls					**119**
Total Calls					**155**
Percentage usable calls					**76.77**

* Threatened species

Table D.4: Anabat results for SN81781 near a cement underground culvert across 21 and 22 September 2016 (two survey nights)

Species Name	Common name	Positive	Potential	Possible	Total
Chalinolobus gouldii	Goulds Wattled Bat	0	0	1	1
*Miniopterus schreibersii (orianae) oceanensis***	Eastern Bentwing-bat	16	5	0	21
Low					2
Short					1
Useable calls					**22**
Total Calls					**25**
Percentage usable calls					**88**

* Threatened species

Table D.5: Anabat results for SN81997 near rock wall near site office between 21 and 22 September 2016 (two survey nights)

Species Name	Common name	Positive	Potential	Possible	Total
Chalinolobus gouldii	Gould's Wattled Bat	1	2	0	3
Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	0	1	1	2
Saccolaimus flaviventris	Yellow-bellied Sheathtail-bat	0	0	7	7
Low					**9**
Short					**0**
Useable calls					**12**
Total Calls					**21**
Percentage usable calls					**57.14**

* Threatened species

Table D.6: Results of short term assessment undertaken at the bridge between 1830 and 1945 on 27 September using SN81081

Species Name	Common name	Positive	Potential	Possible	Total
Austronomus australis	White-striped Free-tailed Bat	0	1	0	1
Miniopterus orianae oceanensis	Eastern Bentwing-bat	40	0	0	40
*Saccolaimus flaviventris**	Yellow-bellied Sheathtail-bat	1	0	1	2
Low					**3**
Short					**0**
Useable calls					**43**
Total Calls					**46**
Percentage usable calls					**93.47**

* Threatened species

Table D.7: Results of short term assessment undertaken at the bridge between 1830 and 1945 on 27 September using SN81147

Species Name	Common name	Positive	Potential	Possible	Total
Miniopterus orianae oceanensis	Eastern Bentwing-bat	12	0	1	13
*Saccolaimus flaviventris**	Yellow-bellied Sheathtail-bat	0	0	2	2
Low					**0**
Short					**0**
Useable calls					**15**
Total Calls					**15**
Percentage usable calls					**100**

* Threatened species

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Annexure E – EPBC Act Significant Impact Criteria

The EPBC Act establishes a process for assessing the environmental impact of activities and developments where "Matters of national environmental significance" (MNES) may be affected. Under the Act, any action which "has, will have, or is likely to have a significant impact on a MNES" is defined as a "controlled action", and requires approval from the Commonwealth Department of the Environment and Energy (DotEE), which is responsible for administering the EPBC Act (DotEE 2013).

The process includes conducting an Assessment of Significance for listed threatened species and ecological communities that represent a matter of NES that will be impacted as a result of the proposed action. Significant impact guidelines (DotEE 2013) that outline a number of criteria have been developed by the Commonwealth, to provide assistance in conducting the Assessment of Significance and help decide whether or not a referral to the Commonwealth is required.

The threatened ecological values that are the subject this assessment include:

- Pteropus poliocephalus (Grey-headed Flying-fox)

Pteropus poliocephalus (Grey-headed Flying-fox)

The Grey-headed Flying-fox is listed as a vulnerable threatened species under the EPBC Act. This species utilises a wide variety of habitats (including disturbed areas) for foraging, and have been recorded travelling long distances on feeding forays. Fruits and flowering plants of a wide variety of species are the main food source. The species roosts in large 'camps' of up to 200 000 individuals. Camps are usually formed close to water and along gullies, however, the species has been known to form camps in urban areas (DotEE 2016a).

Grey-headed Flying Fox has not been recorded on site but is known from within close proximity to the study area. The vegetation within the study area provides marginal potential foraging habitat in the form of individual Fig Trees (*Ficus* sp.) and limited flowering eucalyptus (planted street scapes). It is considered likely that this species would use the site and adjacent areas on occasion for foraging purposes. No roosting camps are located within the site.

Criterion a: lead to a long-term decrease in the size of an important population of a species

The population of Grey-headed Flying-fox within Australia is considered to be a single important population. However, the site does not support key resources for the important population for breeding or dispersal, or support resources necessary to maintain genetic diversity. Furthermore, the site is not at the limit of the species range or distribution.

Criterion b: reduce the area of occupancy of an important population

The population of Grey-headed Flying-fox within Australia is considered to be a single important population. However, the works are not considered to reduce the area of occupancy, as there will not be any impacts to a roosting camp, nor any impacts to important habitat for the species.

Criterion c: fragment an existing important population into two or more populations

The vegetation (foraging habitat) to be impacted by the works occurs within and on the edge of the subject site. Potential foraging habitat for this species is abundant throughout the locality, and the species is known to travel large distances for food sources. Whilst the habitat may contribute as a 'stepping stone' for this highly mobile species to other more substantial foraging habitat sites, this function is unlikely to be significantly inhibited by the works. Furthermore, this species has been recorded in urban environments and is likely to continue to forage adjacent to the site and across the broader locality. Therefore, the works will not fragment an existing important population into two or more populations.

Criterion d: adversely affect habitat critical to the survival of a species

No breeding habitat (camps) would be impacted by the project. However, approximately 4.49 ha of potential foraging habitat consisting of individual trees will be removed.

Under the DECC (2009b) Draft National Recovery Plan for the Grey-headed Flying-fox, foraging habitat within a 50 kilometre radius of a roost site with greater than 30,000 individuals is considered foraging habitat critical to survival. The closest roosting camps to the project footprint are at Centennial Park and Turrella can vary in number of individuals present, from zero up to 50,000 individuals at the Centennial Park camp (National Flying-fox monitoring viewer; DotEE 2015). In addition, the camp at Gordon can also range between zero to 80,000 (Ku-ring-gai Council 2013). Therefore, there is foraging habitat present which meets the definition of habitat critical to the survival of the species. However, the amount of loss of habitat is not considered to be significant in terms of the regional context. From analysis of the Native Vegetation mapping GIS dataset for the Sydney Metropolitan Area (OEH 2013), more than 75,000 (and up to 93,000) hectares of native vegetation occurs within 50km of each of these camps. Noting that the dataset is limited to the Sydney Metropolitan Catchment Management Authority area, and thus does not include all of the native vegetation within 50km of these camps.

Criterion e: disrupt the breeding cycle of an important population

Whilst the Grey-headed flying-fox population within Australia is considered to be a single important population, the study area does not support ‘camps’ of flying foxes, and therefore the works which may remove up to 4.49 ha of potential foraging habitat, is not considered to disrupt the breeding cycle of an important population.

Criterion f: modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

The habitat to be removed consists of individual trees representing a negligible amount of potential foraging resources within the species foraging range. A number of areas providing potential habitat for this species are present in close proximity to the site, at nearby local parks and across the broader landscape. In consideration of the species foraging activity, widely across the landscape on a variety of vegetation, the loss of 4.49 hectares of potential foraging habitat within the project footprint is unlikely to cause a decline in the species.

Criterion g: Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species’ habitat

The proposed works will not result in the establishment of an invasive species that is harmful to the Grey-headed Flying-fox.

Criterion h: Introduce disease that may cause the species to decline

The proposed works will not result in the introduction of a disease that is harmful to the Grey-headed Flying-fox.

Criterion i: Interfere substantially with the recovery of the species

Considering the above factors, the proposed works will not interfere substantially with the recovery of the species.

Conclusion

In consideration of the above, the proposed works are not considered likely to have a significant impact on the Grey-headed Flying-fox, and therefore, an EPBC Act referral is not required.

Annexure F – FBA Methodology and where addressed in document

Table F-1: Location of FBA methodology requirements for a 'Biodiversity Assessment Report' for stages 1 and 2 and where these are addressed in this report.

Report section	Information	Maps & data	FBA reference	Section in this report
Introduction	Introduction to the biodiversity assessment including: • identification of development site footprint, including: ○ operational footprint ○ construction footprint indicating clearing associated with temporary construction facilities and infrastructure • general description of development site • sources of information used in the assessment, including reports and spatial data.	• Site Map (as described in Section 3.2) • Location Map (as described in Section 3.2) • Digital shape files for all maps and spatial data	Chapter 3 and Section 3.2	Chapter 1 – Introduction and Chapter 2 – The project
Landscape features	Identification of landscape features at the development site, including: • IBRA bioregions and subregions, NSW landscape region and area (ha) • native vegetation extent in the outer assessment circle or buffer area • cleared areas • evidence to support differences between mapped vegetation extent and aerial imagery • rivers and streams classified according to stream order • wetlands within, adjacent to and downstream of development site • landscape value score components, including: ○ identification of method applied (ie linear or site-based) ○ per cent native vegetation cover in the landscape ○ connectivity value ○ patch size ○ area to perimeter ration • landscape value score.	• IBRA bioregions and subregions (as described in Paragraphs 4.1.1.3–4) • NSW landscape regions (as described in Paragraphs 4.1.1.5– 6) • Rivers and streams (as described in Paragraphs 4.1.1.8–10 • Wetlands (as described in Paragraphs 4.1.1.11–13) • Other landscape features (as required by SEARs) • Native vegetation extent (as described in Paragraphs 4.1.1.12–15) • State, regional and local biodiversity links (as described in Paragraphs 4.1.1.16–17) • Regional vegetation used to calculate patch size	Section 4.1, Appendix 4 and Appendix 5	Chapter 3 – Landscape features

Report section	Information	Maps & data	FBA reference	Section in this report
Native vegetation	Identify native vegetation extent within the development site, including cleared areas and evidence to support differences between mapped vegetation extent and aerial imagery. Describe PCTs within the development site, including: • vegetation class • vegetation type • area (ha) for each vegetation type • species relied upon for identification of vegetation type and relative abundance • justification of evidence used to identify a PCT (as outlined in Paragraph 5.2.1.8) • EEC status (as outlined in Subsection 5.2.1) • estimate of per cent cleared value of PCT. Describe vegetation zones within the development site, including: • condition class and subcategory (where relevant) • area (ha) for each vegetation zone • survey effort as described in Paragraphs 5.2.1.5–7 (number of plots/transects). Where use of local data is proposed: • identify relevant vegetation type • identify source of information for local benchmark data • justify use of local data in preference to database values.	• Map of native vegetation extent within the development site (as described in Section 5.1) • Map of PCTs within the development site • Map of condition class and subcategory (where relevant) • Map of plot and transect locations relative to PCTs and condition class • Map of EECs • Plot and transect field data (MS Excel format) • Plot and transect field data sheets • Table of current site value scores for each vegetation zone within the development site • Map of vegetation zones with a current site value score of <17.	Chapter 5	Chapter 4 – Native vegetation and Annexure B for flora species list

Report section	Information	Maps & data	FBA reference	Section in this report
Threatened species	Identify ecosystem credit species associated with PCTs on the development site as outlined in Section 6.3, including: • list of species derived • justification for exclusion of any ecosystem credit species predicted above. Identify species credit species on the development site as outlined in Sections 6.5 and 6.6, including: • list of candidate species • justification for inclusions and exclusions based on habitat features • indication of presence based on targeted survey or expert report • details of targeted survey technique, effort, timing and weather • species polygons • species that cannot withstand a further loss. Where use of local data is proposed: • identify relevant species or population • identify aspect of species/population data • identify source of information for local data • justify use of local data in preference to database values. Where expert reports are used in place of targeted survey: • identify the relevant species or population • justify the use of an expert report • indicate and justify the likelihood of presence of the species or population and information considered in making this assessment • estimate the number of individuals or area of habitat (whichever unit of measurement applies to the species/individual) for the development site, including a description of how the estimate was made • identify the expert and provide evidence of their expert credentials.	• Table of vegetation zones and landscape Tg values, particularly indicating where these have changed due to species exclusion • Targeted survey locations • Table detailing the list of species credit species and presence status on site as determined by targeted survey, indicating also where presence was assumed and/or where presence was determined by expert report • Species credit species polygons (as described in Paragraph 6.5.1.19) • Table detailing species and habitat feature/component associated with species and its abundance on site (as described in Paragraph 6.5.1.19) • Species polygons for species that cannot withstand a loss	Chapter 6	Chapter 5 – Threatened Species Annexure A – Habitat assessment table and likelihood of occurrence for threatened species. Annexure B – Fauna species list

Report section	Information	Maps & data	FBA reference	Section in this report
Avoid and minimise impacts	Demonstration of efforts to avoid and minimise impact on biodiversity values in accordance with Section 8.3. Identification of final project footprint during construction and operation in accordance with Subsection 8.3.3. Assessment of direct and indirect impacts unable to be avoided at the development site in accordance with Sections 8.3 and 8.4. The assessment would include but not be limited to: type, frequency, intensity, duration and consequence of impact. Statement of onsite measures proposed to avoid and minimise direct and indirect impacts of the Major Project.	• Table of measures to be implemented before, during and after construction to avoid and minimise the impacts of the project, including action, outcome, timing and responsibility • Map of final project footprint, including construction and operation • Maps demonstrating indirect impact zones where applicable	Chapter 8	Chapter 8 – Avoidance, mitigation, and impacts
Impact summary	Identification of areas not requiring assessment in accordance with Section 9.5. Identification of areas not requiring offset in accordance with Section 9.4. Identification of PCTs and species polygons requiring offset in accordance with Section 9.3. Identification of impacts that require further consideration in accordance with Section 9.2, including: • the entity and/or impact for which further consideration is necessary • supporting information relevant to the impact, as outlined in Subsection 9.2.2. Ecosystem credits and species credits that measure the impact of the Major Project on biodiversity values at the development site, including: • future site value score for each vegetation zone at the development site • change in landscape value score • number of required ecosystem credits for the impact of development on each vegetation zone at the development site • number of required species credits for the impact of development on each threatened species that occurs on the development site.	• Map of areas not requiring assessment • Map of PCTs and species polygons not requiring offset • Map of PCTs and species polygons requiring offset • Map of the occurrence of the entity or impact that requires further consideration • Table of PCTs requiring offset and the number of ecosystem credits required • Table of species and populations requiring offset and the number of species credits required • Full biodiversity Credit Calculator output • Submitted proposal in the Credit Calculator	Chapter 9 Subsections 10.4.3 and 10.4.4	Chapter 9 – Impact summary
Biodiversity credit report	Credit profiles for ecosystem credits and species credits at the development site.	• Table of credit type and matching credit profile • Biodiversity credit report from the Credit Calculator	Subsection 10.4.5	Not provided. No offsets required under FBA.

Annexure G – Arboricultural Impact Assessment

Roads and Maritime Services

WestConnex – M4-M5 Link

Technical working paper: Biodiversity impact assessment

Annexure G – Arboricultural impact assessment

August 2017

Prepared for

Roads and Maritime Services

Prepared by

Eco Logical Pty Ltd

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Glossary of terms and abbreviations

Term	Definition
Alignment	The geometric layout (eg of a road) in plan (horizontal) and elevation (vertical).
AQF	Australian Qualifications Framework
AS	Australian Standards
At-grade	A road at ground level, not on an embankment or in a cutting.
Campbell Road civil and tunnel site	A construction ancillary facility for the M4-M5 Link project at St Peters
CFFMP	Construction Flora and Fauna Management Plan
Concept design	Initial functional layout of a road/road system or other infrastructure. Used to facilitate understanding of a project, establish feasibility and provide basis for estimating and to determine further investigations needed for detailed design.
Construction	Includes all physical work required to construct the project.
Construction ancillary facilities	Temporary facilities during construction that include, but are not limited to construction sites (civil and tunnel), sediment basins, temporary water treatment plants, pre-cast yards and material stockpiles, laydown areas, parking, maintenance workshops and offices.
Darley Road civil and tunnel site	A construction ancillary facility for the M4-M5 Link project located at Leichhardt
DBH	Diameter at Breast Height
Detailed design	The phase of the project following concept design where the design is refined, and plans, specifications and estimates are produced, suitable for construction
Earthworks	All operations involved in loosening, excavating, placing, shaping and compacting soil or rock.
EIS	Environmental impact statement
ELA	Eco Logical Australia
Haberfield civil and tunnel site / Haberfield civil site	Construction ancillary facilities for the M4-M5 Link project located at Haberfield
HDD	Horizontal directional drilling
IACA	Institute of Australian Consulting Arboriculturalists
Impact	Influence or effect exerted by a project or other activity on the natural, built and community environment.
Iron Cove Link	Around one kilometre of twin tunnels that would connect Victoria Road near the eastern abutment of Iron Cove Bridge and Anzac Bridge
Iron Cove Link civil site	A construction ancillary facility for the M4-M5 Link project located at Rozelle
LGA	Local Government Area
m	Metre
mm	Millimetre
NDE	Non-destructive excavation
NO	Number
Northcote Street civil site	A construction ancillary facility for the M4-M5 Link project located at Haberfield
NSW	New South Wales
Parramatta Road East civil site	A construction ancillary facility for the M4-M5 Link project at Haberfield
Parramatta Road West civil and tunnel site	A construction ancillary facility for the M4-M5 Link project at Ashfield
Pre-construction	All work prior to, and in respect of the State Significant Infrastructure, that is excluded from the definition of construction.

Term	Definition
Project	A new multi-lane road link between the M4 East Motorway at Haberfield and the New M5 Motorway at St Peters. The project would also include an interchange at Lilyfield and Rozelle (the Rozelle interchange) and a tunnel connection between Anzac Bridge and Victoria Road, east of Iron Cove Bridge (Iron Cove Link). In addition, construction of tunnels, ramps and associated infrastructure to provide connections to the proposed future Western Harbour Tunnel and Beaches Link project would be carried out at the Rozelle interchange
Project footprint	The land required to construct and operate the project. This includes permanent operational infrastructure (including the tunnels), and land required temporarily for construction
Pyrmont Bridge Road tunnel site	A construction ancillary facility for the M4-M5 Link project at Annandale
Roads and Maritime	NSW Roads and Maritime Services
Rozelle civil and tunnel site	A construction ancillary facility for the M4-M5 Link project located at Lilyfield and Rozelle
Rozelle interchange	A new interchange at Lilyfield and Rozelle that would connect the M4-M5 Link mainline tunnels with City West Link, Anzac Bridge, the Iron Cove Link and the proposed future Western Harbour Tunnel and Beaches Link
Rozelle Rail Yards	The Rozelle Rail Yards is bound by City West Link to the south, Lilyfield Road to the north, Balmain Road to the west, and White Bay to the east. Note that the project only occupies part of the Rozelle Rail Yards site
SEARs	Secretary's Environmental Assessment Requirements. Requirements and specifications for an environmental assessment prepared by the Secretary of the Department of Planning and Environment under section 115Y of the *Environmental Planning and Assessment Act 1979* (NSW).
SP	Species
SRZ	Structural root zone
St Peters interchange	A component of the New M5 project, located at the former Alexandria Landfill site at St Peters. Approved and under construction as part of the New M5 project. Additional construction works proposed as part of the M4-M5 Link project.
STARS	Significance of a Tree Assessment Rating System
Study area	A 15 metre buffer around the project footprint that is the subject of this arboricultural assessment
The Crescent civil site	A construction ancillary facility for the M4-M5 Link project located at Annandale
TPZ	Tree protection zone
Victoria Road civil site	A construction ancillary facility for the M4-M5 Link project located at Rozelle
VTA	Visual tree assessment
Wattle Street civil and tunnel site	A construction ancillary facility for the M4-M5 Link project located at Haberfield
WestConnex program of works	A program of works that includes the M4 Widening, King Georges Road Interchange Upgrade, M4 East, New M5 and M4-M5 Link projects

1 Introduction

1.1 Project overview

NSW Roads and Maritime Services (Roads and Maritime) is seeking approval to construct and operate the WestConnex M4-M5 Link (the project), which would comprise a new multi-lane road link between the M4 East Motorway at Haberfield and the New M5 Motorway at St Peters. The project would also include an interchange at Lilyfield and Rozelle (the Rozelle interchange) and a tunnel connection between Anzac Bridge and Victoria Road, east of the Iron Cove Bridge (Iron Cove Link). In addition, construction of tunnels, ramps and associated infrastructure to provide connections to the proposed future Western Harbour Tunnel and Beaches Link project would be carried out at the Rozelle interchange.

Eco Logical Australia Pty Ltd (ELA) was commissioned by Roads and Maritime to prepare an arboricultural impact assessment for the project.

As identified in **Chapter 1** (Introduction) of the environmental impact statement (EIS), the detail of the design and construction approach presented in the EIS is indicative only, based on a concept design. A summary of the potential impacts on trees from the concept design is outlined in this report; however, this is subject to detailed design and construction planning to be undertaken by the design and construction contractor.

1.2 Purpose of this report

The purpose of this report is to:

- Identify the trees within and adjacent to the project footprint that are likely to be affected by the project (subject trees)
- Assess the current overall health and condition of the subject trees
- Evaluate the significance of the subject trees and assess their suitability for retention (where possible)
- Provide mitigation measures to reduce impacts on the subject trees (where possible) and to compensate for the loss of those trees requiring removal.

1.3 Assessment requirements

Table 1-1 outlines the Secretary's Environmental Assessment Requirements (SEARs) for the project as relevant to the arboricultural assessment, and notes where they have been addressed in this EIS.

Table 1-1 Relevant SEARs addressed in this report

SEARs	
6. Biodiversity	
Requirement	**Section where addressed in report**
3. The Proponent must assess any impacts to trees within the project area. Impacts should be minimised; following the hierarchy of avoid minimise and mitigate impacts to trees.	This report and **Appendix S** (Technical working paper: Biodiversity) of the EIS

1.4 Structure of this report

This report is the Arboricultural Impact Assessment for the project and is structured as follows:

- **Chapter 1** presents the background information on the project
- **Chapter 2** outlines the assessment methodology
- **Chapter 3** contains the results
- **Chapter 4** summarises the findings and recommendations.

2 Assessment methodology

2.1 Study area

Subject trees were identified based on a study area comprising a 15 metre buffer around the project footprint. This buffer is considered the maximum extent for potential impacts to occur to a tree's Tree Protection Zone (see explanation in **Attachment B**). An overview of the study area is shown on **Figure 2-1** and more detailed maps are provided at **Attachment A**. Subject trees are those that satisfy the tree assessment criteria specified in **section 2.2**.

The study area excluded the following:

- Haberfield (Option A: Wattle Street civil and tunnel site (C1a), Haberfield civil and tunnel site (C2a)/ Haberfield civil site (C2b), Northcote Street civil site (C3a) and Campbell Road civil and tunnel site (C10) – these footprints have already been assessed as part of the M4 East and New M5 projects respectively. No additional tree removal for the M4-M5 Link project is assumed to be required in these areas
- Trees assessed and approved for removal as part of the Rozelle Rail Yards Site Management Works. This footprint has already been assessed as part of the *Rozelle Rail Yards – Site Management Works Review of Environmental Factors* (Roads and Maritime 2016).

2.2 Visual tree assessment

The subject trees were assessed in accordance with a stage one visual tree assessment (VTA) as formulated by *The Body Language of Trees. A Handbook for Failure Analysis* (Mattheck & Breloer, 1994), and practices consistent with modern arboriculture. Further information and guidelines on tree assessment are provided in **Attachment B** to **E**.

Subject trees are those trees that are located within the study area, and include both street trees and trees planted within and adjacent to the project footprint, and comprise native and exotic trees. For the purposes of this report, trees must be at least three metres in height with a trunk diameter of greater than 100 millimetres.

The following limitations apply to this assessment:

- Trees were inspected from ground level, without the use of any invasive or diagnostic tools and testing
- Trees on private properties have not been mapped in this report as access was not available and a complete visual inspection and assessment was therefore not possible. Impacts on trees on private properties and their management would need to be addressed during the detailed design phase of the project as necessary
- Tree heights, canopy spread and diameter at breast height (DBH) was estimated, unless otherwise stated
- Tree identification was based on broad taxonomical features present and visible from ground level at the time of inspection
- Trees of the same species, with similar dimensions growing in close proximity to each other, have been documented as a group and presented under a single coordinate/record and identification number.

The subject trees were inspected between 10 January and 9 June 2017. All surveys and assessments were undertaken by ELA's consulting arborists. All arborists hold an Australian Qualifications Framework (AQF) Level 5 in arboriculture.

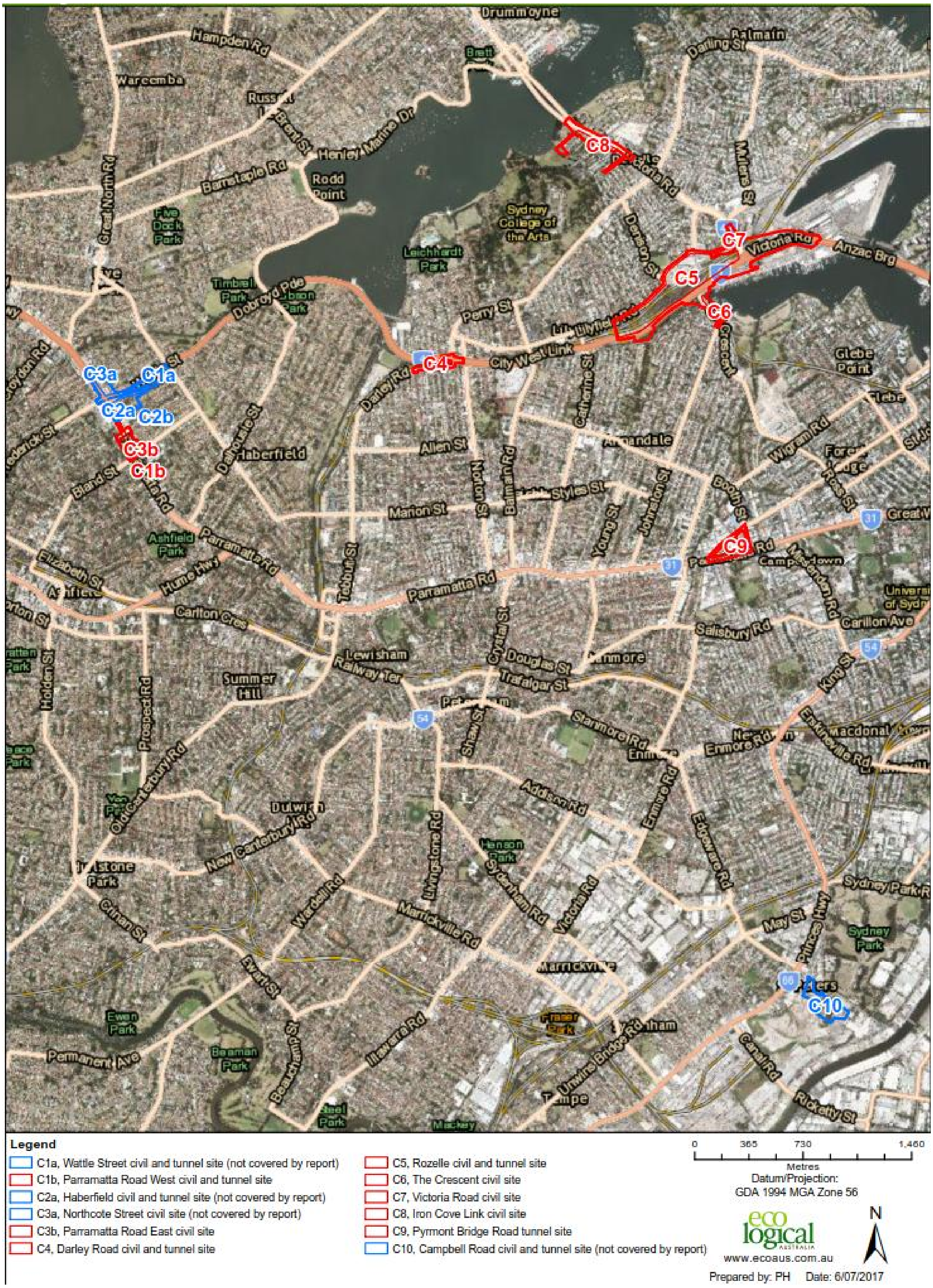

Figure 2-1 Arboricultural assessment study area

2.3 Retention value

This tree retention assessment has been undertaken in accordance with the Institute of Australian Consulting Arboriculturalists (IACA)'s Significance of a Tree Assessment Rating System (STARS). The system uses a scale of Low, Medium and High significance in the landscape. Once the landscape significance of an individual tree has been defined, the retention value can be determined. Each tree must meet a minimum of three assessment criteria to be classified. Further details and the assessment criteria are included in **Attachment F**.

The retention value of a tree or group of trees has been determined using a combination of environmental, cultural, physical and social values. It has also included consideration of a tree's health, life expectancy and suitability for retention within the project footprint.

- **Low:** These trees are not considered important for retention as they are of low significance and/or have a short useful life expectancy, nor do they require special works or design modification to be implemented for their retention
- **Medium:** These trees are moderately important for retention as they are of low significance but have a medium to long useful life expectancy. Their removal should only be considered if adversely affecting the proposed building/works and all other alternatives have been considered and exhausted
- **High:** These trees are considered important for retention as they are of medium or high significance and have a medium to long useful life expectancy. These trees should be retained and protected, if possible. Where possible, design modification should be considered to accommodate the setbacks as prescribed by AS 4970 - *Protection of trees on development sites*.

For the purposes of this assessment, only high retention value trees have been allocated a singular record and identification number. Subject trees assessed as medium or low retention value have been grouped and represented under a colour coded polygon.

2.4 Mapping of assessed trees

Subject trees have been grouped into categories based on their location within the study area and the anticipated level of impact from construction activities, and represented under colour coded polygons on maps in **Attachment A**. These categories are as follows:

- **Areas of trees to retain (N):** Subject trees within the study area that are unlikely to be impacted by the project, subject to detailed design. These trees can successfully be retained
- **Areas of trees to be removed (R):** Subject trees within the study area that would be directly impacted by the project. It is unlikely these subject trees would be retained
- **Areas of trees to investigate for retention (I):** Subject trees within the study area that are anticipated to be directly impacted by the project. Their impact should be further investigated during detailed design due to their retention value, including:
  - Groupings of trees that have the potential to provide vegetative screening of the project and/or where the individual trees are not considered high retention value, but as a group, they provide high values
  - Individual trees identified as high retention value.

Individual trees that are healthy and vigorous with good growth form, locally indigenous, visually prominent and/or culturally or spiritually significant. These are represented as **high retention value trees** and are located throughout the study area, and may be located within each of the areas of trees to retain, to be removed, or to investigate for retention. High retention trees are mapped in **Attachment A** under a single record and identification number (ie shown on maps as individual trees). These trees are considered important and should be retained and protected wherever possible. All opportunities for retaining these subject trees through the use of design modification and tree sensitive construction techniques should be explored.

3 Results

Table 3-1 provides an information summary of subject trees within the project footprint, and includes details such as map reference, number of trees, dominant species, height range and health. **Table 3-2** provides information on the high retention value trees identified in the study area, including observations and measurements specific to each tree. All trees identified during the assessment were planted trees and none were considered native remnant trees.

Key findings of the arboricultural assessment are:

- **Areas of trees to retain:** About 540 subject trees were identified within the study area that can be successfully retained by the project, subject to detailed design. Of these, 21 trees were identified as high retention value
- **Areas of trees to be removed:** About 1,675 subject trees were identified within the study area that would be directly impacted by the project. It is unlikely these subject trees would be retained. Of these, 107 trees were identified as high retention value. While these trees are identified to be removed, all opportunities for retaining these high retention value trees through the use of design modification and tree sensitive construction techniques should be explored where possible. The majority of trees to be removed are a result of the Rozelle interchange and associated surface road upgrades and active transport connections. This includes trees within the Rozelle Rail Yards and Ports Authority land (not including trees already approved to be removed under the Site Management Works), along City West Link and Lilyfield Road, and areas adjacent to Whites Creek (at The Crescent and Brenan Street)
- **Areas to be investigated:** About 355 subject trees were identified within the study area to be investigated further during detailed design to determine their suitability for retention. Of these, 34 trees were identified as high retention value. These areas identified to be further investigated include groups of trees along Lilyfield Road that may offer visual screening, and the approaches to Anzac Bridge.

In total, about 162 high retention value trees have been identified within the study area to be investigated further during detailed design to determine their suitability to be retained.

The EIS includes two options for construction ancillary facilities around Haberfield, which are denoted by the suffix *a* (for Option A) or *b* (for Option B). The above findings are based on Option A (along with the other construction ancillary facilities nominated within the EIS). In the context of this report, Option B would result in additional impacts due to the use of the Parramatta Road West civil and tunnel site (C1b) and Parramatta Road East civil site (C3b).

Should Option B be selected, the following additional findings apply to the overall assessment:

- **Areas of trees to be retained:** Three subject trees were identified within the Parramatta Road study area and could be successfully retained by the project, subject to detailed design
- **Areas of trees to be removed:** About 12 subject trees were identified within the Parramatta Road study area that would be directly impacted by the project. It is unlikely these subject trees would be retained
- **Areas to be investigated:** Up to 17 trees in the Parramatta Road study area would require further investigation during detailed design to determine their suitability for retention. This would be based on the recommended TPZ for these trees, and incorporation of these TPZs into a revised construction layout during detailed design.

Table 3-1 Tree impact area summaries

Map reference	ID	Dominant species	Health and structure range	Height Range	Estimated no. of trees	Proposed outcome
Map 1	17I	*Ficus sp., mixed sp.*	Fair – Good	2m–9m	11	Investigate for retention
Map 1	18I	*Jacaranda mimosifolia,* mixed species	Fair – Good	4m–13m	6	Investigate for retention
Map 1	24R	*Lophostemon confertus*	Fair	3m	1	Remove
Map 1	25R	*Jacaranda mimosifolia*	Fair	6m	1	Remove
Map 1	26R	*Juniperus chinensis, Musa sp.*	Fair – Good	5m–6m	4	Remove
Map 1	27R	*Lophostemon confertus, Archontophoenix alexandrae, Araucaria heterophylla*	Poor – Good	4–14m	6	Remove
Map 1	36N	*Lagerstroemia indica*	Fair	4m	3	Retain
Map 2	1I	*Corymbia maculate*	Good	12m-15m	2	Investigate for retention
Map 2	1N	*Corymbia maculata, Phoenix canariensis, Erythrina X sykesii, Celtis Australis*	Good	3m-10m	6	Retain
Map 2	1R	*Pittosporum undulatum, Lophostemon confertus, Celtis australis, Cinnamomum camphora, Ligustrum lucidum, Eucalyptus x botryoides,* mixed weed species	Fair – Good	2m-12m	30	Remove
Map 2	2I	Mixed species	N/A	1m-2m	N/A	Investigate for retention
Map 2	2N	*Corymbia maculata, Celtis australis, Glochidion ferdinandi, Callistemon viminalis, Ligustrum lucidum*	Fair – Good	3m-10m	21	Retain
Map 2	3I	*Callistemon viminalis*	Poor – Good	4m	1	Investigate for retention
Map 2	3N	*Robinia pseudoacacia, Corymbia maculata, Araucaria cunninghamii*	Poor – Good	9m-12m	3	Retain
Map 2	4I	*Acacia sp., Callistemon viminalis, Tristaniopsis laurina*	Poor – Good	2m-5m	6	Investigate for retention

Map reference	ID	Dominant species	Health and structure range	Height Range	Estimated no. of trees	Proposed outcome
Map 2	4N	*Araucaria cunninghamii, Jacaranda mimosifolia, Ficus hillii*	Fair – Good	3m-9m	8	Retain
Map 2	5I	*Callistemon viminalis, Fraxinus raywood*	Fair – Good	3m-4m	2	Investigate for retention
Map 2	6I	*Jacaranda mimosifolia, Araucaria cunninghamii,* mixed species	Fair – Good	3m-12m	5	Investigate for retention
Map 3	5R	*Casuarina glauca, Phoenix canariensis, Celtis australis, Allocasuarina littoralis, Acacia longifolia, Cupressus sp., Pittosporum undulatum, Cinnamomum camphora, Morus sp.*	Poor – Good	3m-15m	167	Remove
Map 3	6R	*Phoenix canariensis, Ficus hillii, Olea africana, Agonis flexuosa, Casuarina cunninghamiana, Eucalyptus sp., Acacia longifolia, Corymbia maculata, Lophostemon confertus, Pittosporum undulatum*	Poor – Good	1m-11m	72	Remove
Map 3	7I	*Ficus hillii*	Poor – Good	5m-16m	9	Investigate for retention
Map 3	8I	*Ficus hillii, Grevillea robusta, Phoenix canariensis, Olea africana, Ficus benjamina, Nerium oleander,* mixed weed species	Poor – Good	3m-10m	16	Investigate for retention
Map 3	31N	*Casuarina cunninghamiana, Eucalyptus sp., Casuarina glauca*	Fair	8m-12m	57	Retain
Map 3	12I	*Phoenix canariensis, Ficus hillii*	Fair – Good	6m-14m	6	Investigate for retention
Map 3	13N	*Casuarina glauca, Phoenix canariensis*	Fair – Good	4m-16m	27	Retain
Map 3	16R	Unknown species	Unknown	10m	21	Remove
Map 3	17R	*Casuarina glauca, Melaleuca armillaris, mixed natives,* mixed weed species	Fair	7m-12m	127	Remove
Map 4	10R	*Mixed native species, Celtis australis, Acacia sp., Casuarina glauca, Cinnamomum camphora*	Fair	8m-12m	145	Remove
Map 4	13R	*Casuarina cunninghamiana, Callistemon viminalis, Mixed natives*	Fair	8m	82	Remove
Map 4	15I	*Casuarina cunninghamiana, Callistemon viminalis, Phoenix canariensis, Ficus hillii, Ficus rubiginosa*	Fair – Good	3m–12m	51	Investigate for retention
Map 4	16I	*Casuarina glauca, Casuarina cunninghamiana*	Fair	5m–8m	255	Investigate for retention

Map reference	ID	Dominant species	Health and structure range	Height Range	Estimated no. of trees	Proposed outcome
Map 4	22R	*Casuarina glauca, Callistemon viminalis, Mixed native species*	Fair – Good	3m-12m	430	Remove
Map 4	24N	*Casuarina glauca, Casuarina cunninghamiana, Archontophoenix alexandrae, Phoenix canariensis, Ficus elastica*	Fair – Good	3m-8m	86	Retain
Map 4	25N	*Casuarina cunninghamiana, Callistemon viminalis, Phoenix canariensis, Ficus hillii*	Fair – Good	3m-12m	16	Retain
Map 5	7R	*Banksia integrifolia, Tristaniopsis laurina, Corymbia citriodora, Triadica sebifera, Robinia pseudoacacia, Jacaranda mimosifolia*	Good	3m-15m	10	Remove
Map 5	11R	*Casuarina cunninghamiana, Shinus areira*	Good	3m-7m	10	Remove
Map 5	12N	*Ficus hillii, Tristaniopsis laurina, Celtis australis*	Fair	3m-5m	7	Retain
Map 5	14N	*Ficus rubiginosa*	Fair – Good	8m-17m	1	Retain
Map 5	15N	*Grevillea robusta, Washingtonia robusta*	Fair – Good	6m-22m	8	Retain
Map 5	16N	*Grevillea robusta*	Fair – Good	20m-21m	5	Retain
Map 5	34N	*Eucalyptus crebra, Eucalyptus saligna*	Poor – good	20m	2	Retain
Map 5	35N	*Eucalyptus crebra, Callistemon viminalis, Celtis australis, Melaleuca sp., Melaleuca quinquenervia*	Fair – Good	2m-16m	14	Retain
Map 6	18N	Private residential trees	-	-	-	Retain
Map 6	19N	*Ficus benjamina, Melaleuca quinquenervia*	Fair – Good	21m-23m	9	Retain
Map 6	20R	*Callistemon citrinus, Casuarina glauca, melia azedarach, Corymbia maculata, Callistemon viminalis, Casuarina cunninghamiana*	Fair Good	2m-13m	268	Remove
Map 6	37N	Mixed species	Fair – Good	2m – 15m	50	Retain
Map 6	38N	*Acacia sp., Ficus benjamina, Musa sp., Cinnamomum camphora*	Fair – Good	4m – 16m	16	Retain

Map reference	ID	Dominant species	Health and structure range	Height Range	Estimated no. of trees	Proposed outcome
Map 7	8R	*Phoenix canariensis, Casuarina cunninghamiana, Eucalyptus sideroxylon, Eucalyptus grandis, Callistemon citrinus, Eucalyptus crebra, Casuarina glauca, Hakea salicifolia, Corymbia eximia, Cupressus sempervirens, Eucalyptus saligna, Grevillea robusta, Lophostemon confertus, Celtis australis, Ficus macrophylla*	Fair – Good	2m-17m	160	Remove
Map 7	9R	*Melaleuca sp., Casuarina cunninghamiana, Callistemon viminalis, Cinnamomum camphora, Celtis australis, Eucalyptus sideroxylon, Ficus sp., Eucalyptus pilularis, Eucalyptus microcorys, Eucalyptus grandis*	Fair – Good	3m-14m	40	Remove
Map 7	12R	*Lophostemon confertus*	Good	8m	1	Remove
Map 7	18R	*Casuarina cunninghamiana, Phoenix canariensis, Eucalyptus sp., Celtis australis*	Fair – Good	2m-8m	40	Remove
Map 7	20N	*Eucalyptus punctata, Eucalyptus microcorys, Casuarina glauca, Eucalyptus robusta, Eucalyptus fibrosa*	Fair – Good	5m-18m	16	Retain
Map 7	21N	*Eucalyptus sp.*	Fair – Good	6m–8m	2	Retain
Map 7	22N	*Lophostemon confertus*	Fair	9m-10m	4	Retain
Map 7	23N	*Callistemon viminalis, Eucalyptus sp.*	Fair – Good	4m–9m	11	Retain
Map 7	32N	*Lophostemon confertus, Phoenix canariensis*	Fair – Good	3m-5m	4	Retain
Map 8	19R	Mixed species	Good	5m	4	Remove
Map 8	21R	*Casuarina glauca*	Good	6m-7m	28	Remove
Map 9	2R	*Melaleuca quinquenervia*	Fair	4m	1	Remove
Map 9	5N	*Eucalyptus microcorys*	Good	15m-16m	6	Retain
Map 9	3R	*Ficus macrophylla, Acacia sp., Laurus nobilis, Casuarina glauca*	Fair – Good	2m-4m	29	Remove
Map 9	6N	*Tristaniopsis laurina, Ficus rubiginosa*	Poor – Good	5m-15m	4	Retain
Map 9	7N	*Tristaniopsis laurina, Callistemon sp., Acacia sp., Cupressus sp., Eucalyptus grandis*	Fair – Good	3m-13m	27	Retain

Map reference	ID	Dominant species	Health and structure range	Height Range	Estimated no. of trees	Proposed outcome
Map 9	8N	*Casuarina glauca, Celtis australis, Banksia integrifolia, Ficus rubiginosa, Cupaniopsis anacardioides, Cupaniopsis sp.*, fair-good health and structure	Fair – Good	3m-10m	58	Retain
Map 9	11N	*Jacaranda mimosifolia*	Fair	8m	2	Retain
Map 9	39N	*Acacia sp.*	Fair	4m-5m	22	Retain
Map 9	40N	*Casuarina glauca, Eucalyptus robusta*	Good	3m–8m	15	Retain
Map 10	41N	*Corymbia maculata*	Fair – Good	15m	1	Retain
Map 10	42N	*Ficus hillii, Jacaranda mimosifolia*	Poor – Fair	2m-14m	4	Retain
Map 10	14R	*Triadica sebifera*	Fair	10m	2	Remove
Map 10	28N	*Eucalyptus microcorys*	Good	18m	1	Retain

Table 3-2 High retention value tree table

Map reference	Tree ID	Botanical name	No. of trees	Height (m)	Spread (m)	Health	Structure	DBH (mm)	TPZ (m)	SRZ (m)
Map 2	61	*Lophostemon confertus*	1	16	8	Good	Good	600	7.2	2.7
Map 2	62	*Lophostemon confertus*	1	17	9	Good	Good	900	10.8	3.2
Map 2	63	*Lophostemon confertus*	1	12	6	Good	Good	400	4.8	2.3
Map 2	64	*Eucalyptus saligna x botryoides*	1	18	20	Good	Fair	1,200	14.4	3.6
Map 3	21	*Ficus hillii*	1	12	12	Good	Good	700	8.4	2.9
Map 3	22	*Ficus hillii*	1	14	14	Good	Good	900	10.8	3.2
Map 3	23	*Ficus hillii*	1	12	8	Good	Good	300	3.6	2
Map 3	24	*Ficus hillii*	1	8	8	Good	Good	400	4.8	2.3
Map 3	25	*Ficus hillii*	1	8	8	Good	Good	600	7.2	2.7
Map 3	33	*Ficus hillii*	1	11	10	Good	Good	1,000	13.2	3.3
Map 3	34	*Ficus hillii*	1	10	10	Good	Good	600	7.2	2.7
Map 3	35	*Ficus hillii*	1	14	14	Good	Good	1,000	13.2	3.3
Map 3	36	*Ficus hillii*	1	16	14	Good	Good	1,000	13.2	3.3
Map 3	37	*Ficus hillii*	1	12	9	Good	Good	850	10.3	3.1
Map 3	38	*Ficus hillii*	1	13	17	Good	Good	1,000	13.2	3.3
Map 3	39	*Ficus hillii*	1	12	12	Good	Good	1,200	14.4	3.6
Map 3	40	*Ficus hillii*	1	10	8	Fair	Good	800	9.6	3
Map 4	14	*Corymbia maculata*	1	12	5	Good	Good	400	4.8	2.3

Map reference	Tree ID	Botanical name	No. of trees	Height (m)	Spread (m)	Health	Structure	DBH (mm)	TPZ (m)	SRZ (m)
Map 4	15	*Group of native shrubs*	1	2	2	Fair	Fair	150	2	1.5
Map 4	16	*Callistemon viminalis*	20	3	2	Good	Good	150	2	1.5
Map 4	17	*Callistemon viminalis*	10	3	2	Good	Good	150	2	1.5
Map 4	18	*Group of mixed natives*	20	3	2	Fair	Fair	150	2	1.5
Map 4	19	*Ficus rubiginosa*	1	5	6	Good	Fair	200	2.4	1.7
Map 4	20	*Callistemon viminalis*	20	3	2	Fair	Fair	150	2	1.5
Map 5	41	*Casuarina cunninghamiana*	7	15	6	Good	Good	400	4.8	2.3
Map 5	42	*Shinus areira*	3	10	6	Good	Good	600	7.2	2.7
Map 5	84	*Ficus rubiginosa*	1	17	15	Good	Good	1,000	12	3.3
Map 5/ Map 6	43	*Banksia integrifolia*	1	7	5	Good	Good	400	4.8	2.3
Map 5/ Map 6	44	*Tristaniopsis laurina*	1	5	4	Good	Good	200	2.4	1.7
Map 5/ Map 6	45	*Tristaniopsis laurina*	1	4	4	Good	Good	200	2.4	1.7
Map 5/ Map 6	46	*Tristaniopsis laurina*	1	4	3	Good	Good	200	2.4	1.7
Map 5/ Map 6	47	*Tristaniopsis laurina*	1	4	4	Good	Good	150	2	1.5
Map 5/ Map 6	48	*Tristaniopsis laurina*	1	3	3	Good	Good	150	2	1.5
Map 5/ Map 6	49	*Corymbia citriodora*	1	15	12	Good	Good	800	9.6	3
Map 5/ Map 6	50	*Triadica sebifera*	1	8	6	Good	Good	300	3.6	2
Map 5/ Map 6	51	*Robinia pseudoacacia*	1	8	8	Good	Good	550	6.6	2.6

Map reference	Tree ID	Botanical name	No. of trees	Height (m)	Spread (m)	Health	Structure	DBH (mm)	TPZ (m)	SRZ (m)
Map 5/ Map 6	52	*Jacaranda mimosifolia*	1	6	7	Good	Good	300	3.6	2
Map 5/ Map 6	78	*Eucalyptus saligna*	1	20	6	Good	Good	600	7.2	2.7
Map 5/ Map 6	79	*Grevillea robusta*	1	21	6	Good	Fair	550	6.6	2.6
Map 5/ Map 6	80	*Grevillea robusta*	1	21	7	Good	Good	500	6	2.5
Map 5/ Map 6	81	*Grevillea robusta*	1	20	5	Good	Good	500	6	2.5
Map 5/ Map 6	82	*Grevillea robusta*	1	22	5	Fair	Good	350	4.2	2.1
Map 5/ Map 6	83	*Grevillea robusta*	1	21	7	Good	Good	450	5.4	2.4
Map 6	85	*Ficus benjamina*	1	21	14	Good	Good	800	9.6	3
Map 6	86	*Ficus benjamina*	1	22	13	Good	Good	550	6.6	2.6
Map 6	87	*Ficus benjamina*	1	22	13	Good	Good	400	4.8	2.3
Map 6	88	*Ficus benjamina*	1	23	15	Good	Good	1,300	15	3.7
Map 6	89	*Ficus benjamina*	1	23	15	Good	Good	900	10.8	3.2
Map 7	1	*Eucalyptus pilularis*	1	8	7	Good	Good	500	6	2.5
Map 7	2	*Casuarina cunninghamiana*	1	10	6	Good	Good	450	5.4	2.4
Map 7	3	*Eucalyptus microcorys*	1	12	8	Good	Good	550	6.6	2.6
Map 7	4	*Eucalyptus microcorys*	1	14	8	Good	Good	550	6.6	2.6
Map 7	5	*Melaleuca quinquenervia*	3	9	3	Good	Good	200	2.4	1.7
Map 7	6	*Eucalyptus microcorys*	1	10	6	Fair	Good	300	3.6	2

Map reference	Tree ID	Botanical name	No. of trees	Height (m)	Spread (m)	Health	Structure	DBH (mm)	TPZ (m)	SRZ (m)
Map 7	7	*Eucalyptus grandis*	1	16	9	Good	Fair	550	6.6	2.6
Map 7	8	*Casuarina glauca*	17	9	3	Good	Good	300	3.6	2
Map 7	9	*Eucalyptus grandis*	1	14	10	Good	Good	500	6	2.5
Map 7	10	*Ficus macrophylla*	1	16	18	Fair	Good	1,200	14.4	3.6
Map 7	11	*Eucalyptus grandis*	1	16	5	Good	Good	300	3.6	2
Map 7	12	*Ficus macrophylla*	1	14	14	Good	Good	800	9.6	3
Map 7	13	*Ficus macrophylla*	1	12	13	Good	Good	450	5.4	2.4
Map 9	53	*Eucalyptus robusta*	1	8	4	Good	Good	400	4.8	2.3
Map 9	54	*Ulmus parvifolia*	1	10	10	Good	Good	500	6	2.5
Map 9	55	*Eucalyptus microcorys*	1	16	14	Good	Good	800	9.6	3
Map 9	56	*Eucalyptus microcorys*	1	16	14	Good	Good	800	9.6	3
Map 9	56	*Eucalyptus microcorys*	1	16	12	Good	Good	800	9.6	3
Map 9	57	*Eucalyptus microcorys*	1	16	12	Good	Good	800	9.6	3
Map 9	58	*Eucalyptus microcorys*	1	16	14	Good	Good	800	9.6	3
Map 9	59	*Eucalyptus microcorys*	1	16	14	Good	Good	800	9.6	3
Map 9	60	*Ficus rubiginosa*	1	15	12	Good	Good	850	10.3	3.1

Notes: DBH – Diameter at Breast Height; TPZ – Tree Protection Zone; SRZ – Structural Root Zone

4 Recommendations

The recommendations for tree protection have been developed to ensure that impacts of the project on trees are minimised, following the hierarchy of avoid, minimise and mitigate as follows:

- Impacts to trees have been avoided through design and are demonstrated by the number of trees able to be retained
- Impacts to trees have been potentially minimised through the identification of high retention trees or groups of trees that may be able to be retained during detailed design, through further investigation
- Impacts to trees have been mitigated through a commitment for compensatory planting, planted within or in close proximity to the project footprint and in consultation with relevant councils.

4.1 Trees to be investigated for retention

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. These areas have been highlighted in **Attachment A** and include groups of trees as well as all individual high retention value trees. All opportunities for retaining additional trees through tree sensitive design and construction methods will be discussed and explored during detailed design.

4.2 Protection of trees proposed for retention

The following tree protection measures would be required for any trees identified for retention in **Chapter 3** and **Attachment A** as well as trees located on private property which are likely to be impacted by construction activities.

A Construction Flora and Fauna Management Plan (CFFMP) would be developed and implemented during construction. The CFFMP would include measures to manage potential impacts to trees, including:

- The establishment of tree protection zones (TPZs)
- Ground protection measures for trees to be retained.

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 Protection of trees on development sites,* where required for specific trees. Protection of trees will be carried out in consultation with an arborist with a minimum 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.

Further information and guidelines on tree protection is in **Attachment F**.

4.3 Compensatory planting recommendations

Opportunities to retain high retention value trees should be explored where practical during detailed design. Compensatory planting is recommended for trees that cannot be retained as a result of the works. Replacement trees should be planted within, or close to, the project footprint or other locations in consultation with the relevant councils.

Compensatory planting should seek to use opportunities presented by the open space created within the Rozelle interchange, including along Lilyfield Road and City West Link. Opportunities should also be sought as part of landscaping associated with the Iron Cove Link.

4.4 Tree removal work

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).

References

Australian Standards, AS 4373-2007 - *Pruning of Amenity Trees*.

Australian Standards, AS 4970-2009 - *Protection of Trees on Development Sites*.

Harris, R., Clark, J., Matheny, N. and Harris, V. 2004. *Arboriculture.* Upper Saddle River, N.J.: Prentice Hall.

Mattheck, Claus, and Helge Breloer. 1994. *The Body Language of Trees. A Handbook for Failure Analysis*. HMSO, London, UK

Mattheck, C. 2007. *Updated field guide for visual tree assessment*. Karlsruhe: Forschungszentrum Karlsruhe.

WorkCover NSW. 1998. *Code of Practice: Amenity Tree Industry*

Attachments

Attachment A - Tree location maps

Tree Locations and Impact
WestConnex - Map 1
24R
25R
26R
27R
18I
17I
36N
C1b
C3b
C1b Parramatta Road West Civil and Tunnel Site
C3b Parramatta Road East Civil Site
15m Construction Footprint Buffer (Study Area)
Legend
C1b - Parramatta Road West civil and tunnel site
C3b - Parramatta Road East civil site
15m Construction Footprint Buffer (Study Area)
Ancillary Facility
High Retention Value Trees
1N Areas of Trees to Retain
1R Areas of Trees to be Removed
1I Areas of Trees to Investigate For Retention
0 25 50 100
Metres
Datum/Projection:
GDA 1994 MGA Zone 56
N
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Tree Locations and Impact
WestConnex - Map 2
CITY-WEST LINK ROAD
DARLEY ROAD
CHARLES STREET
HUBERT STREET
FRANCIS STREET
JAMES STREET
NORTON STREET
C4
1N
2N
3N
4N
1R
1I
2I
3I
4I
5I
6I
61
62
63
64
15m Construction Footprint Buffer (Study Area)
Legend
C4 - Darley Road civil and tunnel site
15m Construction Footprint Buffer (Study Area)
Ancillary Facility
High Retention Value Trees
1N Areas of Trees to Retain
1R Areas of Trees to be Removed
1I Areas of Trees to Investigate For Retention
0 20 40 80
Metres
Datum/Projection:
GDA 1994 MGA Zone 56
eco logical AUSTRALIA
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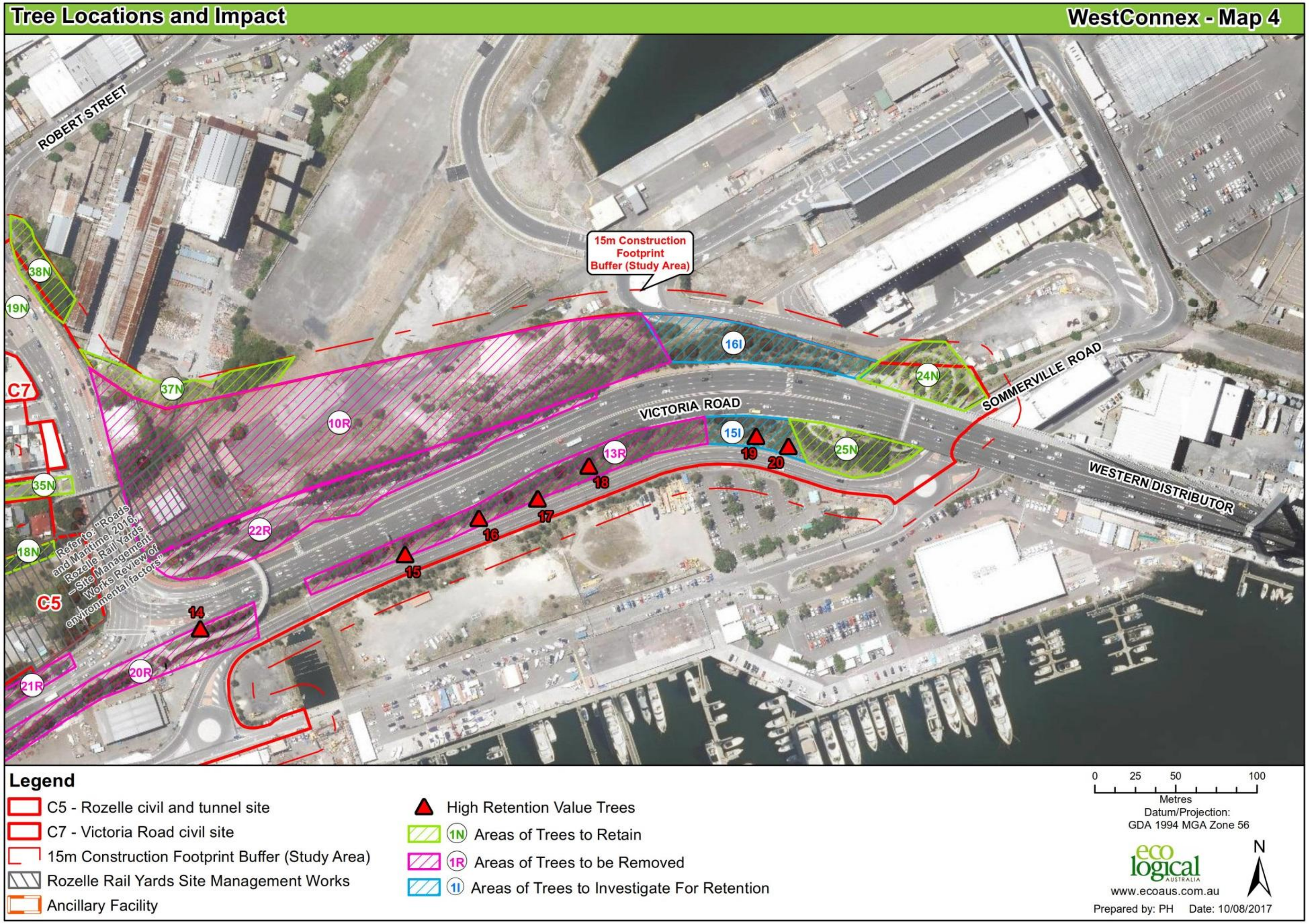
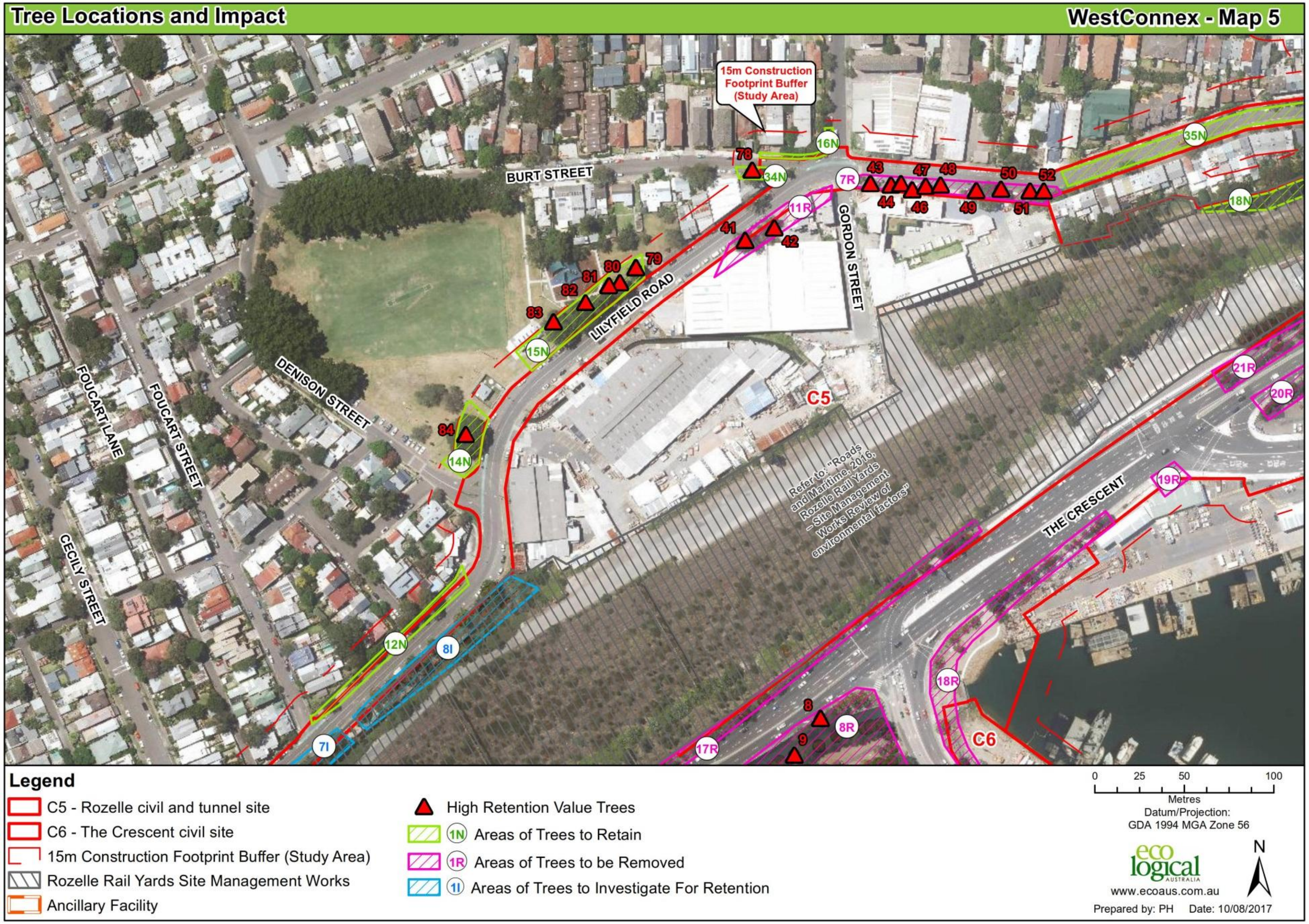
N
Prepared by: PH Date: 10/08/2017


Tree Locations and Impact
WestConnex - Map 3
15m Construction Footprint Buffer (Study Area)
Refer to: "Roads and Maritime, 2016, Rozelle Rail Yards - Site Management Works Review of environmental factors"
C5
JOSEPH STREET
JUSTIN STREET
LAMB STREET
RYAN STREET
LILYFIELD ROAD
CITY-WEST LINK ROAD
RAILWAY PARADE
PRITCHARD STREET
BREILLAT STREET
ANNANDALE STREET
CATHERINE STREET
BRENAN STREET
12N
8I
7I
6R
12I
17R
8R
16R
5R
31N
13N
Legend
C5 - Rozelle civil and tunnel site
15m Construction Footprint Buffer (Study Area)
Rozelle Rail Yards Site Management Works
Ancillary Facility
High Retention Value Trees
1N Areas of Trees to Retain
1R Areas of Trees to be Removed
1I Areas of Trees to Investigate For Retention
0 25 50 100
Metres
Datum/Projection:
GDA 1994 MGA Zone 56
eco logical AUSTRALIA
www.ecoaus.com.au
N
Prepared by: PH Date: 10/08/2017


Tree Locations and Impact
WestConnex - Map 4
ROBERT STREET
VICTORIA ROAD
SOMMERVILLE ROAD
WESTERN DISTRIBUTOR
15m Construction Footprint Buffer (Study Area)
C7
C5
38N
19N
37N
35N
18N
24N
25N
10R
13R
22R
20R
21R
16I
15I
14
15
16
17
18
19
20
Refer to: "Roads and Maritime: 2016. Rozelle Rail Yards – Site Management Works Review of environmental factors"
Legend
C5 - Rozelle civil and tunnel site
C7 - Victoria Road civil site
15m Construction Footprint Buffer (Study Area)
Rozelle Rail Yards Site Management Works
Ancillary Facility
High Retention Value Trees
1N Areas of Trees to Retain
1R Areas of Trees to be Removed
1I Areas of Trees to Investigate For Retention
0 25 50 100
Metres
Datum/Projection:
GDA 1994 MGA Zone 56
N
eco logical AUSTRALIA
www.ecoaus.com.au
Prepared by: PH Date: 10/08/2017



Tree Locations and Impact
WestConnex - Map 5
15m Construction Footprint Buffer (Study Area)
BURT STREET
LILYFIELD ROAD
GORDON STREET
DENISON STREET
FOUCART LANE
FOUCART STREET
CECILY STREET
THE CRESCENT
C5
C6
Refer to: "Roads and Maritime, 2016, Rozelle Rail Yards – Site Management Works Review of environmental factors"
Legend
C5 - Rozelle civil and tunnel site
C6 - The Crescent civil site
15m Construction Footprint Buffer (Study Area)
Rozelle Rail Yards Site Management Works
Ancillary Facility
High Retention Value Trees
1N Areas of Trees to Retain
1R Areas of Trees to be Removed
1I Areas of Trees to Investigate For Retention
0 25 50 100
Metres
Datum/Projection: GDA 1994 MGA Zone 56
eco logical AUSTRALIA
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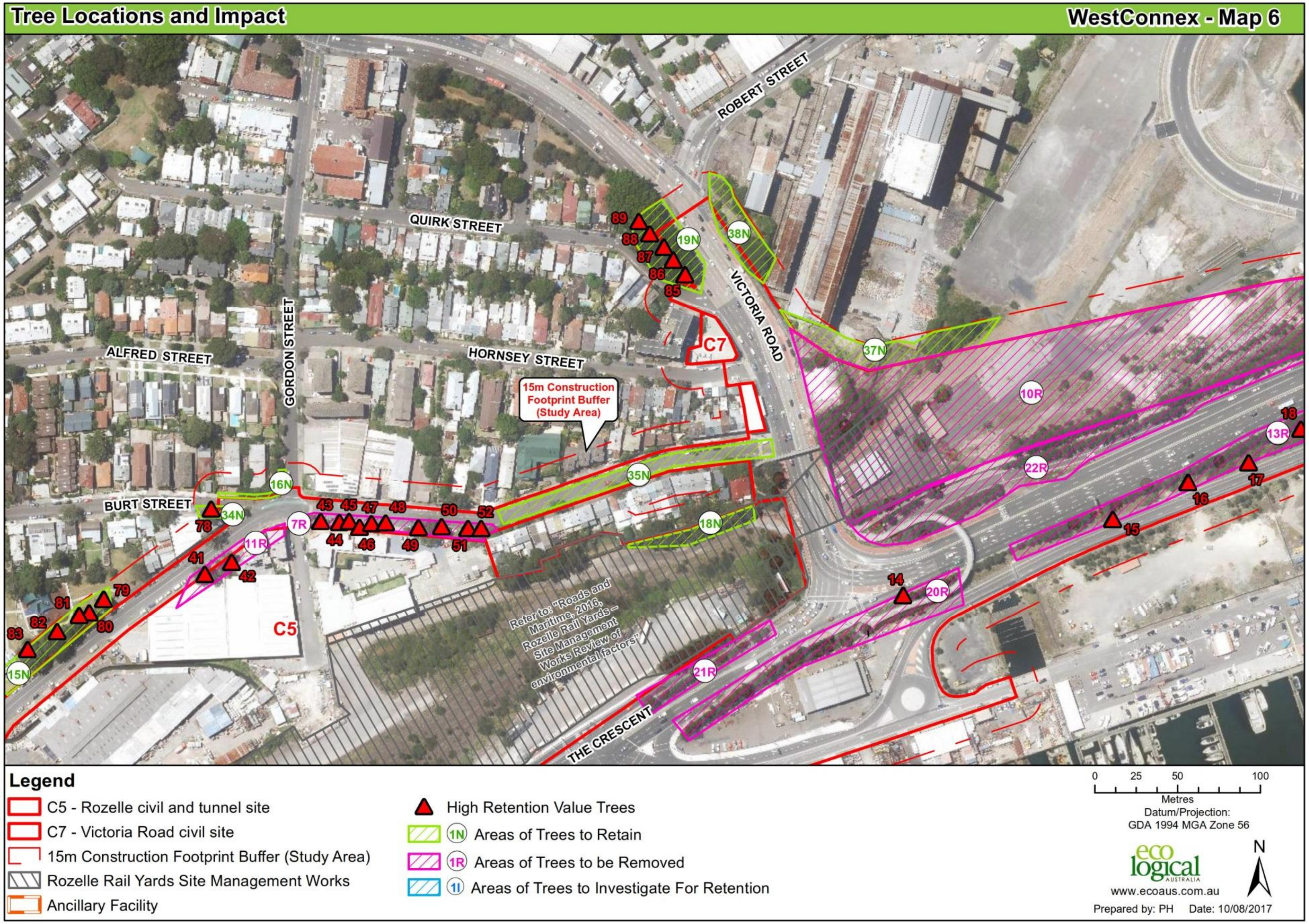
N



Tree Locations and Impact
WestConnex - Map 6
QUIRK STREET
ROBERT STREET
VICTORIA ROAD
ALFRED STREET
GORDON STREET
HORNSEY STREET
BURT STREET
THE CRESCENT
15m Construction Footprint Buffer (Study Area)
Refer to: "Roads and Maritime, 2016, Rozelle Rail Yards – Site Management Works Review of environmental factors"
C5
C7
Legend
C5 - Rozelle civil and tunnel site
C7 - Victoria Road civil site
15m Construction Footprint Buffer (Study Area)
Rozelle Rail Yards Site Management Works
Ancillary Facility
High Retention Value Trees
1N Areas of Trees to Retain
1R Areas of Trees to be Removed
1I Areas of Trees to Investigate For Retention
0 25 50 100
Metres
Datum/Projection:
GDA 1994 MGA Zone 56
eco logical AUSTRALIA
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N

Tree Locations and Impact
WestConnex - Map 7
C5
C6
CITY-WEST LINK ROAD
BAYVIEW CRESCENT
RAILWAY PARADE
PRITCHARD STREET
ANNANDALE STREET
KENTVILLE AVENUE
JOHNSTON STREET
Refer to: "Roads and Maritime, 2016, Rozelle Rail Yards – Site Management Works Review of environmental factors"
15m Construction Footprint Buffer (Study Area)
Legend
C5 - Rozelle civil and tunnel site
C6 - The Crescent civil site
15m Construction Footprint Buffer (Study Area)
Rozelle Rail Yards Site Management Works
Ancillary Facility
High Retention Value Trees
1N Areas of Trees to Retain
1R Areas of Trees to be Removed
1I Areas of Trees to Investigate For Retention
0 25 50 100
Metres
Datum/Projection:
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N


Tree Locations and Impact
WestConnex - Map 8
C5
C6
Refer to: "Roads and Maritime, 2016, Rozelle Rail Yards – Site Management Works Review of environmental factors"
THE CRESCENT
JAMES CRAIG ROAD
15m Construction Footprint Buffer (Study Area)
7R
11R
35N
18N
10R
22R
13R
14
15
20R
21R
19R
17R
18R
8R
43
44
46
47
48
49
50
51
52
8
10
11
12
13
Legend
C5 - Rozelle civil and tunnel site
C6 - The Crescent civil site
15m Construction Footprint Buffer (Study Area)
Rozelle Rail Yards Site Management Works
Ancillary Facility
High Retention Value Trees
1N Areas of Trees to Retain
1R Areas of Trees to be Removed
1I Areas of Trees to Investigate For Retention
0
20
40
80
Metres
Datum/Projection:
GDA 1994 MGA Zone 56
N
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Tree Locations and Impact
WestConnex - Map 9
53
39N
40N
8N
54
3R
C8
7N
11N
2R
6N
60
56
58
55
57
59
5N
15m Construction Footprint Buffer (Study Area)
Legend
C8 - Iron Cove Link civil site
15m Construction Footprint Buffer (Study Area)
Ancillary Facility
High Retention Value Trees
1N Areas of Trees to Retain
1R Areas of Trees to be Removed
1I Areas of Trees to Investigate For Retention
0
40
80
160
Metres
Datum/Projection:
GDA 1994 MGA Zone 56
eco logical AUSTRALIA
www.ecoaus.com.au
N
Prepared by: PH
Date: 9/08/2017

Tree Locations and Impact
WestConnex - Map 10
15m Construction Footprint Buffer (Study Area)
C9
42N
14R
28N
41N
Legend
C9 - Pyrmont Bridge Road tunnel site
15m Construction Footprint Buffer (Study Area)
Ancillary Facility
High Retention Value Trees
1N Areas of Trees to Retain
1R Areas of Trees to be Removed
1I Areas of Trees to Investigate For Retention
0 25 50 100
Metres
Datum/Projection:
GDA 1994 MGA Zone 56
N
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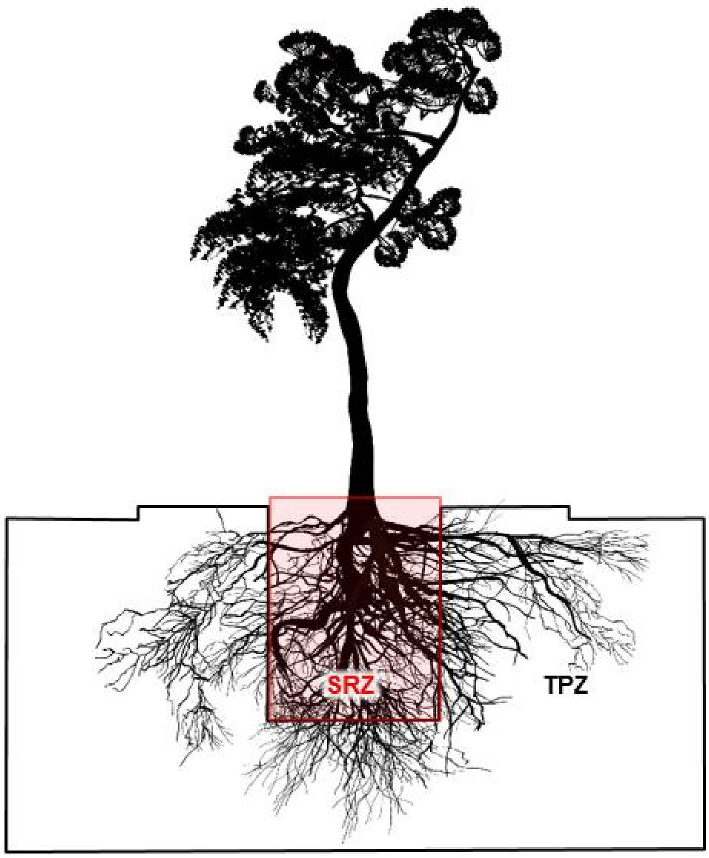
Attachment B - Impact assessment

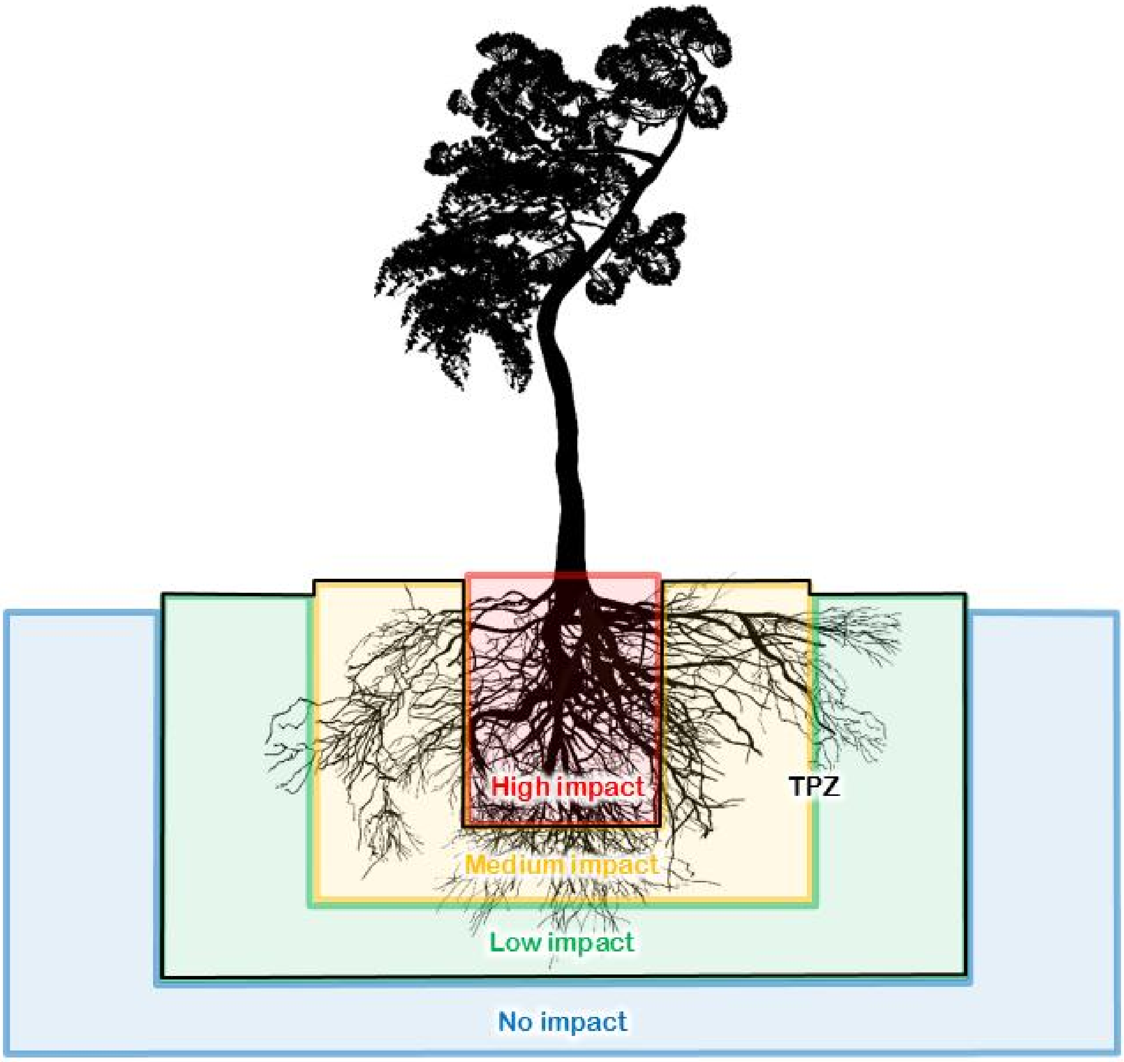
- **Tree protection zone:** The tree protection zone (TPZ) is the optimal combination of crown and root area (as defined by AS 4970-2009) that requires protection during the construction process so that the tree can remain viable. The TPZ is an area that is isolated from the work zone to insure no disturbance or encroachment occurs into this zone. Tree sensitive construction measures must be implemented if works are to proceed within the Tree Protection Zone
- **Structural root zone:** The structural root zone (SRZ) is the area of the root system (as defined by AS 4970-2009) used for stability, mechanical support and anchorage of the tree. The SRZ only considers a tree's structural stability, not the area of root zone required for long term viability. Severance of structural roots (>50 mmØ) within the SRZ is generally not recommended as it may lead to the destabilisation and/or decline of the tree
- **Root investigation:** When assessing the potential impacts of encroachment into the TPZ consideration will need to be given to the location and distribution of the roots, including above or below ground restrictions affecting root growth. Location and distribution of roots may be determined through non-destructive excavation (NDE) methods such as hydro-vacuum excavation (sucker truck), air spade and manual excavation. Root investigation is used to determine the extent and location of roots within the zone of conflict. Root investigation does not guarantee the retention of the tree.



Indicative TPZ and SRZ

Attachment C - Impacts within the TPZ

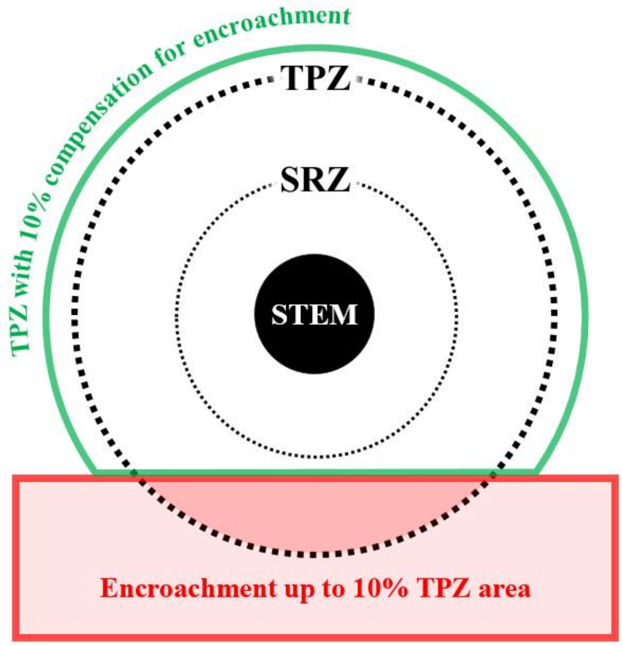
- **No impact (0%):** No likely or foreseeable encroachment within the TPZ
- **Low impact (<10%):** If the proposed encroachment is less than 10% (total area) of the TPZ, and outside of the SRZ, detailed root investigations should not be required. The area lost to this encroachment should be compensated for elsewhere, and be contiguous with the TPZ
- **Medium impact (<20%):** If the proposed encroachment is greater than 10% of the TPZ and outside of the SRZ, the project arborist must demonstrate that the tree(s) remain viable. The area lost to this encroachment should be compensated for elsewhere, and be contiguous with the TPZ. All work within the TPZ must be carried out under the supervision of the project arborist
- **High impact (>20%):** If the proposed encroachment is greater than 20% of the TPZ the SRZ may be impacted. Tree sensitive construction techniques may be used for minor works within this area providing no structural roots are likely to be impacted, and the project arborist can demonstrate that the tree(s) remain viable. Root investigation by non-destructive methods is essential for any proposed works within this area.

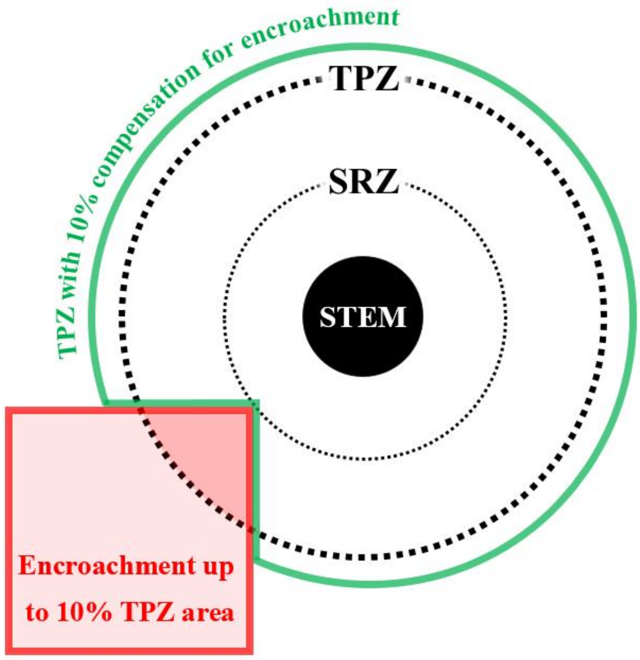


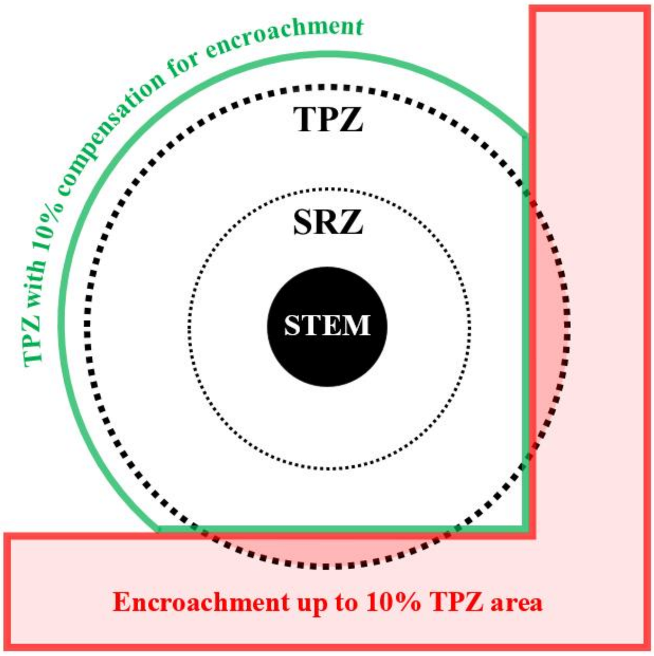
Indicative zones of impact within the TPZ

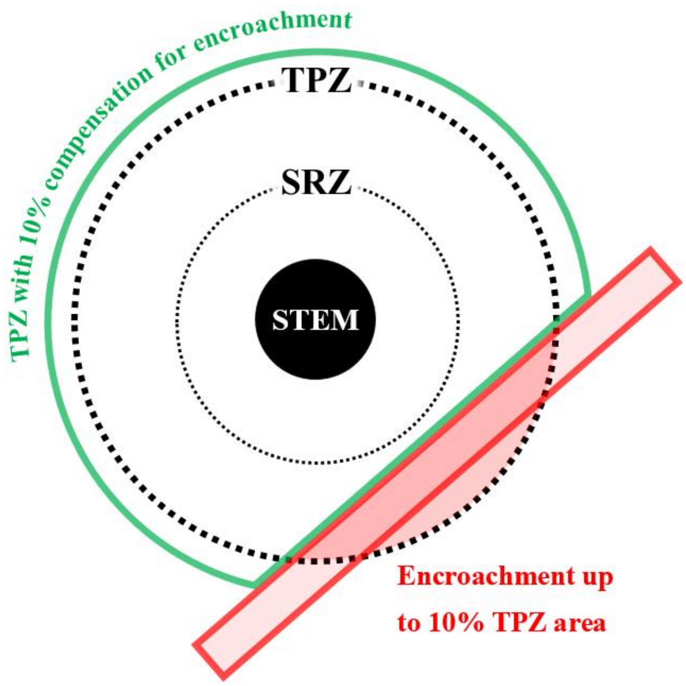
Attachment D - Encroachment within the TPZ

The following examples of minor encroachment are considered to be acceptable and will generally not require detailed root investigation.









Reference

Council of Standards Australia (August 2009)
AS 4970-2009 Protection of Trees on Development Sites
Standards Australia, Sydney.

Attachment E - Tree retention assessment

Tree Significance – Assessment Criteria – STARS©		
Low	**Medium**	**High**
The tree is in fair to poor condition and good or low vigour	The tree is in fair to good condition	The tree is in good condition and good vigour
The tree has form atypical of the species	The tree has form typical or atypical of the species	The tree has a form typical for the species
The tree is not visible or is partly visible from the surrounding properties or obstructed by other vegetation or buildings	The tree is a planted locally indigenous or a common species with its taxa commonly planted in the local area	The tree is a remnant or is a planted locally indigenous specimen and/or is rare or uncommon in the local area or of botanical interest or of substantial age.
The tree provides a minor contribution or has a negative impact on the visual character and amenity of the local area	The tree is visible from surrounding properties, although not visually prominent as partially obstructed by other vegetation or buildings when viewed from the street	The tree is listed as a heritage item, threatened species or part of an endangered ecological community or listed on councils significant tree register
The tree is a young specimen which may or may not have reached dimensions to be protected by local Tree Preservation Orders or similar protection mechanisms and can easily be replaced with a suitable specimen	The tree provides a fair contribution to the visual character and amenity of the local area	The tree is visually prominent and visible from a considerable distance when viewed from most directions within the landscape due to its size and scale and makes a positive contribution to the local amenity.
The tree's growth is severely restricted by above or below ground influences, unlikely to reach dimensions typical for the taxa in situ – tree is inappropriate to the site conditions	The tree's growth is moderately restricted by above or below ground influences, reducing its ability to reach dimensions typical for the taxa in situ.	The tree supports social and cultural sentiments or spiritual associations, reflected by the broader population or community group or has commemorative values.
The tree is listed as exempt under the provisions of the local Council Tree Preservation Order or similar protection mechanisms		The tree's growth is unrestricted by above and below ground influences, supporting its ability to reach dimensions typical for the taxa in situ – tree is appropriate to the site conditions.
The tree has a wound or defect that has the potential to become structurally unsound.		
The tree is an environmental pest species due to its invasiveness or poisonous/allergenic properties.		
The tree is a declared noxious weed by legislation.		

Useful Life Expectancy – Assessment Criteria			
Dead	**Short**	**Medium**	**Long**
Trees that should be removed within the next 5 years. Dead, dying, suppressed or declining trees because of disease or inhospitable conditions. Dangerous trees because of instability or recent loss of adjacent trees. Dangerous trees because of structural defects including cavities, decay, included bark, wounds or poor form. Damaged trees that are clearly not safe to retain. Trees that could live for more than 5 years but may be removed to prevent interference with more suitable individuals or to provide space for new planting. Trees that are damaging or may cause damage to existing structures within 5 years. Trees that will become dangerous after removal of other trees for the reasons.	Trees that appear to be retainable at the time of the assessment for 5-15 years with an acceptable level of risk. Trees that may only live between 5 and 15 more years. Trees that could live for more than 15 years but may be removed for safety or nuisance reasons. Trees that could live for more than 40 years but may be removed to prevent interference with more suitable individuals or to provide space for new planting. Trees that could be made suitable for retention in the medium term by remedial tree care.	Trees that appear to be retainable at the time of the assessment for 15-40 years with an acceptable level of risk. Trees that may only live between 15 and 40 more years. Trees that could live for more than 40 years but may be removed for safety or nuisance reasons. Trees that could live for more than 40 years but may be removed to prevent interference with more suitable individuals or to provide space for new planting. Trees that could be made suitable for retention in the medium term by remedial tree care.	Trees that appear to be retainable at the time of the assessment for more than 40 years with an acceptable level of risk. Structurally sound trees located in positions that can accommodate future growth. Trees that could be made suitable for retention in the long term by remedial tree care. Trees of special significance for historical, commemorative or rarity reasons that would warrant extraordinary efforts to secure their long term retention.

		Tree Significance				
		High	**Medium**	**Low**		
Useful Life Expectancy	**Long** >40 years					
	Medium 15-40 years					
	Short <1-15 years					
	Dead					

	Legend for Matrix Assessment
	Priority for retention (High): These trees are considered important for retention and should be retained and protected. Design modification or re-location of building/s should be considered to accommodate the setbacks as prescribed by AS 4970 – *Protection of trees on development sites*. Tree sensitive construction measures must be implemented if works are to proceed within the Tree Protection Zone.
	Consider for retention (Medium): These trees may be retained and protected. These are considered less critical; however their retention should remain priority with the removal considered only if adversely affecting the proposed building/works and all other alternatives have been considered and exhausted.
	Consider for removal (Low): These tree are not considered important for retention, nor require special works or design modification to be implemented for their retention.
	Consider for removal (Low): These tree are not considered important for retention, nor require special works or design modification to be implemented for their retention.

Attachment F - Tree protection guidelines

The following tree protection guidelines must be implemented during the construction period in the event that no tree-specific recommendations are detailed.

Tree protection fencing

The TPZ is a restricted area delineated by protective fencing or the use of an existing structure (such as a wall or fence).

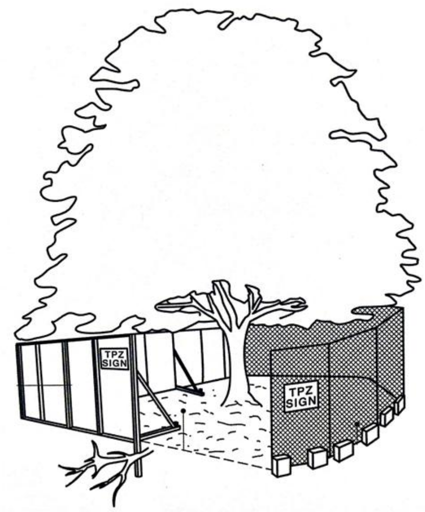
Trees that are to be retained must have protective fencing erected around the TPZ (or as specified in the body of the report) to protect and isolate it from the construction works. Fencing must comply with AS 4687-2007 - *Temporary fencing and hoardings*.

Tree protection fencing must be installed prior to site establishment and remain intact until completion of works. Once erected, protective fencing must not be removed or altered without the approval of the project arborist.

If the protective fencing requires temporary removal, trunk, branch and ground protection must be installed and must comply with *AS 4970-2009, Protection of Trees on Development Sites*.

Tree protection fencing shall be:

- Enclosed to the full extent of the TPZ (or as specified in the Recommendations and Tree Protection Plan).
- Cyclone chain wire link fence or similar, with lockable access gates.
- Certified and Inspected by the Project Arborist.
- Installed prior to the commencement of works.
- Prominently signposted with 300mm x 450mm boards stating 'NO ACCESS – TREE PROTECTION ZONE'.



Crown protection

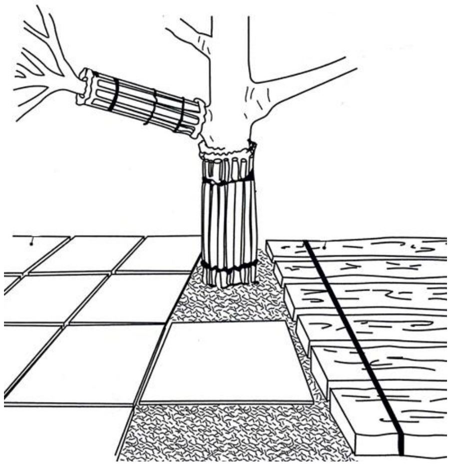
Tree crowns/canopy may be injured or damaged by machinery such as excavators, drilling rigs, trucks, cranes, plant and vehicles. Where crown protection is required, it will usually be located at least one metre outside the perimeter of the crown.

Crown protection may include the installation of a physical barrier, pruning selected branches to establish clearance, or the tying/bracing of branches.

Trunk protection

Where provision of tree protection fencing is impractical or must be temporarily removed, truck protection shall be installed for the nominated trees to avoid accidental mechanical damage.

The removal of bark or branches allows the potential ingress of micro-organisms which may cause decay. Furthermore, the removal of bark restricts the trees' ability to distribute water, mineral ions (solutes), and glucose.



Trunk protection shall consist of a layer of either carpet underfelt, geotextile fabric or similar wrapped around the trunk, followed by 1.8 m lengths of softwood timbers aligned vertically and spaced evenly around the trunk (with an approx. 50 mm gap between the timbers).

The timbers must be secured using galvanised hoop strap (aluminium strapping). The timbers shall be wrapped around the trunk but not fixed to the tree, as this will cause injury/damage to the tree.

Ground protection

Tree roots are essential for the uptake/absorption of water, oxygen and mineral ions (solutes). It is essential to prevent the disturbance of the soil beneath the dripline and within the TPZ of trees that are to be retained. Soil compaction within the TPZ will adversely affect the ability of roots to function correctly.

If temporary access for machinery is required within the TPZ ground protection measures will be required. The purpose of ground protection is to prevent root damage and soil compaction within the TPZ. Ground protection may include a permeable membrane such as geotextile fabric beneath a layer of mulch, crushed rock or rumble boards.

If the grade is to be raised within the TPZ, the material should be coarser or more porous than the underlying material.

Root protection and pruning

If incursions/excavation within the TPZ are unavoidable, exploratory excavation (under the supervision of the Project Arborist) using non-destructive methods may be considered to evaluate the extent of the root system affected, and determine whether or not the tree can remain viable.

If the project arborist identifies conflicting roots that requiring pruning, they must be pruned with a sharp implement such as; secateurs, pruners, handsaws or a chainsaw back to undamaged tissue. The final cut must be a clean cut.

Underground services

All underground services should be routed outside of the TPZ. If underground services need to be installed within the TPZ, they should be installed using horizontal directional drilling (HDD). The horizontal drilling/boring must be at minimum depth of 600 mm below grade. Trenching for services is to be regarded as ‘excavation’.

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