WestConnex

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New M5

Environmental Impact Statement

Biodiversity Assessment Report

Appendix S

November 2015

WestConnex

DOCUMENT TRACKING

Item	Detail
Project Name	The New M5 Environmental Impact Assessment
Project Number	14SYD_349
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Status	FINAL
Version Number	8
Last saved on	19 November 2015

This report should be cited as 'Eco Logical Australia 2015. *The New M5 - Biodiversity Assessment Report*. Prepared for Roads and Maritime Services of NSW.'

ACKNOWLEDGEMENTS

This document has been prepared by Eco Logical Australia Pty Ltd with support from Roads and Maritime Services of NSW and AECOM.

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Template 08/05/2014

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Abbreviations

Abbreviation	Description
BBAM	BioBanking Assessment Methodology 2014
BOPMP	NSW Biodiversity Offsets Policy for Major Projects
CEEC	Critically Endangered Ecological Community
CMA	Catchment Management Authority
DotE	Commonwealth Department of the Environment
EEC	Endangered Ecological Community
EIS	Environmental Impact Statement
ELA	Eco Logical Australia Pty Ltd
EP&A Act	*Environmental Planning and Assessment Act 1979* (NSW)
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth)
FBA	Framework for Biodiversity Assessment
FM Act	*Fisheries Management Act 1994* (NSW)
GDE	Groundwater Dependent Ecosystem
IBRA	Interim Biogeographic Regionalisation for Australia
LGA	Local Government Area
MNES	Matters of National Environmental Significance
NPWS	NSW National Parks and Wildlife Service (part of OEH)
NSW Department of Planning and Environment	NSW Department of Planning and Environment, formerly the Department of Planning and Infrastructure
NW Act	*Noxious Weeds Act 1993* (NSW)
OEH	NSW Office of Environment and Heritage
Roads and Maritime	NSW Roads and Maritime Services
SEARs	Secretary's Environmental Assessment Requirements
TEC	Threatened Ecological Community
TSC Act	*Threatened Species Conservation Act 1995* (NSW)
VIS	Vegetation Information System

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Key terminology

Terminology	Description
Assessment bilateral	Provides for accreditation of New South Wales processes for environmental assessment of proposed actions that would otherwise be assessed by the Australian Government for approval under the EPBC Act. Only one decision including conditions on approval is made by New South Wales, accounting for New South Wales matters and matters of national environmental significance.
BioBanking	A methodology developed by the Office of Environment and Heritage (OEH) which provides a transparent, consistent and scientifically-based set of rules to assess biodiversity values. The BioBanking Assessment Methodology provides rules for the number and type of credits that can be created from undertaking conservation management at a biobank site. The methodology also provides rules for the number and type of credits that a development site will require in order to offset its impacts and thus improve or maintain biodiversity values. This project has used the Major Projects Offset Policy and Framework for Biodiversity Assessment (FBA) to assess the number and type of biodiversity credits required (see below).
Clearing	The removal of vegetation or other obstacles at or above ground level.
Construction footprint	The area directly impacted upon by the construction of the project. 'Construction footprint' is used in this technical working paper as an alternative to 'subject site' as defined by DEC (2004). The construction footprint includes all components relating to construction and operation of the project including (but not limited to): • All excavations/construction, including ancillary equipment. • All stormwater/sediment control measures. • All access requirements for construction or ongoing infrastructure maintenance. • All spoil and construction material storage areas.
Development site	The area of land that is subject to a proposed Major Project that is under the EP&A Act and the area assessed under the FBA.
Direct impacts	Those that directly affect species, populations or ecological communities and their associated habitats. Direct impacts include, but are not limited to, loss of individuals or ecological communities and removal of suitable habitat.
Earthworks	All operations involved in loosening, excavating, placing, shaping and compacting soil or rock.
Environmental Impact Statement	An environmental impact statement referred to in section 78A. 112 or 115Y of the EP&A Act.
Fish	As defined in the *Fisheries Management Act 1994*, as any marine, estuarine or freshwater fish or other aquatic animal (e.g., oysters, prawns, sharks, rays, starfish, insects and worms), at any stage of their life history. It does not include whales, mammals, birds, reptiles and amphibians.

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Terminology	Description
Framework for Biodiversity Assessment	The Framework for Biodiversity Assessment (FBA) is a tool that is applied by accredited ecological consultants. It provides a step by step method to identify and assess impacts on biodiversity. The FBA provides clear guidance on avoiding and minimising the biodiversity impacts of a project. It also provides an objective and repeatable method for determining offset requirements before a development application is submitted.
Indirect impacts	Those which occur when project-related activities affect species, populations or ecological communities in a manner other than direct loss. Indirect impacts include loss of individuals through starvation, exposure, predation by domestic and/or feral animals, loss of breeding opportunities, loss of shade/shelter, hydrological changes, increased soil salinity, erosion, weed invasion, increased noise and/or light, or increased human activity within or directly adjacent to sensitive habitat areas which include sites of known threatened species, endangered ecological communities or features that are potential habitat for threatened species e.g. culverts.
Locality	The locality is defined by a 10 kilometre radius around the study area for the purposes of conducting database search.
New M5	A new multi-lane road link between the M5 East Motorway, east of King Georges Road, and St Peters including: • Twin motorway tunnels between the M5 East Motorway and St Peters. • A new interchange at St Peters. • Connections to the existing road network. • Widening of Campbell Road, Campbell Street and Euston Road through existing road widening reservations.
Primary habitat	For the purposes of this technical working paper primary habitat for threatened species are those areas or resources that may be used or required by threatened species for breeding or roosting purposes.
Portal	The entrance or exit to the project tunnels.
Riparian	Riparian vegetation is vegetation on land that adjoins, directly influences or is influenced by, a body of water and includes streams, rivers, wetlands and estuarine areas.
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 the *Environmental Planning and Assessment Act 1979.*
Secondary habitat	For the purposes of this technical working paper secondary habitat for threatened species are those areas or resources that may be used by threatened species for foraging purposes.
Site establishment works	Preliminary works carried out prior to the commencement of construction, including: • Installation of environmental controls. • Vegetation clearing. • Establishment of construction facilities.
Spoil	Surplus excavated material which is either Excavated Natural Material (ENM) or Virgin Excavated Natural Material (VENM)
Stockpile	Temporarily stored materials such as soil, sand, gravel and spoil/waste.

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Terminology	Description
St Peters interchange	An interchange that will provide road connections from the New M5 tunnels to Campbell Road and Euston Road, St Peters and Gardeners Road, Mascot. Future WestConnex projects would integrate with the interchange to provide additional connections to the surrounding road network. The works associated with the ultimate configuration of the interchange will be subject to separate environmental assessment and approvals process.
Study area	For matters not assessed under the FBA, the entire project corridor was assessed. Matters not assessed under the FBA include MNES, aquatic and groundwater dependent ecosystems. MNES were considered for the project corridor plus a ten kilometre buffer. The project corridor assessed is shown in **Figure 1.** For the purposes of the assessment of impacts to biodiversity according to the FBA, the study area is the 550 metre buffer area where ecological survey investigation was conducted for this technical working paper. The study area can be seen in **Figure 3**.
Supplementary SEARs	Additional matters to be considered in the assessment and inclusion the BAR that would not otherwise be included under the FBA. This provides a mechanism for matters of national environment significance to be included in the assessment process and therefore provides a framework for the bilateral agreement.
The project	The New M5, as described in **Section 1.2**.
Waterway	Any stream, creek, river, lake, wetland, dam or estuary that holds or conveys water either permanently or occasionally.
WestConnex program of works	A new 33 kilometre motorway, intended to link Sydney's west with the airport and the Port Botany precinct. The component projects of the WestConnex program of works are: • M4 Widening – Church Street, Parramatta to Homebush Bay Drive, Homebush • M4 East – Homebush Bay Drive, Homebush to Parramatta Road and City West Link (Wattle Street) at Haberfield • New M5 – (the subject of this assessment) • King Georges Road Interchange Upgrade • M4-M5 Link – Haberfield to St Peters • Sydney Gateway • Southern extension.

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Executive summary

NSW Roads and Maritime Services (Roads and Maritime) is seeking approval to construct and operate the New M5 (the project), which would comprise a new multi-lane road link between the existing M5 East Motorway, east of King Georges Road, and St Peters. The project would also include an interchange at St Peters and connections to the existing road network. The New M5 is also a controlled action under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). In accordance with the EPBC Act environmental assessment bilateral agreement between the Commonwealth and the NSW Government (the assessment bilateral agreement 2015), the information contained in this assessment will also be used by the Commonwealth Minister for the Environment (or delegate) in making his or her decision on the controlled action

The majority of the project takes advantage of previously disturbed areas and for the majority of its length is underground. Opportunities to further avoid impacts in the design have also been explored, and as a result of investigations for this assessment, the following ecological values have been avoided:

- Extensive high quality native vegetation in the Wolli Creek Valley
- A small population of *Syzygium paniculatum* in the Wolli Creek Valley
- A small area of Sydney Turpentine Ironbark Forest in Kingsgrove
- A vegetated riparian corridor along Wolli Creek
- A Grey-headed Flying Fox camp and habitat at Turrella
- Areas of native coastal reedland and mangroves at the confluence of Wolli Creek and the Cooks River.
- Artificial breeding habitat for Green and Golden Bell Frog at Kogarah Golf Course.

The assessed construction footprint covers the project corridor from east of the King Georges Road interchange, east to the interchange at St Peters and surrounding suburbs. The assessment utilised both desktop analysis and field assessment, using the Framework for Biodiversity Assessment (FBA) methodology, to assess the habitat presence and condition of ecological communities. Targeted survey was conducted for migratory bird species and for hollow dependent fauna habitats. Potential indirect impacts that have been considered include:

- Disruptions to ecological connectivity
- Injury and mortality to flora and fauna
- Weeds
- Pathogens
- Hydrological changes
- Dust, noise, vibration and light (including overshadowing).

The design and construction footprint of the project was assessed in this technical working paper. Sufficient flexibility has been provided to allow for refinement of the construction footprint during detailed design, or to minimise environmental impacts, or in response to submissions received during the exhibition of the environmental impact statement (EIS). Therefore, the ecological impacts assessed as part of this technical working paper represents a conservative scenario and it is anticipated that the impacts would be less than assessed.

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A total 3.31 hectares of direct impacts on native vegetation associated with the proposed construction footprint have been identified (see **Figure 5** to **Figure 9**) comprising the following plant community types (PCT):

- *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*.

Of these three PCTs, two are listed as threatened ecological communities. The PCT *Broad-leaved Ironbark - Melaleuca decora shrubby open forest on clay soils of the Cumberland Plain, Sydney Basin Bioregion* is also known as Cooks River Castlereagh Ironbark Forest. This is listed as an endangered ecological community (EEC) under the NSW *Threatened Species Conservation Act 1995* (TSC Act) and a critically endangered ecological community (CEEC) under the EPBC Act. The PCT *Paperbark swamp forest of the coastal lowlands of the NSW North Coast Bioregion and Sydney Basin Bioregion*, is a component of the Swamp Sclerophyll Forest EEC listed under the TSC Act. The PCT *Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion* is not listed under the TSC Act and it does not provide habitat for threatened fauna.

A total of nine hollow bearing trees were present, supporting a total of nine hollows. No trees had very large hollows of a sufficient size to support breeding or roosting habitat for large forest owls. Up to eight trees with hollows would be removed or lopped as a result of the project, accounting for eight hollows of a range of sizes that provide potential habitat for threatened microbats and other hollow dependent fauna.

The project has substantially avoided biodiversity impacts by utilising, as much as possible, already disturbed sites and by being primarily underground construction design. A number of mitigation measures to minimise ecological impacts would be implemented as part of the project in line with Roads and Maritime *Biodiversity Guidelines – Protecting and managing biodiversity on RTA projects* (Roads and Traffic Authority 2011). These measures would be detailed in the 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; pathogen management and monitoring.

This Biodiversity Assessment Report assessed the type and number of credits as a result of the project 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.

It is anticipated that where possible offsets would be delivered via a BioBanking Agreement(s), which provide for ‘in perpetuity’ ecological management of the offsets. Other options for delivery of some offsets may be pursued where BioBanking credits cannot be obtained or are not practicable to meet project or conservation objectives. These options would include delivery of supplementary measures consistent with the FBA and NSW Biodiversity Offsets Policy for Major Projects. Supplementary

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measures for federally listed species or communities must be directed at the matter being impacted and must be consistent with any approved Recovery Plan or list of approved recovery actions and with the Commonwealth Offset Policy.

The third PCT, Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion is not an EEC or CEEC and it was not associated with threatened species habitat. Therefore, according to the NSW Biodiversity Offsets Policy for Major Projects and the Framework for Biodiversity Assessment, this PCT does not require an offset to be determined, despite the offset tool calculating one credit was required.

The following matters, while not assessed under the FBA, are covered in this report:

- Aquatic biodiversity listed under the NSW *Fisheries Management Act 1994*
- Groundwater dependent ecosystems (GDEs)
- Matters of national environmental significance (MNES) listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

An assessment of the potential impacts on GDEs and aquatic habitats concluded there would be no significant impact as a result of the project (AECOM 2015a). There is likely to be no significant impact to aquatic flora and fauna listed under the *Fisheries Management Act 1994*. No protected marine vegetation would be harmed.

There were three MNES that were known or had the potential to occur within the development site. The Cooks River / Castlereagh Ironbark Forest is listed as a CEEC under the EPBC Act. This community met the definition under the EPBC Act because it was:

- Greater than or equal to 0.1 hectares in size and
- Greater than or equal to 30 per cent of the perennial native understorey was made up of native species and
- The patch was contiguous with a native vegetation remnant greater than or equal to 1 hectare in size.

Two threatened fauna are either known or likely to utilise some or the entire development site were:

- *Litoria aurea* (Green and Golden Bell Frog), which is listed as vulnerable under the EPBC Act and is known from habitat near the proposed Arncliffe surface works area
- *Pteropus poliocephalus* (Grey-headed Flying Fox) which is listed as vulnerable under the EPBC Act and is known from a camp at Turrella and likely to use some of the development site for foraging.

The project was referred to the Commonwealth Minister for the Environment on 17 July 2015. The referral suggested that on the basis of the potential adverse impacts to the Cooks River / Castlereagh Ironbark Forest and Green and Golden Bell Frog, the project should be considered a controlled action. The Minister for the Environment's delegate declared the project a controlled action on 13 August 2015. The project was determined to be likely to have a significant impact on two MNES, Cooks River / Castlereagh Ironbark Forest and Green and Golden Bell Frog.

All impacts to MNES have been avoided as far as practicable and all impacts have been assessed in accordance with Commonwealth guidelines (see **Table 35**). Comprehensive mitigation strategies have been put into place to manage potential impacts to MNES. Despite this, there are some unavoidable residual impacts remaining as a result of the project. All these impacts have been identified and would be offset (see **Chapter 7**).

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1 Introduction

1.1 Project background

NSW Roads and Maritime Services (Roads and Maritime) is seeking approval to construct and operate the New M5 (the project), which would comprise a new, tolled multi-lane road link between the existing M5 East Motorway, east of King Georges Road, and St Peters. The project would also include an interchange at St Peters and connections to the existing road network. A full description of the project is provided in **Appendix J**.

Approval is being sought under Part 5.1 of the Environmental Planning and Assessment Act 1979 (EP&A Act). The project is declared to be State significant infrastructure (SSI) under section 115U(2) of the EP&A Act by reason of the operation of clause 14 and Schedule 3 of the State Environmental Planning Policy (State and Regional Development) 2011. Accordingly, the project is subject to assessment under Part 5.1 of the EP&A Act and requires the approval of the Minister for Planning. An environmental impact statement (EIS) is therefore also required.

Roads and Maritime is seeking the project to be declared by the Minister for Planning as State significant infrastructure and critical State significant infrastructure under sections 115U(4) and 115V of the EP&A Act.

On 11 August 2015, the Commonwealth Minister for the Environment determined that the project has the potential to significantly impact on a matter of national environmental significance and is therefore a 'controlled action'. This means that approval of the project will be required from the Commonwealth Minister for the Environment in addition to environmental and planning approvals required under State legislation.

Under the Bilateral Agreement relating to environmental assessment (February 2015) between the Commonwealth Government and the NSW Government, this EIS has been adopted for the purpose of meeting the assessment requirements of both the Commonwealth EPBC Act and the NSW EP&A Act.This technical working paper identifies and assesses the potential biodiversity impacts associated with construction and operation of the project and supports the EIS for the project.

In preparing this report, the Secretary's environmental assessment requirements (SEARs) issued for the New M5 project (SSI 6788) on 5 March 2015, and reissued on 26 August 2015 have been addressed. The key matters raised by the Secretary for consideration in this report and where this report addresses the SEARs are outlined in **Table 1**.

Table 1: Secretary's Environmental Assessment Requirements for the biodiversity impact assessment

Secretary's Environmental Assessment Requirement	Section Addressed in this Report
An assessment of the potential ecological impacts of the proposal, with specific reference to vegetation and habitat clearing, connectivity, edge effects, weed dispersal, riparian and aquatic habitat impacts, soil and water quality impacts and operational impacts. The assessment must:	
Make specific reference to impacts on landscape values, biodiversity values of native vegetation and threatened species or populations, including worst case estimates of vegetation clearing and operational impacts	Chapter 3 Chapter 4 Chapter 5

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Secretary's Environmental Assessment Requirement	Section Addressed in this Report
Demonstrate a design philosophy of impact avoidance on ecological values, and in particular, ecological values of high significance, and be consistent with the 'avoid, minimise or offset' principle	Chapter 6
Be undertaken in accordance with the Framework for Biodiversity Assessment (OEH, 2014a) and the NSW Biodiversity Offsets Policy for Major Projects (OEH, 2014b), and by a person accredited in accordance with section 142B(1)(c) of the Threatened Species Conservation Act, 1995. Impacts on species, populations and ecological communities that will require further consideration and provision of information specified in section 9.2 of the Framework for Biodiversity Assessment include those identified by the OEH. Species specific surveys shall be undertaken for those species and in accordance with the survey requirements specified by the OEH	Chapter 2
In relation to aquatic biodiversity be consistent with the draft Policy and Guidelines for Fish Habitat Conservation and Management – Update 2013 (DPI, 2013).	Chapter 5 Chapter 6
The assessment of potential ecological impacts is to comply with the requirements of the *Guidelines for preparing Assessment Documentation relevant to the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) — WestConnex New M5 Project (EPBC 2015/7520)*. The assessment is to contain detailed identification and assessment of direct and indirect impacts on threatened species and ecological communities that will, are likely to, or may be significantly impacted by the proposal, including but not limited to: • Cooks River/Castlereagh Ironbark Forest of the Sydney Basin Bioregion, • Green and Golden Bell Frog (*Litoria aurea*), • Turpentine Ironbark Forest in the Sydney Basin Bioregion, • Bynoe's Wattle (*Acacia bynoeana*), • Downy Wattle (*Acacia pubescens*), • Deane's Paperbark (*Melaleuca deanei*), • Hairy Geebung (*Persoonia hirsuta*), • Spiked Rice-flower (*Pimelea spicata*), • Magenta Lilly Pilly (*Syzygium paniculatum*), and • Black-eyed Susan (*Tetratheca juncea*).	Chapter 4 Chapter 5 Chapter 6 Chapter 7 Appendix A Appendix G

Matters for further consideration provided by the NSW Office of Environment and Heritage (OEH), in addition to the SEARs include:

- Cooks River/Castlereagh Ironbark Forest
- Sydney Turpentine-Ironbark Forest
- Swamp Oak Floodplain Forest
- River-flat Eucalypt Forest
- Swamp Sclerophyll Forest

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- *Acacia prominens* (Gosford Wattle) endangered population in the Hurstville and Kogarah Local Government Areas
- Long-nosed Bandicoot (*Perameles nasuta*) endangered population in inner western Sydney
- White-fronted Chat (*Epthianura albifrons*) endangered population in the Sydney Metropolitan Catchment Management Area
- *Acacia terminalis* subsp. *terminalis* (Sunshine Wattle)
- *Streblus pendulinus* aka *Streblus brunonianus* (Siah's Backbone)
- *Wilsonia backhousei* (Narrow-leafed Wilsonia)
- Australasian Bittern (*Botaurus poiciloptilus*)
- Sanderling (*Calidris alba*)
- Curlew Sandpiper (*Calidris ferruginea*)
- Greater Sand-plover (*Charadrius leschenaultii*)
- Lesser Sand-plover (*Charadrius mongolus*)
- Sooty Oystercatcher (*Haematopus fuliginosus*)
- Pied Oystercatcher (*Haematopus longirostris*)
- Broad-billed Sandpiper (*Limicola falcinellus*)
- Little Tern (*Sternula albifrons*)
- Terek Sandpiper (*Xenus cinereus*)
- Green and Golden Bell Frog (*Litoria aurea*)
- Black Bittern (*Ixobrychus flavicollis*)
- Grey-headed Flying Fox (*Pteropus poliocephalus*) (if camps are impacted)
- Eastern Freetail Bat (*Mormopterus norfolkensis*) (if maternity or roost sites are impacted)
- Greater Broad-nosed Bat (*Scoteanax rueppellii*) (if breeding or roost sites are impacted).

An additional list of species requiring targeted survey was provided by OEH. The species were:

- *Streblus pendulinus* aka *Streblus brunonianus* (Whalebone Tree)
- Sanderling (*Calidris alba*)
- Curlew Sandpiper (*Calidris ferruginea*)
- Terek Sandpiper (*Xenus cinereus*)
- Greater Broad-nosed Bat (*Scoteanax rueppellii*) (if breeding or roost sites are impacted).
- Eastern Freetail Bat *(Mormopterus norfolkensis)* (if maternity or roost sites are impacted).

1.2 Overview of WestConnex

WestConnex is a 33 kilometre motorway that is intended to link Sydney's west with the airport and the Port Botany precinct. The component projects of the WestConnex program of works are:

- M4 Widening – Pitt Street, Parramatta to Homebush Bay Drive, Homebush (planning approval granted on 21 December 2014 and under construction)
- M4 East – Homebush Bay Drive, Homebush to Parramatta Road and City West Link (Wattle Street) at Haberfield (planning application lodged and subject to planning approval)
- New M5 – (the subject of this EIS)
- King Georges Road Interchange Upgrade (planning approval granted on 3 March 2015 and under construction)
- M4-M5 Link – Haberfield to St Peters (undergoing concept development and subject to planning approval)
- Sydney Gateway (is the subject of further investigations by the NSW Government and would be subject to separate planning approval).

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Separate planning applications have or will be lodged for each component project. Each project will be assessed separately, but the impact of each project will also be considered in the context of the wider WestConnex program of works.

A proposed Southern extension from Arncliffe to Kogarah is currently being investigated by the NSW Government, and would connect the New M5 to the southern and bayside suburbs of Sydney, and the proposed F6 motorway.

The WestConnex Delivery Authority (WDA) was established by the NSW Government to manage the delivery of the WestConnex series of projects for Roads and Maritime on behalf of the State. The WDA was a public subsidiary corporation of the Roads and Maritime. Following the achievement of early milestones for the WestConnex program of works, the NSW Government took the opportunity to evolve this early governance model.

On 1 October 2015 the transfer of the project delivery functions of WDA to Sydney Motorway Corporation (SMC) was finalised, forming a single decision-making entity to finance and deliver the WestConnex program of works. SMC is a private corporation, the shareholders of which are the Minister for Roads, Maritime and Freight and the Treasurer, with a majority independent board of nine directors.

Roads and Maritime is the Government client agency for the WestConnex program of works. In that capacity Roads and Maritime will enter into contractual arrangements with SMC subsidiary entities which will design, build, own and operate the motorway on behalf of Roads and Maritime. Roads and Maritime and SMC are working together to manage the planning approval process for the project. However, for the purpose of the planning application for the project, Roads and Maritime is the proponent.

1.3 Overview of the project

Key components of the project would include:

- Twin motorway tunnels between the existing M5 East Motorway (between King Georges Road and Bexley Road) and St Peters. The western portals along the M5 East Motorway would be located east of King Georges Road, and the eastern portals at St Peters would be located in the vicinity of the Princes Highway and Canal Road. Each tunnel would be about nine kilometres in length and would be configured as follows:
    - Between the western portals and Arncliffe, the tunnels would be built to be three lanes but marked for two lanes as part of the project. Any change from two lanes to three lanes would be subject to future environmental assessment and approval
    - Between the Arncliffe and St Peters, the tunnels would be built to be five lanes but marked for two lanes as part of the project. Any change from two lanes to any of three, four or five lanes would be subject to future environmental assessment and approval
- The western portals along the M5 East Motorway would be located east of King Georges Road, and the eastern portals at St Peters would be located in the vicinity of the Princes Highway and Canal Road
- Tunnel stubs to allow for a potential future connection to the future M4-M5 Link and a potential future connection to southern Sydney
- Surface road widening works along the M5 East Motorway between east of King Georges Road and the new tunnel portals
- A new road interchange at St Peters, which would initially provide road connections from the main alignment tunnels to Campbell Road and Euston Road, St Peters

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- Two new road bridges across Alexandra Canal which would connect St Peters interchange with Gardeners Road and Bourke Road, Mascot
- Closure and remediation of the Alexandria Landfill site, to enable the construction and operation of the new St Peters interchange
- Works to enhance and upgrade local roads near the St Peters interchange
- Ancillary infrastructure and operational facilities for electronic tolling, signage (including electronic signage), ventilation structures and systems, fire and life safety systems, and emergency evacuation and smoke extraction infrastructure
- A motorway control centre that would include operation and maintenance facilities
- New service utilities and modifications to existing service utilities
- Temporary construction facilities and temporary works to facilitate the construction of the project
- Infrastructure to introduce tolling on the existing M5 East Motorway
- Surface road upgrade works within the corridor of the M5 East Motorway.

Construction activities associated with the project would generally include:

- Commencement of enabling and temporary works, including construction power, water supply, ancillary site establishment, demolition works, property and utility adjustments and public transport modifications (if required)
- Construction of the road tunnels, interchanges, intersections and roadside infrastructure
- Haulage of spoil generated during tunnelling and excavation activities
- Fitout of the road tunnels and support infrastructure, including ventilation and emergency response systems
- Construction and fitout of the motorway control centre and ancillary operations buildings
- Upgrades to surface roads and construction of bridges
- Implementation of environmental management and pollution control facilities for the project.

Subject to the project obtaining environmental planning approval, construction of the project is anticipated to commence around mid-2016 and is expected to take around three years to complete.

The M5 Motorway corridor (the M5 East Motorway and the M5 South West Motorway) is the main passenger, commercial and freight corridor between Port Botany, Sydney Airport and south-west Sydney. Traffic demands on the M5 East Motorway currently exceed the design capacity of the roadway, and as a result, present a significant bottleneck to the M5 Motorway corridor with motorists experiencing heavy congestion and unreliable journey times. The project is needed to provide additional capacity along the M5 Motorway corridor, and would allow for a more robust and reliable transport network.

1.4 Study area

The project would be located within the Canterbury, Hurstville, Rockdale, Marrickville, Sydney and Botany Bay local government areas. The project corridor is located from about five to twenty kilometres to the south and south-west of the central business district of Sydney. The project would traverse the suburbs of Beverly Hills, Kingsgrove, Bexley North, Earlwood, Bardwell Park, Bardwell Valley, Arncliffe, Wolli Creek, Tempe, Sydenham, St Peters, Alexandria and Mascot. The study area is located within the Cumberland and Pittwater sub-regions of the Sydney Basin Bioregion.

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The study area includes existing motorways, residential areas, urban landscaped areas, golf courses and remnant native vegetation in varying condition and with varying levels of connectivity to other remnant native vegetation. **Figure 1** provides the project corridor as assessed for matters of national environmental significance, GDEs and riparian ecosystems. For the purposes of this project, the study area has been divided into five sections as described below in **Table 2** and shown in **Figure 3**.

The study area contains the development site footprint, and comprises both an operational and construction footprint.

Table 2: Development site locations

Development Site	Location description
Development site – shown in **Figure 2**	**Alexandria Landfill and Sydney Park**: Area roughly bordered by Canal Road, Princes Highway, Sydney Park Road and Burrows Road, Alexandria and St Peters
	Kogarah Golf Course: Also known as the Arncliffe surface works area
	Bexley North: Areas include Kingsgrove Avenue Reserve, Wolli Creek, and M5 East Motorway
	M5 East: Area includes Beverly Grove Park, M5 East Motorway and Canterbury Golf Course
	Kingsgrove Road: surface works area

1.4.1 Construction footprint

The construction footprint is the area proposed to be impacted, cleared and/or disturbed during the construction of the project, including both above ground and underground elements of the project.

It is assumed that there would be complete vegetation clearance within the construction footprint. Realistically total clearance may not be required, however given that the final detailed design is yet to be finalised, complete clearance was assumed to ensure ecological impacts complied with regulatory requirements (EP&A Act).

The surface construction footprint is shown in **Figure 3**, these areas have the same meaning as development site for the purposes of the FBA and this is a worst case footprint.

It should be noted that the main tunnel alignment has not been assessed because it is underground.

1.4.2 Operational footprint

The operational footprint for the project represents the area that would be physically impacted by the operation of the project, including all operational ancillary infrastructure. The operational footprint differs from the construction footprint but is fully contained within the construction footprint.

1.5 Context of Biodiversity Assessment Report

The NSW Government has developed a NSW Biodiversity Offsets Policy for Major Projects (BOPMP), 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 NSW Department of Planning and Environment (DP&E).

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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 on the development site, and the biodiversity offsets required for any unavoidable impacts. Dr Meredith Henderson is the accredited assessor **(Table 5**) and conducted the assessment in accordance with the requirements of the legislation and the FBA.

While the EPBC Act assessment bilateral 2015 requires that the FBA is applied for undertaking biodiversity assessment, consideration of the supplementary SEARS issued by DoE is still required. How this report meets the supplementary SEARS, which were issued on 26 August 2015, is included at **Appendix I**.

The FBA applies only to terrestrial impacts. Assessment of impacts to aquatic biodiversity and requirements for avoiding, minimising and offsetting these impacts is to be guided by the *Fisheries NSW Policy and guidelines for fish habitat conservation and management (Update 2013)* (Fisheries NSW policy and guidelines) and is to be conducted separately to the BAR.

1.5.1 Assessment guidelines

The assessment presented in this Technical Working Paper: Biodiversity Assessment Report (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:

- 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).
- NSW Framework for Biodiversity Assessment (OEH 2014a).
- NSW offset policy for major projects (State significant development and State significant infrastructure) (OEH 2014b).
- Commonwealth Approved Listing Advice for Turpentine-Ironbark Forest of the Sydney Basin Bioregion (Threatened Species Scientific Committee (TSSC) 2005)
- Commonwealth Approved Conservation Advice for Turpentine Ironbark Forest in the Sydney Basin Bioregion (TSSC 2014a)
- Commonwealth Approved Conservation Advice (including listing advice) for Cooks River/Castlereagh Ironbark Forest of the Sydney Basin Bioregion. (TSSC 2015)
- Commonwealth Significant Impact Guidelines for the Green and Golden Bell Frog (2009).
- Commonwealth Approved Conservation Advice for *Litoria aurea* (Green and Golden bell Frog) (TSSC 2014b)
- Risk Assessment Guidelines for Groundwater Dependent Ecosystems (DPI 2012).

1.6 Report structure

This report is the BAR for the project. It therefore follows the structure as outlined in the FBA. The report is divided into several chapters, which reflect the requirements of the FBA (see **Appendix H**):

- Executive summary
- Chapter 1 – Introduction
- Chapter 2 – Assessment methodology
- Chapter 3 – Landscape features
- Chapter 4 – Native vegetation
- Chapter 5 – Threatened species
- Chapter 6 – Avoidance, mitigation and impacts
- Chapter 7 – Impact summary
- Chapter 8 – Biodiversity credit report

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- References
- Appendix A – Likelihood of occurrence
- Appendix B – Plot and transect field data
- Appendix C – Plot and transect field data sheets
- Appendix D – Flora species recorded
- Appendix E – Fauna species recorded
- Appendix F – Hollow- bearing tree survey results
- Appendix G – EPBC Act Significant Impact Criteria
- Appendix H – FBA Methodology and where addressed in document
- Appendix I – Compliance with Commonwealth requirements
- Appendix J – Detailed project description
- Appendix K – Green and Golden Bell Frog Plan of Management.

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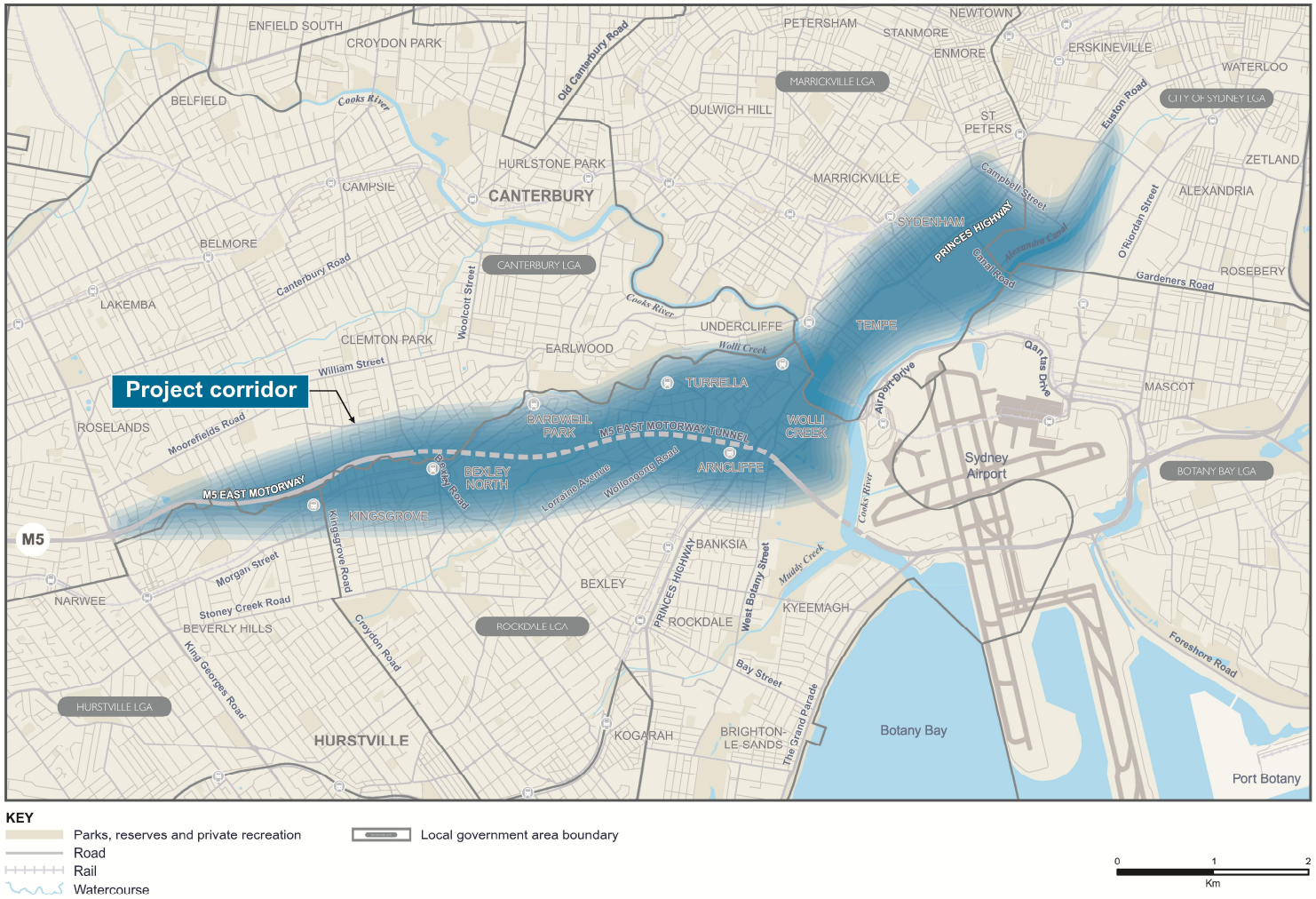

Figure 1: Project corridor assessed for matters of national environmental significance, GDE and riparian ecosystems (Figure courtesy of AECOM)

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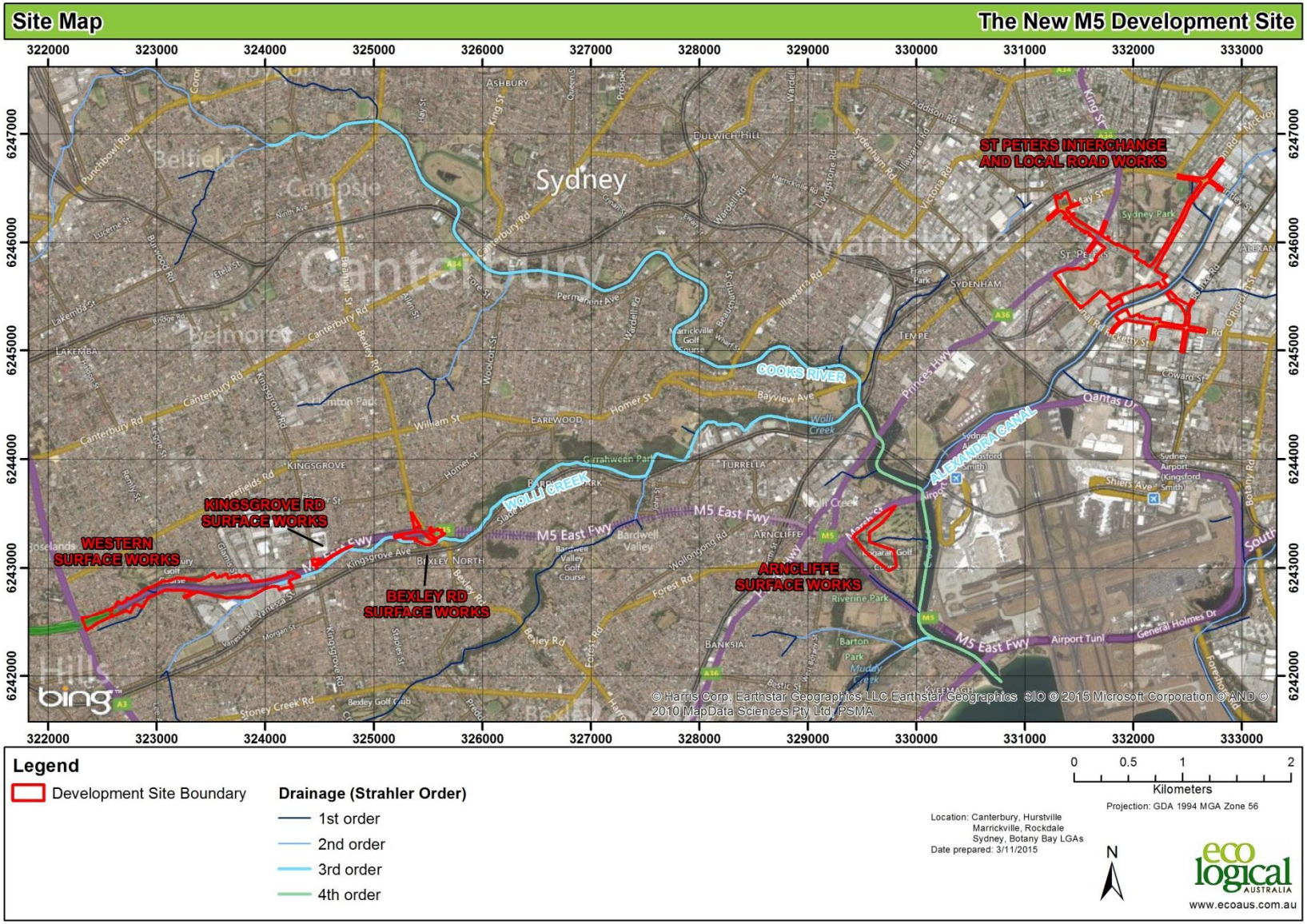

Figure 2: Site map, areas in red outline are the development site assessed under the FBA

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2 Methodology

2.1 Background information

A number of database searches, aerial photographs, previous reports and studies were used in this assessment as described in subsequent sections.

2.1.1 Database searches

ELA reviewed aerial photography as well as the following vegetation and soil datasets which overlap within the study area:

- VIS online vegetation classification database (OEH 2015b).
- Sydney Metropolitan Catchment Management Authority Vegetation Mapping (OEH 2013).
- Native Vegetation Maps of the Cumberland Plain, Western Sydney (NPWS 2002).
- 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 (10 kilometre radius search), accessed 13 Nov 2014.
- NSW Threatened Species Profile Database (OEH 2015c).
- EPBC Act Protected Matters Search Tool (10 kilometre radius search), accessed 1 Dec 2014.
- NSW DPI Fisheries threatened and protected species records viewer (FM Act), accessed 4 June 2015.
- NSW DPI Fisheries Key Fish Habitat Map, accessed 4 June 2015.
- NSW Fisheries Marine Vegetation Map (Botany Bay and Cooks River).
- Bureau of Meteorology Groundwater Dependent Ecosystems Atlas, accessed 3 June 2015.

2.1.2 Previous reports

To understand the context of the development site in relation to previous biodiversity studies, reviews of reports were conducted. There are Green and Golden Bell Frog breeding ponds adjacent to the Kogarah Golf Course and a stand of Cooks River Castlereagh Ironbark Forest at Beverly Grove. ELA reviewed a number of previous reports relevant to the study area, including:

- Beverly Grove Bushland Flora Survey – M5 East Motorway Corridor Beverly Grove (Cumberland Flora and Fauna Interpretive Services 1997).
- Management Plan for Green and Golden Bell Frog at Arncliffe (White 1998).
- Draft Recovery Plan for the Green and Golden Bell Frog (NSW DEC 2005).
- Green and Golden Bell Frog Management Plan for Cooks Cove (Cumberland Ecology 2006).
- Plan of Management: Green and Golden Bell Frog Key Population of the Lower Cooks River (NSW DECC 2008a).
- Biodiversity assessment proposed widening of Marsh Street Wolli Creek (AMCS 2014).

Beverly Grove Bushland Flora Survey – Cumberland Flora and Fauna Interpretive Services 1997

Cumberland Flora and Fauna Interpretive Services was engaged by the former Roads and Traffic Authority (RTA now Roads and Maritime) to undertake detailed surveys of the Beverly Grove bushland, which occurs within part of the M5 East Motorway corridor between Beverly Hills and Kingsgrove. The surveys were conducted to assess if the proposed realignment of the road would impact on areas of high conservation significance such as Cooks River Clay Plain Scrub Forest, as detailed by previous surveys.

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It should be noted that the Cooks River Clay Plain Scrub Forest was renamed by the NSW Scientific Committee in 2002 as Cooks River Castlereagh Ironbark Forest, which is listed as an EEC under the TSC Act.

The assessment provides a description of the vegetation and condition on site and identifies units of vegetation based on structure. The assessment concluded that the Beverly Grove bushland possessed considerable botanical integrity. The core areas of Cooks River Clay Plain Scrub Forest were in good condition with weeds primarily limited to its margins. The assessment concluded that the areas of highest conservation significance (including the good condition Cooks River Clay Plain Scrub Forest) would remain physically unaffected by the motorway construction.

However the bushland at Beverly Grove was considered to be of high conservation significance due to its proximity and potential integration with Sydney Turpentine Ironbark Forest and the Cooks River Clay Plain Scrub Forest being at its eastern most extent. The assessment recommended bushland rehabilitation works be undertaken.

Management Plan for Green and Golden Bell Frog at Arncliffe - White 1998

Following the approval of the original M5 East Motorway proposal a management and monitoring plan was prepared by Dr Arthur White to guide the creation of artificial habitat for Green and Golden Bell Frogs at Arncliffe.

This plan provides useful historical information about the size and distribution of the Green and Golden Bell Frog population in this area at that time.

The plan has lead the creation of habitat on Roads and Maritime land within the Kogarah Golf Course (known as the RTA ponds) which has been successfully managed by Dr White with the assistance of volunteers and the support of Roads and Maritime since 1998.

The success of these efforts lends confidence to any current proposal to create additional habitat at Arncliffe and further insure against stochastic events affecting the RTA ponds.

Draft Recovery Plan for the Green and Golden Bell Frog - NSW Department of Environment and Conservation 2005

This document forms the draft Commonwealth and NSW State recovery plan for the Green and Golden Bell Frog. The recovery plan considers the conservation requirements of the species across its known range and identifies actions to ensure the long-term viability of the species.

The recovery plan also provides information on the species habitat requirements, ecology, distribution, conservation status, key threats, management issues, research and monitoring, captive breeding and translocation, community education and co-ordination of the recovery plan including implementation, responsibility and costs.

The recovery plan outlines a number of key populations in Sydney. The Arncliffe population near Marsh Street is one of these. The plan refers to the habitat creation, enhancement and captive breeding that were part of the M5 East Motorway project. The plan recommends the development of a specific management plan for this population (see DECC 2008a).

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Green and Golden Bell Frog Management Plan for Cooks Cove – Cumberland Ecology 2006

Cumberland Ecology was engaged by Cooks Cove Development Corporation and Boyd Cook Cove Pty Ltd to prepare a Management Plan for the Green and Golden Bell Frog. The plan details management measures to protect the population at the site during all stages of the proposed development (prior, during and post construction).

The plan also details management actions to enhance the population's viability in the long-term, such as habitat improvement, ameliorating water pollution levels, reduce threatening process (e.g. predation by Mosquito Fish) and long-term habitat protection.

Plan of Management Green and Golden Bell Frog Key Population of the Lower Cooks River - NSW DECC 2008a

This document was prepared to satisfy actions outlined in the Draft Recovery Plan for the Green and Golden Bell Frog, which required the NSW Department of Environment and Climate Change to prepare and implement a Green and Golden Bell Frog Management Plan for key populations.

This document provides for the management and monitoring of the species for its long-term viability at Arncliffe, Lower Cooks River. It also provides a detailed threat assessment, outlines past and current management issues, outlines future management actions relating to the enhancement of existing habitat and connectivity within and between sub-populations, and provides a framework for the plans implementation.

Biodiversity assessment proposed widening of Marsh St Wolli Creek – Australian Museum Consulting Services 2014

Australian Museum Consulting Services conducted targeted Green and Golden Bell Frog surveys of ponds constructed between the Kogarah Golf Course and 'cycleway' at Marsh Street Arncliffe in February and March 2014.

The assessment identified high densities of *Gambusia* in the ponds in the golf course. They noted the most recent NSW Bionet record was from December 2009 (Kogarah Golf Course). Green and Golden Bell Frog records in other areas that are recent include RTA ponds, Kogarah Golf Course and Eve Street wetland. Most of the records from Kogarah Golf Course are between sixth fairway and the Sinuous Pond.

Population estimates from Biosphere (White 2002-2015) monitoring in 2012 and 2013 are between 75 and 110 adults. Tadpoles of Green and Golden Bell Frog were found in the RTA ponds but only juveniles around the golf course ponds. Green and Golden Bell Frog were not recorded at every survey in those two years. Breeding was recorded in 2008 at the Crescent Pond on the golf course. It is understood that this is an ephemeral breeding pond and it utilised infrequently.

The report found that the best shelter habitat was vegetation surrounding the RTA ponds and the adjacent drain. The most important habitat for Green and Golden Bell Frog in the golf course was considered to be the ephemeral ponds and drains in the southern and central parts.

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2.1.3 Previous studies

Dr Arthur White (Biosphere) has been conducting annual monitoring of the Green and Golden Bell Frog population at the constructed RTA ponds adjacent to the Kogarah Golf Course. The monitoring occurred as a requirement to fulfil conditions of approval for the construction of the M5 East Motorway.

Population estimates at the re-created frog habitat and ponds ranged from 16 to 110 adult frogs (in 2012). During the last two survey seasons, the population has declined. This could be due to the chytrid fungus as well as predation by *Gambusia* in the adjacent golf course (White A pers. comm. 2015).

Breeding was recorded in the RTA ponds in most years. Frogs only occasionally were breeding in the golf course ponds. This is likely due to the presence of *Gambusia* (White A pers. comm. 2015).

The frogs utilise most of the golf course for foraging, sheltering and occasionally breeding. Few frogs were found in the Marsh Street wetland. Two frogs were last seen in this wetland in 2012, when the population at the RTA ponds was 110.

Frogs were rarely seen in the Eve Street wetland although there are Green and Golden Bell Frog records around this wetland. Green and Golden Bell Frogs occasionally utilise a cycleway which passes underneath the M5 East Motorway to disperse from the RTA ponds into Eve Street wetland (White A pers. comm. 2015).

2.2 Assessment methodology

The assessment presented in this report was undertaken in accordance with the survey guidelines specified by the SEARs, as outlined in **Section 1.5.1**. The number of vegetation plot/transects utilised in this assessment meets or exceeds the FBA minimum number of plots required (OEH 2014b).

2.2.1 Field surveys and database searches

ELA employed a series of field survey methods to undertake the field assessment of the biodiversity values of the study area. The surveys conducted considered the relevant survey guidelines for various threatened species. The data from the previous surveys identified in **Section 2.1.2** was also utilised to inform this assessment. If a threatened species absence from the study area could not be confirmed, then a precautionary approach was adopted, whereby the presence of the species was assumed. This approach is consistent with the SEARs, FBA, and relevant impact assessment guidelines.

The methods used and rationale behind their selection are described below.

Assessment of vegetation mapping

The existing vegetation community mapping (OEH 2013) within the study area was verified to confirm the presence of native vegetation communities, including presence of TECs. Vegetation communities were identified from a combination of floristic surveys and transect traverses, and assigned to PCTs by comparing the dominant canopy species, the general description of location, soil type and other attributes as described in the profiles (OEH 2015c) and OEH online VIS classification database (OEH 2015b). Vegetation polygons assigned to the 'moderate-good' condition category were also assigned to a sub-condition class of poor, moderate or good:

- Poor condition vegetation had predominantly exotic species in the mid storey and ground cover layers, with very few native species in any stratum.
- Moderate condition vegetation had predominantly native species in the mid storey and ground cover layers but included a moderate abundance and cover or exotic species.
- Good condition vegetation was predominantly native, had good native species diverse, and had very few exotic species in any stratum.

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Biometric plots using the methodology described in the FBA

These plots were undertaken in accordance with the FBA. These plot / transect plots include a 20 metre by 20 metre full floristic plot (described below) and a 20 metre by 50 metre plot identifying number of hollow bearing trees and length of fallen wood. They also include 50 metre transect to collect data on canopy cover, midstorey cover, and ground cover for native and exotic species. These data are used to calculate site value scores.

Floristic surveys

Floristic surveys were conducted as part of the plot / transect survey plots (20 metre by 20 metre quadrats). Where a 20 metre by 20 metre quadrat could not fit into a patch of vegetation, e.g. adjacent to a track or drainage line, 40 metres by 10 metres quadrats were used. Above ground vascular plant species were identified to the lowest taxonomic order possible. Nomenclature is consistent with PlantNet NSW.

Random meander survey

Random meander survey technique (Cropper 1993) for threatened flora species: targeted searches for threatened species potentially occurring in the study area. This technique is used in preference to systematic, plot-based surveys when attempting to detect threatened plants. Random meander in suitable habitat is more likely to detect threatened species than plot or transect based survey used in floristic surveys. This technique is considered preferable in terms of searching large areas of potential habitat and generally allows for greater area coverage than a plot-based survey.

Targeted migratory wader survey

A targeted migratory wader survey was conducted to identify if any migratory birds were present in the Eve Street wetland. The survey was conducted from first light for one hour per observer over four separate mornings. The surveys were conducted over a two-week period to increase chances of seeing a diversity of bird species. The type and number of waterfowl were recorded along with the behaviour or activity. Activity was classified as foraging, roosting, foraging and roosting or flying overhead. Observers were positioned overlooking the wetland and birds were identified using handheld Nikon 8x42 or 10x42 binoculars. Where identification was not clear, observers conferred and cross-referenced the observation using a bird identification book (Simpson and Day 2004). Observations of non-target species were also recorded. Notes on the wetland were taken.

Opportunistic fauna surveys and assessment of fauna habitat

Identification of fauna species occurring within the study area was undertaken in conjunction with other surveys i.e. targeted flora surveys, random meanders and transects. Evidence of fauna usage was noted, for example diggings, chewed plant cones, scats.

Fauna habitat assessments identifying potential habitat for threatened fauna species, including marking of habitat features i.e. rock habitats and foraging substrates, presence of termite mounds. Presence of hollow bearing trees and coarse woody debris were recorded as part of the biometric plots. In the absence of fauna surveys, habitat assessments identify important habitat features that may provide potential habitat for threatened fauna.

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Hollow bearing tree survey

A hollow bearing tree survey was undertaken by ELA as part of surveys performed in 2015. This survey was conducted by visiting all of the accessible trees contained within the development site to determine if hollows were present. Hollows were considered present where they could be seen from the ground using binoculars, were greater than one metre from the ground and had some depth, with no wood visible at the back of the hollow. The size, position and location of the hollow was noted along with any evidence of use. All hollows were marked using a GPS. Where trees were not publicly accessible they were not assessed for hollows.

Aquatic assessment

Aquatic assessment was limited to fish, aquatic invertebrates and marine vegetation as defined in the FM Act. The databases and published material were reviewed to identify important habitat, threatened aquatic flora/fauna and protected marine vegetation that may occur in the greater catchment. A rapid assessment of instream habitat and riparian condition was also undertaken from the bank to characterise the local waterways. Access to Alexandra Canal was limited to a road crossing a few hundred meters downstream of the footprint. No access was available into Kogarah Golf Course. All aquatic habitat is managed Golf Course ponds. All other waterways had suitable access for this assessment. The databases and published material (**Section 2.1**) were reviewed to identify important habitat and threatened aquatic fauna that may occur in the greater catchment.

Groundwater dependent ecosystems

No field assessments were conducted for the assessment of GDEs. 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 all project areas, and 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). Potential impacts from construction and dewatering were determined for each of the GDEs identified, and threats these pose to each GDE was assessed. The Australian Groundwater Explorer database was also used to get an indication of groundwater levels expected in the area. None of the bores near or in the project areas had recent data, although a rough indication of groundwater depth was obtained by bore depth data and whether bores were still in use.

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.

2.2.2 Survey effort

The surveys for this assessment were conducted over 12 days between November 2014 and May 2015. Survey effort was prioritised within the study area according to the vegetation communities present and potential habitat for threatened flora and fauna species. All surveys were conducted in accordance with the SEARs, including advice provided by OEH and were consistent with relevant survey guidelines. A summary of the field survey effort for each survey method is provided in **Table 3**.

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Table 3: Summary of survey effort

Method	Total hours	Dates	Time of day
Random meander	40	19 and 20 November 2014	7:30am – 5:30pm
Biometric plots	70	26, 27 and 28 November 2014	7:30am – 5:30pm
Fauna habitat assessment	4*	26, 27 and 28 November 2014	7:30am – 5:30pm
Targeted fauna survey for migratory wader species	8	15, 16, 22 and 23 April 2015	5:45 – 6:45am
Hollow bearing tree survey	16	26 and 27 May 2015	8am – 4pm
Aquatic survey	9	5 June 2015	8am – 5pm

*Note: conducted concurrently with Biometric plots.

2.2.3 Survey conditions

Temperatures during the surveys varied considerably, as shown in **Table 4**, with the minimum temperature recorded as 8.4°C and maximum temperature recorded as 32.6°C. Weather conditions within the survey period were generally dry although heavy falls were recorded on two field days in April 2015.

Table 4: Weather observations during field survey

Date	Temperature °C (Min)	Temperature °C (Max)	Wind Speed km/h (at 9am)	Rainfall (mm)
19 November 2014	17.3	25.6	13	0
20 November 2014	20.2	30.6	13	0
26 November 2014	18.9	26.0	20	0
27 November 2014	18.6	21.2	31	0
28 November 2014	16.8	24.3	13	0
15 April 2015	15.2	26.7	13	0
16 April 2015	17.0	32.6	13	0
22 April 2015	13.6	18.8	33	72.8
23 April 2015	14.0	21.2	9	70.8
26 May 2015	8.4	18.8	15	0
27 May 2015	11.3	22.3	15	0
5 June 2015	8.6	16.9	17	0

Note: Data taken from Sydney Airport automatic weather station, 066037 (BOM 2015).

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2.2.4 Project personnel

This assessment was carried out by appropriately qualified and experienced ecologists and environmental professionals as demonstrated in **Table 5**.

Table 5: Personnel and qualifications

Name	Role	Qualifications
Mark Adams	Project Director	Bachelor Of Science (resources and Environmental Management) ANU, 1994 Masters of Environmental Law (with Distinction) Australian centre for Environmental Law, ANU, 2003
Dr Meredith Henderson	Ecology Assessment	PhD, Victoria University, Melbourne, 2003 BSc (Hons), University of Wollongong, 1991 Accredited Biobanking and major projects assessor
Dr Matthew Dowle	Ecology Assessment	PhD, Macquarie University, Sydney 2012 Bachelor of Advanced Science (Honours), University of NSW 2004
Dr Peter Hancock	Groundwater Assessment	PhD, University of New England, 2004 Bachelor of Natural Resources. University of New England, 1996
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
Danielle Bennett-Adams	Ecology Assessment	Bachelor of Animal Science- Major in Wildlife Studies, University Of Western Sydney, 2007
Joanne Daly	GIS Analysis and Mapping	Bachelor of Environmental Science (Honours), University of Wollongong, 2008

2.2.5 Limitations

Locations of hollow bearing trees, plot locations and other spatial data recorded during the surveys were recorded with hand-held GPS units, which can have errors in the locations of up to 20 metres in overcast conditions or in areas where foliage cover is high.

Vegetation plots undertaken document the species present within the plot. However they do not provide an exhaustive list of the species present within the study area. The floristic surveys and plots may have been conducted outside of the optimal survey period for some flora species. Thus, it is possible that some flora species that may occur in the study area were not recorded due to seasonal considerations.

The hollow-bearing tree survey was limited to areas where access could be obtained. In areas that could not be accessed, binoculars were used to assess the presence of hollows where possible, as was tree age and structure. A precautionary approach was used to assess hollow presence, when a hollow entrance could not be fully sighted due to access limitations, or other reasons made determining hollow presence difficult i.e. the hollow entrance faced upwards.

The GDE assessment was based on a desktop assessment only. ELA relied on information available at the time to determine the type and intensity of potential impacts. This information was limited and detailed information on the volume and extent of groundwater extraction was not available.

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3 Landscape features

In accordance with Chapter 4 of the FBA, the BAR is required to identify a number of landscape features such as the IBRA region, IBRA sub-region, Mitchell landscape, rivers and streams, extent of native vegetation in the area assessed for the development site. The landscape features of the development site are shown in **Figure 2**, **Figure 3** and **Figure 4** and described in **Sections 3.1** to **3.4.**

The FBA also requires that the landscape value is determined. This is described in **Sections 3.6.2** to **3.6.4** below.

3.1 IBRA bioregions and subregions

The study area is located within the Sydney Basin Bioregion which extends north to the Hunter Valley, west to Mudgee and south to Batemans Bay. The study area occurs within a highly urbanised setting surrounded by extensive areas of established urban development to the east, north and south. However, remnant vegetation occurs in the Wolli Creek Valley and adjacent to the Kogarah Golf Course.

The development site is located entirely within the Sydney Basin Bioregion. The construction footprint crosses two IBRA subregions, the Cumberland subregion and the Pittwater subregion. They were used for the 550 metre buffer (**Figure 4**).

3.2 Mitchell Landscapes

The development site occurs across four Mitchell Landscapes. The majority of the development site occurs within the Sydney – Newcastle Barriers and Beaches Mitchell Landscape, with the remainder within the Asfield Plains, Woronora Plateau and Port Jackson Basin Mitchell Landscapes (Mitchell 2002) (**Figure 3**).

3.3 Rivers, stream and estuaries

Three major waterways occur in the vicinity of the study area: Cooks River, Wolli Creek and Alexandra Canal (**Figure 2**). Two of these waterways, Wolli Creek and Alexandra Canal, occur within the development site. All three waterways transition from freshwater to estuarine systems before converging to the Cooks River realignment west of Sydney Airport, finally draining into Botany Bay. Fisheries NSW have mapped these waterways as Key Fish Habitat for most of their length. Urban, industrial and infrastructure development, and associated concrete lining, realignment and rock embankments have modified much of the aquatic and riparian habitat.

3.4 Wetlands

There are no SEPP 14 wetlands in the study area. Artificial waterbodies are scattered across the study area as detention basins and ponds. Some of these artificial wetlands are known to support a variety of wetland fauna, including the Green and Golden Bell Frog at Arncliffe.

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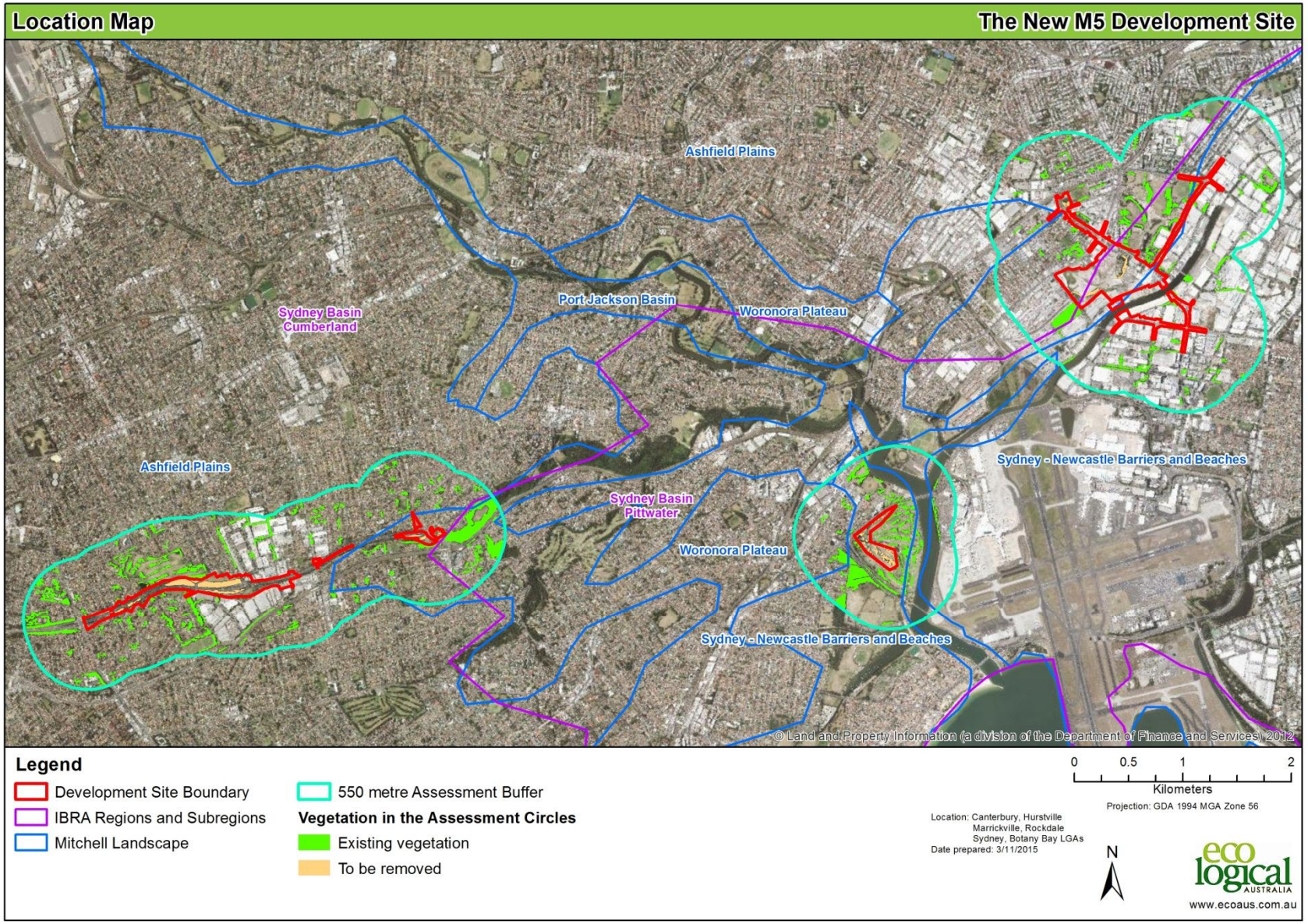

Figure 3: Location map of the development site

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3.5 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.

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. A search of the GDE Atlas (Bureau of Meteorology, accessed 1 September 2015) indicates that there are GDEs in the modelled area of drawdown. GDEs are listed in **Table 6** for areas within the development site.

Table 6: Groundwater Dependent Ecosystems in the development site

Footprint location	GDE description
Western surface works area	1.80 hectares of Cooks River Castlereagh Ironbark Forest along northern edge of the M5 East Motorway and south of Canterbury Golf Course. *Melaleuca* and *Casuarina* in forest suggest possible groundwater link.
Kingsgrove Road surface works	No GDE in footprint.
Arncliffe surface works area, south of M5 East Motorway	No GDE indicated for the footprint, but the reach of Cooks River adjacent to the footprint is highly likely to be an inflow dependent GDE (GDE Atlas). NSW Fisheries mapping for Botany Bay and Cooks River shows no seagrass in this part of the Cooks River.

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Footprint location	GDE description
Alexandria landfill and Sydney Park	No GDEs in footprint.
St Peters interchange and local road upgrades	No GDEs in footprint.

A 1.80 hectare forested area at Beverly Grove is depicted in the GDE Atlas as being likely to be dependent on groundwater. This is classified as Cooks River Castlereagh Ironbark Forest, an EEC under the TSC Act, and discussed in more detail in **Section 4.1.1.** The vegetation community here contains *Melaleuca decora, M. nodosa,* and *Casuarina glauca*, which are species indicative of shallow groundwater tables or water-logged soils.

The modelled area of groundwater drawdown (AECOM 2015a) indicated that there are a further three GDEs that occur outside of the surface disturbance footprints, but inside the groundwater drawdown boundary. These are summarised below (**Table 7**).

Table 7: Potential GDEs outside the development site but inside the extent of drawdown

Location of potential GDE	GDE description
Bardwell Valley Parkland and Broadford Street Reserve	17 hectares of hinterland sandstone gully forest with moderate to high potential to be dependent on groundwater.
Stotts Reserve, Bexley North	3.5 hectares of coastal sandstone ridgetop woodland with moderate potential for groundwater dependence
Forest between the southern bank of Wolli Creek and the rail line behind Wolli Creek Station.	3.4 hectares of estuarine fringe forest and mangrove forest with low to moderate potential for groundwater dependence

Other native vegetation exists in the area modelled for groundwater drawdown, however the vegetation is not considered to be associated with a dependence on groundwater. The areas of vegetation include:

- Landing Lights, Eve Street and Marsh Street wetlands – all located in alluvium
- Tempe Wetlands near Alexandra Canal – the canal is tidal and associated with tidal flows along Cooks River.

3.6 Landscape value score

3.6.1 Current and future native vegetation cover score

The assessment method was chosen in accordance with the linear based assessment outlined in the FBA.

An assessment buffer of 550 metres was applied to the development site in accordance with Appendix 5 of the FBA. This was used to assess the impact of the project on the surrounding vegetation cover (**Figure 4**).

The amount of vegetation within the buffer before the development was calculated using ArcGIS using the Native Vegetation of the NSW NPWS GIS layer (NPWS 2002) (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 development in the buffer area, the total amount of clearing was subtracted from the pre-development cover. The development footprint was then used to calculate the amount of vegetation loss. **Table 8** outlines the vegetation before and after development, 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 buffer area recorded approximately 103 hectares of native vegetation cover before development (**Table 8**). This represents eight per cent native vegetation cover.

After development, the area of native vegetation was 92 hectares. This represents seven per cent native vegetation cover.

The area of native vegetation after development was in the same cover category (six to ten per cent) as before development (six to ten per cent). The native vegetation cover class did not change between before and after development. 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 8: Area of vegetation in buffer area

Area in 550 metre buffer	Native Vegetation Cover (Before Development)	Native Vegetation Cover (After Development)
1508 hectares	103 hectares (8 per cent) (6-10 per cent)	92 hectares (7 per cent) (6-10 per cent)

3.6.2 Connectivity value score

A connectivity assessment was conducted using the FBA technique for linear based developments (OEH 2014b).

No formal State or regional biodiversity links recognised by the methodology are present within the study area.

Local wildlife corridors do exist at a smaller scale. However, these linkages do not meet the definition of State or regional biodiversity links, and therefore linkage impacts were assessed for linear based developments as defined under the FBA (OEH 2014b).

Given there were no links crossed, in accordance with the FBA the connectivity value class entered into the calculator was zero.

3.6.3 Patch size

Threatened species sub-zones, which form the base units of vegetation zones, were mapped for the development site. The threatened species sub-zones allow the entry of data such as adjacent remnant area and patch size for individual Mitchell Landscapes.

The vegetation within the study area is limited to small patches of remnant vegetation which are surrounded by extensive urbanised areas. The patch sizes and scores for each Mitchell Landscape are shown in **Table 9**. In accordance with Table 18 of the FBA, the patch size scores were determined and the mean of these scores calculated. The average score of 1.25 was entered into the calculator.

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Table 9: Mitchell landscapes, patch sizes, size classes and scores

Mitchell Landscape	Patch size (hectares)	Patch size class	Patch size score
Ashfield Plains	3	small	2.5
Woronora Plateau	0	nil	0
Sydney – Newcastle Barriers and Beaches	13	small	2.5
Port Jackson Basin	0	nil	0

3.6.4 Change in area to perimeter ratio

For a linear shaped major project such as the project, the FBA requires the change in area to perimeter ratio of impacted patch size areas to be calculated. **Table 10** describes the area, perimeter and ratios.

Table 10: Change in area, perimeter and ratio before and after development

Before development			After development		
Area (hectares)	Perimeter (metres)	Ratio	Area (hectares)	Perimeter (metres)	Ratio
103	154,448	1,499	92	142,719	1,551

The proportional change was calculated as 3.45 per cent. Given that this was less than 10 per cent, the score entered into the calculator was 1 (in accordance with Table 19 of the FBA).

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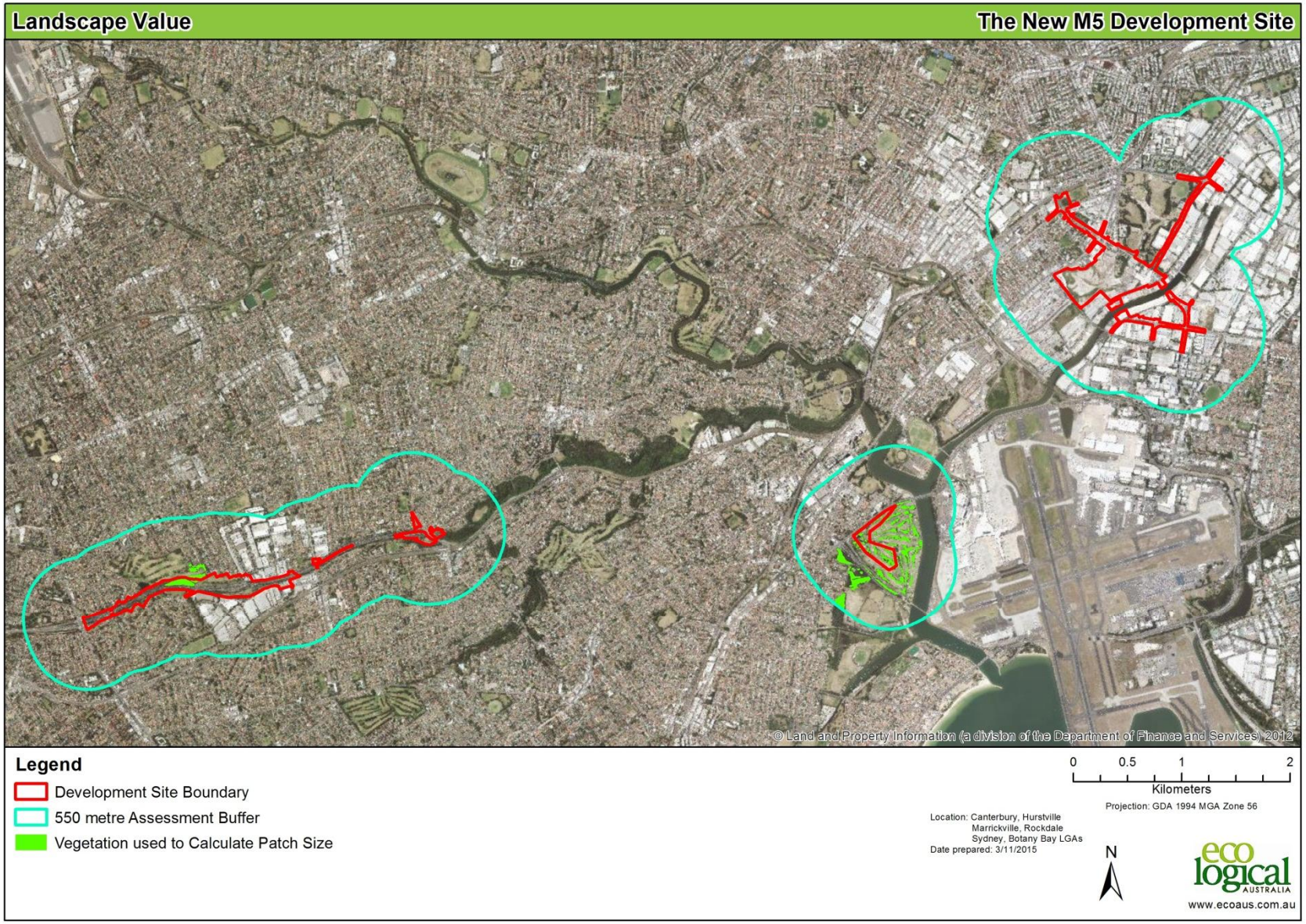

Figure 4: Landscape value assessed

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4 Native vegetation

The FBA requires that the extent of native vegetation within the development site be mapped. This native vegetation is to be classified using PCTs as identified in the VIS Classification database (OEH 2015b). There were four PCTs identified in the study area but only three occur in the development site. Where vegetation was present but it could not be classified as any particular PCT, it was combined into the vegetation type 'urban native and exotic'. This vegetation type is described in **Section 4.2.**

4.1 Stratification of native vegetation into Plant Community Types (PCTs) and ecological communities

There were four PCTs mapped and assessed in the study area, of which only three occur within the development site (**Figure 5** to **Figure 9**). The PCTs are described in **Sections 4.1.1 to 4.1.4**.

4.1.1 Broad-leaved Ironbark Melaleuca decora shrubby open forest on the clay soils of the Cumberland Plain, Sydney Basin Bioregion (PCT 725 or ME002)

This PCT, hereafter referred to as Broad-leaved Ironbark Melaleuca decora shrubby open forest, is also known as Cooks River Castlereagh Ironbark Forest and is in the Cumberland Dry Sclerophyll Forests vegetation class (Keith 2004). It is an EEC under the TSC Act and a CEEC under the EPBC Act. It is 95 per cent cleared in the Sydney Metropolitan CMA. This PCT occurs in an area known as Beverly Grove, between the Canterbury Golf Course and the existing M5 East Motorway (**Figure 6**).

According to the approved Conservation Advice (TSSC 2015), the PCT meets the listing criteria under the EPBC Act because:

- It occurs in the Cumberland Subregion at an elevation below 100 metres above sea level and
- It contains species representative of clay and shale influenced soils and
- It contains representative species across all stratums including *Melaleuca nodosa, Melaleuca decora, Eucalyptus longifolia, Acacia decurrens, Bursaria spinosa, Entolasia stricta* and *Microlaena stipoides* and
- It was greater than or equal to 0.1 hectares in size and
- It had greater than or equal to 30 per cent of the perennial native understorey was made up of native species and
- The patch was contiguous with a native vegetation remnant greater than or equal to 1 hectare in size.

The PCT was classified on the basis of existing mapping by OEH (2013), the vegetation mapping validation undertaken for this assessment, and by comparison of species present with the VIS dataset and the final determination for the listed ecological community under the TSC Act and approved Conservation Advice under the EPBC Act.

Mid-storey species were primarily used to identify this community from other potential PCTs. Within the development site the PCT comprises relatively young regrowth, with the upper stratum largely absent. The mid-storey was dominated by *Melaleuca nodosa*, *Acacia decurrens* and *Bursaria spinosa*.

The understorey was typically dominated by regenerating mid and overstorey species described above and contained relatively few exotic species. The ground cover was dominated by *Microlaena stipoides, Centella asiatica, Entolasia stricta* and *Pratia purpurascens*.

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The area of the PCT to be directly impacted is quantified in **Table 11**.

4.1.2 Paperbark swamp forest of the coastal lowlands of the NSW North Coast Bioregion and Sydney Basin Bioregion (PCT 1064 or ME050)

This PCT, hereafter referred to as the Paperbark swamp forest, is a component of the *Swamp Sclerophyll Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions* EEC which is listed under the TSC Act. Paperbark swamp forest is in the Coastal Swamp Forests vegetation class (Keith 2004). It is 75 per cent cleared in the Sydney Metropolitan CMA. This PCT is found at the Arncliffe surface works area, located in the Kogarah Golf Course and Marsh Street, Arncliffe (**Figure 8**).

The Paperbark swamp forest within the study does not comprise any listed ecological community under the EPBC Act.

The vegetation was identified by conducting vegetation validation, comparison of species present with the VIS dataset and the final determination for the Swamp Sclerophyll Forest. The presence of Eucalypt species in the canopy and location in the landscape were the key features is distinguishing this PCT from other similar PCTs.

Within the development site the Paperbark swamp forest is under-scrubbed, with a cleared understorey and exotic groundcover, consistent with vegetation management on golf course fairways. The PCT occurs only on the Kogarah Golf Course within the development site. The canopy is dominated by *Melaleuca quinquenervia, Casuarina glauca, Eucalyptus botryoides* and *Eucalyptus robusta.* The groundcover is regularly mown and was dominated by exotic grasses, *Poa annua, Cynodon dactylon* and *Pennisetum clandestinum*. Native species diversity was very low, averaging below four species across all biometric plots.

The PCT met the definition of “moderate-good” condition under the methodology. However it was considered to be in poor condition given its highly modified state.

The area of the PCT to be directly impacted is quantified in **Table 11**.

4.1.3 Turpentine Grey Ironbark open forest on shale in the Sydney Basin (PCT 1281 or ME041)

This PCT, hereafter referred to as Turpentine Grey Ironbark open forest, is also known as Sydney Turpentine Ironbark Forest, and is an EEC under the TSC Act and a CEEC under the EPBC Act. Turpentine Grey Ironbark open forest is in the Northern Hinterland Wet Sclerophyll Forests vegetation class (Keith 2004). It is estimated that between five per cent and 0.5 per cent of the original extent of Turpentine Grey Ironbark open forest remains (OEH 2015c). This PCT occurred south of the M5 East Motorway in a park adjacent to Tallawalla Street, Beverly Hills.

The PCT in the study area did not meet the EPBC Act criteria for the CEEC. According to the approved Conservation Advice and Listing Advice (TSSC 2014a, 2005) criteria, remnants of Sydney Turpentine-Ironbark Forest must contain some characteristic components from all structural layers (tree canopy, small tree/shrub midstorey, and understorey) and meet the following condition criteria:

- Canopy cover greater than 10 per cent and a size greater than one hectare; or,
- Occurrences with less than 10 per cent canopy cover if the fragments are greater than one hectare in size and occur in areas of native vegetation in excess of five hectares.

Although two small patches of Turpentine Grey Ironbark open forest were identified in the study area (adjacent to one other), the patches did not meet the EPBC Act definition for Sydney Ironbark

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Turpentine Forest due to their small size of only 0.51 hectares and 0.43 hectares, but they do meet the TSC Act definition.

The PCT was classified on the basis of existing mapping by OEH (2013), the vegetation mapping validation, comparison of species present with the VIS dataset and the final determination for the Sydney Turpentine Ironbark Forest EEC / Turpentine Grey Ironbark Forest CEEC.

Within the study area the Turpentine Grey Ironbark open forest has a sparse understorey, and appears to be partially under-scrubbed. The PCT met the definition of "moderate-good" condition as defined in the FBA methodology. The canopy was dominated by *Syncarpia glomulifera* and *Eucalyptus microcorys,* which is a planted species not associated with the PCT. A sparse shrub layer was present, with much of it considered to be planted native species, including *Indigofera australis*, *Acacia* spp., *Ozothamnus diosmifolius, Breynia oblongifolia* and *Dodonaea triquetra*. The ground layer was dominated by a mix of native and exotic grasses including, *Austrodanthonia* spp.*, Pennisetum clandestinum, Entolasia stricta* and *Lomandra longifolia*.

None of this PCT would be directly impacted by the project.

4.1.4 Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest in sandstone gullies of western Sydney, Sydney Basin (PCT 1181 or ME029)

This PCT, hereafter referred to as Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest, is also known as Coastal Enriched Sandstone Dry Forest (OEH 2013). It is in the Sydney Coastal Dry Sclerophyll Forest vegetation class (Keith 2004) and is not an EEC or CEEC. It is 20 per cent cleared in the Sydney Metropolitan CMA. This PCT occurred adjacent to Bexley Road and north of Wolli Creek in Bexley North (**Figure 7**).

The Sydney Metropolitan CMA vegetation mapping (OEH 2013) was used to identify where this community potentially occurs in the study area. Validation of mapping and a comparison of descriptions from the VIS data set with floristic plot results were then used to identify and assign this PCT.

It is noted that this community was originally mapped as Coastal Sandstone Foreshores Forest under the SMCMA vegetation mapping (OEH 2013), but the assigned PCT (1778) and BVT (ME065) within the mapping report do not occur in the VIS data set. As such, the VIS data set along with distinguishing features such as canopy species, presence of sandstone outcrops, sandy soil and an absence of more fertile soils were used to help confirm the presence of this PCT within the study area.

The PCT was present in a weedy condition. However, this condition met the definition of "moderate-good" under the methodology. In general the canopy was dominated by the following species: *Angophora costata, Eucalyptus piperita, Syncarpia glomulifera, Eucalyptus pilularis* and *Eucalyptus resinifera*. In adjacent areas where the PCT is less disturbed, a smaller tree layer is generally present comprising *Pittosporum undulatum*, *Pittosporum revolutum* and *Elaeocarpus reticulatus*. The understorey was dominated by sclerophyllous shrubs, herbs, ferns and grasses including *Lomandra longifolia, Pteridium esculentum, Breynia oblongifolia, Entolasia stricta, Microlaena stipoides, Dianella caerulea, Persoonia linearis*, and *Lomandra obliqua*.

In the study area, where the PCT was typically weedy, woody and herbaceous weeds were present including *Ligustrum lucidum, L. sinense, Lantana camara, Ochna serrulata, Tradescantia fluminensis* and *Asparagus* spp.

The area of this PCT to be impacted is outlined in **Table 11**.

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4.2 Other vegetation

4.2.1 Urban native and exotic

Areas that consisted of planted indigenous, non-indigenous native and exotic species occurred within local parklands or the road batter from the M5 East Motorway. These areas also often contained large expanses of exotic grasses and other weeds including *Ligustrum lucidum*, *L. sinense, Lantana camara* and a range of herbaceous weeds. These areas generally occurred where the soil profile had been extensively modified.

Parklands within the study area, which include play grounds and sports fields, often only contain large established trees (native and exotic) over exotic grasses, with no shrub layer or evidence of regenerating overstorey species. In contrast, areas along the road batter of the M5 East Motorway primarily consist of regenerating canopy individuals, above a shrub layer, but no large established trees.

These vegetation types were excluded from the calculations.

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Table 11: Vegetation in the development site

Vegetation types	Vegetation Zones for analysis purposes				
Vegetation community	Veg Zone No.	Plant Community Type (PCT)	Ancillary code	Total impacted (ha)	Comment
Broad-leaved Ironbark Melaleuca decora shrubby open forest on the clay soils of the Cumberland Plain, Sydney Basin Bioregion	2	Broad-leaved Ironbark Melaleuca decora shrubby open forest on the clay soils of the Cumberland Plain, Sydney Basin Bioregion	Intact	1.40	-
Paperbark swamp forest of the coastal lowlands of the NSW North Coast Bioregion and Sydney Basin Bioregion	10	Paperbark swamp forest of the coastal lowlands of the NSW North Coast Bioregion and Sydney Basin Bioregion	Weedy	1.82	-
Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest in sandstone gullies of western Sydney, Sydney Basin	17	Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest in sandstone gullies of western Sydney, Sydney Basin	Intact	0.09	-
Urban native and exotic	Excluded from impact assessment as it is not native vegetation and the original PCT cannot be determined – this includes areas on road batters, street tree plantings and areas dominated by exotics.			7.45	Non-native vegetation and other cleared areas do not need to be included in calculations
Total				10.76	

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4.3 Vegetation zones

Vegetation zones are defined as areas of native vegetation that are the same PCT which have similar broad condition states. Vegetation zones and their extent within the development site are outlined in **Figure 5, Figure 6, Figure 7**, **Figure 8** and **Figure 9**. There were three vegetation zones in the development site.

The FBA requires Biometric plots/transects are undertaken to sample vegetation zones. The number of plots/transects undertaken for each vegetation zone is outlined in **Table 12**. Information was collected from the required number of plots/transects for all vegetation zones consistent with FBA.

The vegetation zones outlined in **Table 12** are assessed for impacts in **Section 6**.

Table 12: Vegetation zones and plot requirements

Vegetation zone	Plant community type	Ancillary Code	Area impacted (hectares)	Plots required	Plots collected	Description of plots used
2	Broad-leaved Ironbark Melaleuca decora shrubby open forest on the clay soils of the Cumberland Plain, Sydney Basin Bioregion	Intact	1.40	1	1	Plot collected in the Cooks River Castlereagh Ironbark Forest 'moderate' zone. This area is also known as the Beverly Grove Bushland
10	Paperbark swamp forest of the coastal lowlands of the NSW North Coast Bioregion and Sydney Basin Bioregion	Weedy	1.82	1	3	All plots collected in within Kogarah Golf Course
17	Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest in sandstone gullies of western Sydney, Sydney Basin	Under-scrubbed	0.09	1	3	Plot collected from adjacent vegetation, as access was not obtained for the impact area (urban backyards). Ancillary code (underscrubbed) was matched to a plot of this type elsewhere in the buffer area.
Total			3.31	3	7	

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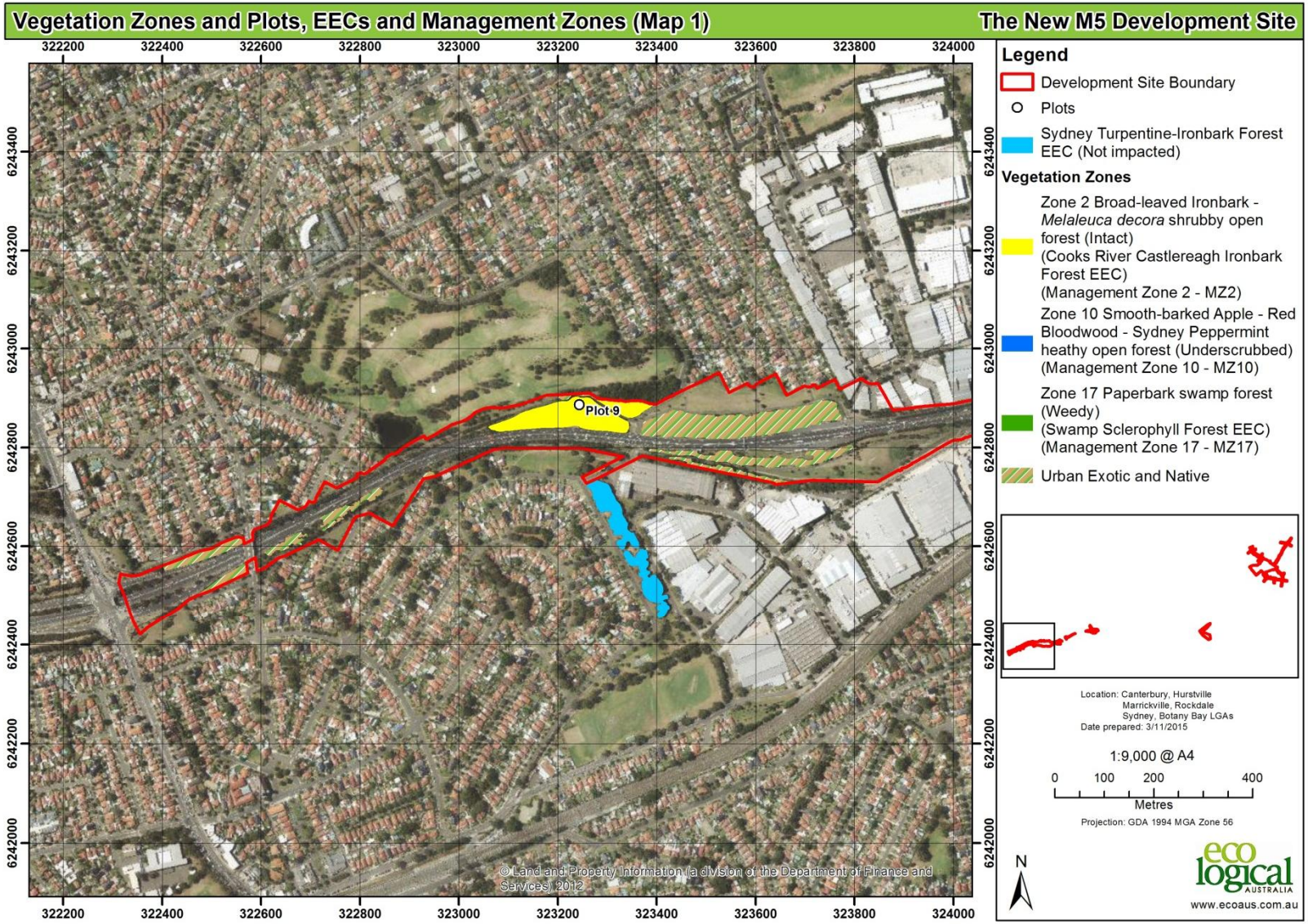

Figure 5: Vegetation zones, PCTs, EECs and management zones within impact area – Map 1

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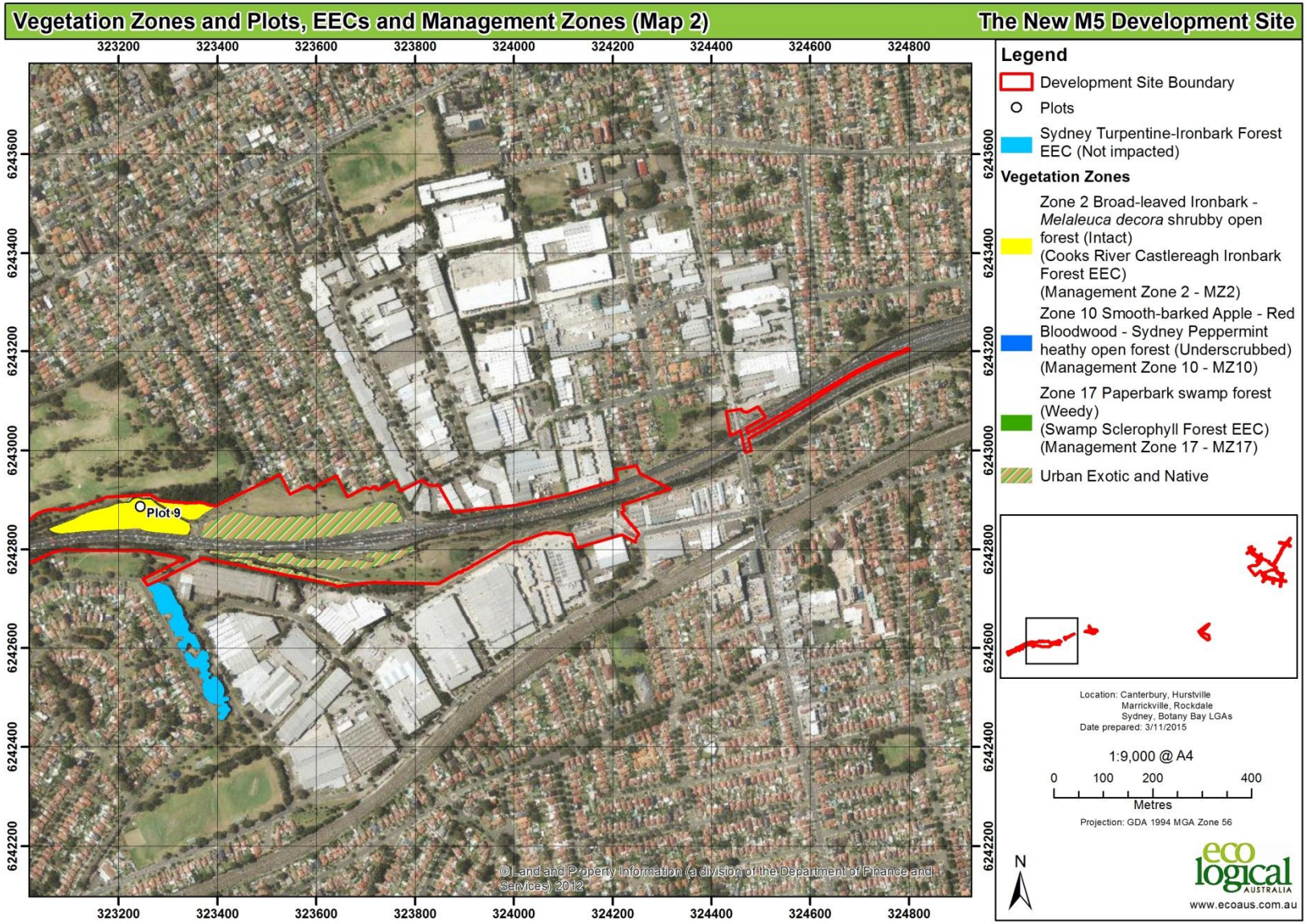

Figure 6: Vegetation zones, PCTs, EECs and management zones within impact area – Map 2

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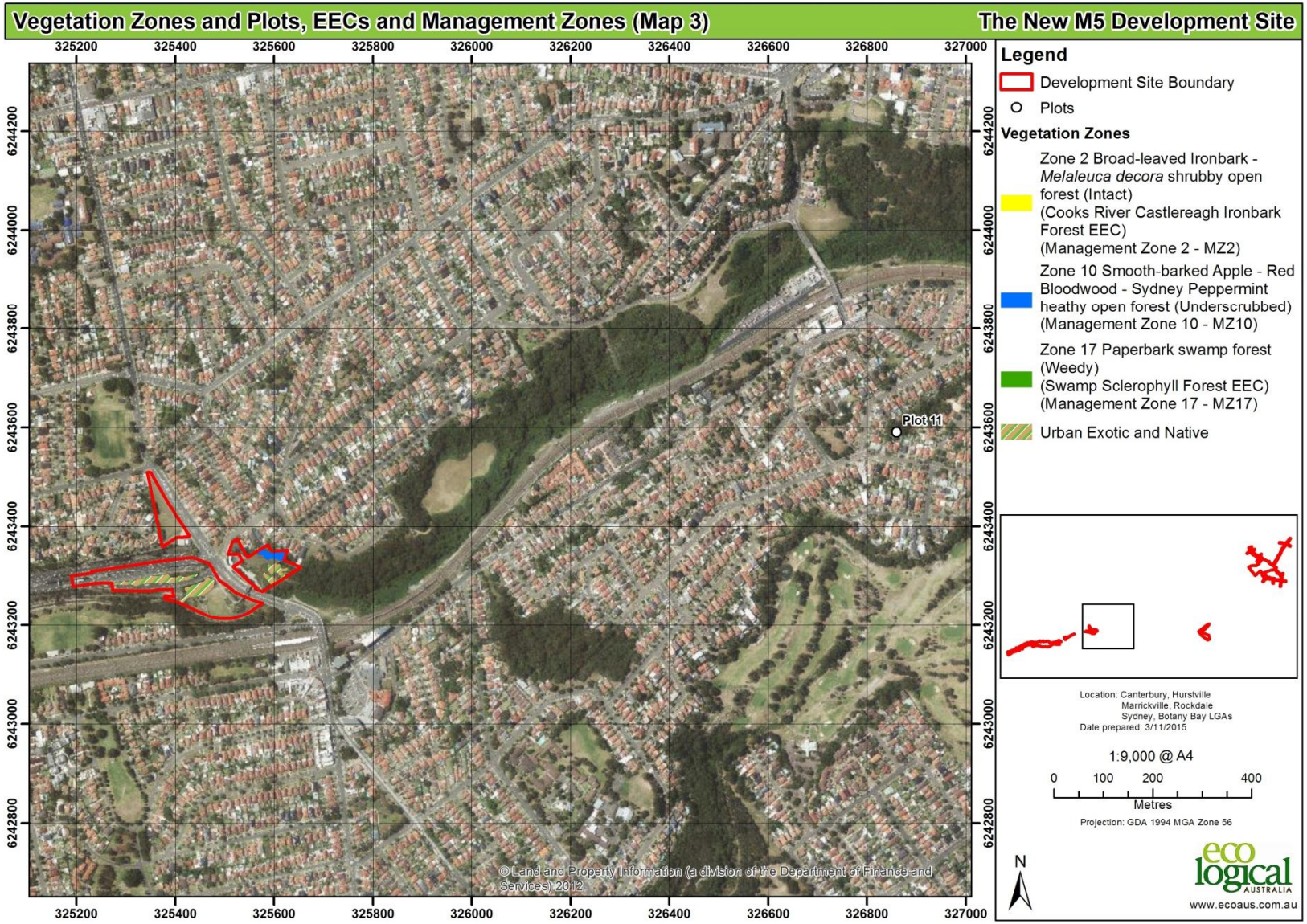

Figure 7: Vegetation zones, PCTs, EECs and management zones within impact area – Map 3

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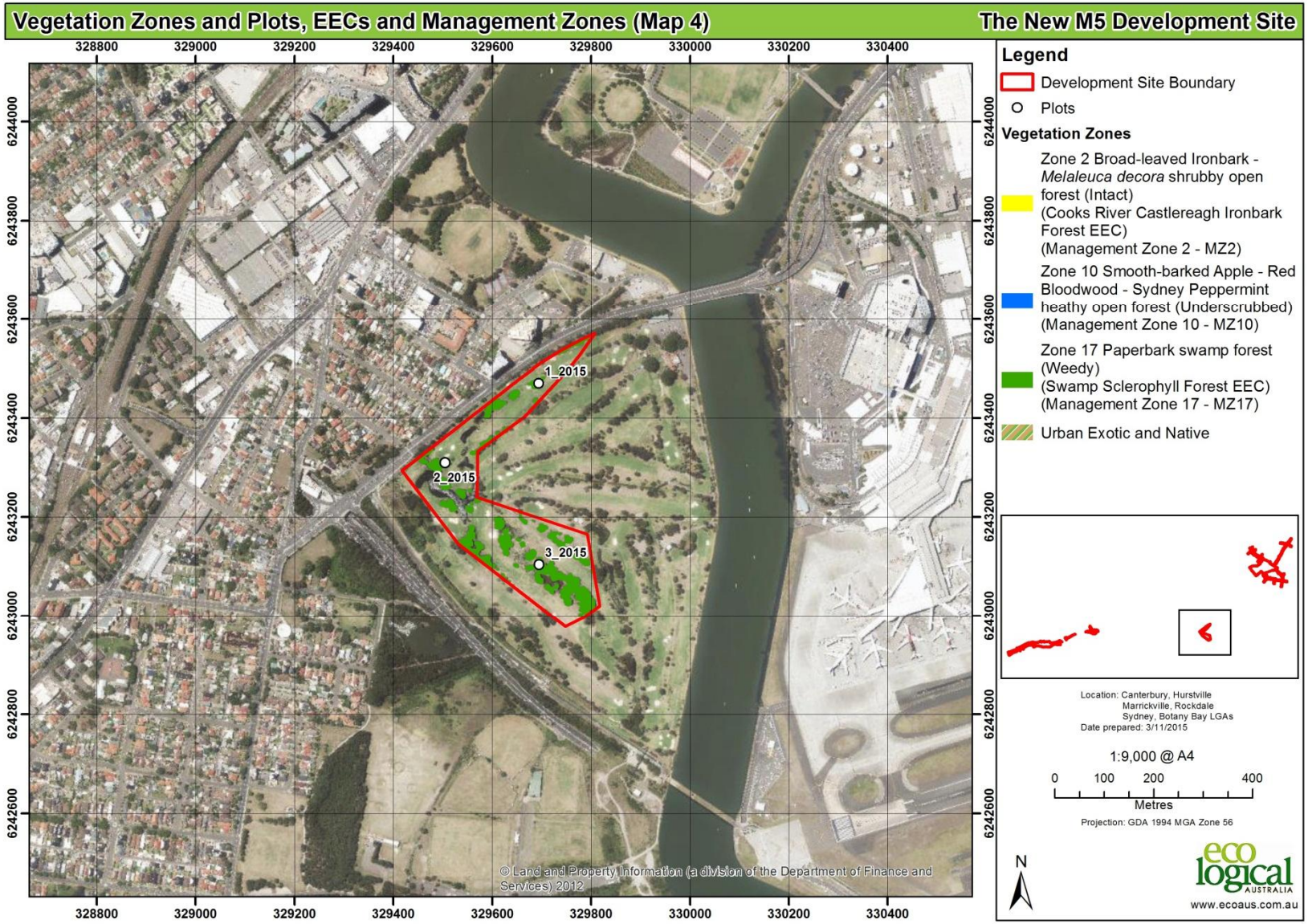

Figure 8: Vegetation zones, PCTs, EECs and management zones within impact area – Map 4

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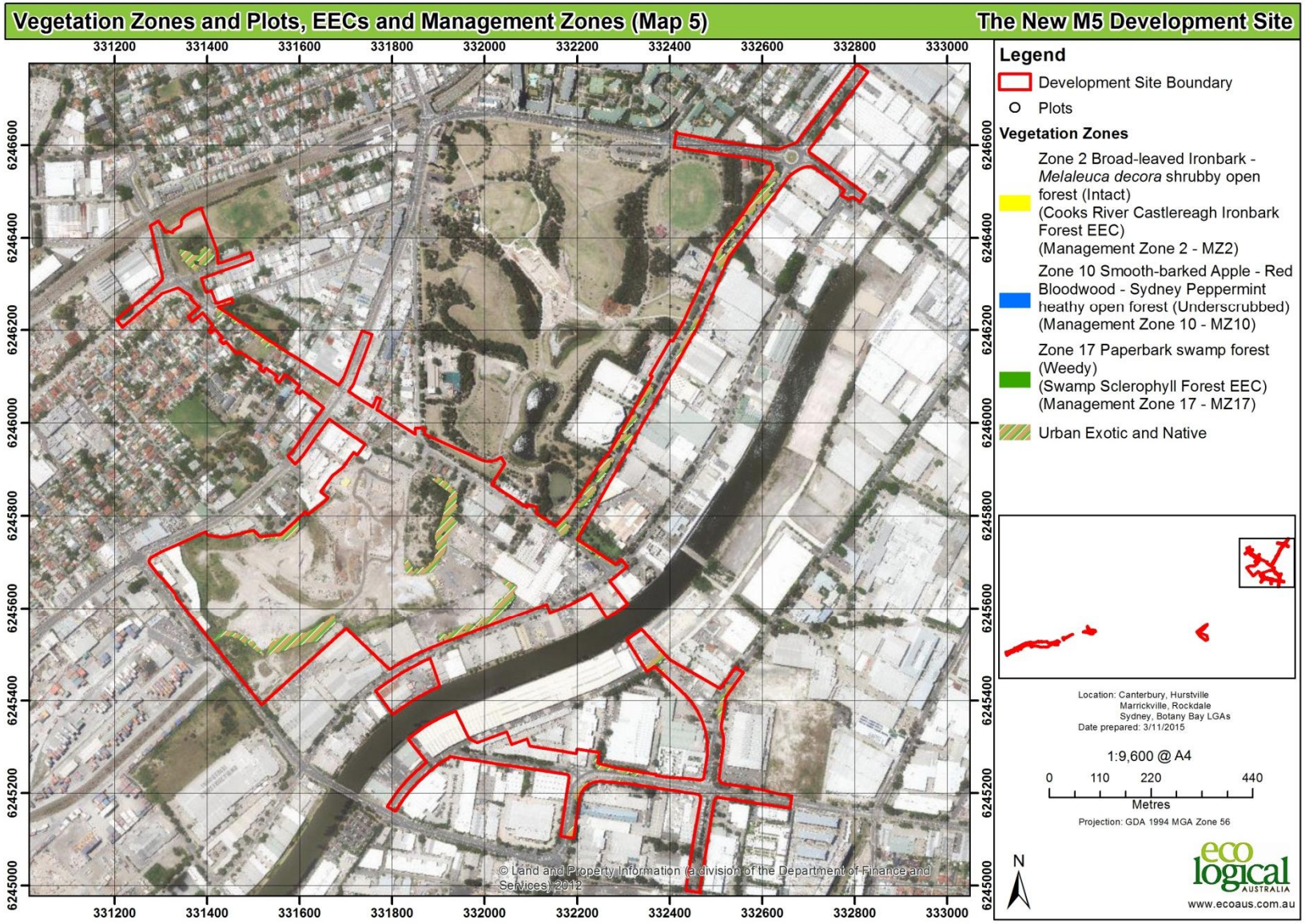

Figure 9: Vegetation zones, PCTs, EECs and management zones within impact area – Map 5

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5 Threatened species

5.1 Ecosystem credit species

The FBA requires that a list of threatened species that can be reliably predicted by habitat surrogates be identified. These species are called ecosystem credit species and they are automatically generated based on the PCT, the IBRA subregion of the development site, the condition and patch size of vegetation. The default list of ecosystem species generated is outlined in **Table 13**. It should be noted that because these species were identified by the tool, it does not mean that the threatened species are present.

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. Habitat components for the threatened species were assessed and species were included or excluded on this basis (**Table 13**). After assessing the habitat present in the vegetation zones, it was considered that all of the predicted ecosystem credit species were unlikely to be present in the development site, therefore they were excluded from the assessment.

Table 13: Ecosystem credit species on development site

Species	Inclusion or exclusion rationale
Melithreptus gularis Black-chinned Honeyeater (eastern subspecies)	Unlikely to occur in the development site given the small and highly modified patches of vegetation present. There is also a paucity of recent records.
Climacteris picumnus Brown Treecreeper (eastern subspecies)	Species unlikely to occur in the development site given relatively poor quality habitat and small patch size. No records in ten kilometres of development site.
Burhinus grallarius Bush Stone-curlew	Highly unlikely to be present. No records of this species in the development site. Individuals of the species in central and eastern NSW restricted to open grassy areas.
Stagonopleura guttata Diamond Firetail	Unlikely to be present given the relatively poor quality of habitat and lack of open grassy woodlands.
Falsistrellus tasmaniensis Eastern False Pipistrelle	Highly unlikely to be present in the development site. All of the hollow bearing trees were along road sides and not in sheltered forests.
Mormopterus norfolkensis Eastern Freetail-bat	Highly unlikely to be present in the development site. All of the hollow bearing trees were along road sides and not in the swamp sclerophyll forests on the golf course.
Callocephalon fimbriatum Gang-gang Cockatoo	Unlikely to be present given lack of suitable hollows and relatively poor quality of habitat in the development site.

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Species	Inclusion or exclusion rationale
Scoteanax rueppellii Greater Broad-nosed Bat	Unlikely to be present due to lack of moist, highly productive forests in development site. Lack of suitable sheltered hollows adjacent to or within dense forest.
Melanodryas cucullata cucullata Hooded Robin (south-eastern form)	Highly unlikely to be present due to lack of structurally diverse open woodland, with tall native grass component. No records within ten kilometres.
Hieraaetus morphnoides Little Eagle	Unlikely to occur in development site due to lack of suitable habitat including open eucalypt forest, woodland or open woodland.
Glossopsitta pusilla Little Lorikeet	Highly unlikely to be present in development site due to lack of suitable hollows and dry open woodland or forest. Very few records in ten kilometres.
Pseudomys novaehollandiae New Holland Mouse	Highly unlikely that the species would occur within the development site given the small area of highly modified habitat and its isolation from larger areas of potentially suitable habitat. There was no heathy understorey in any PCT. No records within ten kilometres of development site.
Grantiella picta Painted Honeyeater	Highly unlikely to be present. This species is concentrated on the inland slopes of the Great Dividing Range and inhabits box-gum woodlands. No records of this species within ten kilometres.
Chthonicola sagittata Speckled Warbler	Rarely reported from the coast, this species is highly unlikely to occur in the development site. It is associated with grassy eucalypt woodlands often on rocky ridges and in gullies. Suitable habitat not present.
Lathamus discolor Swift Parrot	This species is a winter migrant widely ranging across SE Australia mainly following eucalypt flowering events. Unlikely it would forage in the development site due to lack of suitable and higher quality forage species.
Daphoenositta chrysoptera Varied Sittella	This is a sedentary species and was not observed in the development site. The vegetation present is relatively poor quality, fragmented and occurs in small patches.
Saccolaimus flaviventris Yellow-bellied Sheathtail-bat	Unlikely to be present due to lack of suitable hollows and lack of diverse vegetation in mid and ground cover..

5.2 Species credit species

The FBA requires the questions identified in **Table 14** to be addressed in order to determine what species would be filtered into the assessment for consideration as species credit species. The answers identified in **Table 14** are based on the data obtained from the desktop and field surveys. In any cases of ambiguity the default answer of 'Yes' was used, as directed by the methodology. It should be noted that an answer of 'yes' does not mean that the threatened species or its habitat is present, merely that

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the species is retained in the assessment by the tool (an answer of 'no' results in the threatened species being excluded).

Table 14: Geographic and habitat questions and answers

Species	Question: Does any part of the development impact on	Answer
Wahlenbergia multicaulis (Tadgells Bluebell) population, Auburn, Bankstown, Baulkham Hills, Canterbury, Hornsby, Parramatta and Strathfield local government areas	Land situated in damp, disturbed sites	Yes
Meridolum corneovirens Cumberland Plain Land Snail	Land containing bark or leaf litter accumulation	Yes
Chalinolobus dwyeri Large-eared Pied Bat	Land containing escarpments, cliffs, caves, deep crevices, old mine shafts or tunnels	Yes
Pultenaea pedunculata Matted Bush-pea	Land within five kilometres of coast in South East Coastal Plains CMA subregion	No
Litoria aurea Green and Golden Bell Frog	Land within 100 metres of emergent aquatic or riparian vegetation	Yes
Varanus rosenbergi Rosenbergs Goanna	Land within 250 metres of termite mounds or rock outcrops	Yes
Pseudophryne australis Red-crowned Toadlet	Heath or eucalypt forest on sandstone with a build-up of litter or other debris and containing, or within 40 m of, ephemeral or intermittent drainage lines	Yes
Hibbertia superans	Ridgetops	Yes
Hoplocephalus bungaroides Broad-headed Snake	Land within 50 metres of sandstone escarpments with hollow-bearing trees, rock crevices or flat sandstone rocks on exposed cliff edges	Yes
Maundia triglochinoides	Swamps or shallow fresh water on clay	Yes

The candidate species credit species generated by the tool are identified in **Table 15**. On the basis of a review of relevant previous reports (refer **section 2.1.2**), no additional species were added to the list generated by the tool. The list of candidate species was compared against the habitat features in the development site to determine whether the species is likely to be present and subsequently if there is a requirement for targeted survey. A candidate species is not considered present in the development site 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 use habitat on the development site
- Records of the species are at least 20 years old or have doubtful authenticity.

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Table 15: List of candidate species credit species and second filtering step

Species	Part of Supplementary SEARs	Inclusion / exclusion	Rationale
Acacia prominens (Gosford wattle) population, Hurstville and Kogarah local government areas	N	exclude	Areas of potential habitat that are to be impacted within the study area are degraded and unlikely to support this species. Furthermore, random meander surveys did not detect the species which is conspicuous when present.
Acacia pubescens (Downy Wattle)	Y	exclude	Areas of potential habitat that are to be impacted are degraded and unlikely to support this species. Furthermore, random meander survey did not detect the species which is conspicuous when present.
Acacia bynoeana (Bynoes Wattle)	Y	exclude	Areas of potential habitat that are to be impacted within the study area are degraded and unlikely to support this species. Furthermore, random meander survey did not detect the species which is conspicuous when present.
Darwinia biflora	N	exclude	Areas of potential habitat that are to be impacted within the study area are degraded and unlikely to support this species. Furthermore, random meander survey did not detect the species which is conspicuous when present.
Dillwynia tenuifolia	N	exclude	Areas of potential habitat that are to be impacted are degraded and unlikely to support this species, which, in Sydney, is restricted to Western Sydney. Furthermore, random meander survey did not detect the species which is conspicuous when present.
Cercartetus nanus (Eastern Pygmy-possum)	N	exclude	Areas of potential habitat that are to be impacted are degraded and isolated. It is unlikely that this species occurs within the development site. There is a lack of records for this species in the development site and the habitat present does not contain the types of species required by the Eastern Pygmy Possum.
Epacris purpurascens var. *purpurascens*	N	exclude	Areas of potential habitat that are to be impacted within the study area are degraded and unlikely to support this species. Furthermore, random meander survey did not detect the species which is conspicuous when present.

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Species	Part of Supplementary SEARs	Inclusion / exclusion	Rationale
Callocephalon fimbriatum Gang-gang Cockatoo population, Hornsby and Ku-ring-gai Local Government Areas (LGAs)	N	exclude	The species is a vagrant in the Sydney area and unlikely to use habitat in the construction footprint. Furthermore, the listed population does not occur in the study area.
Litoria aurea (Green and Golden Bell Frog)	Y	Include	Targeted surveys for the species were not undertaken during the survey period. However, the species is known to occur within the study area. Annual monitoring reports (Biosphere 2015) from known habitats for the species within the study area were used to assess the presence of the species and suitable habitat.
Gyrostemon thesioides	N	exclude	Areas of potential habitat that are to be impacted within the study area are degraded and unlikely to support this species which is known only from relatively undisturbed sites to the west of Sydney.
Haloragodendron lucasii	N	exclude	Areas of potential habitat that are to be impacted within the study area are degraded and unlikely to support this species which is only known from the north shore of Sydney and the Blue Mountains.
Hibbertia puberula	N	exclude	Areas of potential habitat that are to be impacted within the study area are degraded and unlikely to support this species. Furthermore, random meander survey did not detect the species.
Hibbertia sp. Bankstown	N	exclude	Areas of potential habitat that are to be impacted within the study area are degraded and unlikely to support this species. Furthermore, random meander survey did not detect the species which is only known from Bankstown Airport.
Hibbertia superans	N	exclude	Areas of potential habitat that are to be impacted within the study area are degraded and unlikely to support this species. Furthermore, random meander survey did not detect the species which is not known from Eastern Sydney.
Hoplocephalus bungaroides (Broad-headed Snake)	N	exclude	Areas of potential habitat that are to be impacted within the study area are degraded and unlikely to support this species.

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Species	Part of Supplementary SEARs	Inclusion / exclusion	Rationale
Phascolarctos cinereus (Koala)	N	exclude	The species is locally extinct and would not occur within the study area.
Chalinolobus dwyeri (Large-eared Pied Bat)	N	exclude	The small area of potential habitat that are to be impacted within the study area are highly degraded and are unlikely to support this species, which has a patchy distribution in NSW and is typically associated with areas with extensive cliffs and caves.
Syzygium paniculatum (Magenta Lilly Pilly)	Y	exclude	Areas of potential habitat that are to be impacted within the study area are degraded and unlikely to support this species. Furthermore, random meander survey did not detect the species which is conspicuous when present. The species was recorded at Wolli Creek, but this population will be not be impacted by the project.
Maundia triglochinoides	N	exclude	Areas of potential habitat that are to be impacted within the study area are degraded and unlikely to support this species. Furthermore, random meander survey did not detect any individuals. It is known from relatively undisturbed wetlands with low nutrient content and high water quality. None of the wetlands or aquatic habitats in the study area were of high quality to support a population of this species.
Melaleuca deanei (Deanes Paperbark)	Y	exclude	Areas of potential habitat that are to be impacted within the study area are degraded and unlikely to support this species. Furthermore, random meander survey did not detect the species which is conspicuous when present.
Meridolum corneovirens (Cumberland Plain Land Snail)	N	exclude	Areas of potential habitat that are to be impacted within the study area are degraded and unlikely to support this species. Furthermore, random meander survey did not detect any individuals, which is conspicuous when present. There are no records for this species within a ten kilometre radius.
Grammitis stenophylla (Narrow-leaf Finger Fern)	N	exclude	Areas of potential habitat that are to be impacted within the study area are degraded and unlikely to support this species. Furthermore, random meander survey did not detect the species.

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Species	Part of Supplementary SEARs	Inclusion / exclusion	Rationale
Callistemon linearifolius (Netted Bottle Brush)	N	exclude	Areas of potential habitat that are to be impacted within the study area are degraded and unlikely to support this species. Furthermore, random meander survey did not detect the species which is conspicuous when present.
Persoonia nutans (Nodding Geebung)	N	exclude	There is no suitable habitat for the species within the study area as the species is restricted to the Cumberland Plain in western Sydney.
Pimelea curviflora subsp. *curviflora*	N	exclude	Areas of potential habitat that are to be impacted within the study area are degraded and unlikely to support this species.
Pomaderris prunifolia (Plum-leaf Pomaderris) endangered population, Parramatta, Auburn, Strathfield and Bankstown Local Government Areas	N	exclude	Areas of potential habitat that are to be impacted within the study area are degraded and unlikely to support this species. Furthermore, the listed population does not occur within the development site.
Pseudophryne australis (Red-crowned Toadlet)	N	exclude	Areas of potential habitat that are to be impacted within the study area are degraded and unlikely to support this species. There is a lack of records within the locality and none from within the development site.
Anthochaera phrygia (Regent Honeyeater)	N	exclude	This species is a vagrant in the Sydney area and unlikely to use habitat in the development site.
Varanus rosenbergi (Rosenbergs Goanna)	N	exclude	Areas of potential habitat that are to be impacted within the study area are degraded and unlikely to support this species.
Grevillea parviflora subsp. *parviflora* (Small-flower Grevillea)	N	exclude	Areas of potential habitat that are to be impacted within the study area are degraded and unlikely to support this species. Furthermore, random meander survey did not detect the species which is conspicuous when present.

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Species	Part of Supplementary SEARs	Inclusion / exclusion	Rationale
Petaurus norfolcensis (Squirrel Glider)	N	exclude	Areas of potential habitat that are to be impacted within the study area are degraded and unlikely to support this species. Therefore there is no suitable habitat for this species.
Pterostylis saxicola (Sydney Plains Greenhood)	N	exclude	There is no suitable habitat for this species within the study area. The species is restricted to western Sydney.
Tetratheca glandulosa	N	exclude	Areas of potential habitat that are to be impacted within the study area are degraded and unlikely to support this species. Furthermore, random meander survey did not detect the species.
Caladenia tessellata (Thick Lip Spider Orchid)	N	exclude	There is not suitable habitat for the species within the study area and it is highly unlikely that it would occur there.
Wahlenbergia multicaulis (Tadgells Bluebell) population, Auburn, Bankstown, Baulkham Hills, Canterbury, Hornsby, Parramatta and Strathfield local government areas	N	exclude	Areas of potential habitat that are to be impacted within the study area are degraded and unlikely to support this species. Furthermore, random meander survey did not detect the species.
Leucopogon exolasius (Woronora Beard-heath)	N	exclude	Areas of potential habitat that are to be impacted within the study area are degraded and unlikely to support this species. Furthermore, random meander survey did not detect the species which is conspicuous when present.

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From this second filtering step (**Table 15**), only the Green and Golden Bell Frog was considered as likely to occur within the development site. The potential impacts of the proposal on the Green and Golden Bell Frog is discussed below.

5.2.1 Green and Golden Bell Frog

The Green and Golden Bell Frog (*Litoria aurea*) Key Population of the Lower Cooks River (the Arncliffe key population) is located within the construction and operational footprint of the project at the Kogarah Golf Course, Arncliffe. The Arncliffe key population is one of two key populations around Botany Bay, and one of four in south-eastern Sydney.

The Green and Golden Bell Frog and its habitat were determined to be present within the development site (White 2015). According to the FBA methodology, the Green and Golden Bell Frog is not a species that cannot withstand further loss. The NSW Threatened Species Profile Database (TSPD) (OEH 2015c) suggests that since 1990, this species has been recorded from around 50 locations in NSW. Most of the locations are small, coastal, or near coastal populations.

The Arncliffe population in the vicinity of the Marsh Street wetlands was previously the subject of major road works and infrastructure development associated with the M5 East motorway construction circa 1998. Green and Golden Bell Frog compensatory habitat was created in the form of two breeding ponds in the north-western corner of the Kogarah Golf Course on Roads and Maritime land and a frog underpass connecting the new breeding ponds with the Marsh Street wetlands. In addition, a long-term monitoring and management program was established and is still operating successfully.

Annual monitoring undertaken by Dr Arthur White has identified that the purpose built frog ponds referred to as RTA Ponds are being successfully used for breeding. Habitat enhancement works in the RTA ponds have combined regular interventions to manipulate the water levels to manage vegetation and Green and Golden Bell Frog predators (namely Plague Minnow), and management of chytrid through salt water flushing.

During the annual monitoring, Dr Arthur White identified that the local population centres around the artificially created compensatory habitat RTA ponds. Breeding has not been identified outside these areas since 2000 during the monitoring. Therefore, the RTA ponds are considered to be the key source for adult frogs for the local population, which disperse across the Kogarah Golf Course. It is unlikely that the other ponds within the golf course provide suitable significant breeding habitat as they contain Plague Minnow. However, rare breeding events in the golf course ponds have been recorded previously (Dr Arthur White pers. comm 2015). Predation by Plaugue Minnow is one of the main identified threats to Green and Golden Bell Frog according to the Commonwealth Approved Conservation Advice (TSSC 2014b).

Adult frogs have been recorded in the golf course areas during each annual survey period. Activity is concentrated around the fifth and sixth fairways and also the Crescent Lake further to the north-east. These areas are considered important as foraging habitat and movement corridors for the local population.

The population within the RTA ponds and the golf course has been monitored annually. The monitoring has been conducted in accordance with the Commonwealth survey guidelines for this species (DEWHA 2010). That is, areas of potential and known habitat were surveyed for a minimum of four nights during the months of peak activity for the species (September to March), were conduted during warm and windless weather conditions. The surveys employed a combination of diurnal searches and nocturnal spotlight surveys, tadpole surveys and call playback. Surveys were conducted monthly usually between the months August to May. Results from the monitoring estimate the local population has increased since 2003, with the largest estimate in 2012, with 110 adults.

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It is important to note that the current population is unlikely to remain without constant management and is considered to have poor long term viability (White 2015). The population is now small (<50 adult frogs; Dr Arthur White pers. comm 2015) and is limited by the presence of Plague Minnow and chytrid in ponds other than the RTA ponds. Since 2003, breeding has occurred in the RTA ponds in every year except 2014.

Habitat types within the Kogarah Golf Course locality are described as follows (extracted from Management Plan Green and Golden Bell Frog Lower Cooks River Key Populations, DECC 2008):

- *Breeding habitat*: primarily consist of the permanent and semi-permanent purpose built artificial ponds (RTA ponds) in the north-western corner of the golf course. Two other ponds within the golf course have provided breeding habitat although this is rare presumably due to predation by the Plague Minnow. They key source of adults and juveniles are the RTA ponds (which are actively managed for Plague Minnow and chytrid fungus by Roads and Maritime).

- *Foraging habitat*: Includes grassed areas (native or exotic), tussock vegetation and emergent sedges and reeds bordering water features and ponds. The drainage channel and reed beds that border the southern extremity of the golf course may also provide foraging habitat.

- *Sheltering habitat*: includes similar vegetation to that used as foraging areas that contain rock piles, fallen timber, tussock grasses and other artificial sheltering sites. Sheltering habitat is present surrounding the artificial RTA ponds.

- *Dispersal habitat*: typically includes wet areas such as creek lines, drains, stormwater canals, connecting vegetation, and other easements and depressions. However, in the golf course, fairways currently provide movement habitat between breeding ponds and foraging habitat. An artificial frog passage was built underneath the M5 East Motorway to facilitate movement between the golf course and habitat to the west and south (Marsh Street Wetlands and Old Spring Creek Wetland site). However, this passage is not regularly used (DECC 2008). Frogs have been recorded using the cycleway, which passes under the M5 East Motorway, to move between the RTA ponds/golf course and areas south-west of the M5 East Motorway (Dr Arthur White, pers. comm. 2015).

- *Over-wintering habitat*: no overwintering habitat has been observed in the Arncliffe surface works area (White and Pyke, 2015 in press).

The area to be impacted by the project contains foraging, dispersal and sheltering habitat. The total area of suitable habitat impacted for this species is 7.82 hectares. The RTA ponds, which are the primary source of the population, would not be directly impacted by the project. There may be indirect impacts such as increases in dust, light, noise and vibration during construction that would be managed. A plan of management for this population is being developed to specify the nature and timing of mitigation measures for the Green and Golden Bell frog during the construction activities, along with proposals to breed the species in captivity and create new habitat nearby as an insurance against any residual indirect impacts on the existing RTA ponds. The measures are outlined in **Section 6.6.2**.

Because of the removal of 7.82 hectares of foraging, dispersal and sheltering habitat there is a requirement to provide offsets in addition to mitigating impacts. The biodiversity offsets are described in **Chapter 7** and the Biodiversity Offset Strategy accompanying this BAR.

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5.3 Aquatic biodiversity

Six threatened species/populations listed under the EPBC Act or FM Act potentially occur in the Sydney Metropolitan catchment area (**Appendix A**), excluding marine sharks. This includes two dragonflys (with an aquatic life history stage), one migratory fish (fresh to salt water), one coastal/estuarine fish, one coastal/estuarine ray and one seagrass population. The two species of dragonfly, *Austrocordulia leonardi* and *Archaeophya adamsi*, are unlikely occur in the study area as they have only been recorded in creeks with intact riparian/aquatic vegetation and forested catchments. The migratory fish, *Protoroctes maraena*, uses good quality freshwater habitat, which is not present in the study area or upstream catchment. The estuarine fish, *Epinephelus daemelii*, prefers rocky shores, caves and reefs which are also not present in the study area. The estuarine ray, *Pristis zijsron*, is presumed extinct, but if alive is highly unlikely to occur in highly degraded estuarine habitats such as those which occur within the study area. A population of the seagrass *Posidonia australis* occurs in southern Botany Bay (Fisheries NSW), but is not known to occur near the study area. Although some marine vegetation occurs in Wolli Creek and Cooks River, no seagrass, mangroves or saltmarsh were observed in the study area during land-based surveys of Wolli Creek, Cooks River and Alexandra Canal. Although the exact location of the bridge crossings of Alexandra Canal was not assessed, nor underwater surveys conducted, it is unlikely that large seagrass beds occur anywhere in the canal (none are mapped by Fisheries NSW).

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6 Avoidance, mitigation and impacts

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 (see **Appendix H**).

6.1 Avoidance and minimisation of impacts

Avoidance measures were incorporated into the project in order to reduce ecological impacts, including the clearing of listed ecological communities, threatened species and threatened species habitat. Avoidance measures primarily involved:

- Examining alternate locations for surface area works.
- Examining route alignment and placement of ancillary facilities.

The project for the majority of its length is underground. This therefore reduces the project overall footprint and impacts to terrestrial biodiversity values by limiting vegetation clearance and impacts to terrestrial fauna habitats.

Alternatives to the project 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).

This analysis concluded that a new motorway mostly following a new corridor would provide better and enhanced connections to the M5 motorway corridor, Sydney Airport and Port Botany while also providing for future broader network connections.

The Preliminary Ecological Constraints report (ELA 2015) was used to inform avoidance and minimisation of direct and indirect impacts to biodiversity values, with particular reference to avoidance of listed ecological communities, threatened species and threatened species habitat. This resulted in the avoidance of these biodiversity values:

- Extensive high quality native vegetation in the Wolli Creek Valley
- A small population of *Syzygium paniculatum* in the Wolli Creek Valley
- A small area of Sydney Turpentine Ironbark Forest in Kingsgrove
- A vegetated riparian corridor along Wolli Creek
- A Grey-headed Flying Fox camp and habitat at Turrella
- Areas of native coastal reedland and mangroves at the confluence of Wolli Creek and the Cooks River
- Artificial breeding habitat for Green and Golden bell Frogs at Kogarah Golf Course.

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6.1.1 Alternate locations

The option to construct and operate a new motorway would respond to the diverse travel demands along the M5 Motorway Corridor, and would relieve congestion on the M5 East Motorway by providing additional road capacity. This option could be achieved through the construction and operation of a new motorway that compliments the existing M5 East Motorway (in effect, duplicating that motorway), or the construction and operation of a new motorway that responds to other strategic road network projects under development (such as the extension of the M4 Motorway).

Adherence to the current M5 East Motorway alignment, which was investigated by Roads and Maritime in 2009, would not provide the opportunity to have a direct connection between the M4 and M5 motorways. As such, the duplication of the M5 East Motorway would not fully achieve the broader economic and road network project objectives for the project, specifically the objective of improving motorway access and connections to link Sydney's international gateways, Western Sydney and places of business across the city.

6.1.2 Route alignment

The following alternatives and design refinements were considered by Roads and Maritime:

- The location of the western tunnel portal.
- The location of a mid-point tunnelling construction compound and motorway operations complex.

Short and long tunnel options

Two options were considered for the location of the western tunnel portal:

- A longer tunnel option with tunnel portals located to the west of King Georges Road, in Kingsgrove.
- A shorter tunnel option with tunnel portals located close to the existing M5 East Motorway tunnel portals near Bexley Road, Bexley.

The longer tunnel option was identified as preferred for the following reasons:

- Reduced impact on local residents, with the longer tunnel option generally located adjacent to commercial and industrial properties in Kingsgrove, reducing the impact of the proposed action on local residents.
- Fewer private properties would be subject to acquisition. The proposed portal location for the longer tunnel option aligns with land already subject to a road reservation.
- Reduced construction traffic impacts. Construction staging in the vicinity of Bexley Road would have been complex and have significant traffic impacts for both Bexley Road and the M5 East Motorway.
- Improved air quality outcomes and reduced visual impacts. A longer tunnel option would be able to achieve a lesser grade, providing better operational air quality outcomes and less impact to visual amenity given the need for a smaller cut and cover structure.

The selected option would result in an impact on Cooks River/Castlereagh Ironbark Forest EEC, located north of the M5 East Motorway. Opportunities to minimise the impact to the EEC would be considered further during detailed design.

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Tunnelling construction compound and motorway operations complex

To facilitate the construction and to satisfy operational tunnel ventilation requirements, permanent infrastructure and construction activities are required to occur at the surface, ideally at the tunnel mid-point in addition to the tunnel portals. Additional criteria for the tunnel mid-point site included:

- Sufficient land size to meet the construction requirements and program, with a larger site providing greater spoil handling capacity and construction efficiencies than smaller sized sites.
- Immediate access to arterial road network to avoid construction vehicles using local roads.
- Use of publicly owned land to avoid private property acquisition where possible.

On this basis, the publicly-owned areas of the Kogarah Golf Course were identified. These areas consist of large parcels of publicly-owned land that have the potential for immediate site access to/from Marsh Street.

Within the publicly-owned areas of the golf course, the following design refinements were undertaken to reduce the worst case disturbance footprint in response to environmental, social and economic considerations. This included:

- Reduction in the footprint to assist in maintaining an operational golf course (with a minimum of nine holes) while construction of the proposed action is underway.
- Provision of a 32 metre buffer between the development site and the Green and Golden Bell Frog RTA ponds and provision of a corridor to remaining areas of the golf course. This corridor is to be enhanced frog habitat to mitigate against the loss of foraging, sheltering and dispersal habitat at the Arncliffe surface works area.

6.2 Assessment of impacts

The potential direct and indirect impacts of the proposal on biodiversity are summarised in this chapter 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 as identified in **Chapter 6**. Notwithstanding, the level to which biodiversity impacts have been avoided or minimised the project would have both direct and indirect impacts on a range of biodiversity values during both the construction and operational phases. Impacts are primarily associated with the construction footprint. The potential indirect impacts on biodiversity values are considered to be minimal given the highly modified condition of the habitats to be affected and the proposed mitigation measures (**Section 6.6**).

This biodiversity assessment considered both construction and operational impacts to biodiversity and includes:

- The motorway tunnels.
- Motorway operation complexes, including a motorway control centre and ventilation facilities.
- Modifications to service utilities and associated works at surface roads near the two interchanges and operational ancillary facilities.
- Modifications to the M5 South West Motorway, M5 East Motorway and local roads.
- Construction compounds and temporary works to facilitate the construction of the project.
- Water treatment plant discharges during construction and operation
- Groundwater drawdown as a result of tunnelling.

Impacts of the project on MNES are summarised in **Table 16** and in **Sections 6.3** to **6.5**. The aim of **Table 16** is to provide an overview of the impacts and requirements for assessment under the EPBC Act.

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Table 16: Summary of impacts relevant to MNES

Impact	Which 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 native vegetation	Cooks River / Castlereagh Ironbark Forest	Direct	Local	Major - the proposed action would permanently remove 1.4 hectares.	Long term	Significant	High - Irreversible for the direct impacts
Loss of habitat	Green and Golden Bell Frog	Direct	Site	Moderate –7.82 hectares of foraging, sheltering and dispersal habitat would be modified. The majority of this habitat would be modified and unavailable for the frogs for the period of construction only. A smaller proportion would be lost permanently for the provision of operational facilities.	Short term for construction Long term for permanent facilities	Significant	High – permanent facilities impacts are irreversible Low – impact of modification of foraging, dispersal and sheltering habitat is unknown
Weed spread	Cooks River / Castlereagh Ironbark Forest	Indirect and facilitated	Site	Moderate – the proposed action would indirectly impact the remaining 0.4 hectares within the project area.	Short term	Not significant	Moderate – the indirect impacts may be minimised through ongoing management. The impacts to ecosystem processes are unpredictable.

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Impact	Which MNES	Nature of impact	Scale of impact of proposed action	Intensity of impact of proposed action	Duration	Likely significance of impact	Confidence in assessment
Changed hydrology	Cooks River / Castlereagh Ironbark Forest	Indirect	Site	Minor – there is expected to be an increase in runoff during construction and operation of the project due to an increase in paved surfaces. The impacts of changes to hydrology for the Cooks River / Castlereagh Ironbark Forest patch are expected to be minor as most of the increase in paving would occur downslope of the patch to be retained.	Short term	Not significant	Moderate – impacts are unknown and unpredictable but confined to a patch downslope of vegetation to be retained.
Loss of aquatic habitat	Green and Golden Bell Frog	Direct	Site	Moderate – several artificial ponds would be removed during construction. These habitats are not the primary source of frog adults. Data suggests that the frogs use the habitats only rarely for breeding and mostly for sheltering. At least one of the ponds would be permanently removed for operational facilities.	Short term for majority of ponds Long term for at least one pond	Significant	High – permanent facilities impacts are irreversible Low – impact of modification of foraging, dispersal and sheltering habitat is unknown
Injury and mortality	Green and Golden Bell Frog	Indirect	Site	Moderate – there is potential that some frogs could be injured or killed as part of the construction of the project. A pre-clearance procedure would be established to minimise risks to the frog population.	Short term	Not significant	Moderate – impacts are predictable and mitigation measures would minimise risks to the population

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Impact	Which MNES	Nature of impact	Scale of impact of proposed action	Intensity of impact of proposed action	Duration	Likely significance of impact	Confidence in assessment
Pathogens and animal pests	Green and Golden Bell Frog	Indirect and facilitated	Site	Major – there is potential that the impacts of the chytrid fungus could be exacerbated by the proposed action. Chytrid is currently present at the Arncliffe surface works area and the Kogarah Golf Course. The fungus is managed in the RTA ponds by salt water flushing. While the RTA ponds would not be directly affected by the proposed action, there is a chance that unintended water spillage or discharge of water near the RTA ponds could occur. Measures to reduce the chances of this occurring have been recommended including use of town water to reduce dust, implementation of erosion and sedimentation plan and hygiene protocols. In addition to these measures, only those personnel that have had appropriate induction on the handling of wildlife would be required.	Short term	Not significant	High – impacts are predictable and manageable

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Impact	Which MNES	Nature of impact	Scale of impact of proposed action	Intensity of impact of proposed action	Duration	Likely significance of impact	Confidence in assessment
Pathogens and animal pests	Cooks River / Castlereagh Ironbark Forest	Indirect	Site	Minor – there was no evidence of the *Phytopthora cinnamomi* pathogen being present in the remnant. There was no evidence that plants were unhealthy or experiencing die back due to this pathogen. There is potential that machinery could contain the soil borne pathogen and transfer it to the patch to be retained. However, the area to be cleared is downslope of the retained patch and this pathogen tends to disperse downslope. There would be protocols for unauthorised access and clearing limits which would manage machinery and personnel potentially spreading this pathogen.	Short term	Not significant	Moderate – impacts of this pathogen are predictable but its likelihood of occurrence is unknown
Noise, dust, vibration, light and overshadowing	Green and Golden Bell Frog	Indirect	Site	Moderate – noise, dust and vibration are expected to increase during the construction period. Light could be increased at night during construction. Shading of basking and breeding habitat may also occur as a result of the proposed exclusion fence (for construction only) and permanent facilities (operation).	Short term – noise, dust and vibration and construction lighting Long term – operational shading	Not significant	Low – impacts are known but unpredictable, however a comprehensive set of mitigation measures would limit risks to the frogs

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Impact	Which MNES	Nature of impact	Scale of impact of proposed action	Intensity of impact of proposed action	Duration	Likely significance of impact	Confidence in assessment
Wildlife connectivity and habitat fragmentation	Cooks River / Castlereagh Ironbark Forest	Indirect and facilitated	Local	Minor – the landscape context within which this remnant exists is currently already highly urbanised and fragmented. Where genetic transfer occurs between patches, this is likely to continue. Many of the fauna present are likely to be urban tolerant and wide ranging rather than confined to the patch. The indirect impacts would include increases in edge effects such as increases in light and weed invasion and reductions in ecosystem processes such as pollination and recruitment of plants.	Long term	Not significant	Low – impacts are known but unpredictable
Wildlife connectivity and habitat fragmentation	Green and Golden Bell Frog	Indirect	Site	Moderate – temporary exclusion of the frogs from an area of foraging, sheltering and dispersal habitat would occur during the construction phase. Measures to increase alternative habitat adjacent to the impact area would reduce risk of fragmentation of habitat. Artificial ponds would also be created to provide stepping stones between the RTA ponds and the remaining habitat on the Kogarah Golf Course.	Short term	Significant	Low – impact of modification of foraging, dispersal and sheltering habitat is unknown

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Impact	Which MNES	Nature of impact	Scale of impact of proposed action	Intensity of impact of proposed action	Duration	Likely significance of impact	Confidence in assessment
Trampling and unauthorised access	Cooks River / Castlereagh Ironbark Forest Green and Golden Bell Frog	Facilitated	Site	Minor – the proposed action may increase chances of trampling and unauthorised access during the construction phase. A series of measures designed to limit the risks of trampling would be implemented.	Short term	Not significant	High – impacts are predictable and manageable
Bushfire	All MNES in project area	Additional	Regional	Minor – while the impacts of bushfires can be major, the lack of native vegetation present within and around the project area would limit the ability of bushfires commencing and spreading.	Short term	Not significant	High – impacts are predictable
Groundwater	Cooks River / Castlereagh Ironbark Forest	Indirect	Site	Minor - lowering of groundwater table may stress community particularly when rainfall is low or below average.	Long term	Not significant	High – impacts are predictable
Potential future development in the vicinity – Cooks Cove development	Green and Golden Bell Frog	Additional	Local	Unknown – The future planning of this development is preliminary. DP&E has commenced investigations of the Cooks Cove area as a potential priority precinct (rezoning).	Unknown	Unknown	Low – unknown

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Impact	Which MNES	Nature of impact	Scale of impact of proposed action	Intensity of impact of proposed action	Duration	Likely significance of impact	Confidence in assessment
Future urban growth	All MNES potentially present in south west Sydney	Cumulative and facilitated	Regional	Minor – project increases capacity of existing regional road network and will support economic development across south west Sydney and beyond. 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
Compound impacts arising from existing M5 East Motorway	Green and Golden Bell Frog	Additional, cumulative	Site	Minor – the status of the Green and Golden Bell Frog population at Arncliffe is largely unchanged since the original M5 East Motorway was constructed largely due to the success of the artificial habitat creation and the ongoing management activities at the site	Short term	Not significant	High

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Impact	Which MNES	Nature of impact	Scale of impact of proposed action	Intensity of impact of proposed action	Duration	Likely significance of impact	Confidence in assessment
Compound impacts arising from the Airport West Precinct proposal, which includes the widening of Marsh Street	Green and Golden Bell Frog	Additional, cumulative	Site	Minor – the status of the Green and Golden Bell Frog population at Arncliffe is largely unchanged since the during the last 15 years largely due to the success of the artificial habitat creation and the ongoing management activities at the site. An impact assessment found that the habitats in the study area were heavily modified and that no Green and Golden Bell Frogs were present in the study area. The report concluded that the impacts due to the proposed widening would not be significant. The RTA ponds would not be affected by the proposed road widening.	Short term	Not significant	High
Future major road works to the south of project area	Green and Golden Bell Frog Migratory birds and waders	Cumulative and facilitated	Regional	Unknown – there are concepts for the extension of a road to the south of the project area that may impact on many MNES. There is insufficient information currently available to make any informed assessment about the potential impacts.	Unknown	Unknown	Unknown

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6.3 Direct impacts

6.3.1 Vegetation

The survey and assessment undertaken for this report identified the direct impacts on vegetation communities outlined below in **Table 17**.

Table 17: Direct impacts on native vegetation

PCT name	PCT ID	Threatened ecological community		Area impacted (hectares)	Site value
		TSC Act listing	EPBC Act listing		
Broad-leaved Ironbark Melaleuca decora shrubby open forest on the clay soils of the Cumberland Plain, Sydney Basin Bioregion	725	Cooks River / Castlereagh Ironbark Forest of the Sydney Basin Bioregion	Cooks River / Castlereagh Ironbark Forest of the Sydney Basin Bioregion	1.40	29.34
Paperbark swamp forest of the coastal lowlands of the NSW North Coast Bioregion and Sydney Basin Bioregion	1064	Swamp Sclerophyll Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions	N/A	1.82	19.27
Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest in sandstone gullies of western Sydney, Sydney Basin	1181	N/A	N/A	0.09	39.58
Urban native and exotic vegetation	N/A	N/A	N/A	7.45	-

Impacts to the Cooks River Castlereagh Ironbark Forest are associated with the western surface works between the existing M5 East Motorway and the Canterbury Golf Course.

Impacts to the Swamp Sclerophyll Forest are associated with the Arncliffe surface works area.

The remainder of the vegetation to be cleared are associated with Bexley Road and St Peters interchange and local roadworks.

The amount of vegetation (native and exotic) estimated to be cleared is around 10.8 hectares (excluding areas not surveyed and cleared lands). The total native vegetation to be cleared is 3.31 hectares.

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6.3.2 Threatened species

No threatened flora species were recorded occurring within the development site. No impacts to threatened flora are likely. While the FBA predicts that there would be 24 threatened flora associated with habitats in the study area (see **Section 5.2**), none of these threatened flora have the potential to occur in the development site.

One threatened fauna species is known from within the development site. This species, the Green and Golden Bell Frog may be directly impacted by the construction activities at the Arncliffe surface works area adjacent to the RTA ponds and within the golf course. The RTA ponds provide breeding habitat and the Arncliffe surface works area provide sheltering, foraging and dispersal habitat. The Arncliffe surface works area provides occasional breeding habitat but the ponds are not the key source of adults or tadpoles (Dr Arthur White pers comm 2015). Mitigation measures are suggested to minimise direct impacts to frogs to the extent that there are no residual unavoidable impacts on this species. These are discussed in **Section 6.6**.

Direct impacts to Green and Golden Bell Frog may include:

- Mortality to individuals during clearance of sheltering habitat
- Mortality and injury to individuals during decommissioning of dam/pond within the golf course
- Mortality or injury to individuals during construction of mitigation measures (e.g. frog exclusion fencing)
- Mortality or injury to individuals during operation of the permanent facilities at the Arncliffe surface works area
- Decrease the habitat values of the RTA ponds due to shading, dust, noise and light and potentially accidental water contamination.

6.3.3 Fauna habitat

No critical habitat was identified within the development site for any species, communities or populations.

Green and Golden Bell Frog habitat

The Arncliffe surface works would result in the clearance of 7.82 hectares of Green and Golden Bell Frog foraging, sheltering and dispersal habitat. A Plan of Management for the frogs is being developed. Direct impacts to Green and Golden Bell Frog habitat include the clearing of vegetation suitable for foraging and sheltering and removal of golf course artificial ponds that may be used as sheltering habitat.

Grey-headed Flying Fox habitat

While no direct impacts to Grey-headed Flying Fox known camps are likely, there would be direct impacts to potential foraging habitat for this species. Around 10.80 hectares of native and exotic vegetation would be impacted. Some of this vegetation may be foraging habitat for the Grey-headed Flying Fox, which has a camp at Turrella. This camp is approximately one kilometre east of Bexley Road surface works where the Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest occurs; 4.3 kilometres east of the Cooks River Castlereagh Ironbark Forest at Beverly Grove and 2.1 kilometres north-west of the Swamp Sclerophyll Forest at the Arncliffe surface works area. The direct impacts to this potential foraging habitat are unlikely to present a significant adverse impact to this species (refer **Appendix G**).

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Hollow bearing trees

A total of nine trees were identified as containing hollows (**Appendix F**). Of the nine hollows identified, only five of these were definite hollows, three were possible and one was a fissure in the trunk. A conservative approach was used in determining whether a hollow was present. A precautionary approach was taken and even potential hollows were considered for this assessment.

There were eight hollow bearing trees likely to be impacted by the construction. None of the hollows to be impacted were large enough to be roosting or breeding habitat for large forest owls or large cockatoos. A total of eight hollows would be impacted by the project (**Figure 11**).

6.3.4 Weeds

Weeds were abundant within the study area with some areas supporting weed infestations. Noxious and environmental weeds recorded within the study area during the survey period are identified in **Table 18**.

Table 18: Noxious and environmental weed species recorded in study area

Weed species	Noxious in LGA	Class	Weed of National Significance
Acetosa sagittata (Turkey Rhubarb)		×	×
Araujia sericifera (Moth Vine)		×	×
Asparagus aethiopicus (Asparagus Fern)	Canterbury and Rockdale	4	✓
Cestrum parqui (Green Cestrum)	Canterbury and Rockdale	3	×
Cinnamomum camphora (Camphor Laurel)		×	×
Cotoneaster glaucophyllus (Cotoneaster)		×	×
Erythrina crista-galli (Cockspur Coral Tree)		×	×
Ipomoea indica (Morning Glory)		×	×
Lonicera japonica (Japanese Honeysuckle)		×	×
Lantana camara (Lantana)	Canterbury and Rockdale	4	✓
Ligustrum lucidum (Large-leaved Privet).	Canterbury and Rockdale	4	×
Ligustrum sinense (Small-leaved Privet).	Canterbury and Rockdale	4	×
Ochna serrulata (Mickey Mouse Plant)		×	×
Rubus fruticosus aggregate species (Blackberry)	Canterbury and Rockdale	4	×

Class3: The plant must be fully and continuously suppressed and destroyed.

Class 4: The growth of the plant must be managed in a manner that reduces its numbers spread and incidence and continuously inhibits its reproduction.

The comprehensive list of weeds can be found in **Appendix D**. A total of 38 weeds species were recorded across the study area.

Given the high presence of weeds in the study area it is very likely that any vegetation disturbance could potentially exacerbate the existing weed infestation. This could potentially have indirect impacts on native flora and fauna in adjoining areas by further reducing habitat quality, increasing competition for resources, and altering the structure and composition of vegetation communities.

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Mitigation measures listed in **Section 6.6** would be implemented to contain the spread of weeds during the construction and operation of the project.

6.3.5 Changes to hydrology

A number of activities associated with the proposal may result in impacts to the hydrology of waterways in the study area, namely:

- Dewatering, treatment and discharge of groundwater from the tunnel during construction and operation.
- An increase in runoff during construction and operation as a result of increased paved areas.

The technical working paper for surface water impacts states that potential impacts on surface water quality during construction of the project are considered minor and manageable with the application of standard mitigation measures (AECOM 2015b).

The Construction Environmental Management Plan (CEMP) would control potential surface water quality impacts during construction. Water treatment plants for water treatment during construction and operation would be designed to a minimum standard that would meet the water quality reference criteria developed for the project to improve water quality of these receiving environments. The criteria were developed in accordance with guidelines from the Australian and New Zealand Environment Conservation Council (ANZECC, 2000). As such, provided the criteria are met, there would be a low risk of adverse impacts of treated water discharges on the water quality of the receiving environment

Monitoring of the receiving surface water would be undertaken during initial operation of the project to ensure discharge is meeting these criteria.

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 including gross pollutant traps, wetlands, bioretention systems, and proprietary treatment devices. These treatment measures would be sized during detailed design to mitigate the increase in pollutant loads that would result from the project and would target stormwater pollution reduction targets from the *Botany Bay and Catchment Water Quality Improvement Plan* (SMCMA, 2011).

6.3.6 Loss of aquatic habitat

Impacts to aquatic habitats are not assessed under the FBA but are included in this chapter for completeness. Works in or near waterways may result in impacts to aquatic habitats such as:

- Removal of dams/artificial ponds at the Arncliffe surface works area.
- Discharge of treated water into sections of Wolli Creek (in construction only) and the Cooks River (construction and operation).

Apart from Green and Golden Bell Frog, no threatened aquatic species are likely to occur in the development site. Impacts to Green and Golden Bell Frogs are described elsewhere.

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The following direct impacts to aquatic habitat may occur as a result of the project:

- Wolli Creek (Beverly Hills/Kingsgrove): Open concrete channels and box culverts on 1st and 2nd order headwater streams. Not KFH (confirmed by Fisheries NSW, 22 June 2015). Wolli Creek would receive stormwater discharges during operation, and discharge of treated water during construction. Water quality of discharge would be better than receiving waters.
- Wolli Creek (Kingsgrove - west): Open concrete channel on 3rd order stream. Mapped as KFH (confirmed by Fisheries NSW, 22 June 2015), but does not meet Type 1, 2 or 3 sensitivity classification due to concrete lining (see Table 1 of Fisheries Policy and Guidelines). Wolli Creek would receive stormwater discharges during operation, and discharge of treated water during construction.
- Wolli Creek (Kingsgrove – east): Open concrete channel on 3rd order stream. Mapped as KFH (confirmed by Fisheries NSW, 22 June 2015), but does not meet Type 1, 2 or 3 sensitivity classification due to concrete lining (see Table 1 of Fisheries Policy and Guidelines). Wolli Creek would receive stormwater discharges during operation, and discharge of treated water during construction and impacts are not expected due to the concrete lining.
- Cooks River (Arncliffe): Discharge of treated water into Cooks River during construction and operation and not expected to impact the geomorphology of those waterways because it is sufficiently wide enough and the discharges are insignificant to existing river flows. No marine vegetation present within five metres of shore. Mapped as KFH.
- Arncliffe surface works area dams/ponds (Arncliffe): Removal of up to nine open water dams/ponds. The largest is 0.4 hectares (surface area) at headwater of 1st order stream. Not KFH.
- Alexandra Canal (St Peters/Alexandria): Stormwater discharge only to 2nd order stream. Mapped as KFH.

6.4 Indirect impacts

6.4.1 Pathogens and animal pests

Pathogens

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 Key Threatening Process under the TSC Act (OEH 2014c).

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

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of frogs by amphibian chytrid fungus causing the disease Chytridiomycosis' is a listed KTP under both the EPBC Act and the TSC Act (OEH 2014d). Chytrid fungus is of particular concern in the threatened Green and Golden Bell Frog habitats within the study area, particularly the species' breeding habitat at the RTA ponds.

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 2014e).

The only pathogen likely to be present in the impact area is the chytrid fungus. This pathogen is likely to be present at the Kogarah Golf Course (White A. pers. comm. 2015). The fungus is managed within the RTA ponds by managing water levels and salt levels in that water. A hygiene protocol would be established as part of the Construction Environmental Management Plan. Given the likelihood that chytrid fungus is already established within the species habitat within the study area, it is considered unlikely that the project would exacerbate the effects of chytrid fungus on the Green and Golden Bell Frog, provided the mitigation measures listed in **Section 6.6** are adopted.

Animal 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 such as:

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

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. Animal scats likely to belong to the European Red Fox were noted within the study area. The project is not likely to exacerbate the impacts of the European Red Fox of native fauna.

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. No evidence of feral cats was identified during the field survey however feral and domesticated cats are likely to forage throughout the study area given the surrounding urban development. Given the likely abundance of cats in the locality, and the nature of the impacts associated with the project, the project is unlikely to increase the abundance of cats, introduce them into new areas, or increase predation pressure on native fauna.

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6.4.2 Noise, vibration, light and dust

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 standard 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, overshadowing and vibration is the Green and Golden Bell Frog. The Arncliffe construction compound would be operational 24 hours during construction and the impacts of noise, dust and vibration are expected to continuously operate during this time.

There are two potential impacts of light on Green and Golden bell Frog habitat. One is the increase in light cast on the RTA ponds due to night works and therefore impacting on frog behaviour. The second is the potential for overshadowing from a construction fence (during construction only) and shading cast by permanent facilities during the operational phase of the project. Shadow studies completed for this project show that there would be no shading on the RTA ponds as a result of the permanent facilities between 9.00 am and 3.00 pm during the summer solstice. However, there would be shading on the RTA ponds at 9.00 am at the winter solstice. The RTA ponds would not be in shadow at midday at the winter solstice. Given the frogs would likely be less active during winter or in torpor, the level of shading during winter would not likely cause a significant impact to the population by reducing quality or availability of basking habitat.

Project specific measures to mitigate and minimise the indirect impacts to the Green and Golden Bell Frogs would be provided in the proposed Green and Golden Bell Frog. Measures to limit impacts would include:

- Use of low sodium and / or directional lighting to avoid light spill into the RTA ponds
- Use of transparent fencing that is sound proof alongside the RTA ponds
- Use of three metre temporary noise barriers along the norther, western and southern boundary of the construction zone
- Use of a non-acoustic shed for some construction activities in the construction zone adjacent to the Arncliffe construction compound to minimise noise impacts near the RTA ponds
- Use of non-acoustic shed would also minimise dust
- Use of town water supply to suppress dust in the construction zone adjacent to the RTA ponds and frog habitat on the golf course.

Changes to the availability of light as a result of vegetation clearance may potentially impact both flora and fauna species. The potential impacts include:

- Altering light regimes affecting plant growth.
- Changes to micro-climates caused by overshadowing or increased light potentially increasing the likelihood of weed invasion.

In general noise, vibration and light are unlikely to have a substantial adverse effects on the diurnal and nocturnal threatened birds and mammals that may occur within the study area from time to time, because these types of indirect impacts are already widespread within the study area, and any exacerbation of these impacts would be limited by the proposed mitigation measures. In addition, construction noise and vibration impacts would be temporary. Works are expected to be conducted between mid-2016 and completed by end of 2019.

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6.4.3 Wildlife connectivity and habitat fragmentation

Fragmentation of habitat would be minimal across the study area given that the majority of the impact is generally underground. Where surface works are proposed, the surrounding land is urbanised and the remnant native vegetation is limited to relatively small and highly modified patches with a high perimeter to area ratio, and limited connectivity with any larger patches of remnant vegetation.

The project would not sever or otherwise compromise any state or regional biodiversity links.

6.4.4 Fragmentation and isolation

The project has the potential to result in fragmentation and isolation of remnant native vegetation. Clearing of the Cooks River / Castlereagh Ironbark Forest at the western surface works area would increase fragmentation and isolation of the remaining patch. The impacts of fragmentation increase in edge effects, alteration of light penetration into the patch, increase edge to area ratio and weed invasion. The overall impact of these actions would be to reduce the ecological integrity of the remaining patch.

Measures to minimise these impacts would include the management of weed propagules during construction and are listed in **Section 6.6**.

Isolation of patches of remnant vegetation can result in a lack of gene flow between patches. While vegetation to be removed as part of this project persist in a highly urbanised context, measures to minimise isolation would be implemented via a flora and fauna management plan (see **Section 6.6.2**).

6.4.5 Trampling and unauthorised access

The project has the potential to result in loss of biodiversity through trampling and unauthorised access during construction. Areas of high ecological sensitivity include the Cooks River / Castlereagh Ironbark Forest at the western surface works area and the Green and Golden Bell Frog habitat at the Arncliffe surface works area. Unauthorised access could result in impacts such as direct mortality to flora and fauna, introduction of weeds and disease, introduction of rubbish and increases in clearing.

These impacts would be minimised with the implementation of project specific and general mitigation measures (see **Section 6.6**).

6.4.6 Injury and mortality

Fauna injury or mortality could occur as a result of both the construction and operation of the project.

During the construction of the project, injury or mortality may occur as a result of vegetation clearing or direct collision with vehicles and equipment within the construction site. Although some mobile species may be able to move away quickly and easily such as some birds, 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 Arncliffe surface works area, there is a possibility that Green and Golden Bell Frogs may be injured. A pre-clearing procedure would be established to ensure that the area is free of frogs prior to any habitat removal. An unexpected discovery procedure would also be implemented to ensure that even if frogs remain in areas to be cleared, that there is a clear and robust method to minimise the potential for frogs to be injured or killed.

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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 the alignment transitions from above to below ground the surrounding land is urbanised.

6.4.7 Downstream changes to aquatic and riparian habitat

In Wolli Creek, piping and an increased paved surface may alter downstream hydrologic conditions. This could impact fish passage in shallow riffles or the fish ladder near Turrella Station. Faster runoff events during storms could lead to bank erosion, riparian loss and increased sedimentation of pools.

In all areas, changes to the physico-chemical properties of waterways could occur due to construction runoff and an increase in paved areas, such as water temperature, turbidity, pH, salinity and alkalinity. This may influence available habitat for some invertebrates and fish, although given the highly disturbed nature of the study area any existing aquatic fauna are likely to be hardy species that are tolerant of waterways that are highly affected by impacts associated with urban development. A change in nutrient concentrations could also influence primary productivity in the downstream environment with flow-on effects across the food web.

In stream works, may release or activate pollutants bound in the sediment. This may change dissolved oxygen concentrations of nearby aquatic habitat and be toxic to aquatic fauna. The assessment concluded there were no aquatic habitats to be impacted. However, any in stream works should be conducted in accordance with the relevant Roads and Maritime guidelines for protecting biodiversity.

Water from the groundwater treatment plant proposed for the Arncliffe surface works would be disposed of into concrete-lined sections of Wolli Creek and a concrete channel at the golf course that drains into the Cooks River. This water would be treated to a quality that is similar to, or better than the receiving water, so is unlikely to have a significant ecological impact.

The waterways that are receiving environments for treated groundwater discharge from the project are 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.

6.4.8 Impact on relevant 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 19**.

Table 19: Known and potential Key Threatening Processes and impacts on biodiversity

Key Threatening Process	Relevance to the project	Potential or known
Clearing of native vegetation (TSC Act) Land clearance (EPBC Act)	Clearing of vegetation including native vegetation will be undertaken as part of the project. The loss of native vegetation will be offset in accordance to the Guideline for Biodiversity Offsets (Roads and Maritime Services 2011). This is discussed in **Chapter 7**. Under these circumstances the contribution of the project to this KTP is considered to be acceptable.	Known

Key Threatening Process	Relevance to the project	Potential or known
Infection of frogs by amphibian chytrid causing the disease chytridiomycosis (TSC Act) Infection of amphibians with chytrid fungus resulting in chytridiomycosis (EPBC Act)	Known habitat for frogs within the study area within the Kogarah Golf Course and the RTA ponds. Movement of vehicles, equipment and people during the construction phase carries a risk of introduction and spread of the chytrid fungus in these habitats with potential to impact on frog species. With the implementation of appropriate mitigation measures listed in **Section 6.6** the risk of exacerbating this KTP is considered to be low.	Potential
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 6.6** 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 6.6** 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 within the study area. Movement of vehicles, equipment and people during the construction phase carries a risk of introduction and spread of these exotic vines and scramblers and well as disturbing intact vegetation can increase the risk of weed infestations. Appropriate mitigation measures would 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 6.6** the risk of exacerbating this KTP is considered to be low.	Potential

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

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Key Threatening Process	Relevance to the project	Potential or known
Invasion, establishment and spread of *Lantana camara* (TSC Act)	*L. camara* is present within the study area including within Smooth-barked Apple – Red Bloodwood – Sydney peppermint heathy open forest and within the Broad-leaved Ironbark Melaleuca decora shrubby open forest on the clay soils of the Cumberland Plain. 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 6.6** the risk of exacerbating this KTP is considered to be low.	Potential
Loss of Hollow-bearing Trees (TSC Act)	The project would result in permanent removal or lopping of up to eight hollow bearing trees, containing eight hollows. The hollows present were of low quality and unlikely to be suitable for many hollow dependent fauna. The loss of hollow-bearing trees resulting from the project would be offset through the installation of nest boxes in accordance to the Guideline for Biodiversity Offsets (Roads and Maritime, 2011) as discussed in **Section 6.6** and through the proposed vegetation offsets as discussed in **Chapter 7.**	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 environmental impact statement for the project. The risk of the proposal exacerbating this KTP are considered to be low	Known

6.5 Negligible impacts

6.5.1 Groundwater dependent ecosystems

The Cooks River is marked in the GDE Atlas as being 'highly likely' to have an inflow dependence on groundwater. This means that the Cooks River estuary receives groundwater upwelling diffusely through its bed. Some of this water potentially flows beneath the Kogarah Golf Course and could be intercepted. The volume and rate of groundwater flow into the estuary is unknown, but hydrological connection to the estuary is likely to be limited by concrete and brick lining along the banks. It is unlikely that any ecological components of the estuary would be dependent on upwelling groundwater. Fisheries NSW maps for Cooks River show no seagrass in the channel adjacent to the golf course, so it is unlikely that any reduction in inflow that is caused by abstraction will have a significant impact.

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Although the Cooks River is highly likely to receive groundwater inflow, there are no known ecosystem components which are likely to be impacted if the flux of groundwater was to become less due to extraction of groundwater as a result of tunnelling.

There is a plan to remove part of the potentially groundwater dependent Cook River Castlereagh Ironbark Forest. Apart from the direct impacts to the forest by direct removal, there is also the potential for impact to the part that remains intact if groundwater drawdown extends beneath it. The forest contains species, such as *Melaleuca decora*, *M. nodosa* and *Casuarina glauca*, which may show signs of stress if the water level drops below their rooting depths. Temporary drawdown impacts during construction are likely to be minimal because the high clay content of the soil would buffer against water loss. Permanent drawdown impacts to the vegetation community are likely to be minimal compared to the stress caused by removal of the surrounding vegetation. Drawdown in the western part of the alignment is less than elsewhere along the alignment because the watertable is already drawn down by the existing M5 East Motorway tunnel. Modelling shows that the drawdown impacts beneath the forest will be less than two metres which is in the range of seasonal variation and consequently should not impact the woodland.

Maximal drawdown is five to 20 metres and magnitude will be greatest along the mainline tunnel and decrease toward the drawdown boundary (AECOM 2015a). Therefore, the water table near the drawdown boundary would experience only a minor drop, and the impacts on GDEs in this area would subsequently be minor. There are two GDEs that occur in the edge of the drawdown boundary modelled, and so are unlikely to be impacted by the drawdown. The first is a 17 hectare sandstone gully forest along Bardwell Creek, with a moderate to high potential for groundwater dependence. The second is a 3.4 hectare area of mangrove forest on the southern bank of Wolli Creek at Wolli. The drawdown at this location is predicted to be about one metre. Both of these potential GDEs are along creek lines, so are able to draw on surface water.

Stotts Reserve is a 3.5 hectare area of coastal sandstone ridgetop woodland in Bexley North that has a moderate potential for groundwater dependence. The mainline tunnel runs directly beneath Stotts Reserve, and drawdown could be as much as 10 metres. Woodland in the reserve probably uses soil moisture and surface water during periods of normal rainfall, and groundwater during prolonged dry periods. Drawdown during construction and operation of the tunnel, could lead to some trees in the reserve dying or becoming stressed during dry periods if no supplementary water is provided. However a study in the Pilbara (Pfautsch et al 2015) showed the ability of a eucalypt species to recover after significant short-term declines in groundwater. It is not known how the species in this reserve would respond to short term declines.

There is potential for groundwater drawdown to impact trees near watercourses. The majority of the project alignment has a water table below about two metres depth and below the growth zone. Trees are not completely dependent on the water table, drawing water from the soils and rocks in the unsaturated zone. This would not change as the unsaturated zone is influenced by rain infiltration. 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. The predicted drawdown at the various creeks varies depending on local geology, horizontal distance from the tunnel and depth to the tunnel. Typical drawdown is estimated to be negligible.

As discussed in Section 3.5, there are other areas of vegetation that occur within the predicted drawdown boundary. The vegetation is not expected to be impacted by groundwater drawdown because it is either associated with tidal flows or has a low permeability organic layer restricting groundwater leakage from the alluvium.

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A summary of the areas and potential impacts to GDEs is shown in **Table 20**.

Table 20: Impact to groundwater dependent ecosystems

Location	GDE description	Possible impact to GDE	Significance
Western surface works area	1.80 hectares of Cooks River Castlereagh Ironbark Forest along northern edge of highway and south of golf course. *Melaleuca* and *Casuarina* in forest suggest possible groundwater link.	Vegetation likely to be cleared during development. If vegetation is not cleared, lowering of groundwater table may stress community.	Moderate
Kingsgrove Road surface works	No GDE in footprint.	Nil	Not significant
Arncliffe surface works area, south of M5 East Motorway	No GDE indicated for the footprint, but the reach of Cooks River adjacent to the footprint is highly likely to be an inflow dependent GDE (GDE Atlas). NSW Fisheries mapping for Botany Bay and Cooks River shows no seagrass in this part of the Cooks River.	Drawdown at this site may reduce the flow of water from aquifer to river. The current flow rate at this location is unknown, but is unlikely to be significant because large reaches of the bank and bed are lined with concrete or brick. The channel is modified.	Low. No seagrass beds occur in the area, and reduced groundwater drawdown to the estuarine reach of Cooks River would have negligible impact to ecology.
Alexandria landfill and Sydney Park	No GDEs in footprint.	Nil	Not significant
St Peters interchange and local road upgrades	No GDEs in footprint.	Nil	Not significant
Bardwell Valley Parkland and Broadford Street Reserve	17 hectares of hinterland sandstone gully forest with moderate to high potential to be dependent on groundwater.	Drawdown could lower groundwater to a point where it is below the roots of dependent trees. As this GDE is near the edge of the drawdown boundary, the impact is unlikely to be significant.	Low. This GDE is on the edge of the drawdown area. The forest also has access to surface water in Bardwell Creek. Only half of the forest is inside the drawdown boundary.

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Location	GDE description	Possible impact to GDE	Significance
Stotts Reserve, Bexley North	3.5 hectares of coastal sandstone ridgetop woodland with moderate potential for groundwater dependence	Stotts Reserve is directly above the planned route of the mainline tunnel. Drawdown could be up to 10 metres, and if trees are dependent on groundwater, a large part of the reserve could show signs of stress in prolonged dry periods.	Low. Under prolonged dry conditions, the vegetation at Stotts Reserve may show signs of stress. However, the community should recover with sufficient rainfall.
The forest between the southern bank of Wolli Creek and the rail line behind Wolli Creek Station.	3.4 hectares of estuarine fringe forest and mangrove forest with low to moderate potential for groundwater dependence	This tract of vegetation is on the bank of Wolli Creek, near the edge of the drawdown boundary. It is unlikely that drawdown would be significant here.	Low. There is unlikely to be any significant impact on the estuarine fringe forest or mangrove forest along Wolli Creek.

6.5.2 Alteration of artificial or highly disturbed waterways.

The waterways in the study area are highly disturbed from concrete channelisation, culverts, constructed rock banks and sedimentation which limits the significance of potential impacts associated with the proposal. However, surface works during construction could lead to impacts on less disturbed habitats downstream, as a result of erosion, sedimentation or the release or activation of pollutants bound to sediment.

During construction and operation, the project would discharge treated groundwater and construction water to Wolli Creek, which is either concrete or rock-lined in the upper reaches, and sufficiently wide in the lower reaches to accommodate the extra flow. Discharges to Alexandra Canal and the Cooks River are of a similar magnitude and not expected to impact the geomorphology of those waterways for the same reasons. Specific localised mitigation measures are proposed where outlet scour protection and energy dissipation is required prior to releasing water into local creeks / waterways. These protection measures would be included as part of the detailed design (AECOM 2015b).

The control and mitigation of potential geomorphology impacts during operation are as follows:

- Hydrodynamic modelling would need to be undertaken to inform scour and erosion control measures at these locations.
- Drainage and discharge infrastructure shall incorporate measures to trap and remove sediments and gross pollutants that may impact the geomorphic condition of the receiving waters.
- Treated groundwater discharge volume and velocity would be regulated and managed to ensure impacts to the receiving environment are minimised.

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6.6 Mitigation measures

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 21** and described in detail below. It is anticipated that the standard control measures (i.e. inductions etc.) would be incorporated in a flora and fauna management plan.

6.6.1 Standard mitigation measures

The mitigation and management measures would be detailed within a flora and fauna management plan, which would be prepared with consideration to the *Roads and Maritime Biodiversity Guidelines – Protecting and Managing Biodiversity on Roads and Maritime Projects* (the Biodiversity Guidelines) (Roads and Traffic Authority 2011). The measures would include, but are not limited, to the following:

- The disturbance and clearance of established vegetation would be minimised as far as feasible.
- Pre-clearing surveys would be undertaken prior to the commencement of construction by a suitably qualified ecologist to identify the presence of hollow bearing trees and other habitat features, and threatened flora and fauna. This would be undertaken in accordance with Guide 1 of the Biodiversity Guidelines.
- Installation of nest boxes in accordance with the Biodiversity Guidelines and nest box management plan.
- Exclusion zones would be identified to protect against accidental vegetation damage. This would be undertaken in accordance with Guide 2 of the Biodiversity Guidelines.
- Clearing of vegetation would be undertaken in accordance with Guide 4 of the Biodiversity Guidelines to manage risks to fauna during vegetation clearing activities.
- Where reasonable and feasible habitat elements (such as woody debris) would be stored and reused on site, or in adjacent bushland in accordance with Guide 5 of the Biodiversity Guidelines.
- Weed spread would be managed in accordance with Guide 6 of the Biodiversity Guidelines. A risk assessment process would be used for each site to determine the need to clean machinery prior to entering the construction compound sites. A weed management plan would be prepared as part of the flora and fauna management plan.
- The identification of pathogens would be undertaken as part of pre-clearing inspections. A risk assessment process would be used for each site to determine the need to clean machinery prior to entering the construction compound sites. In the event that pathogens are identified within the construction footprint, appropriate mitigation measures would be identified and implemented in accordance with Guide 7 of the Biodiversity Guidelines. These measures would be consistent with the actions set out in the threat abatement plan under the EPBC Act (Commonwealth of Australia 2014). The threat abatement plan aims to minimise the spread of the pathogen and mitigate impacts of the pathogen.
- Any handling of fauna would be carried out by appropriately licenced person and undertaken in accordance with Guide 9 of the Biodiversity Guidelines. This measure would be consistent with the actions set out in the threat abatement plan to manage the spread of the chytrid fungus (DEH 2006). The threat abatement plan aims to manage the chytrid fungus where it is present within a frog population. Chytrid is endemic within the Green and Golden Bell Frog population in NSW. Strict hygiene protocols would be established for the handling of frogs found in the project area.
- Works within aquatic habitats or riparian zones would be undertaken to limit impacts on aquatic flora and fauna, and their habitats, and impacts on riparian areas. This would be undertaken in accordance with Guide 10 of the Biodiversity Guidelines.

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- A Green and Golden Bell Frog Plan of Management is being prepared for works being undertaken at the Kogarah Golf Course. This Plan of Management details key measures to address known and potential impacts to the Green and Golden Bell Frog key population at Arncliffe. Many of the measures listed in the plan address threats outlined in the threat abatement plans for chytrid, predation of feral cats and predation by European Red Fox.

6.6.2 Project specific measures

Project specific measures are recommended for matters where impacts would remain after the implementation of measures detailed in **Section 6.6.1**, or where additional mitigation measures would further reduce biodiversity impacts. The project specific mitigation measures are controls or protocols which would seek to provide no residual avoidable impacts on threatened species, native vegetation, or riparian and aquatic habitats.

Native vegetation management

The flora and fauna management plan would outline areas identified for native vegetation rehabilitation, in particular the PCTs and EECs impacted by the project. The plan should also outline that planting of native trees and other vegetation should as far as practicable include habitat species suitable for foraging of a range of fauna, including the Grey-headed Flying Fox. The plan would specify how native vegetation in proximity to the construction footprint is to be protected and managed so as to prevent adverse direct and indirect impacts. Areas to be managed via the flora and fauna management plan include (but are not limited to):

- Cooks River Castlereagh Ironbark Forest at the western surface works
- Bexley Road surface works
- Arncliffe surface works area.

Specific attention would be made to consistemcy with approved threat abatement plans under the EPBC Act for the Cooks River / Castlereagh Ironbark Forest. The relevant abatement plans are for threats caused by dieback from Phytophthora cinnamomi infection, predation by feral cats and predation by the European red fox.

Sediment and erosion management

The flora and fauna management plan would minimise the indirect impacts on all the adjoining vegetation by measures such as:

- Potential chemical pollutants (e.g. fuels, oils, lubricants, paints etc.) would be stored in appropriate containers within bunded areas within construction compounds to minimise the risk of the pollution of aquatic environments
- Water quality would be managed through the implementation of suitable erosion and sediment control measures in accordance with Managing Urban Stormwater – Soils and Construction, Volume 2D, Main Road Construction (DECC 2008b).

Green and Golden Bell Frog Plan of Management

The flora and fauna management plan includes a specific Plan of Management for the Green and Golden Bell Frog at the Arncliffe surface works area to minimise impacts on the species throughout the construction process. The Plan of Management, consistent with available management guidelines and policies, would include (but not be limited to) the mitigation measures provided in **Table 21**.

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The Green and Golden Bell Frog Management Plan has been prepared and will be reviewed by a suitable independent expert. The objectives of the plan are to:

- Minimise or eliminate all avoidable construction impacts by removing and excluding frogs from the construction zone and implementing strict ongoing construction protocols and exclusions.
- Compensate for unavoidable construction impacts by augmenting existing foraging habitat including supplementary feeding.
- Insure against stochastic impacts on RTA ponds by establishing a captive breeding colony and managing non construction related threats known to adversely impact the RTA ponds.
- At least double the availability of suitable habitat in the vicinity by creating new habitat at Marsh Street wetlands and re-instating habitat within Kogarah Golf Course post construction.

Together these objectives are designed to ensure the long term persistence of the species at Arncliffe which is the ultimate aim of this management plan. It is a commitment in the Plan of Management to undertake water quality monitoring of the breeding ponds. More detail on the water quality monitoring regime including frequency, sampling locations and parameters will be provided in the Habitat Creation and Captive Breeding Plan due for completion by March 2016.

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Table 21: Mitigation measures

Impact	Flora and fauna management plan / standard mitigation measures	Project Specific	Responsibility	Timing*
Vegetation				
Clearing of native vegetation	• Inductions • Pre-clearing process • Exclusion zones • Clearing of vegetation and removal of bushrock • Re-use of woody debris and bushrock • Weed management • Nest boxes • Fauna handling for animal welfare • Pathogen management	• Native vegetation management measures • Where possible, construction work activities will minimise disturbance to waterways and riparian land • Riparian land disturbed by the Stockpiles are to be located outside the riparian corridors.	Environmental representative and construction contractor	Pre-construction Construction
Run off	• Erosion and sedimentation controls • Re-establishment of native vegetation	• Sediment and erosion management and mitigation measures	Construction contractor	Pre-construction Construction Operation
Spread of weeds	• Weed management • Re-establishment of native vegetation where possible to limit weed spread	• Sediment and erosion management and mitigation measures	Environmental representative and construction contractor	Construction Operation
Spread of pathogens	• Pathogen management		Construction contractor	Construction
Threatened fauna				
Loss of native fauna from clearance	• Use of cleared vegetation and bushrock • Fauna handling • Pre-clearance survey	• See Green and Golden Bell Frog measures below	Environmental representative and fauna handlers	Construction
Loss of habitat for fauna	• Re-establishment of native vegetation for foraging and other uses • Re-use of woody debris	• Native vegetation management measures	Environmental representative, construction contractor and nest box installers	Pre-construction Construction Operation

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Impact	Flora and fauna management plan / standard mitigation measures	Project Specific	Responsibility	Timing*
Loss of hollow bearing trees	• Pre-clearing process • Re-use of woody debris • Nest boxes	N/A	Environmental representative, construction contractor and nest box installers	Construction Operation
Green and Golden Bell Frog Construction related	• Construction clearing areas defined • Frog exclusion zone (construction zone) • Temporary frog protection zone • Increase environmental and safety awareness and reporting • Pre-clearance survey • Translocation plan • Removing other threatening processes • Hygiene protocol • Site inductions • Pre-start checklist • Stop work procedure • Sediment and erosion control • Light spill management • Dust suppression • Contaminated lands management • Acid sulfate soils management • Use of herbicides and other chemicals	Green and Golden Bell Frog Plan of Management for construction at the Arncliffe surface works area	Roads and Maritime, environmental representative and construction contractor and project ecologist	Pre-construction Construction
Green and Golden Bell Frog Temporary frog protection zone	• Enhanced frog habitat • Supplementary feeding • Habitat management • Habitat re-instatement	Green and Golden Bell Frog Plan of Management for construction at the Arncliffe surface works area	Roads and Maritime, environmental representative and construction contractor	Construction Operation

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Impact	Flora and fauna management plan / standard mitigation measures	Project Specific	Responsibility	Timing*
Green and Golden Bell Frog Other measures	• Captive breeding program • Translocation • Monitoring and reporting • Water quality monitoring • Long-term habitat creation at Marsh Street wetland	Green and Golden Bell Frog Plan of Management for construction at the Arncliffe surface works area	Roads and Maritime, environmental representative and construction contractor	Pre-construction to operation

* The three categories for timing are:

- Pre-construction = Work in respect of the project that includes design, survey, acquisitions, fencing, investigative drilling or excavation, building/road dilapidation surveys, minor clearing (except where threatened species, populations or ecological communities would be affected), establishing ancillary facilities such as site compounds or other relevant activities determined to have minimal environmental impact (e.g. minor access tracks and adjustments to services/utilities etc).
- Construction = All work in respect of the project other than that defined as a preconstruction activity/work.
- Operation = The operation of the project, but not including commissioning trials of equipment, or temporary use of parts of the project during construction

6.6.3 Assessment of mitigation measures for Bilateral assessment

The Commonwealth assessment Bilateral requires that there is an assessment of the mitigation measures proposed for the project. **Table 22** contains a description of the proposed avoidance and mitigation measures, an assessment of the expected or predicted effectiveness of the mitigation measure, including the scale and intensity of impacts of the proposed (mitigation) action and the on-ground benefits to be gained through these measures. **Table 35** provides a description of the outcomes that the avoidance and mitigation measure will achieve for the MNES.

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Table 22: Assessment of avoidance and mitigation measures for Bilateral assessment process

Impact	Flora and fauna management plan / standard mitigation measures	Benefits/Outcomes	Level of confidence in effectiveness of mitigation measure
Vegetation			
Clearing of native vegetation	• Inductions	• Project boundaries clearly defined • Expectations and roles of all personnel working on the project are clearly defined • All personnel will be familiar with the ecological constraints / values associated with the project • All personnel will understand the process for dealing with unintended or potential impacts to these constraints / values	High – measure is standard and mandatory
	• Exclusion zones	• Prevent impacts to areas outside of the construction footprint	High
	• Pre-clearing process	• Minimises the risks and potential injury to fauna during the clearing process • Clearly defines the project boundaries	High if pre-clearance carried out systematically and by experienced personnel
	• Supervised clearing of vegetation and removal of bushrock	• Prevents impacts to native vegetation outside of the project boundary • Prevents removal of bushrock outside of the project boundary • Provides a framework for minimising impacts to vegetation and bushrock within the project boundary	High
	• Re-use of woody debris and bushrock	• Provides compensatory habitat for fauna within revegetation and/or other designated areas	High
	• Weed management	• Controls weeds within the project boundary • Prevents the potential spread of weeds outside the project boundary	High if implemented with appropriate framework of plan
	• Nest boxes	• Provides compensatory habitat for arboreal mammals and birds	High as only catering for urban tolerant species

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Impact	Flora and fauna management plan / standard mitigation measures	Benefits/Outcomes	Level of confidence in effectiveness of mitigation measure
	• Fauna handling for animal welfare	• Minimises the risks and injury to fauna • Minimises the risks and injury to project personnel	High
	• Pathogen management	• Controls pathogens within the project boundary • Prevents the potential spread of pathogens outside the project boundary	High if implemented within appropriate framework or plan
Run off	• Erosion and sedimentation controls	• Reduces impacts from erosion and sedimentation occurring within the project boundary • Limits erosion and sedimentation outside the project boundary • Water quality will be managed and a reduction in water quality avoided • Provides the procedure for storing chemical pollutants	High if implemented within plan
	• Re-establishment of native vegetation	• Revegetation and rehabilitation of temporary impact areas	High if managed in accordance with appropriate plan
Spread of weeds	• Weed management	• Controls weeds within the project boundary • Prevents the potential spread of weeds outside the project boundary	High if managed in accordance with appropriate plan
	• Re-establishment of native vegetation where possible to limit weed spread	• Revegetation and rehabilitation of temporary impact areas • Controls weeds within the project boundary • Prevents the potential spread of weeds outside the project boundary	High if managed in accordance with appropriate plan
Spread of pathogens	• Pathogen management	• Controls pathogens within the project boundary • Prevents the potential spread of pathogens outside the project boundary	High if managed in accordance with appropriate plan

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Impact	Flora and fauna management plan / standard mitigation measures	Benefits/Outcomes	Level of confidence in effectiveness of mitigation measure
Threatened fauna			
Loss of native fauna from clearance	• Re-use of vegetation and bushrock	• Prevents impacts to native vegetation outside of the project boundary • Prevents removal of bushrock outside of the project boundary • Provides a framework for minimising impacts to vegetation and bushrock within the project boundary	High
	• Fauna handling for animal welfare	• Minimises the risks and injury to fauna • Minimises the risks and injury to project personnel	High
	• Pre-clearance survey	• Minimises the risks and potential injury to fauna during the clearing process • Clearly defines the project	High
Loss of habitat for fauna	• Re-establishment of native vegetation for foraging and other uses	• Revegetation and rehabilitation of temporary impact areas • Provides foraging resources for local fauna	High
	• Re-use of woody debris	• Provides compensatory habitat for fauna within revegetation and/or other designated areas	High
Loss of hollow bearing trees	• Pre-clearing process	• Minimises the risks and potential injury to fauna during the clearing process • Clearly defines the project boundaries	High – few trees with hollows and no large hollows
	• Re-use of woody debris	• Provides compensatory habitat for fauna within revegetation and/or other designated areas	High
	• Nest boxes	• Provides compensatory habitat for arboreal mammals and birds	High
Green and Golden Bell Frog construction related	• Construction clearing areas defined	• Clearly defined project boundaries defined • Project personnel clearly understand the project boundaries	High

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Impact	Flora and fauna management plan / standard mitigation measures	Benefits/Outcomes	Level of confidence in effectiveness of mitigation measure
	• Frog exclusion zone (construction zone)	• Prevents impacts to frogs and potential habitat outside of the construction footprint	High
	• Increase environmental and safety awareness	• Project personnel become aware of the threatened Green and Golden Bell Frog • Project personnel understand the process and reasons behind project protocol to prevent and limit impacts to the Green and Golden Bell Frog	High
	• Pre-clearance survey	• Relocation of frogs out of the construction areas and into the frog habitat area • Minimises the risks and potential injury to Green and Golden Bell Frog during the clearing process	Moderate – measure needs to be implemented during appropriate season
	• Translocation plan	• Provides a protocol for the transportation of frogs to reduce harm and potential impacts, such as spread of pathogens and weeds	High when conducted by experienced frog ecologist
	• Removing other threatening processes	• Reduces potential impacts to Green and Golden Bell Frog and their habitat from non-construction related activities • Prevents the exacerbation of threatening processes	Moderate when managed and conducted by experienced ecologist
	• Hygiene protocol	• Prevents the potential spread of diseases and pathogens such as the Chytrid Fungus	High
	• Site inductions	• Clearly defined project boundaries defined • Expectations and roles of all personnel working on the project are clearly defined • All personnel will be familiar with the Green and Golden Bell Frog and its habitat, and the framework / protocols in place to reduces impacts • All personnel will understand the process for dealing with unintended or potential impacts to the frogs	High

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Impact	Flora and fauna management plan / standard mitigation measures	Benefits/Outcomes	Level of confidence in effectiveness of mitigation measure
	• Pre-start checklist	• Identifies the daily risks and the controls to reduce the risks • Identifies the daily tasks for working in close vicinity to frog habitat, such as determining if any frogs have accessed the site during shutdown	High and needs to be mandatory
	• Stop work procedure	• Outlines the procedure for dealing with unintended occurrences of the Green and Golden Bell Frog within the construction area, to reduce injury or harm to frogs	High when done in conjunction with pre-start checklist and with suitably qualified staff
	• Sediment & erosion control	• Reduces impacts from erosion and sedimentation to Green and Golden Bell Frog habitat • Reduces the potential for spread of weeds and pathogens • Water quality will be managed and a reduction in water quality avoided • Provides the procedure for storing chemical pollutants	High
	• Light spill management	• Reduces impacts from light on Green and Golden Bell Frogs	High
	• Dust suppression	• Reduces impacts from dust on Green and Golden Bell Frogs	High
	• Contaminated lands management	• Provides a protocol for management of contamination lands to reduce impacts to Green and Golden Bell Frog habitat	High
	• Acid sulphate soils management	• Provides a protocol for the management of acid sulphate soils to prevent impacts to Green and Golden Bell Frog habitat during the construction process	High
	• Use of herbicides and other chemicals	• Provides a protocol for use of herbicides and other chemical when working within the vicinity of Green and Golden Bell Frog habitat, to reduce the potential for contamination to frog habitat	High

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Impact	Flora and fauna management plan / standard mitigation measures	Benefits/Outcomes	Level of confidence in effectiveness of mitigation measure
Green and Golden Bell Frog - Enhanced habitat	• Enhanced frog habitat	• Ensures the long term survival of the local population by expanding the habitats available for the frog and the areas under active management	Moderate – created frog habitat has been successful at this site previously – should take into consideration lessons from other infrastructure projects
	• Supplementary feeding	• Ensures the long term survival of the local population by providing additional food resources for the frog during the construction process	Moderate
	• Habitat management	• Ensures the management of frog habitat to provide suitable habitat for the long term survival of the local frog population	High – management of this site has shown that the frog population can be maintained
	• Habitat re-instatement	• Re-establishes suitable frog habitat in temporary construction areas, where frog habitat was removed	Moderate – created frog habitat has been successful at this site previously – should take into consideration lessons from other infrastructure projects
Green and Golden Bell Frog - Other measures	• Captive breeding program	• Provides an insurance for the long term survival of the local frog population against unexpected serious impacts from the construction process	Low to moderate – previous attempts were successful but it will depend on the number of adults captured. Lessons from other programs should be implemented
	• Translocation	• Provides the protocol for the transportation of frogs between (to and from) the construction site and the site of the captive breeding program	Low to moderate – mixed success with other translocations. Lessons from other programs should be applied.
	• Monitoring and reporting	• Provides a mechanism for adaptive management of the Green and Golden Bell Frog mitigation measures during and post construction	High

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Impact	Flora and fauna management plan / standard mitigation measures	Benefits/Outcomes	Level of confidence in effectiveness of mitigation measure
	• Long-term habitat creation at Marsh Street wetland	• Ensures the long term survival of the local population by expanding and enhancing the habitats available for the frog • Would guard against stochastic events at the RTA ponds • New ponds and habitat would be managed in perpetuity	Moderate to high – habitat creation at the RTA ponds successfully maintained the population at Arncliffe. A number of other programs and projects have successfully created long term habitat. Lessons from all of these previous works should be incorporated into this project.

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7 Impact summary

Although avoidance and mitigation measures have been considered and implemented during the design of the project, impacts on biodiversity, including TECs and known threatened species habitats, will occur in association with the proposal. In accordance with the FBA and the Guideline for Biodiversity Offsets (Roads and Maritime Services 2011), these impacts will be offset.

This chapter identifies areas not requiring assessment, areas not requiring offset, identification of PCTs and species polygons requiring offset and identification of matters requiring further consideration. All calculations for offsets were done in accordance with Section 10, and mathematical equations in Appendix 1 of the FBA.

7.1 Areas not requiring assessment or 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.
- Vegetation zones with a site value score of less than 17 (none of the zones met this criteria).
- Smooth-barked Apple – Red Bloodwood – Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney (PCT 1181 / BVT ME029) was identified in the tool as requiring an offset of one ecosystem credit. However, this PCT is neither an EEC/CEEC under the TSC or EPBC Acts nor is it associated with threatened species habitat. Therefore, according to the NSW Major Projects Offsets Policy, this PCT does not require an offset to be determined.

7.2 Ecosystems requiring offsets

Two PCTs require ecosystem credits. Ecosystem credits required are outlined below in **Table 23** and area shown in **Figure 5** to **Figure 9**.

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Table 23: PCTs requiring offset and ecosystem credits

PCT requiring offsets	Area (hectare)	Vegetation zone	Future site value score	Loss in site value score	Offset multiplier	Ecosystem credits required
Broad-leaved Ironbark - Melaleuca decora shrubby open forest on clay soils of the Cumberland Plain, Sydney Basin Bioregion (PCT 725/ BVT ME002) EEC under TSC Act / CEEC under EPBC Act	1.4	2	0	29.34	3	31
Paperbark swamp forest of the coastal lowlands of the NSW North Coast Bioregion and Sydney Basin Bioregion (PCT 1064/ BVT ME050) EEC under TSC Act	1.82	17	0	19.27	3	27

7.3 Species requiring offsets

One threatened species, the Green and Golden Bell Frog, requires offsets due to the impacts to foraging, sheltering and dispersal habitat at the Arncliffe surface works area. All areas in the development site were considered Green and Golden Bell Frog habitat. This forms the basis of the species polygon which was used in the assessment methods to calculate the volume of species credits to be offset. The volume of credits is shown in **Table 24**. The area of habitat that requires offsetting is shown in **Figure 10**.

Table 24: Species requiring offset and credits required

Species requiring offsets	TS offset multiplier	Required species credits
Green and Golden Bell Frog	2.6	203

7.4 Landscape features requiring offsets

There are no landscape features that require an offset to be determined. Table 4 of the FBA outlines that where impacts to vegetation in the riparian buffer zone bordering rivers and streams 4th order or greater, state biodiversity links, important wetlands and their buffers or the buffer zone along estuaries occur, an offset is required to be determined. No such landscape features are impacted by this project.

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7.5 Aquatic biodiversity offsets

This section refers to aquatic habitats that are not considered under the FBA. No saline wetland 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 key fish habitat (KFH). As there were no aquatic biodiversity values impacted by the project, there is no requirement to provide offsets.

7.6 Impacts requiring further consideration

The FBA specifies that there may be matters where impacts require further consideration by the consent authority. These are impacts that are considered to be complicated or severe. The NSW OEH listed a number of matters that require further consideration. These matters are as follows:

- Cooks River/Castlereagh Ironbark Forest
- Sydney Turpentine-Ironbark Forest
- Swamp Oak Floodplain Forest
- River-flat Eucalypt Forest
- Swamp Sclerophyll Forest
- *Acacia prominens* (Gosford Wattle) endangered population in the Hurstville and Kogarah Local Government Areas
- Long-nosed Bandicoot endangered population in inner western Sydney
- White-fronted Chat endangered population in the Sydney Metropolitan Catchment Management Area
- *Acacia terminalis* subsp. *terminalis*
- *Streblus pendulinus* aka *Streblus brunonianus*
- *Wilsonia backhousei*
- Australasian Bittern
- Sanderling
- Curlew Sandpiper
- Greater Sand-plover
- Lesser Sand-plover
- Sooty Oystercatcher
- Pied Oystercatcher
- Broad-billed Sandpiper
- Little Tern
- Terek Sandpiper
- Green and Golden Bell Frog
- Black Bittern
- Grey-headed Flying Fox (if camps are impacted)
- Eastern Freetail Bat (if maternity or roost sites are impacted)
- Greater Broad-nosed Bat (if breeding or roost sites are impacted)

In addition to those matters listed above, the FBA requires further consideration of impacts in the buffer zone along estuaries. None of the development occurs within 50 metres of an estuarine area where native vegetation is present. Therefore, for the purposes outlined in section 9.2.3.2 of the FBA, impacts in the buffer zone along estuaries do not require further consideration. Inclusion or exclusion as matters for further consideration

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The list of matters for further consideration outlined above are the species and ecological communities present within five kilometres of the development boundary produced from OEH advice to the SEARs. Many of the listed matters for further consideration are highly unlikely to be impacted project given the absence of suitable habitats as identified in **Table 25**.

Only three listed matters occur within the development site:

- Cooks River Castlereagh Ironbark Forest
- Swamp Sclerophyll Forest
- Green and Golden Bell Frog.

Despite these matters occurring within and being impacted by the project, they should not be considered further because they are unlikely to become extinct in the IBRA subregion or be reduced in viability and have been fully considered in this assessment. None of these matters are listed as critically endangered under the TSC Act. Following consideration of those matters identified by OEH, as described in **Table 25**, it is considered that there are no other impacts requiring further consideration.

7.7 Supplementary SEARs

Supplementary SEARs were issued on 26 August 2015 to address MNES identified by the Commonwealth as being potentially impacted by the project. **Table 26** outlines the MNES, their presence or absence from the development site and the relevant sections of this BAR where they have been addressed. All relevant impacts are known and are predictable. All direct impacts are irreversible and would be offset in accordance with the FBA. All significant residual impacts have been addressed by the FBA. The offset requirements are described in **Section 8**.

There would be no significant indirect impacts to any MNES or their habitat. All indirect impacts would be managed by mitigation measures outlined in **Section 6.6** and are not expected to result in significant impacts.

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Table 25: Rationale for exclusion of matters for further consideration

Matter	Include or exclude	Rationale
Cooks River/Castlereagh Ironbark Forest	exclude	Occurs within the development site, it is unlikely to become extinct in the IBRA subregion of Cumberland
Sydney Turpentine-Ironbark Forest	exclude	Does not occur within the development site
Swamp Oak Floodplain Forest	exclude	Does not occur within the development site
River-flat Eucalypt Forest	exclude	Does not occur within the development site
Swamp Sclerophyll Forest	exclude	Although EEC is in development site, it is unlikely to become extinct in the IBRA subregion of Pittwater (B)
Acacia prominens (Gosford Wattle) endangered population in the Hurstville and Kogarah Local Government Areas	exclude	Does not occur within the development site
Long-nosed Bandicoot endangered population in inner western Sydney	exclude	Does not occur within the development site
White-fronted Chat endangered population in the Sydney Metropolitan Catchment Management Area	exclude	Does not occur within the development site
Acacia terminalis subsp. *terminalis*	exclude	There is very little potential habitat for this species in the development site and it was not detected there despite being conspicuous when present
Streblus pendulinus aka *Streblus brunonianus*	exclude	Does not occur within the development site
Wilsonia backhousei	exclude	There is very little potential habitat for this species in the development site and it was not detected there despite being conspicuous when present.
Australasian Bittern	exclude	There is only a very small amount of marginal potential habitat for this species within the development site and the species was not recorded there despite targeted survey. The impacts of the project on the species would be negligible.

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Matter	Include or exclude	Rationale
Sanderling	exclude	There is only a very small amount of marginal potential habitat for this species within the development site and the species was not recorded there despite targeted survey. The impacts of the project on the species would be negligible.
Curlew Sandpiper	exclude	There is only a very small amount of marginal potential habitat for this species within the development site and the species was not recorded there despite targeted survey. The impacts of the project on the species would be negligible.
Greater Sand-plover	exclude	There is only a very small amount of marginal potential habitat for this species within the development site and the species was not recorded there despite targeted survey. The impacts of the project on the species would be negligible.
Lesser Sand-plover	exclude	There is only a very small amount of marginal potential habitat for this species within the development site and the species was not recorded there despite targeted survey. The impacts of the project on the species would be negligible.
Sooty Oystercatcher	exclude	Survey did not detect this species and there is little to no habitat for this species in the development site.
Pied Oystercatcher	exclude	There is only a very small amount of marginal potential habitat for this species within the development site and the species was not recorded there despite targeted survey. The impacts of the project on the species would be negligible.
Broad-billed Sandpiper	exclude	There is only a very small amount of marginal potential habitat for this species within the development site and the species was not recorded there despite targeted survey. The impacts of the project on the species would be negligible.
Little Tern	exclude	There is only a very small amount of marginal potential habitat for this species within the development site and the species was not recorded there despite targeted survey. The impacts of the project on the species would be negligible.
Terek Sandpiper	exclude	There is only a very small amount of marginal potential habitat for this species within the development site and the species was not recorded there despite targeted survey. The impacts of the project on the species would be negligible.

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Matter	Include or exclude	Rationale
Green and Golden Bell Frog	exclude	This species is present within the development site. The RTA ponds would not be disturbed and mitigation measures would manage impacts to foraging habitat. It is considered unlikely that the project would threaten the viability of the local population of the species and the species would not become extinct within the IBRA subregion.
Black Bittern	exclude	There is only a very small amount of marginal potential habitat for this species within the development site and the species was not recorded there despite targeted survey. The impacts of the project on the species would be negligible.
Grey-headed Flying Fox (if camps are impacted)	exclude	No camps to be impacted. Species is close to development site but the camp would not be directly or indirectly affected. Impacts on potential foraging habitat would be minor in the context of the available foraging habitat in the region.
Eastern Freetail Bat (if maternity or roost sites are impacted)	exclude	No maternity roosts occur within development site and impacts on potential foraging habitat would be minor in the context of the available foraging habitat in the region.
Greater Broad-nosed Bat (if breeding or roost sites are impacted)	exclude	No maternity roosts occur within development site. Hollow bearing tree survey identified that trees with hollows were either on road verges or in suburban parks. It is expected that noise and other disturbances to the HBT would render the HBT as unsuitable maternity roost habitat for this bat species.

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Table 26: Rationale for assessment of supplementary SEARs

Matter of National Environmental Significance	Presence in development site	Impact	Section in BAR
Cooks River / Castlereagh Ironbark Forest of the Sydney Basin Bioregion	Present at Beverly Grove near the existing M5 Motorway and the Canterbury Golf Course	The avoid option has been exhausted The community would be directly impacted by the project Residual unavoidable impacts to be offset in accordance with FBA requirements via the purchase and retirement of biodiversity credits	Section 4.1.1 Section 6.3.1 Section 6.6.2 Chapter 7 Chapter 8 Appendix G
Litoria aurea (Green and Golden Bell Frog)	Present at the Arncliffe surface works area	No residual impact on breeding ponds Residual unavoidable impacts to foraging, sheltering and dispersal habitat to be offset in accordance with FBA requirements by the purchase and retirement of biodiversity credits Detailed, credible and robust plan of management for the species has been developed. The plan outlines the specific measures to minimise risks to the population at Arncliffe.	Section 5.2.1 Section 6.3.2 Section 6.3.3 Section 6.4.2 Section 6.4.5 Section 6.6.2 Chapter 7 Chapter 8 Appendix G
Turpentine Ironbark Forest in the Sydney Basin Bioregion	Not present in the development site Vegetation in the study area does not meet the EPBC Act threshold criteria Vegetation is not a MNES	No impact	Section 4.1.3

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Matter of National Environmental Significance	Presence in development site	Impact	Section in BAR
Acacia bynoeana (Bynoe's Wattle)	Not present in development site Targeted survey of vegetation showed species was not present The species prefers dry sclerophyll forests or heath on sandy soil. The PCT Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion is a dry sclerophyll forest. Where it occurs in the development site, it is highly modified, being underscrubbed and does not support a population of this species.	No impact	Section 5.2 Appendix A
Acacia pubescens (Downy Wattle)	Not present in the development site Targeted survey of vegetation showed species was not present This species was most likely to have been present in the Cooks River / Castlereagh Ironbark Forest remnant but it was not found in this vegetation during targeted survey	No impact	Section 5.2 Appendix A
Melaleuca deanei (Deane's Paperbark)	Not present in the development site The species occurs in two distinct areas, in the Ku-ring-gai / Berowra and Holsworthy / Wedderburn areas which are outside the development site The species is not associated with any of the PCTs present in the development site	No impact	Section 5.2 Appendix A

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Matter of National Environmental Significance	Presence in development site	Impact	Section in BAR
Persoonia hirsuta (Hairy Geebung)	Not present in the development site The species is found in sandy soils in dry sclerophyll open forest, woodland and heath on sandstone. The PCT Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion is a dry sclerophyll forest. Where this vegetation occurs in the development site, it is highly modified, being underscrubbed and does not support a population of this species.	No impact	Appendix A
Pimelea spicata (Spiked Rice-flower)	Not present in the development site Targeted survey showed species was not present This species is associated with Cumberland Plain Woodland and other grassy woodland types, which were not present in the development site.	No impact	Appendix A
Syzygium paniculatum (Magenta Lilly Pilly)	Not present in the development site Targeted survey showed that the species was present in the 550 metre buffer survey area but not in the development site. No plants of this species are to be removed or impacted by the project.	No residual impact	Section 5.2 Appendix A

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Matter of National Environmental Significance	Presence in development site	Impact	Section in BAR
Tetratheca juncea (Black-eyed Susan)	Not present in the development site This species is only known from the northern portion of the Sydney Basin bioregion and the southern portion of the North Coast bioregion in the local government areas of Wyong, Lake Macquarie, Newcastle, Port Stephens, Great Lakes and Cessnock. Targeted survey of the vegetation in the development site showed that this species was not present	No impact	Appendix A

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Figure 10: Green and Golden Bell Frog species polygon

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8 Biodiversity credit report

The project has been assessed as a Major Project in accordance with the Framework for Biodiversity Assessment. The assessed development site covers all the areas required for construction and operation of the project.

ELA undertook both desktop analysis and field assessment, using the FBA methodology to assess biodiversity values within the development site.

Two plant community types required offsets as a result of the project. These were:

- Broad-leaved Ironbark - Melaleuca decora shrubby open forest on clay soils of the Cumberland Plain, Sydney Basin Bioregion - 31 credits
- Paperbark swamp forest of the coastal lowlands of the NSW North Coast Bioregion and Sydney Basin Bioregion – 27 credits

One species credit species required an offset. This was the Green and Golden Bell Frog, which requires 203 credits.

High conservation value biodiversity values were largely avoided through refining the project design primarily by:

- Limiting surface impacts by designing the project as a tunnel between Kingsgrove and St Peters
- Some widening works at Beverly Grove and surface infrastructure at St Peters and the Kogarah Golf Course
- Taking advantage of urbanised areas.

Where impacts on biodiversity values are unavoidable, mitigation measures are proposed to further minimise impacts.

Mitigation measures have been proposed and are listed in **Section 6.6**. They include but are not limited to:

- Delineation of clearance areas
- Implementation of Green and Golden Bell Frog Plan of Management
- Site inductions, exclusion of construction zones and signage
- Use of directional and low sodium lighting
- Use of non-acoustic shed to minimise noise
- Dust suppression
- Management of traffic within the site
- Implementation of erosion and sediment control
- Management of weeds where works occur adjacent to native vegetation.

Consistent with the FBA, a biodiversity offset strategy has been prepared as Stage 3, to compensate for the loss of native vegetation, endangered ecological communities and threatened species habitat which cannot be avoided or mitigated.

A copy of the credit report from the tool is included in **Appendix L**. As noted in **Section 7.1**, Smooth-barked Apple – Red Bloodwood – Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney (PCT 1181 / BVT ME029) is neither an EEC/CEEC under the TSC or EPBC Acts nor is it associated with threatened species habitat. Therefore, according to the NSW Major Projects Offsets Policy, this PCT does not require an offset to be determined.

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References

AECOM 2015a, Technical Working Paper: Groundwater. Technical Working Paper for the New M5 Environmental Impact Statement, report to Roads and Maritime Services.

AECOM 2015b, Technical Working Paper: Surface Water. Technical Working Paper for the New M5 Environmental Impact Statement, report to Roads and Maritime Services.

Allison, F.R. and Hoye, G.A. 1998. Eastern Freetail-bat. In: Strahan, R. (Ed.) The Mammals of Australia, pp. 484-485, Australian Museum/ Reed Publications, Sydney.

Australian Museum Business Services 1995. Fauna impact statement for proposed forestry activities in the Urbenville Management Area., Report prepared for State Forests of New South Wales. Australian Museum Business Services, Sydney.

Australian Museum Consulting 2014. *Biodiversity Assessment for proposed widening of Marsh Street, Wolli Creek.* Consultancy report for NSW Roads and Maritime Services.

Baker, G.B., R. Gales, S. Hamilton & V. Wilkinson 2002. Albatrosses and petrels in Australia: a review of their conservation and management. Emu. 102:71-97.

Benson, D. and McDougall L 1996 Ecology of Sydney Plant Species Part 4 – Fabaceae: Peas and Wattles. Cunninghamia 4(4); 553-756.

Benson, D. & McDougall, L. 1998. Ecology of Sydney plant species Part 6: Dicotyledon family Myrtaceae. Cunninghamia 5(4): 808-987.

BirdLife International 2009. Species factsheet: Diomedea antipodensis. [Online]. Available from: http://www.birdlife.org.

BirdLife International 2014. Species factsheet: Calonectris leucomelas. Downloaded from http://www.birdlife.org on 03/12/2014. Recommended citation for factsheets for more than one species: BirdLife International (2014) IUCN Red List for birds. Downloaded from http://www.birdlife.org on 03/12/2014.

Blakers, M., Davies, S., and Reilly, P.N 1984. The Atlas of Australian Birds. RAOU Melbourne University Press.

Bureau of Meteorology (BOM) 2015. Atlas of Groundwater Dependent Ecosystems. Available: http://www.bom.gov.au/water/groundwater/gde/map.shtml [Accessed 3 June 2015]

Bureau of Meteorology (BOM) 2015. Daily Weather Observations from Sydney Airport, Station 066037. Available at: http://www.bom.gov.au/climate/dwo/201411/html/IDCJDW2125.201411.shtml

Chapman, GA and Murphy, CL, 1989, Soil Landscapes of the Sydney 1:100 000 sheet Map, Soil Conservation Service of NSW, Sydney.

Commonwealth of Australia 2009. Significant Impact Guidelines for the vulnerable Green and Gold Bell Frog (*Litoria aurea*). Available: http://www.environment.gov.au/system/files/resources/e882f6c7-a511-4fba-9116-2f2f7ef941aa/files/litoria-aurea-policy.pdf

© ECO LOGICAL AUSTRALIA PTY LTD

Commonwealth of Australia 2013. *Matter of National Environmental Significance Significant Impact Guidelines 1.1 Environment Protection and Biodiversity Conservation Act 1999.*

Commonwealth of Australia 2014. Threat abatement plan for disease in natural ecosystems caused by *Phytophthora cinnamomi*. Commonwealth of Australia, Canberra ACT.

Cropper, SC, 1993. *Management of endangered plants.* CSIRO Australia, Melbourne.

Cumberland Ecology 2006. *Green and Gold Bell Frog Management Plan for Cooks Cove*. A report prepared for Boyd Cook Cove.

Cumberland Flora and Fauna Interpretive Services, 1997. Beverly Grove Bushland Flora Survey. A report provided for Roads and Maritime Services of NSW

Churchill, S. 1998. Australian Bats. Reed New Holland, Sydney

Debus, S.J.S. 1994. 'The Sooty Owl Tyto tenebricosa in New South Wales', Australian Birds, 28:s4-s19.

Debus, S.J.S. 1997. 'The Barking Owl in New South Wales', Australian Birds, 30(3).

Debus, S.J.S. and Chafer, C.J. 1994. The Powerful Owl Ninox strenua in New South Wales. Australian Birds 28 supplement: S21-S38.

Department of the Environment (DotE) 2014b. Species Profile and Threats Database, Department of Environment, Canberra. Available Https://www.environment.gov.au/sprat

Department of Environment and Conservation (DEC). 2004. *Draft Threatened Species Survey Guidelines*. OEH, Hurstville.

Department of the Environment (DotE), 2014. Protected Matters Search Tool. Available: http://www.environment.gov.au/epbc/protect/index.htm.

Department of the Environment (DotE) 2015. *Species Profile and Threats Database.* [Online] Available from: http://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl

Department of Environment and Conservation NSW (DEC) 2005. Draft Recovery Plan for the Green and Golden Bell Frog (Litoria aurea). DEC NSW, Hurstville, NSW. Available: http://www.environment.nsw.gov.au/resources/nature/recoveryplangreengoldbellfrogdraft.pdf.

NSW Department of Environment and Climate Change (DECC) 2008a. Management Plan for the Green and Golden Bell Frog Key Population of the Lower Cooks River.

Department of Environment and Climate Change, 2008b. Managing Urban Stormwater – Soils and Construction, Volume 2D, Main Road Construction. Available: http://www.environment.nsw.gov.au/resources/stormwater/08207soilsconststorm2d .pdf

Department of Environment and Climate Change NSW (DECC) 2007. Threatened Species Profiles http://www.threatenedspecies.environment.nsw.gov.au/index.aspx.

Department of Environment, Climate Change and Water NSW. 2009. Draft National Recovery Plan for the Grey-headed Flying-fox Pteropus poliocephalus. Prepared by Dr Peggy Eby. Department of Environment, Climate Change and Water NSW, Sydney.

© ECO LOGICAL AUSTRALIA PTY LTD

Department of the Environment and Heritage (DEH) 2005. Background Paper to the Wildlife Conservation Plan for Migratory Shorebirds. [Online]. Canberra, ACT: Department of the Environment and Heritage. Available from: http://www.environment.gov.au/biodiversity/migratory/publications/pubs/shorebird-plan-background.pdf.

Department of the Environment, Water, Heritage and the Arts (DEWHA) 2010. Litoria aurea in Species Profile and Threats Database [Online]. Canberra, ACT: DEWHA. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=1870.

Department of the Environment, Water, Heritage and the Arts (DEWHA) 2010. Survey guidelines for Australia's threatened frogs. [Online]. Canberra, ACT: Department of the Environment, Water, Heritage and the Arts.

Dwyer, P.D. 1995. Common Bent-wing Bat (Miniopterus schreibersii), In: R. Strahan (Ed.) The Australian Museum Complete Book of Australian Mammals, pp494-495, Angus and Robertson Publishers, Sydney.

Eby, P. 1998. 'An analysis of the diet specialisation in frugivorous Pteropus poliocephalus in Australian subtropical rainforest', Austral Ecology, 23:443-456

Eco Logical Australia 2015. WestConnex Stage 2 – Preliminary Ecological Constraints. Prepared for WestConnex Delivery Authority.

Ehmann, E. 1997. Threatened Frogs of New South Wales: Habitats, status and conservation, Frog and Tadpole Study Group, Sydney.

Elliott, G. & K. Walker 2005. Detecting population trends of Gibson's and Antipodean wandering albatrosses. Notornis. 52:215-222.

Environment Australia 2000. Comprehensive and Regional Assessments for North-East NSW. Report to National Parks and Wildlife Service.

Environment Australia (EA) 2001. National Recovery Plan for Albatrosses and Giant-Petrels 2001-2005. [Online]. Canberra, ACT: Environment Australia. Available from: http://www.environment.gov.au/archive/biodiversity/threatened/publications/recovery/albatross/index.html.

Frith, H.J., Crome, F.H.J, and Brown, B.K. 1977 Aspects of the Biology of the Japanese Snipe Gallinago hardwickii, Aust. J. Ecology 2: 341-368.

Garnett, S. (Ed) 1993. Threatened and extinct birds of Australia. Royal Australian Ornithologists Union and Australian NPWS, Royal Australian Ornithologists Union Report, No. 82.

Goldingay, R. & B. Lewis 1999. Development of a conservation strategy for the Green and Golden Bell Frog Litoria aurea in the Illawarra Region of New South Wales. Australian Zoologist. 31:376-387.

Higgins, P.J. & S.J.J.F. Davies (eds) 1996. Handbook of Australian, New Zealand and Antarctic Birds. Volume 3: Snipe to Pigeons. Oxford University Press, Melbourne.

Hindwood, K.A. & D.L. Serventy 1941. The Gould Petrel of Cabbage Tree Island. Emu. 41:1-19.

© ECO LOGICAL AUSTRALIA PTY LTD

Hoye, G. A., and Richards. G, C. 2008 Greater Broad-nosed Bat Scoteanax rueppellii. Pp.551 – 552. In van Dyck, S. and Strahan, R. (eds). The Mammals of Australia. Third Edition. Reed New Holland, Sydney.

Hutton, I. 1991. Birds of Lord Howe Island: Past and Present. Coffs Harbour, NSW: author published.

Hyem, E.L. 1979. 'Observation on Owls in the Upper Manning River District, New South Wales', Corella, 3(2):17-25.

Lane, B.A. & A.E. Jessop 1985. National Wader Count - Report to Participants. Unpublished report for Royal Australasian Ornithologists Union, Melbourne.

Mansergh, I. M. 1984. The status, distribution and abundance of Dasyurus maculatus (Tiger Quoll) in Australia with particular reference to Victoria", Australian Zoolology, 21(2):109-22.

Marchant, S. & P.J. Higgins, eds. 1990. Handbook of Australian, New Zealand and Antarctic Birds. Volume One - Ratites to Ducks. Melbourne, Victoria: Oxford University Press.

Marchant and Higgins 1993. Handbook of Australian, New Zealand and Antarctic Birds. Oxford University Press, Melbourne.

McAllan, I.A.W., B.R. Curtis, I. Hutton & R.M. Cooper 2004. The birds of the Lord Howe Island Group: a review of records. Australian Field Ornithology. 21:1-82.

McKilligan, N. 2005. Herons, Egrets and Bitterns: Their Biology and Conservation in Australia. Melbourne: CSIRO Publishing.

Mitchell, P 2002. NSW Ecosystems Study: Background and Methodology. Groundtruth Consulting, Gladesville, NSW.

Morcombe, M. 2004. Field Guide to Australian Birds, Steve Parish Publishing.

Naarding, J.A. 1983 Latham's Snipe (Gallinago hardwickii) in Southern Australia. Wildlife Division Technical Report. 83/01. Tasmania: National Parks and Wildlife Service.

NSW Department of Primary Industries 2012. Risk assessment guidelines for groundwater dependent ecosystems, Volume 1 – The conceptual framework, NSW Department of Primary Industries, Office of Water, Sydney

NSW Department of Primary Industries 2013. Policy and Guidelines for Fish Habitat Conservation and Management – Update 2013. Available: http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0009/468927/Policy-and-guidelines-for-fish-habitat.pdf

NSW Department of Primary Industries (DPI) 2015a. *Fisheries NSW Threatened & Protected Species - Records Viewer.* http://www.dpi.nsw.gov.au/fisheries/species-protection/records/viewer [Accessed 04/06/2015]

NSW Department of Primary Industries (DPI) 2015b. Fisheries Marine Vegetation Map (Botany Bay and Cooks River). Available: http://www.dpi.nsw.gov.au/research/areas/aquatic-ecosystems/estuarine-habitats-maps. [Accessed June 2015].

NSW Department of Primary Industries (DPI), 2015c. *Mapping of Key Fish Habitat – LGAs in Sydney Area.* NSW DPI, Fisheries Ecosystem Branch. [Accessed 4 June 2015].

NSW Department of Primary Industries 2015d. Species Profiles, Factsheets and Scientific Determinations, NSW Fisheries http://www.dpi.nsw.gov.au/fisheries/species-protection.

NSW Department of Primary Industries (DPI) 2015. Weeds declared in the Local Control Authority area of Canterbury City Council. Available: http://weeds.dpi.nsw.gov.au/WeedDeclarations/Results?RegionId=21

NSW Department of Primary Industries (DPI) 2015. Weeds declared in the Local Control Authority area of Rockdale City Council. Available: http://weeds.dpi.nsw.gov.au/WeedDeclarations/Results?RegionId=96

NSW National Parks and Wildlife Service 1995. Endangered Fauna of Western New South Wales, NSW National Parks and Wildlife Service, Hurstville.

NSW National Parks and Wildlife Service 1997. Urban Bushland Biodiversity Study - Western Sydney, National Parks and Wildlife Service.

NSW National Parks and Wildlife Service (NPWS), 2002. Interpretation Guidelines for the Native Vegetation Maps of the Cumberland Plain, Western Sydney, Final Edition NSW NPWS, Hurstville.

NSW National Parks and Wildlife Service 2003. Draft Recovery Plan for the Barking Owl. New South Wales National Parks and Wildlife Service, Hurstville, NSW.

NSW Scientific Committee. 1999. Final Determinations http://www.environment.nsw.gov.au/committee/finaldeterminations.htm

NSW Scientific Committee. 2001. Final Determinations http://www.environment.nsw.gov.au/committee/finaldeterminations.htm

NSW Scientific Committee. 2009. Final Determinations http://www.environment.nsw.gov.au/committee/finaldeterminations.htm

NSW Scientific Committee. 2011. Final Determinations http://www.environment.nsw.gov.au/committee/finaldeterminations.htm

Office of Environment and Heritage, 2013. *The Native Vegetation of the Sydney Metropolitan Area. Volume 2: Vegetation Community Profiles Version 2.0.* Office of Environment and Heritage, Department of Premier and Cabinet, Sydney.

Office of Environment and Heritage, 2014a. Atlas of NSW Wildlife. (online). Available: http://wildlifeatlas.nationalparks.nsw.gov.au/wildlifeatlas/watlas.jsp [Accessed November 2014].

Office of Environment and Heritage, 2014b. Threatened Species Profiles. Available: http://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?

Office of Environment and Heritage, 2014a. Framework for Biodiversity Assessment. State Government of NSW.

Office of Environment and Heritage, 2014b. Major Projects offsets policy. State Government of NSW.

Office of Environment and Heritage 2014c. Introduction and establishment of Exotic Rust Fungi of the order Pucciniales pathogenic on plants of the family Myrtaceae - key threatening process listing. Available http://www.environment.nsw.gov.au/determinations/exoticrustfungiFD.htm. [Accessed January 2014].

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Office of Environment and Heritage 2014d. Infection of frogs by amphibian chytrid causing the disease chytridiomycosis - key threatening process listing. Available: http://www.environment.nsw.gov.au/animals/AmphibianChytridKTPListing.htm. [Accessed January 2014].

Office of Environment and Heritage 2014e. Infection of native plants by *Phytophthora cinnamomi* - key threatening process listing. Available: http://www.environment.nsw.gov.au/determinations/PhytophthoraKTPListing.htm [Accessed January 2014].

Office of Environment and Heritage, 2015b. NSW Vegetation Information System (online). Available: http://www.environment.nsw.gov.au/NSWVCA20PRapp/LoginPR.aspx

Office of Environment and Heritage (OEH), 2015c. Threatened Species Profile Database (online). Available: http://www.environment.nsw.gov.au/asmslightprofileapp/account/login?ForceLogin=1

Patterson, R.M. 1991 Bird observations 1990 - systematic list. Tasmanian Bird Report. 20:32-52.

Pyke. G. H. and White A. W. 1996. Habitat requiements for the Green and Golden Bell Frog Litoria aurea (Anura: Hylidae). Australian Zoologist. 30: 224-232

Reed P.C., Lunney D. and Walker P. 1990. A 1986-1987 survey of the koala Phascolarctos cinereus (Goldfuss) in New South Wales and an ecological interpretation of its distribution, in A.K. Lee, K.A. Handasyde and G.D. Sanson (Eds). Biology of the Koala. pp 55-74. Surrey Beatty and Sons, Sydney.

Reid, T.A., M.A. Hindell, D.W. Eades & M. Newman 2002. Seabird Atlas of South-east Australian Waters. Royal Australasian Ornithologists Union Monograph 4. Melbourne, Victoria: Birds Australia (R.A.O.U.).

Roads and Maritime Services 2011. Environmental Impact Assessment Practice Note – Biodiversity Assessment. Roads and Maritime Services, North Sydney.

Royal Botanic Garden (RBG) 2013. NSW FloraOnline database (PlantNET). Available online: http://plantnet.rbgsyd.nsw.gov.au/search/spatial.htm.

Rudman, W. B. 1999 Threatened and Endangered Landsnail species – Meridolum corneovirens

Schodde, R. and Tidemann, S. (Eds) 1986 Readers Digest complete book of Australian Birds, 2nd Edn., Reader's Digest Services Pty Ltd, Sydney.

Simpson, K. and Day, N. 1999. Field guide to the birds of Australia 6th edn., Penguin Books Australia Ltd, Ringwood Victoria.

Simpson, K. and Day, N. 2004. Field guide to the birds of Australia 7th edn., Penguin Books Australia Ltd, Ringwood Victoria.

Surman, C.A., N.G. Cheshire & R.D. Wooler 1997. Gould's Petrel Pterodroma leucoptera off south-western Australia. Marine Ornithology. 25:70-71.

Threatened Species Scientific Committee (TSSC) 2005. Commonwealth Listing Advice on Turpentine-Ironbark Forest of the Sydney Basin Bioregion. Commonwealth Threatened Species Scientific Committee, Canberra.

Threatened Species Scientific Committee (TSSC) 2014a. Approved Conservation Advice for Turepntine-Ironbark Forest in the Sydney Basin Bioregion. Commonwealth Threatened Species Scientific Committee, Canberra.

Threatened Species Scientific Committee (TSSC), 2014b. Approved Conservation Advice for *Litoria aurea* (Green and Golden Bell Frog). Commonwealth Threatened Species Scientific Committee, Canberra.

Threatened Species Scientific Committee (TSSC), 2015. Approved Conservation Advice (including listing advice) for Cooks River/Castlereagh Ironbark Forest of the Sydney Basin Bioregion. Commonwealth Threatened Species Scientific Committee, Canberra.

Tozer,MG, Turner K, Simpson CC, Keith DA, Beukers P, Mackenzie B, Tindall D & Pennay C 2006. Native Vegetation of Southeast NSW: A Revised Classification and Map for the Coast and Eastern Tablelands. Version 1.0. Department of Environment & Conservation and Department of Natural Resources, Sydney.

Tozer MG, Turner K, Keith DA, Tindall D, Pennay C, Simpson C, MacKenzie B, Beukers P & Cox S 2010. Native vegetation of southeast NSW: a revised classification and map for the coast and eastern tablelands. Cunninghamia 11(3), 359–406.

Walsh, N.G. and Entwisle, T.J. 1999 Flora of Victoria Vol 4 Royal Botanic Gardens Melbourne.

Webb J.K. and Shine R. 1998. Ecological characteristics of a threatened snake species Hoplocephalus bungaroides (Serpentes: Elapidae), Animal Conservation, 1: 185-193.

White, A.1998. Management Plan for Green and Golden Bell Frog at Arncliffe.

White, A pers.comm 2015. Green and Golden Bell Frogs advice to Roads and Maritime.

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Appendix A Likelihood of occurrence

Provided below are the likelihood tables for threatened species listed under the Commonwealth EPBC Act and NSW TSC and FM Acts. Species, populations and communities from the relevant database searches considered to have the potential, are likely or are known to occur within the development site are highlighted blue.

Key to the table:

- TSC Act = Listing under the NSW *Threatened Species Conservation Act 1995*
- EPBC Act = Listing under the *Environment Protection and Biodiversity Conservation Act 1999*
- FM Act = Listings under the *Fisheries Management Act 1994*
- CE = Critically Endangered
- E = Endangered (EPBC Act and FM Act)
- E1 = Endangered (TSC Act)
- E2 = Endangered Population (TSC Act and FM Act)
- E4 = Extinct (TSC Act)
- V = Vulnerable
- M = Migratory (EPBC Act)
- Mar = Marine (EPBC Act)
- P = Protected (FM Act)
- PE = Presumed Extinct (FM Act)

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Name	TSC Act	EPBC Act	Habitat Associations	Known		Likelihood of Occurrence*
				Locality	Development site	
Ecological Communities						
Blue Gum High Forest	CEEC	CEEC	A moist, tall open forest community, with dominant canopy trees of *Eucalyptus saligna* (Sydney Blue Gum) and *E. pilularis* (Blackbutt). *Allocasuarina torulosa* (Forest Oak) and *Angophora costata* (Sydney Red Gum) also occur. Species adapted to moist habitat such as *Acmena smithii* (Lillypilly), *Ficus coronata* (Sandpaper Fig), *Calochleana 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.	No	No	No No suitable habitat present
Castlereagh Scribbly Gum Woodland	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 *E. 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 (OEH 2014b).	Yes	No	Unlikely Suitable habitat conditions not present
Castlereagh Swamp Woodland	E	-	Occurs in western Sydney in the Castlereagh and Holsworthy areas, on deposits from ancient river systems along today's intermittent creeklines, 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*.	Yes	No	Unlikely Suitable habitat conditions not present

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Coastal Saltmarsh	EEC	V	Coastal Saltmarsh occurs in the intertidal zone on the shores of estuaries and lagoons that are permanently or intermittently open to the sea. It is frequently found as a zone on the landward side of mangrove stands. Characteristic plants include *Baumea juncea*, Sea Rush (*Juncus kraussii* subsp. *australiensis*), Samphire (*Sarcocornia quinqueflora* subsp. *quinqueflora*), Marine Couch (*Sporobolus virginicus*), Streaked Arrowgrass (*Triglochin striata*), Knobby Club-rush (*Ficinia nodosa*), Creeping Brookweed (*Samolus repens*), Swamp Weed (*Selliera radicans*), Seablite (*Suaeda australis*) and Prickly Couch (*Zoysia macrantha*) (OEH 2014b).	Yes	No	No Suitable habitat conditions present within the study area, but not in development site
Coastal Upland Swamps in the Sydney Basin Bioregion	EEC	E	The Coastal Upland Swamp in the Sydney Basin Bioregion includes open graminiod heath, sedgeland and tall scrub associated with periodically waterlogged soils on the Hawkesbury sandstone plateau (OEH 2014b). 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 plateaux, in the the south it occurs on the Woronora plateau (OEH 2014b). It occurs in elevations from 20 m to over 600 m above sea level, with the majority of swamps occurring within 200 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 (OEH 2014b).	No	No	No No suitable habitat present
Cooks River Castlereagh Ironbark Forest	E	CEEC	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 *E. 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 (OEH 2014b). Was observed during the field surveys.	Yes	Yes	Known

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Cumberland Plain Woodland	CEEC	CEEC	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 *E. tereticornis (*Forest Red Gum), with *E. crebra (*Narrow-leaved Ironbark), *Corymbia maculata* (Spotted Gum) and *E. 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) (OEH 2014b).	Yes	No	No Suitable habitat not present
Eastern Suburbs Banksia Scrub	EEC	EEC	Once occupied around 5,300 hectares of land between North Head and Botany Bay in Sydney's eastern suburbs. Surviving stands totalling approximately 146 hectares have been recorded from the local government areas 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*, *B. ericifolia*, *B. serrata*, *Eriostemon australasius*, *Lepidosperma laterale*, *Leptospermum laevigatum*, *Monotoca elliptica* and *Xanthorrhoea resinifera* (OEH 2014b).	Yes	No	No Suitable habitat not present
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 in which 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, backswamps, 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 sedgeland vegetation, such as *Paspalum distichum*, *Leersia hexandra*, *Pseudoraphis spinescens* and *Carex appressa* (OEH 2014b). Was observed during the field surveys. This EEC does not include artificial wetlands or ponds.	Yes	No	No Suitable habitat not present

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Freshwater Wetlands of the Sydney Basin Bioregion	EEC	-	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 (OEH 2014b).	Yes	No	No Suitable habitat not present
Littoral Rainforest	EEC	CEEC	It occurs only on the coast and is found at locations in the NSW North Coast Bioregion, Sydney Basin Bioregion and South East Corner Bioregion. Littoral Rainforest is generally a closed forest, the structure and composition of which is strongly influenced by its proximity to the ocean. The plant species of this community are predominantly rainforest species. Several species have compound leaves, and vines may be a major component of the canopy. These features differentiate littoral rainforest from forest or scrub, but while the canopy is dominated by rainforest species, scattered emergent individuals of sclerophyll species, occur in many stands (OEH 2014b).	Yes	No	No Suitable habitat not present
River-Flat Eucalypt Forests (previously known as Alluvial Woodland)	EEC	-	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), *E. amplifolia* (Cabbage gum), *Angophora floribunda* (Rough-barked Apple) and *A. subvelutina* (Broad-leaved Apple). A layer of small trees may be present, including *Melaleuca decora, M. styphelioides* (Prickly-leaved Teatree), Backhousia myrtifolia (Grey Myrtle), *Melia azedarach* (White Cedar), *Casuarina cunninghamiana* (River Oak) and *C. 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.	Yes	No	No Suitable habitat not present

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Shale Sandstone Transition Forest	EEC	EEC	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), (*E. punctata*) Grey Gum, *E. globoidea, E. eugenioides* (Thin-leaved Stringybark) and *E. fibrosa* (Broad-leaved Ironbark) and *E. crebra* (Narrow-leaved Ironbark). Areas of low sandstone influence have an understorey that is closer to Cumberland Plain Woodland. High sandstone influence sites have poor rocky soils.	Yes	No	No Suitable habitat not present
Southern Sydney Sheltered Forest	EEC	-	It on transitional sandstone soils is found within an estimated total extent of less than 45,000 ha, bounded approximately by Hurstville, Carss Park, Bundeena, Otford, Stanwell Tops, Darkes Forest, Punchbowl Creek and Menai. It is an open forest dominated by eucalypts with scattered sub-canopy trees, a diverse shrub layer and a well-developed groundcover of ferns, forbs, grasses and graminoids. The dominant trees include *Angophora costata*, *Eucalyptus piperita* and occasionally *Eucalyptus pilularis*. *Corymbia gummifera* occurs frequently within the community, although generally at lower abundance than the other eucalypts. It is distinguished from vegetation more typical of sandstone gullies in the eastern Sydney basin due to the occurrences of *Eucalyptus pilularis*, *Acacia binervata*, *Elaeocarpus reticulatus*, *Pittosporum undulatum* and its relatively dense groundcover of ferns, grasses, rushes, lilies and forbs (OEH 2014b).	Yes	No	No Suitable habitat not present
Swamp Oak Floodplain Forest	EEC	-	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 (OEH 2014b).	Yes	No	No Suitable habitat not present

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Swamp Sclerophyll Forest on Coastal Floodplains	EEC	-	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 (OEH 2014b).	Yes	Yes	Known from Arncliffe surface works area
Turpentine-Ironbark Forest in the Sydney Basin Bioregion	EEC	CEEC	Open forest, with dominant canopy trees including *Syncarpia glomulifera* (Turpentine), *Eucalyptus punctata* (Grey Gum), *Eucalyptus paniculata* (Grey Ironbark) and *E. eugenioides* (Thin-leaved Stringybark). In areas of high rainfall (over 1050 mm per annum) *E. 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 Panax). 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. A transitional community, between Cumberland Plain Woodland in drier areas and Blue Gum High Forest on adjacent higher rainfall ridges.	Yes	No	No. The community is not present within the development footprint. It is adjacent to development site.
Upland Basalt Eucalypt Forests of the Sydney Basin Bioregion	-	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 (a.s.l.), although outliers may occur at elevations as low as 350 m (e.g. closer to the coast) or as high as 1200 m a.s.l. (e.g. on higher plateau). The ecological community occurs in areas of high rainfall, generally ranging from 1000 to 1800 mm/year (TSSC	No	No	No Suitable habitat not present

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Western Sydney Dry Rainforest and Moist Woodland on Shale	E	CE	The Western Sydney Dry Rainforest and Moist Woodland ecological 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.	No	No	No Suitable habitat not present

Disclaimer: Data extracted from the Atlas of NSW Wildlife and EPBC Protected Matters Report are only indicative and cannot be considered a comprehensive inventory. 'Migratory marine species' and 'listed marine species' listed on the EPBC Act (and listed on the DEW protected matters report) have not been included in this table, since they are considered unlikely to occur within the study area due to the absence of marine habitat.

CEEC = Critically Endangered Ecological Community; EEC = Endangered Ecological Community.

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Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Associations	Records		Likelihood of Occurrence
					Locality	Impact area	
Plants							
Acacia bynoeana	Bynoe's Wattle	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 (OEH 2014b).	4	0	Unlikely Closest record < 500 m south of the development site. Species not detected during targeted survey
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 The Hills local government areas. Grows in dry sclerophyll forest and heathlands amongst or within rock platforms on sandstone outcrops (OEH 2014b).	1	0	Unlikely Habitat unlikely to be suitable.
Acacia prominens Endangered population	*Acacia prominens* Endangered population	E2	-	Endangered population in the Gosford Wattle, Hurstville and Kogarah Local Government Areas. Occurs at a few sites along the railway line at Penshurst, at Carss Bush Park, Carss Park and there is an unconfirmed record at Oatley Park, Oatley. This population is disjunct from other populations (Hunter Valley to Gosford region) and at the southern limit of the range of the species. Grows in open situations on clayey or sandy soils (OEH 2014b).	6	0	Unlikely Closest record 800 m south-west of study area. Species not detected during targeted survey.
Acacia pubescens	Downy Wattle	V	V	*Acacia pubescens* occurs on the NSW Central Coast in Western Sydney, mainly in the Bankstown-Fairfield-Rookwood area and the Pitt Town area, with outliers occurring at Barden Ridge, Oakdale and Mountain Lagoon. It is associated with Cumberland Plains Woodlands, Shale / Gravel Forest and Shale / Sandstone Transition Forest growing on clay soils, often with ironstone gravel (NPWS 1997; Benson and McDougall 1996).	1576	0	Unlikely Habitat unlikely to be suitable. Species not detected during targeted survey.

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Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Associations	Records		Likelihood of Occurrence
					Locality	Impact area	
Acacia terminalis subsp. *terminalis*	Sunshine Wattle	E	E	*Acacia terminalis* subsp. *terminalis* 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 (OEH 2014b).	76	0	Unlikely Closest record < 500 m south of EIA area.
Allocasuarina glareicola		-	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 (OEH 2014b).	0	0	No Suitable habitat not present.
Allocasuarina portuensis	Nielsen Park She-oak	E	E	The original known habitat of the Nielsen Park She-oak is at Nielsen Park, in Woollahra local government area. There are no plants left at the original site where it was discovered.	18	0	No Suitable habitat not present.
Asterolasia elegans		E	E	*Asterolasia elegans* 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 (DECC 2007).	0	0	Unlikely Habitat unlikely to be suitable.
Caesia parviflora var. *minor*	Small Pale Grass-lily	E	-	This variety occurs uncommonly in Tasmania, southern Victoria and south-east South Australia with an outlying population in NSW, in Barcoongere State Forest, between Grafton and Coffs Harbour. This variety may be more common than currently known, as Pale Grass-lilies are often not identified to variety level. Found in damp places in open forest on sandstone (OEH 2014b).	1	0	Unlikely Habitat unlikely to be suitable.
Caladenia tessellata	Thick Lip Spider Orchid	E	V	The Thick Lip Spider Orchid is known from the Sydney area (old records), Wyong, Ulladulla and Braidwood in NSW. Generally found in grassy sclerophyll woodland on clay loam or sandy soils, though the population near Braidwood is in low woodland with stony soil (OEH 2014b).	9	0	Unlikely Habitat unlikely to be suitable.

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Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Associations	Records		Likelihood of Occurrence
					Locality	Impact area	
Callistemon linearifolius	Netted Bottlebrush	V	-	*Callistemon linearifolius* has been recorded from the Georges River to Hawkesbury River in the Sydney area, and north to the Nelson Bay area of NSW, growing in dry sclerophyll forest (OEH 2014b). For the Sydney area, recent records are limited to the Hornsby Plateau area near the Hawkesbury River (OEH 2014b).	22	0	Unlikely Habitat unlikely to be suitable. Closest record 8 km west of development site.
Cryptostylis hunteriana	Leafless Tongue Orchid	V	V	It is known from a range of vegetation communities including swamp-heath and woodland (OEH 2014b). 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 of this community and is often found in association with the C. subulata (Large Tongue Orchid) and the C. erecta (Tartan Tongue Orchid) (OEH 2014b).	0	0	No Suitable habitat not present.
Darwinia biflora		V	V	*Darwinia biflora* is an erect or spreading shrub to 80cm high associated with habitats where weathered shale capped ridges intergrade with Hawkesbury Sandstone, where soils have a high clay content (NPWS 1997).	1	0	Unlikely Habitat unlikely to be suitable.
Deyeuxia appressa		E	E	A highly restricted NSW endemic known only from two pre-1942 records in the Sydney area. Was first collected in 1930 at Herne Bay, Saltpan Creek, off the Georges River, south of Bankstown. Was then collected in 1941 from Killara, near Hornsby. Has not been collected since and may now be extinct in the wild due to the level of habitat loss and development that has occurred within these areas	0	0	No Presumed extinct

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Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Associations	Records		Likelihood of Occurrence
					Locality	Impact area	
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 (OEH 2014b).	24	0	Unlikely Closest record is 4 km west of development site. Not detected during targeted survey
Eucalyptus camfieldii	Camfield's Stringybark	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 (OEH 2014b).	3	0	Unlikely Habitat unlikely to be suitable.
Eucalyptus nicholii	Narrow-leaved Black Peppermint	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 (DECC 2007). This species is widely planted as an urban street tree and in gardens but is quite rare in the wild (DECC 2007). Plantings undertaken for horticultural and aesthetic purposes are not considered threatened species under the TSC Act.	9	0	No It is noted that specimens have been recorded within the locality. However, they are likely to be planted and well outside natural range.
Eucalyptus scoparia	Wallangarra White Gum	E	-	Known in NSW only from the Tenterfield district where it is very uncommon. Grows on rocky hillsides in shrubby woodland close to granite outcrops (OEH 2014b).	3	0	No Suitable habitat not present. Well outside natural range.

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Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Associations	Records		Likelihood of Occurrence
					Locality	Impact area	
Genoplesium baueri	Bauer's Midge Orchid	V	-	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 and flowers from December to March (OEH 2014b).	2	0	Unlikely Habitat unlikely to be suitable. No open scribbly gum woodland present.
Grammitis stenophylla	Narrow-leaf Finger Fern	E	-	In NSW, *Grammitis stenophylla* has been found on the south, central and north coasts, and as far west as Mount Kaputar National Park near Narrabri, in moist places, usually near streams, on rocks or in trees, in rainforest and moist eucalypt forest.	1	0	No Suitable habitat not present.
Grevillea caleyi	Caley's Grevillea	CE	E	All sites occur on the ridgetop between elevations of 170 to 240 m asl, in association with laterite soils and a vegetation community of open forest, generally dominated by *Eucalyptus sieberi* and *E. gummifera.* Restricted to an 8 km square area around Terrey Hills, approximately 20 km north of Sydney.	1	0	No Suitable habitat not present. Well outside natural distribution.
Grevillea parviflora subsp. *parviflora*	Small-flower Grevillea	V	V	*Grevillea parviflora* subsp. *parviflora* is sporadically distributed throughout the Sydney Basin mainly around Picton, Appin and Bargo. Separate populations are also known further north from Putty to Wyong and Lake Macquarie and Cessnock and Kurri Kurri. It grows in sandy or light clay soils over thin shales, often with lateritic ironstone gravels. It often occurs in open, slightly disturbed sites such as tracks (DECC 2007).	0	0	Unlikely Habitat unlikely to be suitable.
Hibbertia puberula		E	-	*Hibbertia puberula* extends from Wollemi National Park south to Morton National Park and the south coast near Nowra. Early records of this species are from the Hawkesbury River area and Frenchs Forest in northern Sydney, South Coogee in eastern Sydney, the Hacking River area in southern Sydney, and the Blue Mountains. It favours low heath on sandy soils or rarely in clay, with or without rocks underneath (OEH 2014b).	1	0	No Suitable habitat not present.

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Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Associations	Records		Likelihood of Occurrence
					Locality	Impact area	
Hibbertia sp. Bankstown		CE	CE	This species is endemic to New South Wales and is currently known to occur in only one population at Bankstown Airport in Sydney's southern suburbs, in the Bankstown local government area. The airport site is very heavily modified from the natural state, lacks canopy species and is currently a low grass/shrub association with many pasture grasses and other introduced herbaceous weeds (OEH 2014b).	1	0	No Suitable habitat not present.
Hibbertia stricta subsp. *furcatula*		E	-	*Hibbertia stricta* subsp. *furcatula* (synonym *Hibbertia* sp. nov. 'Menai') is known to occur in two populations, one in the southern outskirts of Sydney, and one near Nowra on the South Coast of NSW. The Southern Sydney population occurs on both sides of the Woronora River gorge, near Loftus and in Royal National Park	7	0	No Suitable habitat not present.
Hypsela sessiliflora		E	X	Known to grow in damp places, on the Cumberland Plain, including freshwater wetland, grassland/alluvial woodland and an alluvial woodland/shale plains woodland (Cumberland Plain Woodland) ecotone. Currently known from only two adjacent sites on a single private property at Erskine Park in the Penrith LGA. Previous sightings are all from western Sydney, at Homebush and at Agnes Banks (OEH 2014b).	1	0	No Suitable habitat not present.
Leucopogon exolasius	Woronora Beard-heath	V	V	The plant occurs in woodland on sandstone. It is found along the upper Georges River area and in Heathcote National Park (OEH 2014b)	1	0	No Suitable habitat not present.
Marsdenia viridiflora subsp. *viridiflora*		E2	-	Recent records are from Prospect, Bankstown, Smithfield, Cabramatta Creek and St Marys. Previously known north from Razorback Range and grows in vine thickets and open shale woodland (OEH 2014b).	9	0	Unlikely Habitat unlikely to be suitable. Closest record 7.5 km west.

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Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Associations	Records		Likelihood of Occurrence
					Locality	Impact area	
Maundia triglochinoides		V	-	Grows in swamps, lagoons, dams, channels, creeks or shallow freshwater 30 - 60 cm deep on heavy clay, low nutrients. Restricted to coastal NSW and extending into southern Queensland. The current southern limit is Wyong; former sites around Sydney are now extinct (OEH 2014b).	2	0	No. Artificial ponds in the development site were not suitable as these were high in nutrients .
Melaleuca biconvexa	Biconvex Paperbark	V	V	*Melaleuca biconvexa* occurs in coastal districts and adjacent tablelands from Jervis Bay north to the Port Macquarie district. It grows in damp places often near streams (OEH 2014b)	1	0	No Not recorded during surveys despite being conspicuous.
Melaleuca deanei	Deane's Paperbark	V	V	Found in heath on sandstone, and also associated with woodland on broad ridge tops and slopes on sandy loam and lateritic soils (OEH 2014b).	13	0	No. Most recent record within the study area is over 100 years old. Plant is conspicuous and easily detected.
Pelargonium sp. Striatellum	Omeo's Stork's-bill	E	E	In NSW, Pelargonium sp. Straitellum (G.W. Carr 10345) is known from the Southern Tablelands (Royal Botanic Garden (RBG) 2013). Otherwise, only known from the shores of Lake Omeo near Benambra in Victoria where it grows in cracking clay soil that is probably occasionally flooded (Walsh & Entwisle 1999).	0	0	No. Suitable habitat not present.
Persoonia hirsuta	Hairy Geebung	E	E	*Persoonia hirsuta* occurs from Singleton in the north, south to Bargo and the Blue Mountains to the west (DECC 2007). It grows in dry sclerophyll eucalypt woodland and forest on sandstone (Royal Botanic Garden (RBG) 2013).	16	0	No. Closest record 1 km north

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Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Associations	Records		Likelihood of Occurrence
					Locality	Impact area	
Persoonia nutans	Nodding Geebung	E	E	Restricted to the Cumberland Plain in western Sydney, between Richmond and Macquarie Fields. The species has a disjunct distribution, with the majority of populations (and 99 per cent of individuals) occurring in the north of the species range. Associated with dry woodland, Castlereagh Scribbly Gum Woodland, Agnes Banks Woodland and sandy soils associated with tertiary alluvium, occasionally poorly drained (Benson and McDougall 1998) (OEH 2014b).	7	0	No. Not recorded during surveys despite being conspicuous.
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 shaley/lateritic soils over sandstone and shale/sandstone transition soils on ridgetops and upper slopes amongst woodlands (DECC 2007).	2	0	No. Habitat unlikely to be suitable.
Pimelea spicata	Spiked Rice-flower	E	E	In western Sydney, *Pimelea spicata* occurs on an undulating topography of well-structured clay soils, derived from Wianamatta shale (DEC 2004). It is associated with Cumberland Plains Woodland (CPW), in open woodland and grassland often in moist depressions or near creek lines (*Ibid.*). Has been located in disturbed areas that would have previously supported CPW (*Ibid.*).	182	0	No. Closest record is 8 km west of the development site. No CPW present within the development site and surveys of the Beverly Grove area revealed none of this species.

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Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Associations	Records		Likelihood of Occurrence
					Locality	Impact area	
Pomaderris prunifolia Endangered population	*Pomaderris prunifolia* Endangered population	E2	-	Endangered population for Parramatta, Auburn, Strathfield and Bankstown Local Government Areas. However, known from only three sites within the listed local government areas, at Rydalmere, within Rookwood Cemetery and at The Crest of Bankstown.	14	0	No Not in the LGA. Closest record is 8 km north-west of the development site.
Posidonia australis - Port Hacking, Botany Bay, Sydney Harbour, Pittwater, Brisbane Waters and Lake Macquarie populations	Posidonia	E2	-	The species can grow in coarse sandy to fine silty sediments between the low tide line and approximately 10 m depth. It may also occur in deeper water if water clarity is good. It can form large, dense stands (called meadows), and is also often found mixed with other species of seagrass such as Zostera (Eelgrass) and Halophila (Paddleweed) (NSW Department of Primary Industries, 2015).	1	0	No Nearest seagrass beds are within Botany Bay and are not part of development site.
Prasophyllum fuscum	Slaty Leek Orchid	CE	V	Grows in moist heath, often along seepage lines. The known population grows in moist sandy soil over sandstone amongst sedges and grasses in an area that appears to be regularly slashed by the local council. The type specimen is from "moist meadows towards the Georges River" in the Sydney area. The species is likely to be extinct from this area (OEH 2014b).	1	0	No Suitable habitat not present.

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Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Associations	Records		Likelihood of Occurrence
					Locality	Impact area	
Prostanthera marifolia	Seaforth Mintbush	CE	CE	Occurs in localised patches in or in close proximity to the endangered Duffys Forest ecological community. Located on deeply weathered clay-loam soils associated with ironstone and scattered shale lenses, a soil type which only occurs on ridge tops and has been extensively urbanised (OEH 2014b). Known from only three locations in Manly and Warringah LGAs.	3	0	No Suitable habitat not present and well outside known extent of species.
Pterostylis gibbosa	Illawarra Greenhood	E	E	Known from a small number of populations in the upper Hunter Valley (Milbrodale), the Illawarra region (Albion Park and Yallah) and near Nowra (DECC 2007). Plants grow in a variety of woodland and open forest communities with shallow rocky soils.	0	0	No Suitable habitat not present. Well outside natural range of this species.
Pterostylis saxicola	Sydney Plains Greenhood	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 (NPWS 1997). Known from Georges River National Park, Ingleburn, Holsworthy, Peter Meadows Creek, St Marys Tower (NSW Scientific Committee 1999).	1	0	No Suitable habitat not present.
Pultenaea parviflora		E	V	Endemic to the Cumberland Plain. Core distribution is from Windsor to Penrith and east to Dean Park. Outlier populations are recorded from Kemps Creek and Wilberforce. 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 (OEH 2014b).	2	0	No Habitat unlikely to be suitable. Survey of Beverly Grove revealed none of this species present.

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Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Associations	Records		Likelihood of Occurrence
					Locality	Impact area	
Pultenaea pedunculata	Matted Bush-pea	E	-	The Matted Bush-pea occurs in a range of habitats. NSW populations are generally among woodland vegetation but plants have also been found on road batters and coastal cliffs. It is largely confined to loamy soils in dry gullies in populations in the Windellama area (OEH 2014b).	1	0	No Habitat unlikely to be suitable.
Senecio spathulatus	Coastal Groundsel	E	-	Coast Groundsel grows on frontal dunes and occurs in Nadgee Nature Reserve (Cape Howe) and between Kurnell in Sydney and Myall Lakes National Park (with a possible occurrence at Cudmirrah) (OEH 2014b).	5	0	No Suitable habitat not present. Frontal dunes not in development site.
Streblus pendulina	Siah's Backbone	-	E	Siah's Backbone occurs from Cape York Peninsula to Milton, south-east New South Wales (NSW). Siah's Backbone is found in warmer rainforests, along watercourses. The altitudinal range is from near sea level to 800 m above sea level. The species grows in well-developed rainforest, gallery forest and drier, more seasonal rainforest (OEH 2014b).	0	0	No Suitable habitat not present. Species is a rainforest species.

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Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Associations	Records		Likelihood of Occurrence
					Locality	Impact area	
Syzygium paniculatum	Magenta Lillypilly	V	V	It 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. In the Ourimbah Creek valley, *S. paniculatum* occurs within gallery rainforest with *Alphitonia excelsa*, *Acmena smithii*, *Cryptocarya glaucescens*, *Toona ciliata*, *Syzygium oleosum* with emergent *Eucalyptus saligna*. At Wyrrabalong NP, *S. paniculatum* occurs in littoral rainforest as a co-dominant with *Ficus fraseri*, *Syzygium oleosum*, *Acmena smithii*, *Cassine australe*, and *Endiandra sieberi*.	28	0	Not present in development site. It was present in the Wolli Creek Valley outside of the development site. Habitat within the development site unlikely to be suitable. Species not found in development site during targeted survey.
Tetratheca glandulosa		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 (DECC 2007). 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. *T. juncea* also displays a preference for southern aspect slopes, althoughoccurs onslopes with different aspects (DECC 2007).	2	0	Unlikely Habitat unlikely to be suitable.

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Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Associations	Records		Likelihood of Occurrence
					Locality	Impact area	
Tetratheca juncea		V	V	Confined to the northern portion of the Sydney Basin bioregion and the southern portion of the North Coast bioregion in the local government areas of Wyong, Lake Macquarie, Newcastle, Port Stephens, Great Lakes and Cessnock. It is usually found in low open forest/woodland with a mixed shrub understorey and grassy groundcover. However, it has also been recorded in heathland and moist forest (OEH 2014b).	17	0	No. Suitable habitat not present.
Thelymitra sp. Kangaloon (D.L.Jones 18108)	Kangaloon Sun-orchid	CE	CE	Known from only a few small populations near Wyong on the NSW Central Coast. Grows in grassy woodlands and on the margins of derived grasslands (DotE 2014b).	0	0	No Suitable habitat not present.
Thesium australe	Austral Toadflax	V	V	Occurs in grassland on coastal headlands or grassland and grassy woodland away from the coast. Often found in association with Kangaroo Grass (*Themeda australis*).	1	0	No Suitable habitat not present.
Triplarina imbricata	Creek Triplarina	E	E	Found only in a few locations in the ranges south-west of Glenreagh and near Tabulam in north-east NSW. Along watercourses in low open forest with Water Gum (*Tristaniopsis laurina*) (OEH 2014b).	1	0	No Suitable habitat not present.

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Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Associations	Records		Likelihood of Occurrence
					Locality	Impact area	
Wahlenbergia multicaulis Endangered population	Tadgell's Bluebell Endangered population	E2	-	Found in the LGAs of Auburn, Bankstown, Baulkham Hills, Canterbury, Hornsby, Parramatta and Strathfield. In Western Sydney most sites are closely aligned with the Villawood Soil Series, which is a poorly drained, yellow podsolic extensively permeated with fine, concretionary ironstone (laterite). However, the sites in Hornsby LGA are on the 'Hawkesbury' soil landscape. Found in disturbed sites and grows in a variety of habitats including forest, woodland, scrub, grassland and the edges of watercourses and wetlands. Typically occurs in damp, disturbed sites (with natural or human disturbance of various forms), typically amongst other herbs rather than in the open. In Western Sydney it is found in remnants of Cooks River/ Castlereagh Ironbark Forest.	39	0	No. Development site not in these LGAs. Survey of the Beverly Grove area revealed none of this species.
Wilsonia Backhousia	Narrow-leafed Wilsonia	V	-	This species occurs on the margins of salt marshes and lakes. In NSW Narrow-leaf Wilsonia is found on the coast between Mimosa Rocks National Park and Wamberal north of Sydney (Nelson's Lake, Potato Point, Sussex Inlet, Wowly Gully, Parramatta River at Ermington, Clovelly, Voyager Point, Wollongong and Royal National Park) (OEH 2014b).	8	0	No. Saltmarshes and lakes not within the development site.

Disclaimer: Data extracted from the Atlas of NSW Wildlife and EPBC Protected Matters Report are only indicative and cannot be considered a comprehensive inventory. 'Migratory marine species' and 'listed marine species' listed on the EPBC Act (and listed on the DEW protected matters report) have not been included in this table, since they are considered unlikely to occur within the study area due to the absence of marine habitat.

CE = Critically Endangered E = Endangered; E2 = Endangered Population; V = Vulnerable; M = Migratory, X = Extinct

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Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Associations	Records		Likelihood of occurrence
					Locality	Impact area	
Fish							
Austrocordulia leonardi	Sydney Hawk Dragonfly	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* (NSW Department of Primary Industries, 2015).	0	0	No Suitable habitat not present.
Archaeophya adamsi	Adam's Emerald Dragonfly	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 vegetation (NSW Department of Primary Industries, 2014).	0	0	No Suitable habitat not present.
Epinephelus daemelii	Black Rockcod	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 (NSW Department of Primary Industries, 2015).	0	0	No Suitable habitat not present.

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Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Associations	Records		Likelihood of occurrence
					Locality	Impact area	
Pristis zijsron	Green Sawfish	PE (FM Act)	V	Green Sawfish were once widely distributed in the northern Indian Ocean, around south and south-east Asia and around northern Australia and have been recorded as far south as Jervis Bay. The last confirmed sighting of the Green Sawfish in NSW was in 1972 from the Clarence River at Yamba. Green sawfish live on muddy or sandy-mud soft bottom habitats in inshore areas. They also enter estuaries, where they have been found in very shallow water (NSW Department of Primary Industries, 2015).	0	0	No Presumed extinct. Potential habitat will not be impacted.
Prototroctes maraena	Australian Grayling	P (FM Act)	V	Australian grayling occur 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 (NSW Department of Primary Industries, 2015).	0	0	No Suitable habitat not present.
Frogs							
Crinia tinnula	Wallum Froglet	V	-	The Wallum Frog is restricted to the Wallum swamps and associated lowland meandering watercourses on coastal plains (Ehmann 1997). Occurs in elevations up to around 50 m and is closely associated with freshwater habitats in the coastal zone (DECC 2007). Found most commonly in wallum wetlands characterised by low nutrients, highly acidic, tanin-stained waters that are typically dominated by paperbarks and tea-trees. Also found in sedgeland and wet heathland (DECC 2007).	2	0	No Suitable habitat not present.
Heleioporus australiacus	Giant Burrowing Frog	V	V	Forages in woodlands, wet heath, dry and wet sclerophyll forest (Ehmann 1997). Associated with semi-permanent to ephemeral sand or rock based streams (Ehmann 1997), where the soil is soft and sandy so that burrows can be constructed (Environment Australia 2000).	0	0	No Suitable habitat not present.

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Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Associations	Records		Likelihood of occurrence
					Locality	Impact area	
Litoria aurea	Green and Golden Bell Frog	E	V	This species has can utilise a variety of natural and man-made waterbodies (Pyke & White 1996) such as coastal swamps, marshes, lakes, other estuary wetlands, riverine floodplain wetlands, stormwater detention basins, farm dams, bunded areas, drains, ditches and other structures capable of storing water (DECC 2007). Large permanent swamps and ponds exhibiting well-established fringing vegetation (especially bulrushes–*Typha* sp. and spikerushes–*Eleocharis* sp.) adjacent to open grassland areas for foraging and free from predatory fish such as Plague Minnow (*Gambusia holbrooki*) are also preferable (Ehmann 1997 and DECC 2007).	150	31	Known Suitable habitat present within development site at Arncliffe surface works area.
Litoria littlejohni	Littlejohn's Tree Frog	V	V	The species distribution includes the plateaus and eastern slopes of the Great Dividing Range from Watagan State Forest (90 km north of Sydney) south to Buchan in Victoria (DECC 2007). It occurs along permanent rocky streams with thick fringing vegetation associated with eucalypt woodlands and heaths among sandstone outcrops. It appears to be restricted to sandstone woodland and heath communities at mid to high altitude. It forages both in the tree canopy and on the ground, and it has been observed sheltering under rocks on high exposed ridges during summer (NSW Scientific Committee 2011).	0	0	No Suitable habitat not present.

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Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Associations	Records		Likelihood of occurrence
					Locality	Impact area	
Litoria raniformis	Growling Grass Frog	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 (DECC 2007; Ehmann 1997). This species is common in lignum shrublands, black box and River Red Gum woodlands, irrigation channels and at the periphery of rivers in the southern parts of NSW (DECC 2007). This species occurs in vegetation types such as open grassland, open forest and ephemeral and permanent non-saline marshes and swamps (DECC 2007). Open grassland and ephemeral permanent non-saline marshes and swamps have also been associated with this species (Ehmann 1997).	0	0	No Suitable habitat not present.
Mixophyes balbus	Stuttering Frog	E	V	Occurs in a variety of forest habitats from rainforest through wet and moist sclerophyll forest to riparian habitat in dry sclerophyll forest (DECC 2007) that are generally characterised by deep leaf litter or thick cover from understorey vegetation (Ehmann 1997). Breeding habitats are streams and occasionally springs. Not known from streams disturbed by humans (Ehmann 1997) or still water environments (NSW Scientific Committee 2011).	0	0	No Suitable habitat not present.
Pseudophryne australis	Red-crowned Toadlet	V	-	Found in steep escarpment areas and plateaus, as well as low undulating ranges with benched outcroppings on Triassic sandstones of the Sydney Basin (DECC 2007). It also mainly occupies the upper parts of ridges, usually being restricted to within about 100 metres of the ridgetop (DECC 2007). Associated with open forest to coastal heath (Ehmann 1997). Utilises small ephemeral drainage lines which feed water from the top of the ridge to the perennial creeks below for breeding, and are not usually found in the vicinity of permanent water (Ehmann 1997).	44	0	Unlikely Habitat unlikely to be suitable.
Reptiles							

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Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Associations	Records		Likelihood of occurrence
					Locality	Impact area	
Varanus rosenbergi	Heath Monitor	V	-	Associated with Sydney sandstone woodland and heathland. Rocks, hollow logs and burrows are utilised for shelter (Environment Australia 2000). Terrestrial termitaria are required for reproduction.	2	0	No Suitable habitat not present.
Hoplocephalus bungaroides	Broad-headed Snake	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 (DECC 2007). They utilise rock crevices and exfoliating sheets of weathered sandstone during the cooler months and tree hollows during summer (Webb & Shine 1998). Some of the canopy tree species found to regularly co-occur at known sites include *Corymbia eximia, C. gummifera, Eucalyptus sieberi, E. punctata* and *E. piperita* (DECC 2007).	0	0	No Suitable habitat not present.
Diurnal birds							
Anseranas semipalmata	Magpie Goose	V	-	Activities centred on terrestrial sedge-dominated wetlands; mainly those on floodplains of rivers (Marchant & Higgins 1993 Simpson & Day 1999). Now confined to northern Australia, principally the Fitzroy River and east Kimberley, WA, northern Northern Territory, coastal Cape York Peninsula and patchily through eastern Queensland.	2	0	Unlikely Habitat unlikely to be suitable.

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Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Associations	Records		Likelihood of occurrence
					Locality	Impact area	
Anthochaera phrygia (aka *Xanthomyza phrygia)*	Regent Honeyeater	E	E & M	Associated with temperate eucalypt woodland and open forest including forest edges, wooded farmland and urban areas with mature eucalypts, and riparian forests of River Oak (*C. cunninghamiana*) (Garnett 1993). It primarily feeds on nectar from box and ironbark eucalypts and occasionally from Banksia and mistletoes (NPWS 1995). It is reliant on locally abundant nectar sources with different flowering times to provide reliable supply of nectar (Environment Australia 2000). Suitable habitat likely to be present within the study area.	12	0	Unlikely Suitable habitat present within impact area, however it would be considered only to be a vagrant and occasional visitor. It would not rely solely on any of the vegetation within the development site.

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Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Associations	Records		Likelihood of occurrence
					Locality	Impact area	
Botaurus poiciloptilus	Australasian Bittern	V	E	Terrestrial wetlands with tall dense vegetation, occasionally estuarine habitats (Marchant & Higgins 1993). Reedbeds, swamps, streams, estuaries (Simpson & Day 1999).	4	0	Unlikely There is only a very small amount of marginal potential habitat for this species within the development site and the species was not recorded there despite targeted survey..
Burhinus grallarius	Bush Stone-curlew	E	-	Associated with dry open woodland with grassy areas, dune scrubs, in savanna areas, the fringes of mangroves, golf courses and open forest / farmland (Marchant & Higgins 1993). Forages in areas with fallen timber, leaf litter, little undergrowth and where the grass is short and patchy (Environment Australia 2000; Marchant & Higgins 1993). Is thought to require large tracts of habitat to support breeding, in which there is a preference for relatively undisturbed in lightly disturbed.	8	0	No Suitable habitat not present.

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Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Associations	Records		Likelihood of occurrence
					Locality	Impact area	
Calamanthus fuliginosus	Striated Fairywren	E	-	Distributed across coastal swamp heaths and tussock fields of SE NSW in Moreton N.P and in the far south (OEH 2014b). Prefers low lying vegetation including; swamp, coastal heathland, tussock grasslands and low shrubby vegetation. Nests are hidden amidst tussock grass or shrubs from July to January (OEH 2012b).	1	0	No There is only a very small amount of marginal potential habitat for this species within the development site.
Callocephalon fimbriatum	Gang-gang Cockatoo	V	-	During summer it is found in dense, tall, wet forests of mountains and gullies, alpine woodlands (Morcombe 2004). In winter they occur at lower altitudes in drier more open forests and woodlands, particularly box-ironbark assemblages (Shields & Chrome 1992). They sometimes inhabit woodland, farms and suburbs in autumn/winter (Simpson & Day 2004).	4	0	Unlikely There are few records of this species in the study area and none within the development site despite this species being conspicuous.
Calyptorhynchus lathami	Glossy Black Cockatoo	V	-	Associated with a variety of forest types containing Allocasuarina species, usually reflecting the poor nutrient status of underlying soils (Environment Australia 2000; NPWS 1997; DECC 2007). Intact drier forest types with less rugged landscapes are preferred (DECC 2007). Nests in large trees with large hollows (Environment Australia 2000).	4	0	Unlikely Habitat unlikely to be suitable.

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Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Associations	Records		Likelihood of occurrence
					Locality	Impact area	
Chthonicola sagittata	Speckled Warbler	V	-	Occupies a wide range of eucalypt dominated communities with a grassy understorey, often on rocky ridges or in gullies (DECC 2007). Typical habitat would include scattered native tussock grasses, a sparse shrub layer, some eucalypt regrowth and an open canopy (DECC 2007). Large, relatively undisturbed remnants are required for the species to persist in an area (DECC 2007). Pairs are sedentary and occupy a breeding territory of about ten hectares, with a slightly larger home-range when not breeding (DECC 2007).	0	0	No Suitable habitat not present.
Daphoenositta chrysoptera	Varied Sittella	V	-	Distribution includes most of mainland Australia except deserts and open grasslands. Prefers eucalypt forests and woodlands with rough-barked species, or mature smooth-barked gums with dead branches, mallee and Acacia woodland. Feeds on arthropods from bark, dead branches, or small branches and twigs.	4	0	Unlikely Habitat unlikely to be suitable.
Dasyornis brachypterus	Eastern Bristlebird	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.	1	0	Unlikely Habitat unlikely to be suitable.
Ephippiorhynchus asiaticus	Black-necked Stork	E	-	Associated with tropical and warm temperate terrestrial wetlands, estuarine and littoral habitats, and occasionally woodlands and grasslands floodplains (Marchant & Higgins 1993). Forages in fresh or saline waters up to 0.5m deep, mainly in open fresh waters, extensive sheets of shallow water over grasslands or sedgeland, mangroves, mudflats, shallow swamps with short emergent vegetation and permanent billabongs and pools on floodplains (Marchant & Higgins 1993; DECC 2007).	1	0	Unlikely Paucity of recent records.

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Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Associations	Records		Likelihood of occurrence
					Locality	Impact area	
Epthianura albifrons	White-fronted Chat	V	-	Endemic to Australia, in particular southern regions of Australia. In NSW it occupies temperate to arid habitats from foothills to 1000 m altitude (OEH 2014b). In NSW the White-fronted Chat occurs in open habitats near the coast in close proximity to waterways including estuaries, saltmarsh or marshy wetlands (NSW Scientific Committee 2009).	14	0	Unlikely Suitable habitat not present within impact area.
Erythrotriorchis radiatus	Red Goshawk	CE	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 (Marchant & Higgins 1993; Debus 1993 & 1991; DECC 2007).	1	0	No Suitable habitat not present. Paucity of records from within the development site.
Esacus magnirostris	Beach Stone-curlew	CE	-	In Australia, it occupies coastlines from about Point Cloates in Western Australia, across northern Australia south to north-eastern NSW, with occasional vagrants to south-eastern NSW and Victoria. In NSW, the species occurs regularly to about the Manning River, and the small population of north-eastern NSW is at the limit of the normal range of the species in Australia. They are found exclusively along the coast, on a wide range of beaches, islands, reefs and in estuaries, and may often be seen at the edges of or near mangroves.	2	0	No Suitable habitat not present. No coastlines in development site.

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Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Associations	Records		Likelihood of occurrence
					Locality	Impact area	
Falco subniger	Black Falcon	V	-	The Black Falcon 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 (Marchant & Higgins 1993).	1	0	No Suitable habitat not present. There is a paucity of records for this species in development site.
Glossopsitta pusilla	Little Lorikeet	V	-	In NSW Little Lorikeets are distributed in forests and woodlands from the coast to the western slopes of the Great Dividing Range. 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 *melaleuca* and mistletoes. On the western slopes and tablelands *Eucalyptus albens* and *E. melliodora* are particularly important food sources for pollen and nectar respectively.	5	0	Unlikely Habitat unlikely to be suitable.
Hieraaetus morphnoides	Little Eagle	V	-	Utilises open eucalypt, sheoak and acacia forest, woodland or open woodland. Uses tall trees for nesting, with a large stick nest being built. Lays eggs in spring, and young fledge in early summer. Preys on birds, reptiles and mammals, and occasionally feeds on large insects or carrion.	4	0	Unllikely Suitable habitat not present within development site.

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Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Associations	Records		Likelihood of occurrence
					Locality	Impact area	
Ixobrychus flavicollis	Black Bittern	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 (DECC 2007).	2	0	Unlikely Habitat unlikely to be suitable.
Lathamus discolor	Swift Parrot	E	E	Breeds in Tasmania between September and January. Migrates to mainland in autumn, where it forages on profuse flowering Eucalypts. Hence, in this region, autumn and winter flowering eucalypts are important for this species. Favoured feed trees include Swamp Mahogany (*Eucalyptus robusta*), Spotted Gum (*Corymbia maculata*), Red Bloodwood (*C. gummifera*), Mugga Ironbark (*E. sideroxylon*), and White Box (*E. albens*) (DECC 2007).	9	0	Unlikely This species is a winter migrant widely ranging across SE Australia mainly following eucalypt flowering events. Unlikely it would forage in the development site.
Lophochroa leadbeateri	Major Mitchell's Cockatoo	V	-	Found across the arid and semi-arid inland, from south-western Queensland south to north-west Victoria, through most of South Australia. In NSW it is found regularly as far east as about Bourke and Griffith, and sporadically further east. Inhabits a wide range of treed and treeless inland habitats, always within easy reach of water.	3	0	No Suitable habitat not present.

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Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Associations	Records		Likelihood of occurrence
					Locality	Impact area	
Lophoictinia isura	Square-tailed Kite	V	-	In coastal areas associated tropical and temperate forests and woodlands on fertile soils with an abundance of passerine birds (Marchant & Higgins 1993, DECC 2007). May be recorded inland along timbered watercourses (DECC 2007). In NSW it is commonly associated with ridge or gully forests dominated by *Eucalyptus longiflora* (Woollybutt), *E. maculata* (Spotted Gum), or *E. elata, E. smithii* (Peppermint Gum) (DECC 2007).	4	0	Unlikely Habitat unlikely to be suitable.
Melithreptus gularis gularis	Black-chinned Honeyeater (eastern subspecies)	V	-	Predominantly associated with box-ironbark association woodlands and River Red Gum (NSW Scientific Committee, 2001). Also associated with drier coastal woodlands of the Cumberland Plain and the Hunter, Richmond and Clarence Valleys (NSW Scientific Committee, 2001).	1	0	Unlikely Habitat unlikely to be suitable. Paucity of records in development site.
Neophema pulchella	Turquoise Parrot	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 (Marchant & Higgins 1993). Spends much of the time on the ground foraging on seed and grasses (DECC 2007). 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 (Environment Australia 2000).	1	0	Unlikely Habitat unlikely to be suitable. Paucity of records in development site.

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Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Associations	Records		Likelihood of occurrence
					Locality	Impact area	
Oxyura australis	Blue-billed Duck	V	-	The Blue-billed Duck prefers deep water in large permanent wetlands and swamps with dense aquatic vegetation. The species is completely aquatic, swimming low in the water along the edge of dense cover. It will fly if disturbed, but prefers to dive if approached (OEH 2014b). Blue-billed Ducks are partly migratory, with short-distance movements between breeding swamps and over-wintering lakes with some long-distance dispersal to breed during spring and early summer. Young birds disperse in April-May from their breeding swamps in inland NSW to non-breeding areas on the Murray River system and coastal lakes (OEH 2014b).	1	0	Unlikely Habitat unlikely to be suitable. Paucity of records in development site.
Petroica boodang	Scarlet Robin	V	-	Occurs from the coast to the inland slopes in NSW. After breeding (July-Jan), some disperse to the lower valleys and plains of the tablelands and slopes, and may appear as far west as the eastern edges of the inland plains in autumn and winter. Primarily resides in dry eucalypt forests and woodlands, with usually open and grassy understorey, with scattered shrubs. Abundant logs and fallen timber are important habitat components.	1	0	Unlikely Habitat unlikely to be suitable. Paucity of records in development site.
Petroica phoenicea	Flame Robin	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	0	Unlikely Habitat unlikely to be suitable. Paucity of records in development site.

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Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Associations	Records		Likelihood of occurrence
					Locality	Impact area	
Petroica rodinogaster	Pink Robin	V	-	It is found in Tasmania and the uplands of eastern Victoria and far south-eastern NSW. On the mainland, the species disperses north and west and into more open habitats in winter, regularly as far north as the ACT area, and sometimes being found as far north as the central coast of NSW. Inhabits rainforest and tall, open eucalypt forest, particularly in densely vegetated gullies.	1	0	Unlikely Habitat unlikely to be suitable. Paucity of records in development site.
Pezoporus wallicus wallicus	Eastern Ground Parrot	V	-	Predominantly restricted to coastal heath and sedgelands that provide a high density of cover and food foraging resources (Blakers et al. 1984; Simpson & Day 1999).	2	0	No Suitable habitat not present.
Polytelis swainsonii	Superb Parrot	V	V	It is found throughout eastern inland NSW. Birds breeding in this region are mainly absent during winter, when they migrate north to upper Namoi and Gwydir Rivers. The other main breeding sites are in the Riverina along the corridors of the Murray, Edward and Murrumbidgee Rivers where birds are present all year round. Inhabits Box-Gum, Box-Cypress-pine and Boree Woodlands and River Red Gum Forest and in the Riverina the birds nest in the hollows of large trees (dead or alive) mainly in tall riparian River Red Gum Forest or Woodland (OEH 2014b).	1	0	Unlikely Habitat unlikely to be suitable.
Ptilinopus superbus	Superb Fruit-Dove	V	-	Inhabits rainforest and similar closed forests where it forages high in the canopy, eating fruits of many tree species such as figs and palms (DECC 2007). 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, moves south through Sydney, especially in autumn. Breeding occurs from September to January (Blakers *et al*. 1984).	13	0	Unlikely Suitable habitat not present within development site.

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Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Associations	Records		Likelihood of occurrence
					Locality	Impact area	
Rostratula australis (a.k.a. R. benghalensis)	Painted Snipe (Australian subspecies)	E	V	Prefers fringes of swamps, dams and nearby marshy areas where there is a cover of grasses, lignum, low scrub or open timber (DECC 2007). Nests on the ground amongst tall vegetation, such as grasses, tussocks or reeds (ibid.). Breeding is often in response to local conditions; generally occurs from September to December (DECC 2007). Forages nocturnally on mud-flats and in shallow water and feeds on worms, molluscs, insects and some plant-matter.	2	0	Unlikely Habitat unlikely to be suitable.
Stagonopleura guttata	Diamond Firetail	V	-	Typically found in grassy eucalypt woodlands, but also in open forest, mallee, Natural Temperate Grassland, and in secondary grassland derived from other communities (DECC 2007). It is often found in riparian areas and sometimes in lightly wooded farmland (DECC 2007). Appears to be sedentary, though some populations move locally, especially those in the south (DECC 2007).	2	0	Unlikely Habitat unlikely to be suitable.
Stictonetta naevosa	Freckled Duck	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 (OEH 2014b).	1	0	Unlikely Habitat unlikely to be suitable.
Nocturnal Birds							
Ninox connivens	Barking Owl	V	-	Occurs in a variety of habitats such as savanna woodland, open eucalypt forests, wetland and riverine forest. Habitat is typically dominated by Eucalypts (often Redgum species), however often dominated by Melaleuca species in the tropics (DECC 2007). It usually roosts in dense foliage in large trees such as *Allocasuarina cunninghamiana*, other Casuarina and Allocasuarina, eucalypts, Angophora, Acacia and rainforest species from streamside gallery forests (NPWS 2003). It usually nests near watercourses or wetlands (NPWS 2003) in large tree hollows with entrances averaging 2-29 metres above ground, depending on the vegetation structure and canopy height (Debus 1997).	1	0	Unlikely Habitat unlikely to be suitable.

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Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Associations	Records		Likelihood of occurrence
					Locality	Impact area	
Ninox strenua	Powerful Owl	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 (Environment Australia 2000, Debus & Chafer 1994). Large trees with hollows at least 0.5m deep are required for shelter and breeding (Environment Australia 2000).	71	0	Unlikely Suitable habitat not present within development site. Lack of large hollows in development site.
Tyto novaehollandiae	Masked Owl	V	-	Associated with forest with sparse, open, understorey, typically dry sclerophyll forest and woodland (DECC 2007) and especially the ecotone between wet and dry forest, and non-forest habitat (Environment Australia 2000). Known to utilise forest margins and isolated stands of trees within agricultural land (Hyem 1979) and heavily disturbed forest where its prey of small and medium sized mammals can be readily obtained.	3	0	Unlikely Habitat unlikely to be suitable.
Tyto tenebricosa	Sooty Owl	V	-	Sooty Owls are associated with tall wet old growth forest on fertile soil with a dense understorey and emergent tall Eucalyptus species (Environment Australia 2000, Debus 1994). Pairs roost in the daytime amongst dense vegetation, in tree hollows and sometimes in caves. The Sooty Owl is typically associated with an abundant and diverse supply of prey items and a selection of large tree hollows (Debus 1994, Garnett 1993, Hyem 1979).	1	0	Unlikely Habitat unlikely to be suitable.
Mammals (excluding bats)							

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Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Associations	Records		Likelihood of occurrence
					Locality	Impact area	
Cercartetus nanus	Eastern Pygmy Possum	V	-	Found in wet and dry eucalypt forest, subalpine woodland, coastal banksia woodland and wet heath. Pygmy-Possums feed mostly on the pollen and nectar from banksias, eucalypts and understorey plants and will also eat insects, seeds and fruit. The presence of *Banksia* sp. and *Leptospermum* sp. are an important habitat feature (DECC 2007). Small tree hollows are favoured as day nesting sites, but nests have also been found under bark, in old bird's nests and in the branch forks of tea-trees.	4	0	No Suitable habitat not present.
Dasyurus maculatus *Dasyurus maculatus maculates*	Spotted-tailed Quoll Spotted-tailed Quoll (SE Mainland Population)	V -	- E	The Spotted-tailed Quoll inhabits a range of forest communities including wet and dry sclerophyll forests, coastal heathlands and rainforests (Mansergh 1984; DECC 2007), 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 (DECC 2007). Maternal den sites are logs with cryptic entrances; rock outcrops; windrows; burrows (Environment Australia 2000).	2	0	No Suitable habitat not present.
Isoodon obesulus obesulus	Southern Brown Bandicoot	E	E	This species is 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. This species 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.	0	0	No Suitable habitat not present.

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Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Associations	Records		Likelihood of occurrence
					Locality	Impact area	
Perameles nasuta – endangered population	Long-nosed Bandicoot population in inner western Sydney	E2	-	The area includes the local government areas (LGA) of Marrickville and Canada Bay, with the likelihood that it also includes Canterbury, Ashfield and Leichhardt LGAs. Shelters mostly under older houses and buildings. They forage in parkland and back-yards (OEH 2014b).	24	0	No Suitable habitat not present.
Petrogale penicillata	Brush-tailed Rock Wallaby	E	V	Rocky areas in a variety of habitats, typically north facing sites with numerous ledges, caves and crevices (DECC 2007).	0	0	No Suitable habitat not present.
Phascolarctos cinereus	Koala	V-E2	-	Associated with both wet and dry Eucalypt forest and woodland that contains a canopy cover of approximately 10 to 70 per cent (Reed et al. 1990), with acceptable Eucalypt food trees. Some preferred Eucalyptus species are: *Eucalyptus tereticornis, E. punctata, E. cypellocarpa, E. viminalis.*	36	0	No Suitable habitat not present.
Pseudomys novaehollandiae	New Holland Mouse	-	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 (DoE 2014a).	0	0	No Suitable habitat not present.
Mammals (Bats)							
Chalinolobus dwyeri	Large-eared Pied Bat	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 (Churchill 1998; DECC 2007). This species roosts in caves, rock overhangs and disused mine shafts and as such is usually associated with rock outcrops and cliff faces (Churchill 1998; DECC 2007).	0	0	No Suitable habitat not present within development site.

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Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Associations	Records		Likelihood of occurrence
					Locality	Impact area	
Miniopterus australis	Little Bent-wing Bat	V	-	Prefers well-timbered areas including rainforest, wet and dry sclerophyll forests, Melaleuca swamps and coastal forests (Churchill 1998). This species shelter in a range of structures including culverts, drains, mines and caves (Environment Australia 2000). Relatively large areas of dense vegetation of either wet sclerophyll forest, rainforest or dense coastal banksia scrub are usually found adjacent to caves in which this species is found (DECC 2007). Breeding occurs in caves, usually in association with *M. schreibersii* (Environment Australia 2000, DECC 2007).	4	0	No Suitable habitat not present within development site.
Miniopterus schreibersii oceanensis	Eastern Bent-wing Bat	V	-	Associated with a range of habitats such as rainforest, wet and dry sclerophyll forest, monsoon forest, open woodland, paperbark forests and open grassland (Churchill 1998). It forages above and below the tree canopy on small insects (AMBS 1995 and Dwyer 1995). Will utilise caves, old mines, and stormwater channels, under bridges and occasionally buildings for shelter (Environment Australia 2000 and Dwyer 1995).	64	0	No Suitable habitat not present within development site.
Mormopterus norfolkensis	Eastern Freetail Bat	V	-	Most records of this species are from dry eucalypt forest and woodland east of the Great Dividing Range (Churchill 1998). Individuals have, however, been recorded flying low over a rocky river in rainforest and wet sclerophyll forest and foraging in clearings at forest edges (Environment Australia 2000; Allison & Hoye 1998). Primarily roosts in hollows or behind loose bark in mature eucalypts, but have been observed roosting in the roof of a hut (Environment Australia 2000; Allison & Hoye 1998).	9	0	No Suitable habitat not present within development site.

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Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Associations	Records		Likelihood of occurrence
					Locality	Impact area	
Myotis macropus (formerly *M. adversus*)	Southern Myotis, Large-footed Myotis	V	-	The Large-footed Myotis is found in the coastal band from the north-west of Australia, across the top-end and south to western Victoria. It is rarely found more than 100 km inland, except along major rivers. Will occupy most 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 (Churchill 1998). While roosting (in groups of 10-15) is most commonly associated with caves, this species has been observed to roost in tree hollows, amongst vegetation, in clumps of Pandanus, under bridges, in mines, tunnels and stormwater drains (Churchill 1998). Forages over streams and pools catching insects and small fish by raking their feet across the water surface.	5	0	No Suitable habitat not present within development site.
Pteropus poliocephalus	Grey-headed Flying-Fox	V	V	Inhabits a wide range of habitats including rainforest, mangroves, paperbark forests, wet and dry sclerophyll forests and cultivated areas (Churchill 1998, Eby 1998). Camps are often located in gullies, typically close to water, in vegetation with a dense canopy (Churchill 1998).	209	14	Likely Suitable foraging habitat present within impact area.
Saccolaimus flaviventris	Yellow-bellied Sheathtail-bat	V	-	Found in almost all habitats, from wet and dry sclerophyll forest, open woodland (Churchill 1998), open country, mallee, rainforests, heathland and waterbodies. Roosts in tree hollows; may also use caves; has also been recorded in a tree hollow in a paddock (Environment Australia 2000). The Yellow-bellied Sheathtail-bat is dependent on suitable hollow-bearing trees to provide roost sites, which may be a limiting factor on populations in cleared or fragmented habitats (Environment Australia 2000).	1	0	Unlikely Suitable habitat not present within development site.

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Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Associations	Records		Likelihood of occurrence
					Locality	Impact area	
Scoteanax rueppellii	Greater Broad-nosed Bat	V	-	Associated with moist gullies in mature coastal forest, or rainforest, east of the Great Dividing Range (Churchill, 1998), tending to be more common in productive forests (Hoye & Richards 2008). Within denser vegetation types use is made of natural and man-made openings such as roads, creeks and small rivers, where it hawks backwards and forwards for prey (Hoye & Richards 2008).	1	0	Unlikely Suitable habitat not present within development site.
Invertebrates							
Meridolum corneovirens	Cumberland (Large) Land Snail	E	-	Associated with open eucalypt forests, particularly Cumberland Plain Woodland (CPW) described in Benson (1992). Found under fallen logs, debris and in bark and leaf litter around the trunk of gum trees or burrowing in loose soil around clumps of grass (NPWS 1997; Rudman 1998). Urban waste may also form suitable habitat (NSW NPWS 1997; Rudman 1998).	3	0	Unlikely Habitat unlikely to be suitable.
Migratory and marine species							
Actitis hypoleucos	Common Sandpiper	-	M	In Australia, the Common Sandpiper 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.	0	0	Unlikely Suitable habitat not present within impact area.
Apus pacificus	Fork-tailed Swift	-	M	Sometimes travels with Needletails. Varied habitat with a possible tendency to more arid areas but also over coasts and urban areas (Simpson & Day 1999).	0	0	Unlikely Habitat unlikely to be suitable.

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Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Associations	Records		Likelihood of occurrence
					Locality	Impact area	
Ardea alba	Great Egret	-	M	Occurs in a range of wetland habitats, including swamps and marshes; margins of rivers and lakes; damp or flooded grasslands, pastures or agricultural lands; reservoirs; sewage treatment ponds; drainage channels; salt pans and salt lakes; salt marshes; estuarine mudflats, tidal streams; mangrove swamps; coastal lagoons; and offshore reefs (DotE 2014b). It usually frequents shallow waters. It forages in a wide range of wet and dry habitats including permanent and ephemeral freshwaters, wet pasture and estuarine mangroves and mudflats.	0	0	Unlikely Habitat unlikely to be suitable.
Ardea ibis	Cattle Egret	-	M	Cattle Egrets forage on pasture, marsh, grassy road verges, rain puddles and croplands, but not usually in the open water of streams or lakes and they avoid marine environments (McKilligan 2005). Some individuals stay close to the natal heronry from one nesting season to the next, but the majority leaves the district in autumn and return the next spring. Cattle Egrets are likely to spend the winter dispersed along the coastal plain and only a small number have been recovered west of the Great Dividing Range (McKilligan 2005).	0	0	Unlikely Habitat unlikely to be suitable.
Arenaria interpres	Ruddy Turnstone	-	M	Frequents beaches along the coast of NSW. Flies from Siberia or Alaska to Australia in August - September each year (ibid).	0	0	Unlikely Habitat unlikely to be suitable.
Calidris acuminata	Sharp-tailed Sandpiper	-	M	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.	0	0	Unlikely Suitable habitat not present.
Calidris alba	Sanderling	V	M	Occur in coastal areas on low beaches, near reefs and inlets along tidal mudflats and bare open coastal lagoons (DECC 2007). Rarely seen in near-coastal wetlands such as lagoons, hypersaline lakes, saltponds and samphire flats (DECC 2007)	8	0	Unlikely Suitable habitat not present.

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Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Associations	Records		Likelihood of occurrence
					Locality	Impact area	
Calidris canutus	Red Knot	-	M	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.	0	0	Unlikely Habitat unlikely to be suitable.
Calidris ferruginea	Curlew Sandpiper	E	M	Intertidal mudflats of estuaries, lagoons, mangrove channels; around lakes, dams, floodwaters, flooded saltbush surrounds of inland lakes (Morcombe 2004).	37	0	Unlikely Suitable habitat not present within development site.
Calidris ruficollis	Red-necked Stint	-	M	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 saltworks, sewage farms, saltmarsh, shallow wetlands including lakes, swamps, riverbanks, waterholes, bore drains, dams, soaks and pools in saltflats, flooded paddocks or damp grasslands. They are often in dense flocks, feeding or roosting.	0	0	Unlikely Suitable habitat not present within development site.
Calidris tenuirostris	Great Knot	V	M	Sheltered coastal habitats containing large intertidal mudflats or sandflats, including inlets, bays, harbours, estuaries and lagoons (DECC 2007). Often recorded on sandy beaches with mudflats nearby, sandy spits and inlets, or exposed reefs or rock platforms (Higgins & Davies 1996).	27	0	Unlikely Suitable habitat not present within development site.

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Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Associations	Records		Likelihood of occurrence
					Locality	Impact area	
Calonectris leucomelas	Streaked Shearwater	-	M	*Calonectris leucomelas* is found in the western Pacific, breeding on the coast and on offshore islands of Japan, Russia, and on islands off the coasts of China, North Korea and South Korea. It migrates south during winter, being found off the coasts of Vietnam, New Guinea, the Philippines and Australia (BirdLife 2014)	0	0	Unlikely Habitat unlikely to be suitable.
Charadrius bicinctus	Double-banded Plover	-	M	In Australia, the Double-banded Plover is found mainly on the east coast and Tasmania and is a regular visitor to Norfolk and Lord Howe Islands. It has been recorded occasionally in Western Australia. It is widespread throughout New Zealand. The Double-banded Plover is found on coastal beaches, mudflats, sewage farms, river banks, fields, dunes, upland tussock grasses and shingle.	0	0	Unlikely Suitable habitat not present within development site.
Charadrius leschenaultii	Greater Sand-plover	V	M	Entirely coastal in NSW, foraging on intertidal sand and mudflats in estuaries, roosting during high tide on sandy beaches or rocky shores (DECC 2007)	6	0	Unlikely Suitable habitat not present within development site.
Charadrius mongolus	Lesser Sand-plover	V	M	Favours coastal areas including beaches, mudflats and mangroves where they forage (DECC 2007). They may be seen roosting during high tide on sandy beaches or rocky shores (DECC 2007).	10	0	Unlikely Suitable habitat not present within development site.

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Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Associations	Records		Likelihood of occurrence
					Locality	Impact area	
Charadrius veredus	Oriental Plover	-	M	Recorded in all states but most common in coastal areas and northern Australia. It breeds in Mongolia, and passes through east China on migration. The Oriental Plover is found generally inland; in open grasslands in arid and semi-arid zones; and less often in estuarine or littoral environments.	0	0	Unlikely Habitat unlikely to be suitable.
Diomedea epomophora epomophora	Southern Royal Albatross	-	V M	The Southern Royal Albatross is marine and pelagic. During the non-breeding season it has a wide and possibly circumpolar distribution, ranging north to about 35°S. It is moderately common throughout the year in offshore waters of southern Australia, mostly off southeastern NSW, Victoria and Tasmania. It has been observed where the water surface temperature is 6 to 20°C. The Southern Royal Albatross feeds pelagically (in the open ocean) on squid and fish. Because it forages on the continental shelf and the shelf break, it is less vulnerable to capture by longline fishing gear than many other species of albatrosses.	0	0	No No habitat present.
Diomedea epomophora sanfordi	Northern Royal Albatross	-	E M	The Northern Royal Albatross ranges widely over the Southern Ocean, with individuals seen in Australian waters off south-eastern Australia (Environment Australia 2001). The Northern Royal Albatross feeds regularly in Tasmanian and South Australian waters, and less frequently in NSW waters	0	0	No No habitat present.
Diomedea exulans antipodensis	Antipodean Albatross	V	V M	The Antipodean Albatross is marine, pelagic and aerial. It is endemic to New Zealand, however forages on cephalopods, fish and crustaceans (BirdLife International 2009 in open water in the south-west Pacific Ocean, Southern Ocean and the Tasman Sea, notably off the coast of NSW (Elliott & Walker 2005 and Environment Australia 2001). Their foraging behaviours, such as flying long distances to search for food, following boats, feeding aggressively on offal and diving for baits, make them susceptible to being drowned in longline fishing gear.	0	0	No No habitat present.

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Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Associations	Records		Likelihood of occurrence
					Locality	Impact area	
Diomedea exulans dabbenena	Tristan Albatross	-	E M	The Tristan Albatross is a marine, pelagic seabird. It forages in open water in the Atlantic Ocean near the Cape of Good Hope, South Africa. It sleeps and rests on ocean waters when not breeding. There is currently only one definitive record of the Tristan Albatross from Australian waters. A bird banded as a chick on Gough Island was recaptured four years later off Wollongong (NSW) (Environment Australia 2001).	0	0	No No habitat present.
Diomedea gibsoni	Gibson's Albatross	V	V M	Gibson's Albatross is marine, pelagic and aerial. It has been recorded foraging between Coffs Harbour, NSW, and Wilson's Promontory, Victoria (Garnett & Crowley 2000). Males and females appear to use different foraging areas, with females frequenting the Tasman Sea in the vicinity of 40° S, while males either disperse westwards at lower latitudes or north-east towards the mid-Pacific Ocean (EA 2001). The only Australian record of this species is from a recapture off Wollongong, NSW, in September 1997. This albatross visits Australian waters while foraging for squid, fish and crustaceans Marchant & Higgins 1990) and during the non-breeding season (EA 2001).	0	0	No No habitat present.
Diomedea exulans	Wandering Albatross	E	V & M	It occurs where water surface temperatures range from -2° to 24°C. In the Australasian region, it occurs inshore, offshore and in pelagic waters. It regularly feeds in sheltered harbours and straits, and sometimes gathers at outfalls of unmodified sewage.	6	0	No No habitat present.
Fregretta grallaeria grallaria	White-bellied Storm-petrel	V	V	The White-bellied Storm-Petrel (Tasman Sea) breeds on small offshore islets and rocks in the Lord Howe Island group, including Roach Island and Balls Pyramid (Baker et al. 2002; Hutton 1991; McAllan et al. 2004). In the non-breeding season, it reaches and forages over near-shore waters along the continental shelf of mainland Australia. The White-bellied Storm-Petrel (Tasman Sea) feeds on small crustaceans and squid (Hutton 1991).	0	0	No No habitat present.

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Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Associations	Records		Likelihood of occurrence
					Locality	Impact area	
Gallinago hardwickii	Latham's Snipe	-	M	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 (Simpson and Day 1999). Can occur in habitats that have saline or brackish water, such as saltmarsh, mangrove creeks, around bays and beaches, and at tidal rivers (Frith et al. 1977; Naarding 1983; Patterson 1991). They are regularly recorded in or around modified or artificial habitats including pasture, ploughed paddocks, irrigation channels and drainage ditches, ricefields, orchards, saltworks, and sewage and dairy farms (Frith et al. 1977; Lane & Jessop 1985; Naarding 1983). They can also occur in various sites close to humans or human activity (e.g. near roads, railways, airfields, commercial or industrial complexes) (Frith et al. 1977; Naarding 1983).	0	0	Unlikely Habitat unlikely to be suitable.
Haematopus fuliginosus	Sooty Oystercatcher	V	-	A coastal species that inhabits rock coastlines, coral cays, reefs and occasionally sandy beaches and Marchant & Higgins 1993; Simpson & Day 1999).	24	0	No Suitable habitat not present.
Haematopus longirostris	Pied Oystercatcher	E	-	Roosts and forages on sandy beaches, sand banks, mudflats and estuaries (Marchant & Higgins 1993, Simpson & Day 1999).	64	0	No Suitable habitat not present.
Haliaeetus leucogaster	White-bellied Sea-Eagle	-	M	Forages over large open fresh or saline water bodies, coastal seas and open terrestrial areas (Marchant & Higgins 1993, Simpson & Day 1999). 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 one kilometre away (Marchant & Higgins 1993).	0	0	Unlikely Habitat unlikely to be suitable.

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Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Associations	Records		Likelihood of occurrence
					Locality	Impact area	
Heteroscelus brevipes	Grey-tailed Tattler	-	M	Grey-tailed Tattlers breed in Siberia and on passage are seen along the East Asian-Australasian Flyway (the migration route to Australia). When non-breeding they are found in China, Philipines, Taiwan, Vietnam, Malay Peninsula, Indonesia, New Guinea, Micronesia, Fiji, New Zealand and Australia. They are more commonly seen in the north of Australia. Grey-tailed Tattlers are usually seen in small flocks on sheltered coasts with reefs and rock platforms or with intertidal mudflats. They are also found in intertidal rocky, coral or stony reefs, platforms and islets that are exposed at high tide, also shores of rock, shingle, gravel and shells and on intertidal mudflats in embayments, estuaries and coastal lagoons, especially those fringed with mangroves.	0	0	No Habitat unlikely to be suitable.
Hirundapus caudacutus	White-throated Needletail	-	M	Forages aerially over a variety of habitats usually over coastal and mountain areas, most likely with a preference for wooded areas (Marchant & Higgins 1993; Simpson & Day 1999). Has been observed roosting in dense foliage of canopy trees, and may seek refuge in tree hollows in inclement weather (Marchant & Higgins 1993).	0	0	Unlikely Habitat unlikely to be suitable.
Limicola falcinellus	Broad-billed Sandpiper	V	M	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 (DECC 2007). In NSW, the main site for the species is the Hunter River estuary, with birds occasionally reaching the Shoalhaven estuary (DECC 2007). Broad-billed Sandpipers favour sheltered parts of the coast such as estuarine sandflats and mudflats, harbours, embayments, lagoons, saltmarshes and reefs as feeding and roosting habitat (DECC 2007).	4	0	Unlikely Habitat unlikely to be suitable.

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Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Associations	Records		Likelihood of occurrence
					Locality	Impact area	
Limosa limosa	Black-tailed Godwit	V	M	Primarily found along the coast on sandspits, lagoons and mudflats (DECC 2007). The species has also been found to occur inland on mudflats or shallow receding waters of portions of large muddy swamps or lakes (Higgins & Davies 1993).	8	0	Unlikely Habitat unlikely to be suitable.
Limosa lapponica	Bar-tailed Godwit	-	M	Mainly coastal, usually sheltered bays, estuaries and lagoons with large intertidal mudflats or sandflats. Breeds in Northern Russia, Scandinavia, NW Alaska (DEH 2005).	0	0	Unlikely Suitable habitat not present .
Macronectes giganteus	Southern Giant-Petrel	E	E M	The Southern Giant-Petrel is marine bird that occurs in Antarctic to subtropical waters. It possibly concentrates north of 50° S in winter, as it is rare in waters of the southern Indian Ocean, but common off South America, South Africa, Australia and New Zealand. It occurs in both pelagic and inshore waters. It is attracted to land at sewage outfalls.It is an opportunist scavenger and predator of penguin carcasses, seal and whale carrion, live birds including Albatrosses Diomedea, a wide variety of smaller seabirds, and penguin chicks. Cephalopods (octopus and squids) are taken by surface-seizing, euphausiids (krill) are scooped from the surface of the water. It is also recorded consuming other crustaceans, kelp, fish, jellyfish, and rabbits Oryctolagus cuniculus.	0	0	Unlikely Habitat unlikely to be suitable.

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Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Associations	Records		Likelihood of occurrence
					Locality	Impact area	
Macronectes halli	Northern Giant-Petrel	E	E M	The Northern Giant-Petrel is marine and oceanic. Visits areas off the Australian mainland mainly during the winter months (May-October). Immature and some adult birds are commonly seen during this period in offshore and inshore waters from around Fremantle (WA) to around Sydney (NSW). It is attracted to land at sewage outfalls, and scavenges at colonies of penguins and seals, also consuming live birds including Albatrosses *Diomedea, euphausiids* (krill) and other crustaceans, cephalopods (octopus and squid), and fish (Marchant & Higgins 1990). Foraging behaviours of Giant-Petrels, such as following boats, feeding aggressively on offal and diving for baits make them susceptible to being drowned in longline fishing gear (DEH 2006).	0	0	Unlikely Habitat unlikely to be suitable.
Merops ornatus	Rainbow Bee-eater	-	M	Resident in coastal and subcostal northern Australia; regular breeding migrant in southern Australia, arriving September to October, departing February to March, some occasionally present April to May. 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 (ibid). Nest is a chamber at the end of a burrow, up to 1.6 m long, tunneled in flat or sloping ground, sandy back or cutting (*ibid*).	0	0	No Suitable habitat not present.
Monarcha melanopsis	Black-faced Monarch	-	M	Rainforest and eucalypt forests, feeding in tangled understorey (Blakers et al. 1984).	0	0	Unlikely Habitat unlikely to be suitable.
Monarcha trivirgatus	Spectacled Monarch	-	M	Wet forests, mangroves (Simpson and Day 1999).	0	0	Unlikely Habitat unlikely to be suitable.
Myiagra cyanoleuca	Satin Flycatcher	-	M	Wetter, denser forest, often at high elevations (Simpson & Day 2004).	0	0	Unlikely Habitat unlikely to be suitable.

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Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Associations	Records		Likelihood of occurrence
					Locality	Impact area	
Neophema chrysogaster	Orange-bellied Parrot	CE	CE	Breeds only in coastal south-west Tasmania and spends the winter in coastal Victoria and South Australia (March/April - October/November), mostly within 3 km of the coast. It nests in hollows in eucalypt trees which grow adjacent to its feeding plains. It feeds on the seeds of several sedges and heath plants, including buttongrass. Its main food preferences are found in sedgelands which have not been burned for between 3-15 years.	0	0	Unlikely Habitat unlikely to be suitable.
Numenius madagascariensis	Eastern Curlew	-	M	Intertidal coastal mudflats, coastal lagoons, sandy spits (DEH 2005). Breeds in Russia, NE China (ibid).	0	0	Unlikely Suitable habitat not present.
Numenius minutus	Little Curlew	-	M	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 (Simpson and Day 1999).	0	0	Unlikely Suitable habitat not present.
Numenius phaeopus	Whimbrel	-	M	Intertidal coastal mudflats, river deltas and mangroves, occasionally sandy beaches (DEH 2005). Breeds Siberia and Alaska (ibid.).	0	0	Unlikely Suitable habitat not present.
Onychoprion fuscata	Sooty Tern	V	-	The Sooty Tern is found over tropical and sub-tropical seas and on associated islands and cays around Northern Australia. In NSW only known to breed at Lord Howe Island. Occasionally seen along coastal NSW.	3	0	Unlikely Habitat unlikely to be suitable.
Pandion cristatus	Eastern Osprey	V	-	Associated with waterbodies including coastal waters, inlets, lakes, estuaries, beaches, offshore islands and sometimes along inland rivers (Schodde and Tidemann 1986). Osprey may nest on the ground, on sea cliffs or in trees. Osprey generally prefer emergent trees, often dead or partly dead with a broken off crown.	17	0	Unlikely Habitat unlikely to be suitable.

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Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Associations	Records		Likelihood of occurrence
					Locality	Impact area	
Pluvialis fulva	Pacific Golden Plover	-	M	Breeds North Siberia, Alaska (DEH 2005). Mainly coastal, beaches, mudflats and sandflats and other open areas such as recreational playing fields in Australia (ibid.).	0	0	Unlikely Suitable habitat not present.
Pluvialis squatarola	Grey Plover	-	M	The Grey Plover breeds around the Arctic regions and migrates to the southern hemisphere, being a regular summer migrant to Australia, mostly to the west and south coasts. It is generally sparse but not uncommon in some areas. It is occasionally found inland. The Grey Plover is almost entirely coastal, being found mainly on marine shores, inlets, estuaries and lagoons with large tidal mudflats or sandflats for feeding, sandy beaches for roosting, and also on rocky coasts.	0	0	Unlikely Suitable habitat not present.
Procelsterna cerulea	Grey Ternlet	V	-	Widely distributed in the southern Pacific Ocean, breeding on oceanic islands including Lord Howe Island.	1	0	Unlikely Habitat unlikely to be suitable.
Pterodroma leucoptera leucoptera	Gould's Petrel	V	E	The Australian subspecies of the Gould's Petrel breeds only on Cabbage Tree Island and on nearby Boondelbah Island, near Port Stephens, in NSW. Gould's Petrel is a pelagic marine species, spending much of its time foraging at sea and coming ashore only to breed. The 'at sea' distribution of this species is poorly known. It often occurs in the warm waters of the East Australian Current, where the sea-surface temperature ranges from 9.7–23.0 °C (Hindwood & Serventy 1941; Reid et al. 2002); and off south-western Western Australia, where cold subantarctic waters intrude into warmer waters with a sea-surface temperature of about 15 °C (Surman et al. 1997). It has most often been recorded over the continental slope, less often over open ocean and rarely over the continental shelf (Reid et al. 2002).	0	0	Unlikely Habitat unlikely to be suitable.

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Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Associations	Records		Likelihood of occurrence
					Locality	Impact area	
Pterodroma neglecta neglecta	Kermadec Petrel		V	In Australia, the Kermadec Petrel (western) breeds on Balls Pyramid, which lies to the south of Lord Howe Island, and on Phillip Island, in the Norfolk Island group. Its pelagic distribution is poorly known (DotE 2014b).	0	0	Unlikely Habitat unlikely to be suitable.
Puffinus carneipes	Flesh-footed Shearwater	V	M	The only breeding colony on the east coast of Australia is Lord Howe Island. It is a trans-equatorial migrant, east coast migrants travel to northern Pacific Ocean (mainly to waters off Korea, Japan and Russia) and very occassionally to North America. Breeding season starts in November with the construction of burrows, followed by nesting between November to January and young fledged in May (DotE 2014b).	0	0	Unlikely Habitat unlikely to be suitable.
Puffinus leucomelas	Streaked Shearwater	-	M	*Calonectris leucomelas* is found in the western Pacific, breeding on the coast and on offshore islands of Japan, Russia, and on islands off the coasts of China, North Korea and South Korea. It migrates south during winter, being found off the coasts of Vietnam, New Guinea, the Philippines and Australia (DotE 2014b).	0	0	Unlikely Habitat unlikely to be suitable.
Rhipidura rufifrons	Rufous Fantail	-	M	The Rufous Fantail is a summer breeding migrant to southeastern Australia (Morcombe, 2004). The Rufous Fantail is found in rainforest, dense wet eucalypt and monsoon forests, paperbark and mangrove swamps and riverside vegetation (Morcombe, 2004). Open country may be used by the Rufous Fantail during migration (Morcombe, 2004).	0	0	Unlikely Habitat unlikely to be suitable.
Sternula albifrons	Little Tern	E	M	Almost exclusively coastal, preferring sheltered areas (DECC 2007), however may occur several kilometres inland in harbours, inlets and rivers (Smith 1990). Australian birds breed on sandy beaches and sand spits (Simpson & Day 1999).	51	0	Unlikely Habitat unlikely to be suitable.

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Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Associations	Records		Likelihood of occurrence
					Locality	Impact area	
Sterna nereis nereis	Australian Fairy Tern	-	V	Within Australia, the Fairy Tern occurs along the coasts of Victoria, Tasmania, South Australia and Western Australia; occurring as far north as the Dampier Archipelago near Karratha. The subspecies has been known from New South Wales (NSW) in the past, but it is unknown if it persists there (DotE 2014b).	0	0	Unlikely Habitat unlikely to be suitable.
Thalassarche bulleri	Buller's Albatross	-	V M	Buller's Albatross breed in New Zealand (Snares, Solander and Chatham Islands), but are regular visitors to Australian waters. They are frequently seen off the coast from Coffs Harbour, south to Tasmania and west to Eyre Peninsula (Blakers et al. 1984), however, some of these birds may be the Pacific Albatross (Environment Australia 2001). Buller's Albatross are most common off south-east Tasmania between January–April (DotE 2014b).	0	0	Unlikely Habitat unlikely to be suitable.
Thalassarche cauta cauta	Shy Albatross	V	V M	The recent separation of Shy Albatrosses from other closely related taxa confounds our understanding of its at-sea distribution. Shy Albatrosses appear to occur over all Australian coastal waters below 25° S. It is most commonly observed over the shelf waters around Tasmania and southeastern Australia (DotE 2014b).	0	0	Unlikely Habitat unlikely to be suitable.
Thalassarche cauta salvini	Salvin's Albatross	-	V M	Salvin's Albatross is a non-breeding visitor to Australian waters. Salvin's Albatross breeds on Bounty, Snares and Chatham Islands, south of New Zealand, as well as on Crozet Island in the Indian Ocean. The species forages over most of the southern Pacific Ocean, where it is particularly common in the Humboldt Current, off South America. There are small numbers in the Indian Ocean and sometimes in the South Atlantic Ocean (DotE 2014b).	0	0	Unlikely Habitat unlikely to be suitable.
Thalassarche cauta steadi	White-capped Albatross	-	V M	The White-capped Albatross is probably common off the coast of south-east Australia throughout the year (DotE 2014b).	0	0	Unlikely Habitat unlikely to be suitable.

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Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Associations	Records		Likelihood of occurrence
					Locality	Impact area	
Thalassarche eremita	Chatham Albatross	-	E M	Breeding for the Chatham Albatross is restricted to Pyramid Rock, Chatham Islands, off the coast of New Zealand. The principal foraging range for this species is in coastal waters off eastern and southern New Zealand, and Tasmania (DotE 2014b).	0	0	Unlikely Habitat unlikely to be suitable.
Thalassarche melanophris	Black-browed Albatross	V	V M	The Black-browed Albatross breeds within Australian jurisdiction on Heard Island, McDonald Islands, Macquarie Island and Bishop and Clerk Islets. Individuals are mostly confined to subantarctic and Antarctic waters surrounding these islands in the breeding season. During this time, the species is an uncommon visitor to the continental shelf-break of southern Australia - reaching South Australia, Tasmania and western and eastern Bass Strait in the south-east and Antarctica (DotE 2014b).	0	0	Unlikely Habitat unlikely to be suitable.
Thalassarche melanophris impavida	Campbell Albatross	-	V M	The Campbell Albatross is a non-breeding visitor to Australian waters. Non-breeding birds are most commonly seen foraging over the oceanic continental slopes off Tasmania, Victoria and New South Wales. After breeding, birds move north and may enter Australia's temperate shelf waters (DotE 2014b).	0	0	Unlikely Habitat unlikely to be suitable.
Tringa stagnatilis	Marsh Sandpiper	-	M	Coastal - Permanent or ephemeral wetlands of varying degrees of salinity, commonly inland (DEH 2005). Breeds Eastern Europe to Eastern Siberia (ibid).	0	0	Unlikely Suitable habitat not present within impact area..
Xanthomyza Phrygia	Regent Honeyeater	E	E, M	SEE DIURNAL BIRDS ABOVE	12	1	SEE DIURNAL BIRDS ABOVE

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Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Associations	Records		Likelihood of occurrence
					Locality	Impact area	
Xenus cinereus	Terek Sandpiper	V	M	In Australia, 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 (OEH 2014b).	11	0	Unlikely Habitat unlikely to be suitable.

Disclaimer: Data extracted from the Atlas of NSW Wildlife and EPBC Protected Matters Report are only indicative and cannot be considered a comprehensive inventory. 'Migratory marine species' and 'listed marine species' listed on the EPBC Act (and listed on the DEW protected matters report) have not been included in this table, since they are considered unlikely to occur within the study area due to the absence of marine habitat.

CE = Critically Endangered E = Endangered; E2 = Endangered Population; P = Protected; V = Vulnerable; M = Migratory

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Appendix B Plot and transect field data

Plots labelled from “9 and 11” were gathered during the December 2014 survey period, “1_2015, 2_2015 and 2_2015” during the May 2015 survey period.

Vegetation Zone 2

Vegetation Type: Broad-leaved Ironbark - Melaleuca decora shrubby open forest on clay soils of the Cumberland Plain, Sydney Basin Bioregion

Condition: Moderate/Good

AncillaryCode: Intact

Plot Name	NPS	NOS	NMS	NGC (G)	NGC (S)	NGC (O)	EPC	NTH	OR	FL	Easting	Northing	Zone
Plot 9	24	0	47	18	2	40	24	0	0	2	323244	6242887	56

Vegetation Zone 10

Vegetation Type: Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion

Condition: Moderate/Good

Ancillary code: Underscrubbed

Plot Name	NPS	NOS	NMS	NGC (G)	NGC (S)	NGC (O)	EPC	NTH	OR	FL	Easting	Northing	Zone
Plot 11	11	38	0	2	0	0	58	1	1	2	326861	6243591	56

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Vegetation Zone 17

Vegetation Type: Paperbark swamp forest of the coastal lowlands of the NSW North Coast Bioregion and Sydney Basin Bioregion

Condition: Moderate/Good

Ancillary code: Weedy

Plot Name	NPS	NOS	NMS	NGC (G)	NGC (S)	NGC (O)	EPC	NTH	OR	FL	Easting	Northing	Zone
1_2015	2	32.2	0	0	0	0	78	0	0	0	329694	6243470	56
2_2015	4	13.9	0	0	0	0	94.7	2	0	0	329504	6243310	56
3_2015	5	27.5	0	0	0	0	109.8	0	0	0	329695	6243104	56

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