Appendix I

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WESTCONNEX M4 WIDENING

Pitt Street, Parramatta to Homebush Bay Drive, Homebush

Biodiversity Assessment

Final

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WestConnex Delivery Authority

WESTCONNEX M4 WIDENING

Biodiversity Assessment

Final

Prepared by

Jacobs SKM

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Glossary of terms and abbreviations

Term	Meaning
AHD	Australian height datum
ANZECC	Australian and New Zealand Environment Conservation Council
ASS	Acid sulphate soils
AusRivAs	Australian River Assessment
CBD	Central Business District
CMA	Catchment Management Authority
CEMP	Construction Environmental Management Plan
CSIRO	Commonwealth Science and Industrial Research Organisation
DBH	Diameter at breast height
DEC	(NSW) Department of Environment and Conservation
DECC	(NSW) Department of Environment and Climate Change
DECCW	(NSW) Department of Environment, Climate Change and Water
DGRs	Director Generals Requirements
DII	(NSW) Department of Industry and Investment
DoE	(Commonwealth) Department of the Environment
DP&E	(NSW) Department of Planning and Environment
DSEWPaC	Department of Sustainability, Environment, Water, People and Communities
EIS	Environmental Impact Statement
EP&A Act	(NSW) *Environmental Planning and Assessment Act 1979*
EPBC Act	(Commonwealth) *Environment Protection and Biodiversity Conservation Act 1999*
FM Act	(NSW) *Fisheries Management Act 1994*
GPS	Global positioning system
Ha	Hectares
HBT	Hollow bearing trees
ITS	Intelligent Transport System
Km	Kilometre
LGA	Local Government Area
m	Metre
m^2	Metres squared
MNES	Matter of National Environmental Significance
NPW Act	(NSW) *National Parks and Wildlife Act 1974*
NPWS	(NSW) National Parks and Wildlife Service (now included under OEH)

Term	Meaning
NSW	New South Wales
OEH	(NSW) Office of Environment and Heritage
Proposal footprint	Refers to the area of the proposed works and includes any ancillary locations
Riparian	Transition zone between land and watercourse
RCE	Riparian Channel and Environment Inventory
REF	Review of Environmental Factors
Roads and Maritime	(NSW) Roads and Maritime Services
RTA	Roads and Traffic Authority (now known as Roads and Maritime Services)
SEPP	State Environmental Planning Policy
SIS	Species Impact Statement
SKM	Sinclair Knight Merz (now JacobsSKM)
Study area	Encompasses the project footprint and any adjoining or adjacent habitat where potential indirect impacts may occur
Study region	The broader bioregional context defined by Thackway and Creswell (1995) as the Sydney Bioregion and occurs within a 10 kilometre radius of the project footprint
TEC	Threatened Ecological Communities
TN	Total nitrogen
TP	Total phosphorus
TSC Act	(NSW) *Threatened Species Conservation Act 1995*
TSS	Total suspended solids
WDA	WestConnex Delivery Authority

Executive summary

The WestConnex Delivery Authority (WDA) is proposing to widen and upgrade the M4 Motorway generally between Pitt Street, Parramatta and Homebush Bay Drive, Homebush. This report details the methods and results of a biodiversity assessment to identify the known or potential presence of threatened species, populations and ecological communities in the M4 Motorway study area, in order to assess the extent and magnitude of ecological impacts associated with the project. The report addresses the requirements for assessment of significance under the (NSW) *Environmental Planning and Assessment Act 1979* (EP&A Act) and the (Commonwealth) *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Mitigation measures to ameliorate ecological impacts arising from the project are also provided.

Planted vegetation dominates the motorway verges and consists of a diversity of plant species, both exotic and non-indigenous, as well as species representative of the original local vegetation, which may have been sourced and planted from local seed. Small and isolated patches of remnant vegetation are also present. A high level of disturbance from urban development has altered the species composition and vegetation structure this vegetation such that the current condition is highly degraded.

Vegetation condition was generally low throughout the planted and modified vegetation communities and habitats. The remnant Swamp Oak Floodplain Forest and Shale-Gravel Transition Forest vegetation communities have a moderate vegetation condition. Areas of Mangrove Forest are generally the least disturbed and have a high ecological condition. Vegetation consistent with listed Threatened Ecological Communities in the study area is limited to a few small degraded and isolated patches. As such impacts to Threatened Ecological Communities are small in scale being limited to about 0.17 hectares of moderate condition vegetation and 0.35 hectares of low condition vegetation. These occur as highly disturbed remnants within an urban landscape and have minimal ecological importance in terms of floristic diversity, fauna habitat values and threatened flora habitat.

Natural habitats for fauna have been extensively removed or modified for commercial, industrial and residential development and are now largely confined to narrow, linear strips of planted trees and degraded riparian habitats. Fauna habitats include hollow-bearing trees and dead-standing trees which are scarce. Remaining patches of habitat are small and fragmented and can be described as:

- Linear strips of Grey Mangrove (*Avicennia marina*) and Swamp Oak (*Casuarina glauca*) occurring along the edges of Duck River. These habitats have a high proportion of exotic vegetation.
- A small patch of remnant woodland with disturbed groundcover of dense exotic grasses.
- Narrow corridors of immature planted vegetation with an absence of tree hollows and logs and a dense groundcover of exotic grasses.
- Cleared and modified landscapes with occasional planted trees.

Areas of Grey Mangrove are restricted to the banks and tidal flats of Duck River, and have naturally low floristic diversity. Areas of Swamp Oak forest are present on river-flat areas above the river banks adjacent to the bike path comprising a mix of planted and remnant Swamp Oak trees with a mix of native and exotic flora in the understorey. These habitats provide potential foraging and nesting/roosting opportunities for semi-aquatic bird species, such as cormorants, ducks and ibis.

A small number of trees in the study area support small hollow cavities, cracks and fissures as well as decorticating bark which may be utilised by hollow-dependent fauna including threatened microbat species. However the relative habitat value of these is considered low in the context of the urban landscape and potentially suitable only to smaller species such as microbats, reptiles and amphibians and it is unlikely that these microhabitats support large populations of hollow-dependent fauna. There are limited other potential roost sites present for microbat species in the form of cavities under concrete bridges and culverts and no

evidence of roosting by microbats by the Eastern Bentwing-bat or any other species was recorded.

Accumulated rubbish was observed within all waterways either in-stream or on the banks. Some aquatic macrophytes were observed at A'Becketts Creek although this site was thickly choked with riparian weeds. Generally all waterways assessed were heavily silted, with little in-stream habitat. Although A'Becketts Creek had small gravel beds in the few locations where the stream had a natural base, much of the channel contained fragments of large concrete blocks and bricks.

The waterways were generally very turbid and two to four times higher than the upper threshold of the Australian and New Zealand Environment Conservation Council ANZECC guidelines for estuarine waters in South East Australia. The aquatic habitat assessment and water quality indicate that the ecosystem health of these creeks is poor, as a result of the urban development and the high proportion of impervious surfaces. The riparian zones are very fragmented, there is little in-stream habitat and high levels of siltation. Mangroves, which are protected in NSW under the (NSW) *Fisheries Management Act 1994* (FM Act) provide the best habitat in the study area. Generally however, creeks lacked habitat diversity and are unlikely to provide significant or important fish habitat.

The biodiversity assessment identifies the following key factors associated with the proposed M4 Widening project:

- The project would not have a significant impact on a Matter of National Environmental Significance (MNES) listed under the EPBC Act or species, population or community listed under the (NSW) *Threatened Species Conservation Act 1995* (TSC Act) and FM Act.
- The small scale of the impacts predicted and the condition of the vegetation in the project area was considered in assessing the need for biodiversity offsets according to the principles for use of biodiversity offsets in NSW and the EPBC Act environmental offsets policy.
- The removal of around 0.28 hectares of mangrove forest which is classified as important fish habitat under the FM Act and a Type 2 sensitive fish habitat according to (NSW) Department of Primary Industries - Fisheries (2013). Considering the limited opportunities to avoid and minimise impacts to these areas of fish habitat, it is proposed to offset this impact, and this would be achieved through consultation with Department of Primary Industries - Fisheries.
- The removal of small isolated and fragmented areas of low to moderate condition endangered ecological communities listed under the (NSW) *Threatened Species Conservation Act 1995* equating to a total loss of 0.52 hectares. Further impacts to these communities should be avoided where possible.
- The project is unlikely to substantially contribute to further fragmentation of habitats and impacts to wildlife connectivity considering the existing high levels of fragmentation limiting fauna species to highly mobile species, and existing bridge and viaduct structures will be duplicated allowing for movements beneath the project.

Key mitigation measures to minimise and avoid biodiversity impacts include but are not limited to:

- Placement of piers in waterways would be avoided where possible and any piers required in waterways would be designed to allow for fish passage.
- Undertaking pre-clearing surveys.
- Employing a staged habitat removal process.
- Avoidance and minimisation of vegetation removal where possible.
- Management of invasive species, pests and diseases.
- A threatened species unexpected finds procedure.

1 Introduction

1.1 Background

The WestConnex Delivery Authority (WDA) is proposing to widen the M4 Motorway as Stage 1a of the WestConnex scheme. The NSW Government has established WDA to deliver the WestConnex scheme. The Authority has been established as an independent subsidiary agency of the (NSW) Roads and Maritime Services (Roads and Maritime).

This report details the methods and results of a biodiversity assessment to identify where applicable threatened species, populations and ecological populations in relation to the project area to assess the extent and magnitude of impacts on biodiversity associated with the project.

The assessment addresses the requirements for assessment of significance under Part 5.1 of the (NSW) *Environmental Planning and Assessment Act 1979* (EP&A Act) and the (Commonwealth) *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and includes recommended mitigation measures to ameliorate potential ecological impacts arising from the project.

1.2 Project description

The WDA is proposing to widen and upgrade the M4 Motorway generally between Pitt Street, Parramatta and Homebush Bay Drive, Homebush (the M4 Widening project). The location of the project area is provided in **Figure 1-1**.

The M4 Widening project would include the following key features:

- Construction of a new two lane viaduct for westbound traffic, on the southern side of the existing viaduct structure between Church Street, Parramatta and Wentworth Street, Granville.
- Reconfiguration of the traffic lanes on the existing viaduct structure to four lanes eastbound and two lanes westbound.
- Construction of a new bridge/viaduct over Duck River at Auburn.
- Widening of the existing motorway to the south of the westbound carriageway between Wentworth Street, Granville and Duck River, Auburn.
- Widening of the at-surface carriageway of the motorway predominantly within the existing motorway corridor (utilising both the existing median and verge areas), between Junction Street, Auburn and Homebush Bay Drive, Homebush to provide four traffic lanes westbound and four traffic lanes eastbound.
- Construction of a new westbound G-loop on-ramp to the M4 Motorway at Homebush Bay Drive, Homebush.
- Construction of a new eastbound on-ramp to the M4 Motorway from Hill Road, Lidcombe.
- Provision of Intelligent Transport Systems (ITS) infrastructure for motorway operations.
- Provision of road infrastructure and services to support the future implementation of Managed Motorway operations.

- Widening and/or lengthening of existing ramps at Church Street, James Ruse Drive, Silverwater Road, Hill Road and Homebush Bay Drive.
- Provision of tolling infrastructure such as gantries and control systems.
- Provision of new and modified noise barriers.
- Provision of new asphalt wearing surface to the existing M4 Motorway.

The project is located approximately 13 kilometres to the west of the Sydney central business district (CBD) and generally follows the alignment of the existing M4 Motorway. Figure 1.1 shows the project location and key features. The project extends from Pitt Street, Parramatta in the west to east of the Homebush Bay Drive interchange at Homebush in the east.

The project traverses the suburbs of Merrylands, Parramatta, Holroyd, Granville, Silverwater, Auburn, Lidcombe, Sydney Olympic Park, Homebush and Homebush West. The project spans four local government areas (LGAs) being Holroyd, Parramatta, Auburn and Strathfield.

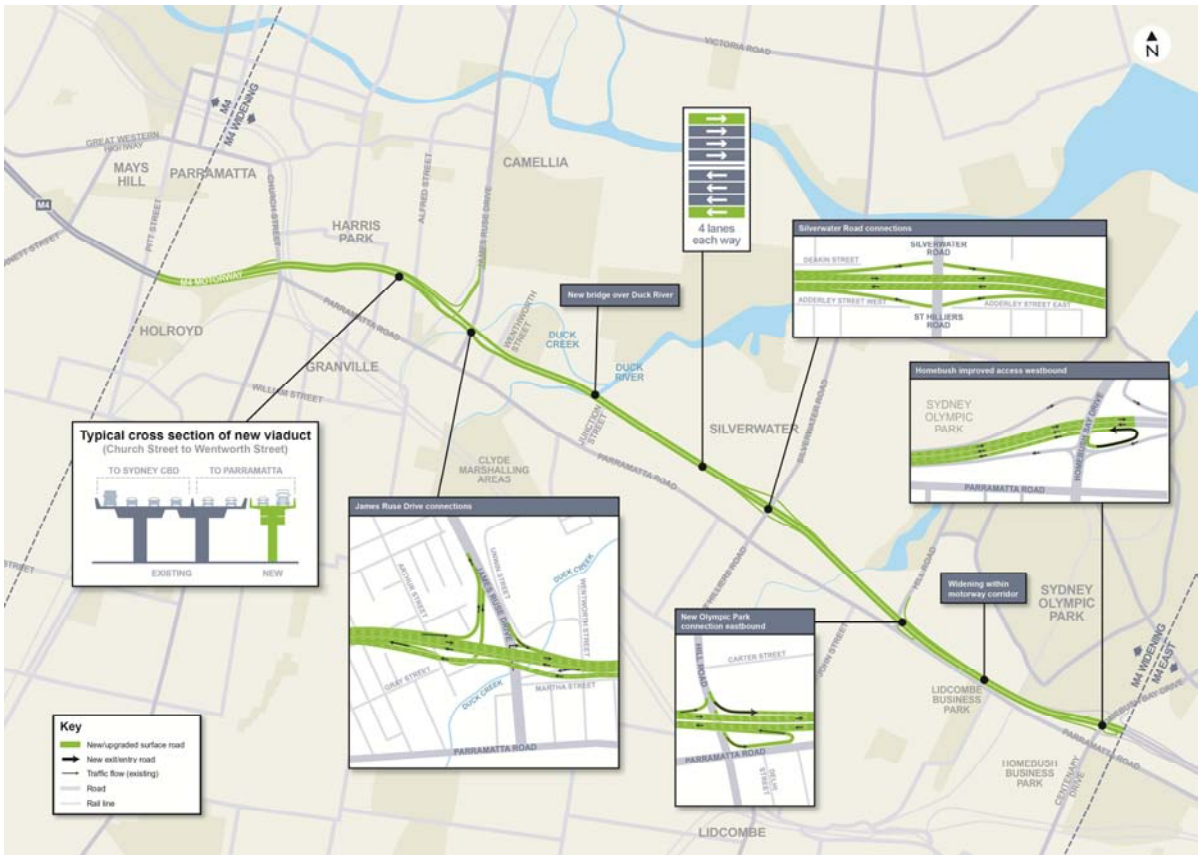
1.3 Study area

For the purpose of investigating impacts on biodiversity, the project study area includes the proposed upgrade sections of the M4 Motorway corridor as discussed in section 1.2, and immediately adjacent lands potentially subject to indirect impacts. The following areas are discussed throughout the report and are defined as:

- **Project footprint**: this area comprises the limits of the upgrade design, and for the purposes of this proposal include areas where communications infrastructure may be installed within the M4 Motorway corridor and associated arterial roads.
- **Study area**: includes the M4 Motorway corridor, associated arterial roads and areas of private property intersected by the project footprint and adjoining areas which may potentially be impacted indirectly.
- **Locality**: this area comprises a 10 kilometre radius surrounding the project footprint.

The study area is located in the Sydney Basin bioregion as defined by Thackway and Cresswell (1995), and in the Cumberland sub-region of the Hawkesbury-Nepean and Sydney Metro catchment management areas.

Figure 1-1 Location of the project (source WDA)



1.4 Legislative context

The information presented in this biodiversity assessment addresses the potential impacts on threatened species, populations, or ecological communities or their habitats in relation to State and Commonwealth environmental and threatened species legislation, namely the:

- (NSW) *Environmental Planning and Assessment Act 1979* (EP&A Act).
- (NSW) *Threatened Species Conservation Act 1995* (TSC Act).
- (NSW) *Fisheries Management Act 1994* (FM Act).
- (Commonwealth) *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

1.4.1 (NSW) Environmental Planning and Assessment Act 1979

The project is being assessed as state significant infrastructure under Part 5.1 of the EP&A Act. An environmental impact statement (EIS) is required.

According to the Director-General's requirements (DGRs) the EIS must address the *Draft Guidelines for Threatened Species Assessment* (Department of Environment and Conservation and Department of Primary Industries 2005). In addressing the guidelines the assessment is to address the important factors and/or heads of consideration with respect to assessing potential impacts on threatened species, populations or ecological communities, or their habitats as listed under the TSC Act and FM Act.

1.4.2 Director-General's requirements

The DGRs in relation to biodiversity for the project are to assess the potential ecological impacts of the project with specific reference to vegetation and habitat clearing, connectivity, edge effects, riparian and aquatic habitat impacts and soil and water quality impacts. The assessment of these impacts must:

- Make specific reference to impacts on threatened species and endangered ecological communities, including Eastern Bent- wing Bat (*Miniopterus schreibersii oceanensis*) and Grey-headed Flying-fox (*Pteropus poliocephalus*).
- Consider impacts to adjoining waterways, riparian vegetation and aquatic habitats, including consideration of water quality, marine vegetation, fish passage and habitat, soil types (including salinity), erosion and sedimentation, and ongoing water management.
- Identify appropriate avoidance, mitigation and management measures, including details of alternative options considered, and proposed arrangements for long-term management.
- Take into account the *'Draft Guidelines for Threatened Species Assessment'* (Department of Environment and Conservation/Department of Primary Industries 2005), *'Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities'* (Department of Environment and Conservation 2004), draft '*Policy and Guidelines for Fish Habitat Conservation and Management – Update 2013*' (Department of Primary Industries 2013) and the '*Guidelines for Aquatic Habitat Management and Fish Conservation'* (Department of Primary Industries 1999).
- Include details of any offset of ecological impacts and native vegetation clearing, taking into account the principles for the use of biodiversity offsets in NSW (Department of Environment, Climate Change and Water 2008).

Table 1-1 is a quick reference guide to sections of the report where each requirement is addressed.

Table 1-1 Summary of the Director-General's requirements for biodiversity assessment

DGRs	Refer to
Reference to vegetation and habitat clearing, connectivity, edge effects, riparian and aquatic ecology impacts, and soil and water quality impacts	Vegetation and habitat clearing are discussed at section 4.1. Connectivity and edge effects are considered at sections 4.2 and 5.4. Section 4.8 deals with aquatic and riparian impacts. Soil and water quality impacts are discussed at sections 2.3.4, 3.3.3, 4.1.2, and 4.8. Mitigation measures for potential impacts on water quality are provided at section 5.5
Specific reference to threatened species and endangered ecological communities	The likelihood of threatened flora and fauna, and ecological communities occurring in the study area is assessed at Appendix A. A description of the findings of the fieldwork in relation to threatened species and ecological communities is offered at sections 3.3, 3.4, 3.6, and 3.7. The potential impacts of the project on threatened species and ecological communities is described at sections 4.1.1 and 4.1.2. Significance assessments for threatened species and ecological communities is provided at Appendix E. Specific reference to habitat loss for Eastern Bent-wing Bat (*Miniopterus schreibersii oceanensis*) is at section 4.1.2, while significance assessments for the species are at section 6.1 and Appendix E.1. Specific consideration of Grey-headed Flying-fox (*Pteropus poliocephalus*) habitat in the study area, occurrence in the study area, and potential impacts are at sections 3.3.2, 4.1.2, and 4.3.2. Significance assessments for the species are at sections 6.1 and 6.2.1, and Appendix E.
Consider impacts on waterways	Sections 3.3.3 and 4.8describe the condition and types of existing aquatic habitats, and groundwater-dependent ecosystems. Sections 4.6, 4.7 and 4.8 assess the potential impacts on hydrology, groundwater-dependent ecosystems, and aquatic ecosystems. Section 5.5 offers specific advice on avoidance and mitigation measures for aquatic habitats and riparian zones. The potential significance of impacts on aquatic fauna and flora are assessed at section 6. Data on water quality and waterway condition are offered at Appendix D.
Identify avoidance, mitigation and management measures	Section 5 offers advice on avoiding and minimising impacts on flora and fauna, and on construction mitigation measures, habitat re-establishment, wildlife connectivity, aquatic habitat and riparian zones, and offsetting.
Take into account relevant policy and guidelines for assessment	Assessments of significance for threatened flora and fauna, and ecological communities are presented at section 6, and Appendix E. These were prepared as per the requirements of the Draft Guidelines for Threatened Species Assessment' (Department of Environment and Conservation/Department of Primary Industries

DGRs	Refer to
	2005), and 'Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities' (Department of Environment and Conservation 2004). The sensitivity and functionality of waterways in the study area as fish habitat were classified according to the Department of Primary Industries (2013) updated 'Policy and Guidelines for Fish Habitat Conservation and Management'. This is presented at section 3.3.3.
Take into account any offset of ecological impacts and native vegetation clearing	The potential requirement for offsets to compensate for loss of native vegetation is detailed at section 5.6. A minimum offset ratio is offered, taking into account the NSW offset principles for major projects (Department of Environment, Climate Change and Water 2008).

1.4.3 (NSW) Threatened Species Conservation Act 1995

The TSC Act identifies threatened species, populations and ecological communities, as listed under Schedules 1, 1A and 2 that are to be identified as potential subject species and therefore require a significance assessment under section 5A of the EP&A Act. The TSC Act also lists Key Threatening Processes comprising matters that threaten the survival or evolutionary development of a species, population or ecological community.

1.4.4 (NSW) Fisheries Management Act 1994

The FM Act establishes provisions for the identification, conservation and recovery of threatened fish, aquatic invertebrates and marine vegetation. This Act also covers the identification and management of key threatening processes which affect threatened species or could cause other species to become threatened.

The Minister for Fisheries would need to be notified of any proposed dredging or reclamation works (Part 7 Division 3 of the FM Act), associated with the proposed upgrade in accordance with section 199 of the Act.

The (NSW) Planning and Infrastructure (P&I) is responsible for the management of fish and marine vegetation, including mangroves, under the FM Act. The project would be referred to the (NSW) Department of Industry and Investment (DII)) during the assessment phase and P&I would provide appropriate conditions to be included in the overall project approval.

1.4.5 (Commonwealth) Environment Protection and Biodiversity Conservation Act 1999

The EPBC Act objective is to protect the environment, particularly matters of national environmental significance (MNES), and to provide an environmental assessment pathway for the development on Commonwealth land. It streamlines the national environmental assessment and approvals process, protects Australian biodiversity and integrates management of important natural and cultural places. The EPBC Act identifies nine MNES:

- World Heritage properties.
- National heritage places.

- Wetlands of international importance (Ramsar wetlands).
- Threatened species and ecological communities.
- Migratory species.
- Commonwealth marine areas.
- Nuclear actions (including uranium mining).
- Great Barrier Reef.
- Protection of water resources from coal seam gas development or large coal mining development.

The EPBC Act is triggered by actions that would be likely to have a significant impact upon MNES. Under the EPBC Act, such actions require approval from the Australian Government Minister for the Environment and should be referred to the Australian Government Department of the Environment (DoE) for consideration. Actions deemed by DoE to require Commonwealth approval would be 'controlled actions' which require an environmental assessment. The EPBC Act also lists Key Threatening Processes comprising matters that threaten the survival or evolutionary development of a native species or ecological community.

1.5 Study aims

The aims of the biodiversity assessment are to:

- Describe the characteristics and ecological condition of the vegetation communities and habitats within the study area.
- Determine the occurrence, or likelihood of occurrence of threatened species, populations and ecological communities listed under the TSC Act, FM Act and EPBC Act within the study area.
- Assess the potential impacts on biodiversity in the study area as a result of the project and address the heads of consideration for assessing potential impacts on threatened species, population or ecological communities, or their habitats under Part 5.1 of the EP&A Act.
- Assess the potential impacts of the project on MNES (significant impact guidelines 1.1 under the EPBC Act).
- Propose further investigations and/or mitigation measures to mitigate impacts on any conservation significant biodiversity values identified in the study area.

2 Methodology

2.1 Personnel

Ecological surveys for the assessment were conducted under the (NSW) *National Parks and Wildlife Act 1974* (NPW Act) (Scientific Research Permit SL100044) and Animal Research Authority (TRIM09/1895) maintained by the Principal Ecologist. The qualifications and role of personnel involved in the field assessments and reporting are provided in **Table 2-1**.

Table 2-1 Qualifications and role of key personnel

Personnel	Qualifications	Project tasks
Andrew Carty	BEnvSc; DipBushRegen; Accredited Biobanking Assessor	Biodiversity assessment report; flora and fauna surveys, vegetation mapping, BioBanking assessment
Jonathon Carr	BEnvSc	Field assistant flora and fauna surveys, BioBanking assessment
Mirella Verhoeven	BEnvSc(Hons)	Biodiversity assessment report, aquatic habitat assessment
Kate Byrnes	BSc (Hons)	Aquatic habitat assessment
Chris Thomson	BAppSc; GradCertNatRes	Practice review and reporting

2.2 Background review

A review of existing reports and government maintained databases was undertaken as the first stage of the investigation. The following information was reviewed:

- NSW vegetation types database (Office of Environment and Heritage (OEH) 2012). http://www.environment.nsw.gov.au/biobanking/vegtypedatabase.htm.
- NSW threatened species profile database (OEH 2013). http://www.environment.nsw.gov.au/biobanking/biobankingtspd.htm.
- Native Vegetation of the Cumberland Plain - Final Edition (National Parks and Wildlife Service (NPWS) 2002).
- The native vegetation of the Cumberland Plain, western Sydney: systematic classification and field identification of communities (Tozer 2003).
- NSW BioNet (OEH 2013).
- DPI Threatened and Protected Species – Records Viewer http://www.dpi.nsw.gov.au/fisheries/species-protection/records/viewer.
- DPI Noxious Weed listings http://www.dpi.nsw.gov.au/agriculture/pests-weeds/weeds/noxweed.
- Atlas of NSW Wildlife maintained by OEH (OEH April 2013).
- The Protected Matters Search Tool provided under the EPBC Act (March 2013).

The review focused on identifying and listing the threatened flora and fauna species, populations and ecological communities previously recorded from a 10 kilometre radius of the project. The background review also aimed to identify any sensitive ecological sites such as National Parks and

other reserves, fish habitat and areas protected by State Environmental Planning Policies. After collation of database records and species and community profiles a 'likelihood of occurrence' assessment was prepared with reference to the broad habitats contained within the study area. This was further refined after field surveys and assessment of habitat present. The list of threatened species recorded from the locality is provided as **Appendix A**.

2.3 Field surveys

The following provides a description of the ecological surveys conducted in the study area which included terrestrial flora and fauna surveys and aquatic habitat assessments. These surveys were conducted over two seasons to capture any potential seasonal constraints for the species being targeted. This included a winter survey (July 2013) and follow-up summer survey (February 2014).

2.3.1 Vegetation and flora survey

A combination of aerial photograph interpretation, broad-scale vegetation mapping (NPWS 2002) and elevation data was used to stratify the vegetation and habitats in the study area and select appropriate survey locations. The stratification was based on a number of factors, with the most dominant of these being the provenance (ie remnant vegetation or roadside planted/landscaped vegetation) given the extent of even-aged planted vegetation used on the original construction of the M4 Motorway. Where remnant vegetation was concerned the vegetation structure, dominant species, soil types and landscape position was considered. The location and number of sampling sites used in the field survey was determined according to the extent and condition of each vegetation type present to ensure adequate representation.

The flora survey aimed to provide baseline data for the presence of threatened plant species, populations, vegetation types and threatened ecological communities to provide a basis for the prediction of impacts. The survey comprised the following steps:

- A thorough review of the broad-scale vegetation mapping, previous specialist reports conducted in close proximity, threatened species records, and other available literature and scientific databases to gain an appreciation of the diversity of flora including threatened species that could potentially occur in the study area.
- Stratified sampling techniques to classify and map vegetation communities, threatened species habitat and develop an inventory of flora species specific to each vegetation association.
- Targeted searches for threatened flora species in areas of suitable habitat.

Vegetation association classification and mapping

Transect sampling was used to identify vegetation community types and boundaries. The number of transects sampled was proportional to the size of the stratification units identified with a minimum of two 100 metre transects sampled per 2-50 hectares of each stratification unit and three 100 metre transects sampled per 51-250 hectares of stratification unit in accordance with Department of Environment and Conservation (DEC) (2004).

Digital mapping of vegetation communities was conducted using ArcGIS® software. A combination of field data, aerial photograph interpretation and biophysical data such as elevation and soil type were used to delineate community boundaries. Description of the vegetation communities was based on their structure and dominant canopy species (Specht 1981) and correlated with Keith (2004), Tozer (2003) and NPWS (2002) and compared with final determinations and listing advice for threatened ecological communities.

After field identification the vegetation communities in the study area were matched to relevant Biometric vegetation types as reported in the (NSW) Office of Environment and Heritage (OEH) (2012) as well as broad-scale vegetation classification for the region produced by Tozer (2003).

Plot sampling

Quadrat based sampling was used in conjunction with general traverses of the study area, and in particular those areas associated with the project footprint. Quantitative data on plant species richness were collected from a series of 20 x 20 metre plots (400 metres squared) sampled within each remnant vegetation association. Data collected within each plot included:

- Heights of structural layers (ie canopy, sub-canopy, shrub and groundcovers).
- The abundance/cover of each species and vegetation layer.
- Landscape features (eg slope, gully, and aspect).
- Soil features (eg soil type, rocks, organic matter).
- Geographical coordinates and a photographic record.

Transects and general traverses

General traverses comprised random searches throughout targeted areas to develop a plant list (**Appendix B**) and to complete searches for threatened species, as well as to opportunistically record the distribution of vegetation communities, significant habitat attributes and any other factors that may be of interest. The location of all threatened species, vegetation community boundaries and any other ecological factors were recorded with a Geographic Positioning System (GPS).

Threatened Ecological Community assessment

Identification of the listed Cumberland Plain Woodland and Shale-Gravel Transition Forest (TSC Act and EPBC Act) was delineated using the NSW final determination (NSW Scientific Committee 2009) and Federal listing advice (DEWHA 2010). Condition thresholds are not provided for the State-listed community. Condition thresholds for the Commonwealth listed community have been developed and these are detailed in **Table 2-2**.

Table 2-2 Conditions thresholds for the federally listed Cumberland Plain Woodland and Shale-Gravel Transition Forest (DEWHA 2010)

No	Category	Yes	No
1	Are diagnostic native tree species dominant (*Eucalyptus fibrosa, E. tereticornis, E. moluccana*) with a minimum projected foliage cover of 10%	Go to 2	Not the listed ecological community
2	Is the patch size of the ecological community 0.5 hectare (ha) or greater in size?	Go to 3	Not the listed ecological community
3	Of the perennial understorey vegetation cover present does greater than 50% consist of native species?	The listed ecological community is present	Go to 4
4	Is the patch 5 ha or greater in size?	Go to 7	Go to 5
5	Is the patch contiguous with a native vegetation patch 5 ha or greater in size?	Go to 7	Go to 6
6	Does the patch contain at least one tree per ha that is larger >80 cm Diameter at Breast Height (DBH) or has a hollow?	Go to 7	Not the listed ecological community
7	Of the perennial understorey vegetation cover present does greater than 30% consist of native species?	The listed ecological community is present	Not the listed ecological community

The area of vegetation patches was determined using Geographic Information System (GIS) software. The cover of perennial understory species was determined using the vegetation and condition assessment methods as specified in section 2.3.6.

Vegetation and habitat condition assessment

A vegetation and habitat condition assessment was conducted using the Biobanking Assessment Methodology (DECC 2008). The assessment aimed to provide a measure of habitat condition for each of the remnant vegetation types only and identify the floristic diversity, structure of the vegetation, the type and distribution of plant communities present as well as the density of fauna habitat features in the study area. Only three condition assessment plots were undertaken in the study area, one in each remnant vegetation community.

2.3.2 Fauna survey

The fauna survey was targeted within the road reserve along the length of the study area including proposed upgrade areas with notes taken from observations outside the corridor where adjoining habitat was present, particularly in relation to habitat condition and connectivity to the road reserve.

The stratification of habitat types was primarily based on the presence of remnant versus planted vegetation given the high prevalence of landscape plantings within the study area. Vegetation type was also considered for remnant vegetation and based on the dominant species in the canopy and mid-strata.

The fauna survey method adopted a habitat assessment approach focused on identifying potential habitat for threatened species and identifying habitat usage by threatened fauna. This method was selected due to the predominance of planted and disturbed vegetation, the narrow linear nature of the habitat along the road corridor and adjoining urban landscape and therefore paucity of habitat for fauna. The location and number of sampling sites used in the field survey was determined according to the extent and condition of each vegetation type present to ensure adequate representation.

In addition to this, targeted searches were conducted for threatened frogs, microchiropteran bats, in particular the Eastern Bentwing-bat, Grey-headed Flying-fox, Cumberland Land Snail, and diurnal birds and reptiles using the methods described below and summarised in **Table 2-6**.

Fauna habitat assessment

Throughout the study area details of the habitat type and condition were recorded. The details and habitat criteria assessed included:

- Type and structure of the vegetation, including an assessment of the 'naturalness' in terms of the presence of native remnant vegetation or planted and regrowth areas.
- Dominant flora species and a subjective assessment of the floristic diversity at different structural layers, in addition to flowering and fruiting food resources for species such as the Grey-headed Flying-fox.
- Tree species and height of canopy trees including the proportion of each species.
- Presence of significant keystone species and critical habitat elements for threatened fauna.
- Disturbance regimes including the presence key threatening processes such as invasion and dominance of exotic species.
- The presence of tree hollows, dead stags or hollow logs providing potential shelter for hollow-dependent fauna, including microchiropteran bats and birds.

- The presence of artificial structures that may be used by roosting bats or nesting birds, such as concrete culverts or under bridges including a search for roosting Eastern Bentwing-bat and any other roosting bat species
- The structure or the habitat in terms of complexity and presence of shelter and food resources for fauna, in particular threatened species.
- Presence and condition of wet areas or waterbodies, significant aquatic habitats where present, with a particular focus on the likely presence of habitat for the endangered Green and Golden Bell Frog (*Litoria aurea*) and listed migratory birds.
- Size of remnant patches and extent of connectivity to habitats outside the road reserve.
- Site photographs and Global Positioning System (GPS) coordinates.

The data was used in combination with the opportunistic fauna survey to identify habitats of conservation value for fauna, in particular threatened fauna known from the locality.

Searches for threatened fauna usage

The occurrence of specific habitat features appropriate for threatened fauna species known or potentially occurring at site was evaluated as part of the habitat assessment. Features known to be used by threatened species were assessed such as hollow-bearing trees, nest trees, watercourses, specific food trees, wetland habitats, leaf litter and artificial structures suitable for roosting or denning purposes. Evidence of habitat use by fauna species was inspected such as:

- Diggings in the soil and scats attributed to the Long-nosed Bandicoot.
- Regurgitation pellets and nest/roost sites for forest owls.
- Inspection for 'whitewash' and pellets under any potential owl roost sites.
- Chewed cones beneath Casuarina trees indicating Glossy Black Cockatoo feeding.
- Signs of bats roosting under bridge structures, such as accumulation of droppings and staining.
- Signs of a roost camp for the Grey-headed Flying-fox.

At each assessment site an assessment was made on the potential presence of habitat for Cumberland Plain Land Snail. Targeted searches for the species were carried out all sites which had potential habitat features present. This involved a general traverse of the site and lifting any logs and building refuse when encountered and raking through patches of dense leaf litter.

Opportunistic surveys

Opportunistic fauna surveys were conducted during the survey period, and were based on direct observation, including the use of binoculars, and identifying bird and frog calls as well as reptiles encountered during the surveys. A list of fauna species encountered was compiled and is presented as **Appendix C**.

Targeted frog and bat survey

Targeted nocturnal spotlighting survey was conducted in February 2014 to sample the summer season. **Figure 2-1** shows the locations of the frog and bat survey sites. This survey targeted frogs,microbats (including Eastern Bentwing-bat), and Grey-headed Flying-fox as well as Green and Golden Bell Frog over one afternoon and evening.. Weather conditions were overcast, with light rain, and mild temperature ranging from 25-30 degrees Celsius.

Freshwater habitats within the study area are limited to small constructed drains and active sediment basins located in the road reserve. Six sites were identified as potential frog habitat during the winter survey and these sites were re-visited to document a targeted habitat assessment for the Green and

Golden Bell Frog given the known presence of populations in the Homebush Bay area. The habitat assessment included consideration of:

- The width, depth and length of the waterbody.
- The type and abundance of any macrophytes (eg floating, emergent, submerged).
- Substrate type, and the presence and abundance of fine and coarse woody debris, silt, moss, and algae.
- Extent and condition of riparian vegetation.
- Bank and bed stability.
- Disturbance and surrounding land uses.
- Current velocity.
- Water quality.

Each of the six sites was then surveyed after dark, on the same day. Two ecologists listened for frog calls for a minimum 15 minutes at each site, yielding a total survey effort of three person hours. Frog calls were also broadcast, including calls of threatened species (ie *Litoria aurea*). Active streamside searches were not conducted because the waterways were either inaccessible (eg fenced off), or it was unsafe (eg steep unstable banks).

In addition to the frog survey, a bat call recording device was also deployed at each of the six nocturnal survey sites for the duration of the frog surveys. This technique aimed to record bat calls continuously, yielding 1.5 hours of call recording across the six sites. The bat call survey aimed to survey for all microchiropteran bat species including the Eastern Bentwing-bat. Spotlighting and listening for calls of the Grey-headed Flying-fox was conducted at each of the six sites.

2.3.3 Aquatic habitat assessment

The study area crosses A'Becketts Creek, Duck Creek, Duck River and Haslams Creek. A desktop assessment of the study area was conducted to identify any other small unnamed creeks or drainage system however no more were identified. A literature review was conducted to obtain background information on catchment history, the catchment area and land use to aide in interpreting the existing habitat conditions.

Aquatic habitat was surveyed at the four sites, in line with the (NSW) *Department of Primary Industries Policy and Guidelines for Fish Habitat Conservation and Management* (2013). A modified riparian, channel and environmental inventory (RCE) assessment was conducted at the four locations with an additional assessment conducted at a downstream location on A'Becketts Creek near James Ruse Drive. Information was gathered and verified on the condition of the waterway, including presence of pollutants, turbidity, weed invasion and sedimentation. The criteria assessed included:

- Watercourse geomorphology and flow regime.
- Water quality (visual assessment).
- Surrounding land use and impacts on the waterway.
- Condition and extent of riparian vegetation and in-stream vegetation.
- Presence of fish habitat including spawning and refuge areas and any potential barriers to fish passage.

Waterways were then classified based on the type (sensitivity) of the waterway (DPI 2013) as detailed in **Table 2-3**. Note that concrete lined or piped sections of stream are not considered key habitat (not including a waterway crossing).

Waterways were then classified based on the class (functionality as fish habitat) of the waterway (DPI 2013) as detailed in **Table 2-4**.

WestConnex study area

Design

Indicative construction footprint

Vegetation communities

- Map Unit 1: Mangrove Forest
- Map Unit 2: Swamp Oak Floodplain Forest
- Map Unit 4: Freshwater Drainage Lines
- Map Unit 5: Estuarine Drainage Lines

NSW SPATIAL - GIS MAP file : NB11510WCX_GIS_F007_r2r2

SCALE 1:5,000 | A3

SHEET 1 of 5 | COORDINATE SYSTEM GDA 1994 MGA Zone 56

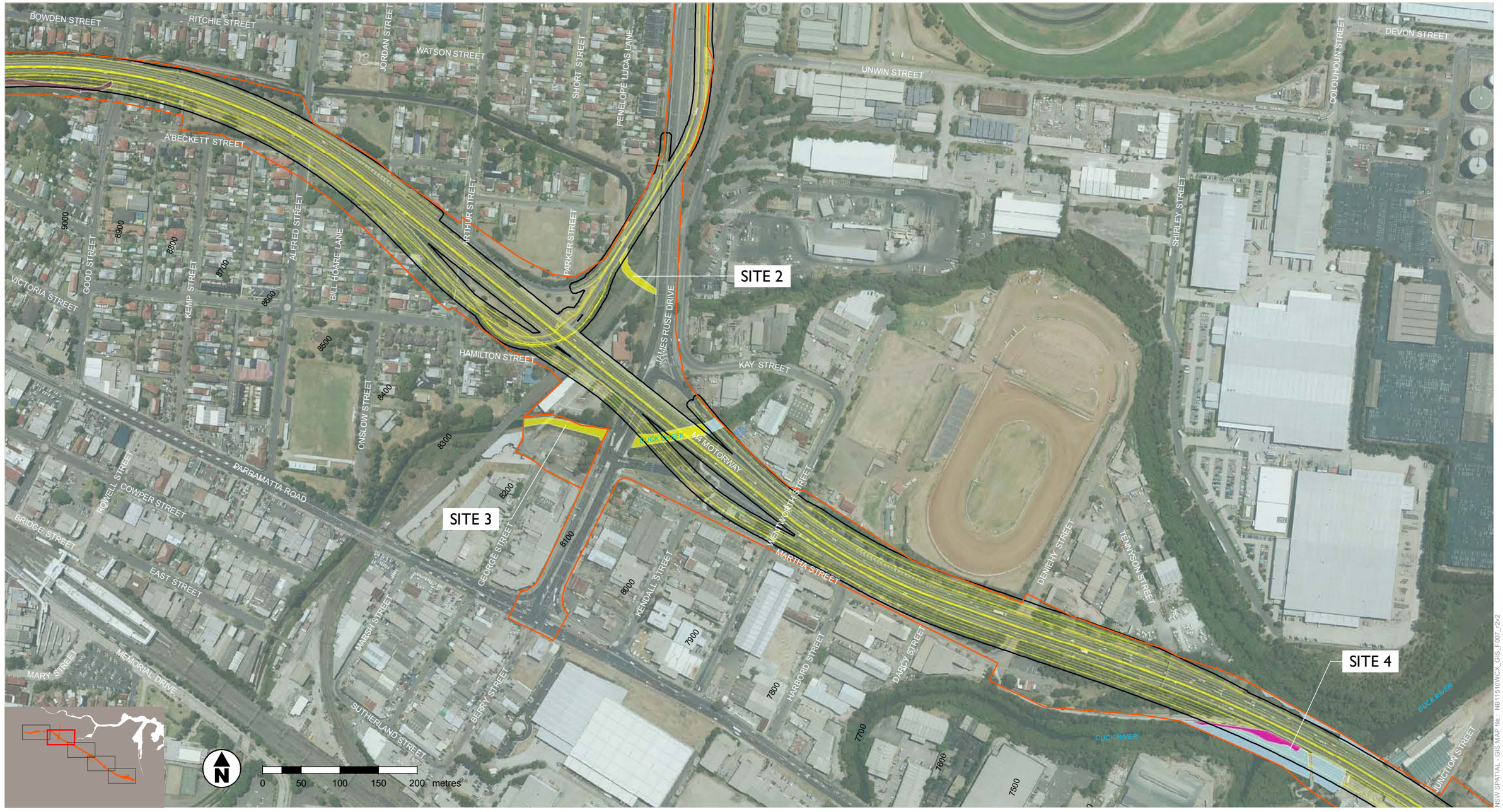
TITLE

Figure 2-1 a
Frog and Anabat call recording survey sites in February 2014

PROJECT
WestConnex Stage 1a - M4 Widening

CLIENT
ROADS AND MARITIME SERVICES

DRAWN	PROJECT #	MAP #	REV	VER
KM	NB11510			
CHECK	DATE			
CT	17/05/2014	F007	2	1



WestConnex study area

Design

Indicative construction footprint

Vegetation communities

- Map Unit 1: Mangrove Forest
- Map Unit 2: Swamp Oak Floodplain Forest
- Map Unit 4: Freshwater Drainage Lines
- Map Unit 5: Estuarine Drainage Lines

SCALE 1:5,000 | A3

SHEET 2 of 5 | COORDINATE SYSTEM GDA 1994 MGA Zone 56

TITLE

Figure 2-1 b
Frog and Anabat call recording survey sites in February 2014

PROJECT
WestConnex Stage 1a - M4 Widening

CLIENT
ROADS AND MARITIME SERVICES

DRAWN	PROJECT #	MAP #	REV	VER
KM	NB11510	F007	2	1
CHECK	DATE			
CT	17/05/2014			

NSW SPATIAL GIS MAP file : NB11510WCX_GIS_F007_r2v2

WestConnex study area
Design
Indicative construction footprint

Vegetation communities
- Map Unit 1: Mangrove Forest
- Map Unit 2: Swamp Oak Floodplain Forest
- Map Unit 4: Freshwater Drainage Lines
- Map Unit 5: Estuarine Drainage Lines

SCALE 1:5,000 | A3
SHEET 3 of 5 | COORDINATE SYSTEM GDA 1994 MGA Zone 56

TITLE
Figure 2-1 c
Frog and Anabat call recording survey sites in February 2014

PROJECT
WestConnex Stage 1a - M4 Widening

CLIENT
ROADS AND MARITIME SERVICES

DRAWN	PROJECT #	MAP #	REV	VER
KM	NB11510			
CHECK	DATE	F007	2	1
CT	17/05/2014			

NSW SPATIAL - GIS MAP File : NB11510WCX_GIS_F007_r2v2

WestConnex study area

Design

Indicative construction footprint

Vegetation communities

- Map Unit 1: Mangrove Forest
- Map Unit 2: Swamp Oak Floodplain Forest
- Map Unit 4: Freshwater Drainage Lines
- Map Unit 5: Estuarine Drainage Lines

SCALE 1:5,000 | A3

SHEET 4 of 5 | COORDINATE SYSTEM GDA 1994 MGA Zone 56

TITLE

Figure 2-1 d
Frog and Anabat call recording survey sites in February 2014

PROJECT
WestConnex Stage 1a - M4 Widening

CLIENT
ROADS AND MARITIME SERVICES

DRAWN	PROJECT #	MAP #	REV	VER
KM	NB11510			
CHECK	DATE			
CT	17/05/2014	F007	2	1

WestConnex study area
Design
Indicative construction footprint

Vegetation communities
- Map Unit 1: Mangrove Forest
- Map Unit 2: Swamp Oak Floodplain Forest
- Map Unit 4: Freshwater Drainage Lines
- Map Unit 5: Estuarine Drainage Lines

SCALE 1:5,000 | A3
SHEET 5 of 5 | COORDINATE SYSTEM GDA 1994 MGA Zone 56

TITLE
Figure 2-1 e
Frog and Anabat call recording survey sites in February 2014

PROJECT
WestConnex Stage 1a - M4 Widening

CLIENT
ROADS AND MARITIME SERVICES

DRAWN	PROJECT #	MAP #	REV	VER
KM	NB11510			
CHECK	DATE			
CT	17/05/2014	F007	2	1

NSW SPATIAL - GIS MAP file : NB11510WCX_GIS_F007_r2v2

Table 2-3 Fish habitat sensitivity classification scheme (adapted from DPI 2013).

Type	Fish habitat	Waterway characteristics
Type 1	Highly sensitive	Vegetation: Native seagrasses *Posidonia australis*, *Zostera Heterozostera*, *Ruppia* or *Halophila;* Saltmarsh; coral Status: State Environmental Planning Policy 14 (SEPP14) or other listed wetlands, marine parks and reserves, protected or threatened species or area Habitat/form: Mound springs, lakes and lagoons with natural opening and closing regime, freshwater habitat with gravel beds, boulders, snags or native aquatic plants
Type 2	Moderately sensitive	Vegetation: Native seagrasses *Zostera Heterozostera*, *Ruppia* or *Halophila;* mangroves, saltmarsh <5m^2, marine macrolagae Habitat/form: rocky reefs, lakes and lagoons permanently or artificially open, aquatic habitat within 100m of reserved or protected area, intertidal mudflats and sandy beaches with large populations of infauna, weir pools and dams across a natural waterway and up to full supply level, freshwater habitats, wetlands, lakes and lagoons not described in Type 1
Type 3	Minimally sensitive	Vegetation: lack of native aquatic or wetland vegetation Habitat/form: Unstable or unvegetated sand or mud substrate, sandy beaches with little/no infauna; coastal and freshwater habitats not included in Types 1 or 2

Table 2-4 Key fish habitat classification scheme (adapted from DPI 2013).

Classification	Key fish habitat	Waterway characteristics
Class 1	Major	Marine or estuarine waterway; permanently flowing or flooded freshwater waterway, critical habitat; habitat of threatened or protected fish species.
Class 2	Moderate	Intermittent stream, creek or waterway with clearly defined banks with semi-permanent to permanent waters in pools or in connected wetland areas, freshwater aquatic vegetation, Type 1 and 2 habitats present.
Class 3	Minimal	Named or unnamed waterway with intermittent flow and sporadic refuge, breeding or feeding areas for aquatic fauna. Semi-permanent pools form within the waterway or adjacent wetlands after rain. Any minor waterway that interconnects with wetlands or Class 1-3 fish habitats.
Class 4	Unlikely	Waterway (generally unnamed) with intermittent flow after rain events only, little or no defined drainage channel, little or no flow or free standing water or pools post rain events (eg dry gulles or shallow floodplain depressions with no aquatic flora present).

2.3.4 Water quality

Water quality was measured with a Hydrolab multi-parameter probe where there was safe access and water was of sufficient depth (ie Duck River, Haslams Creek, Duck Creek). Parameters measured were water depth (metres), temperature (degrees Celsius), turbidity (NTU), dissolved oxygen (mg/l and per cent), conductivity (mS/cm), salinity (ppt), Oxygen Reduction Potential (ORP) (mv) and acidity (pH). Field data sheets were completed at each site, noting the colour and appearance of the water, odours, litter, slicks and any other observations.

Parameters were compared to the Australian and New Zealand Environment Conservation Council guidelines for estuarine waters in South East Australia (ANZECC).

2.3.5 Survey effort

A summary of the flora and fauna survey effort is summarised in **Table 2-5** and **Table 2-6**. Not all map units were subject to plot assessments due to the highly modified and planted nature of these areas (Map Units 6, 7 and 8) or due to the very small patch size (Map Units 4 and 5).

Table 2-5 Flora survey effort per habitat stratification unit

Habitat	Area in study area (ha)	Sampling effort plot / condition assessments	Sampling effort plot traverses (100 m+)
Map Unit 1: Mangrove Forest	0.6	1	2
Map Unit 2: Swamp Oak Floodplain Forest	0.1	1	1
Map Unit 3: Shale-Gravel Transition Forest	0.4	1	2
Map Unit 4: Freshwater Drainage Lines	1.0	0	5
Map Unit 5: Estuarine Drainage Lines	0.5	0	2
Map Unit 6: Planted Monocultures (6a Casuarina species; 6b Ficus species; 6c Spotted Gum; 6d Native Shrubs; 6e Tallowwood)	6a: 2.6 6b: 3.7 6c: 0.5 6d: 0.1 6e: 0.6	0	8
Map Unit 7: Mixed Plantings	19.3	0	10
Map Unit 8: Exotic Vegetation	1.0	0	3
Map Unit 9: Shale Plains Woodland	0.08	1	1

Table 2-6 Summary of fauna survey effort

Technique	Method	Survey effort
Fauna habitat assessment	Habitat assessment data were collected at numerous sites over four days to gather information on the type and condition of the fauna habitats within the road reserve. At each site details of the habitat type and condition were noted from variable plot sizes depending on the width of the road reserve and size of the vegetation patch. The assessment focused on identifying important features for threatened fauna species.	28 person hours
Cumberland Plain Land Snail	At each assessment site an assessment was made on the potential presence of habitat for Cumberland Plain Land Snail. Targeted searches for the species were carried out all sites which had potential habitat features present. This involved a general traverse of the site and lifting any logs and building refuse when encountered and raking through patches of dense leaf litter.	About 2 person hours
Diurnal bird census	Opportunistic surveys for diurnal bird species were conducted along the study area, and more detailed time-based searches were conducted where potential habitat was present. Time based searches involved a single observer moving along a random meander within the habitat areas. The survey aimed to record all birds seen or heard.	About 4 person hours over 3 days
Amphibian searches	Amphibian habitat was centred on drains and riparian areas. Frogs were identified by calls and capture when encountered. A targeted nocturnal survey was conducted at six sites	5 person-hours
Reptiles searches	Reptile surveys consisted of hand searches for active and resting individuals under rocks, logs, bark, leaves and timber and artificial debris. The survey was opportunistic during the targeted Cumberland Plain Land snail surveys.	2 person-hours
Scats, tracks and opportunistic records of threatened fauna	The species and location of mammal scats, scratches and other evidence of threatened fauna presence when encountered were noted to provide locality records.	Opportunistic during all site survey times over 6 days
Inspection of culverts for microbats including Eastern Bentwing-bat	Physical inspections were conducted in drainage structures and viaducts where access was available under the motorway to search for roosting microchiropteran bats or potential roosting habitat.	2 person hours
Bat call recordings for microchiropteran bats including Eastern Bentwing0bat	Hand-held Anabat bat call recorded deployed at six sites during the nocturnal surveys	1.5 hours
Spotlighting survey	Hand-held spotlights and head torch were used at six sites in the study area targeted Grey-headed Flying-fox and Green and Golden Bell Frog	1.5 hours

Technique	Method	Survey effort
Visual aquatic habitat assessment	Modified Riparian, Channel and Environmental Inventory (RCE) field sheets were completed for five locations. This reported on the condition of the riparian zone, the stream bank and channel form, substrate and vegetation. Water quality was measured with a Hydrolab multi-parameter probe where there was safe access and water was of sufficient depth (three locations).Habitat assessment data were collected at four locations and reported no the condition of the habitat, noting the presence of significant features for fish and aquatic fauna. Water quality, field observation and additional habitat details were recorded on a Field Record Sheet. Photos were taken at each site.	16 person hours

2.3.6 Limitations

The entire motorway corridor is fenced and access was permitted only where gates are located, and there was no provision for parking on the motorway or pulling over to the side of the carriageway and this restricted some areas to drive-by inspections, however these areas comprised planted roadside landscapes with minimal habitat and this restriction was not expected to limit the results of the assessment. Access to private land adjacent to the road corridor was arranged where required, and nocturnal surveys were also conducted in roadside areas.

The list of flora and fauna species recorded from this study should not be seen to be fully comprehensive, but rather an indication of the species present at the time of the survey. A period of several seasons or years is often needed to identify all the species present in an area, especially as some species are only apparent at certain times of the year (eg orchids or migratory birds) and require specific weather conditions for optimum detection (eg frogs). Hence the conclusions of this report are based upon available data and the field surveys and are therefore merely indicative of the environmental condition of the site at the time of the survey. It should be recognised that site conditions, including the presence of threatened species, can change with time. To address this limitation, the assessment has aimed to identify the presence and suitability of the habitat for threatened species.

2.4 Threatened species assessment

2.4.1 Likelihood of occurrence

State and nationally listed threatened species identified from the background reviews were considered in terms of their likelihood to occur in the habitats present within the study area based on their identified habitat requirements. The results of this review are provided in **Appendix A**. The likelihood of occurrence was classified according to the criteria described in **Table 2-7**. The presence of all potentially occurring threatened species were targeted during the surveys with particular emphasis on those species with a high or moderate likelihood of occurrence. Species with a high or moderate likelihood of occurrence were subject to assessments of significance under the relevant legislation (TSC Act and/or EPBC Act).

Table 2-7 Likelihood of occurrence includes one or more of the following criteria

Likelihood of Occurrence	Criteria
Unlikely	▪ Species highly restricted to certain geographical areas not within the project footprint ▪ Specific habitat requirements are not present in the study area
Low	Species not recorded during field surveys and fit one or more of the following criteria: ▪ Have not been recorded previously in the study area/surrounds and for which the study area is beyond the current distribution range ▪ Use specific habitats or resources not present in the study area ▪ Are a non-cryptic perennial flora species that were specifically targeted by surveys and not recorded
Moderate	Species not recorded during the field surveys that fit one or more of the following criteria: ▪ Have infrequently been recorded previously in the study area/surrounds ▪ Use specific habitats or resources present in the study area but in a poor or modified condition ▪ Are unlikely to maintain sedentary populations, however may seasonally use resources within the study area opportunistically or during migration ▪ Are cryptic flowering flora species that were not seasonally targeted by surveys and that have not been recorded
High	Species recorded during the field surveys or species not recorded that fit one or more of the following criteria: ▪ Have frequently been recorded previously in the study area/surrounds ▪ Use habitat types or resources that are present in the study area that are abundance and/or in good condition within the study area ▪ Are known or likely to maintain resident populations surrounding the study area ▪ Are known or likely to visit the site during regular seasonal movements or migration

2.4.2 Significance assessments

Significance assessments were conducted for species, populations and communities that have been positively identified or that have a moderate or high potential to occur in the study area. Species with similar taxonomy or ecological requirements were assessed together, for example cave-roosting microchiropteran bats.

For threatened biodiversity listed under the TSC Act and FM Act, the assessment considered the heads of consideration for threatened species assessment detailed in the Department of Environment and Conservation/Department of Primary Industries (2005) *Draft Guidelines for Threatened Species Assessment*. The guidelines present methods to consider the impacts on biodiversity of projects assessed under Part 3A as updated by Part 5.1 of the EP&A Act, including presenting heads of consideration for determining the significance of impacts.

For threatened biodiversity listed under the EPBC Act significance assessment were completed in accordance with the *Matters of National Environmental Significance Significant Impact Guidelines 1.1* (Department of the Environment, Water, Heritage and the Arts 2009).

3 Existing environment

3.1 Landscape context

The study area is located in the Sydney Basin bioregion (Thackway and Cresswell 1995), and in the Sydney Metro catchment management area in the Cumberland sub-region. The Cumberland Plain comprises gently undulating plains and low hills. The Cumberland Plain is formed on sediments derived from Wianamatta Shale comprising clay-based soils. On the fringes of the Cumberland Plain these clay soils grade into sandstone-derived soils. There are also alluvial soils associated with major creeks and rivers and associated with the floodplain of the Duck River and Haslams Creek which cross the M4 Motorway corridor.

The study area is contained within the Sydney Harbour and Parramatta River Catchment. The M4 Motorway corridor is located in a low relief landscape with elevations generally below 20 metres Australian Height Datum (AHD) and slopes less than five per cent. The motorway is elevated in some sections (between Church St, Parramatta and James Ruse Drive, Granville) and contains numerous bridges (viaducts) that raise the road surface above creeks, roads and other infrastructure.

The geology of the area is derived from the Wianamatta Group with the Ashfield Shale underlying most of the proposed expansion. Three soil landscapes are encountered across the study area and are described below in **Table 3-1**. The M4 Motorway corridor is located near the Parramatta River, and therefore there is the potential for some of the study area to be reclaimed land or landfill and consequently classified as a disturbed soil (McLoughlin 2000).

Table 3-1: Soil landscapes of the study area (McLoughlin 2000)

Soil Landscape	Description
Birrong	Fluvial, localised flooding, high soil erosion hazard, saline subsoils, seasonal waterlogging, very low soil fertility
Blacktown	Residual, moderately reactive highly plastic subsoil, low soil fertility, poor soil drainage.
Disturbed	Limitations dependent on nature of fill material. Mass movement hazard, unconsolidated low wet-strength materials, impermeable oil, poor drainage, localised very low fertility and toxic materials.

Source: McLoughlin (2000)

3.2 Land use

Land surrounding the M4 Motorway corridor comprises:

- Industrial land.
- Densely populated residential suburbs.
- Public parklands including natural and constructed waterways with a mix of naturally occurring riparian vegetation and planted and maintained landscapes.
- Commercial properties.
- Narrow roadside landscapes established with the construction of the motorway and consisting of predominantly planted native species and exotic grassy drainage swales.

3.3 Vegetation communities and habitat

3.3.1 Vegetation communities

Planted vegetation dominates the motorway verges and consists of a diversity of plant species, both exotic and non-indigenous, as well as species representative of the original local vegetation, which may have been sourced from local seed. Small and isolated patches of remnant vegetation are also present, however a high level of disturbance from urban development has altered the species composition and vegetation structure of any remnant vegetation in the study area such that there current condition is highly degraded.

The remnant vegetation communities were classified according to Tozer (2003), threatened ecological communities and the Biometric Vegetation Types database (OEH 2012). These are described in **Table 3-2** including the conservation status and regional cleared estimate according to OEH (2012) and the approximate area for each type in the study area. A total of three separate remnant vegetation community types were identified and five additional map units consisting of highly modified and/or planted and exotic vegetation including several subtypes, described as:

- Map Unit 1: Mangrove Forest (**Plate 3-1**).
- Map Unit 2: Swamp Oak Floodplain Forest (**Plate 3-2**).
- Map Unit 3: Shale-Gravel Transition Forest.
- Map Unit 4: Freshwater Drainage Lines.
- Map Unit 5: Estuarine Drainage Lines
- Map Unit 6: Planted Monocultures (6a Casuarina species, 6b Ficus species; 6c Spotted Gum; 6d Native Shrubs; 6e Tallowwood)
- Map Unit 7: Mixed Plantings
- Map Unit 8: Exotic vegetation

A summary of the vegetation community descriptions and corresponding fauna habitat types is provided in **Table 3-2**. The distribution of these communities in the study area is displayed in **Figure 3-1a** to **Figure 3-1e**. A comprehensive list of the flora species present within the study area has been included as **Appendix B**.

The vegetation condition for remnant areas was assessed using the vegetation condition assessment plots according to the biobanking methodology (Seidel and Briggs 2008). Condition was not assessed in planted and disturbed vegetation (Map Units 6, 7, and 8) or within Map Unit 4 due to the very small patch size. The results of the condition assessments are summarised for each relevant map unit in **Table 3-2** including corresponding threatened ecological communities and a description of each map unit including ecological condition.

Table 3-2 Vegetation and fauna habitat types in the study area

Map Unit	Biometric Vegetation Type	Description	Status	Condition	Area in study area (ha)	Cleared estimate #	Fauna habitat type and characteristics
Map Unit 1: Mangrove Forest	Mangrove forest in estuaries of the Sydney Basin and South East Corner	This community occurs on estuarine mudflats exposed to daily tidal inundation (Plate 3-1). In the study area this community occurs along Duck Creek between the James Ruse Drive and Silverwater Road intersections This community is dominated by Grey Mangrove (*Avicennia marina subsp. australasica*). The understorey is generally dominated by areas of open water and muddy flats with abundant pneumatophores of Grey Mangrove protruding for the sediments. There are some saltmarsh associated species on muddy flats beneath the Grey Mangroves including Creeping Brookweed (*Samolus repens*), Streaked Arrow-grass (*Triglochin striata*), Saltwater Couch (*Sporobolus virginicus var. minor*) and Austral Seablite (*Suaeda australis*). This community is in relatively good condition with only a light abundance of weed species on the edges of this community. Condition assessments in this community recorded a high habitat condition based on the site values present. This community is naturally low in floral diversity, with a closed to open canopy, no mid-storey, limited ground cover and abundant regeneration of canopy species. This community scored about 98 out of a potential benchmark of 100.	Fish habitat including mangroves are protected under the FM Act	High	0.6	50%	Mangrove Forest habitats provide potential habitat for a range of migratory and threatened bird species as well as a range of common bird species. Numerous migratory bird species have been recorded in the Parramatta River estuary downstream of Duck Creek with Bar-tailed Godwit (*Limosa laponnica*) and Sharp-tailed Sandpiper (*Calidris acuminata*) being the most common species (SOPA 2011). There is potential for the endangered population of White-fronted Chat (*Epthianura albifrons*) to utilise habitats in the study area for foraging and nesting, although habitat suitability is considered marginal. There are records of this species to the north of the study area in Newington Nature Reserve. The threatened Curlew Sandpiper (*Calidris ferruginea*) has also been recorded in the estuarine habitats of the Homebush area. One species was observed in this habitat during the surveys comprising Great Cormorant (*Phalacrocorax carbo*). A small hollow stag was identified in a dead mangrove tree on the northern bank of Duck River adjacent to the

Map Unit	Biometric Vegetation Type	Description	Status	Condition	Area in study area (ha)	Cleared estimate #	Fauna habitat type and characteristics
							cycle way. This area constitutes the main intact fauna corridor within the study area linking habitats upstream to the south of the study area and areas of habitat to the north.
Map Unit 2: Swamp Oak Floodplain Forest	Swamp Oak - Prickly Tea-tree - Swamp Paperbark swamp forest on coastal floodplains, Sydney Basin and South East Corner	Swamp Oak Floodplain Forest is restricted to a small area adjacent to Duck River in the study area. This community is dominated by Swamp Oak (*Casuarina glauca*) which includes planted and remnant trees (Plate 3-2). There is also a relatively large remnant Broad-leaved Ironbark (*Eucalyptus fibrosa*) present in this community possibly part of former natural woodland communities on higher elevated areas surrounding Duck River. The understorey is dominated by a mix of native and exotic species, with exotic species generally being dominant over the majority of the patch with several small patches dominated by native flora. Native species present include Basket Grass (*Oplismenus aemulus*), Wild Violet (*Viola banksii*) and Weeping Grass (*Microlaena stipoides*). Dominant exotic flora species include Paddy's Lucerne (*Sida rhombifolia*), Panic Veldt-grass (*Ehrharta erecta*), Madeira Vine (*Anredera cordifolia*) and Purple-top (*Verbena bonariensis*). Condition assessments in this community recorded a moderate habitat condition based on the site values present. Naturally, this community is low in floral	Endangered, TSC Act	Moderate	0.1	95%	Swamp Oak Forest in the study area occurs as a small fragmented patch which provides habitat for several common vertebrate fauna species. Threatened fauna species are unlikely to be reliant on this area of habitat Some of the remnant Swamp Oak trees are senescent with decorticating bark and small fissures which provide habitat for small fauna such as skinks, invertebrates and frogs and potentially microbats.

Map Unit	Biometric Vegetation Type	Description	Status	Condition	Area in study area (ha)	Cleared estimate #	Fauna habitat type and characteristics
		diversity, with a closed to open canopy, an open mid-storey layer, a relatively dense ground cover and often abundant regeneration of canopy species. This community scored about 69 out of a potential benchmark of 100. Site values included a discontinuous canopy, limited mid storey cover, an exotic dominated understorey, moderate native diversity levels, regeneration of canopy species and a stag/hollow was present.					
Map Unit 3: Shale-Gravel Transition Forest	Broad-leaved Ironbark - Grey Box - *Melaleuca decora* grassy open forest on clay/gravel soils of the Cumberland Plain, Sydney Basin	There is a very small patch of remnant vegetation with affinities to Shale-Gravel Transition Forest. This vegetation type is restricted to several small patches and trees at the intersection of Hill Road and the M4 Motorway. One patch was isolated by the westbound on ramp at this location and could not be accessed due to safety concerns. Also included are about six remnant *Melaleuca decora* on the northern side of the M4 Motorway adjacent to Hill Road. This community is dominated by an open canopy of Woollybutt (*Eucalyptus longifolia*) and a small tree stratum of *Melaleuca decora.* A mid-storey layer of Prickly-leaved Paperbark (*Melaleuca nodosa*) is also present. The understorey is dominated by exotic flora species including Panic Veldt-grass, Moth Vine (*Araujia sericifera*), Paddy's Lucerne and Cobbler's Peg (*Bidens pilosa*). This patch of vegetation has been subject to significant disturbances as evidenced by the highly depleted floristic	Endangered, TSC Act	Moderate	0.4	75%	Grassy Woodland in the study area is limited to several small isolated patches of disturbed habitat and several small trees surrounded by urban development. Habitat for Cumberland Plain Snail is typically low to very low and influenced by the dense cover of exotic grasses; lack of microhabitat features, small patch size and lack of connectivity. Part of this area is currently being utilised by Sacred Ibis (*Threskiornis aethiopica*) for nesting and/or roosting, with hatchlings observed in one nest during the surveys. A small hollow was observed in one of the Woollybutt (*Eucalyptus longifolia*) trees in this community.

Map Unit	Biometric Vegetation Type	Description	Status	Condition	Area in study area (ha)	Cleared estimate #	Fauna habitat type and characteristics
		diversity and dominance of exotic flora in understorey. However the upper structural layers of this community have been retained despite these disturbances. This area may have been subject to restoration practices in the past. Condition assessments in this community recorded a moderate habitat condition based on the site values present. Naturally, this community has a high floral diversity (benchmark 38 species), with an open canopy, mid-storey and ground layers, with hollow trees and fallen timber. This community scored about 48 out of a potential benchmark of 100. Site values included a low floristic diversity, a discontinuous canopy, intact mid storey cover, an exotic dominated understorey, no regeneration of canopy species and a hollow tree was present.					
Map Unit 4: Freshwater Drainage Lines	(in part) Phragmites australis and Typha orientalis coastal freshwater wetlands of the Sydney Basin	This map unit occurs in natural and constructed freshwater drainage channels where there is continuous moisture. This community varies throughout the study area from areas of open water to areas with low to moderate densities of macrophyte vegetation. This map unit occurs mostly as thin strips along modified drainage lines. Riparian vegetation is generally absent or dominated by exotic vegetation. These areas are considered to be in a low condition due to the highly modified nature of these areas.	Endangered, TSC Act	Low	1.0	70%	Freshwater Wetland habitats in the study area support low quality habitat conditions. Naturally occurring riparian vegetation is absent, with planted Swamp Oak in some locations. Habitat for threatened fauna species is generally absent. These areas provide habitat for common frogs and reptiles, such as Common Eastern Froglet (*Crinia signifera*) and the Eastern Water Skink (*Eulamprus quoyii*). Common birds in this habitat include the Great Egret (*Ardea*

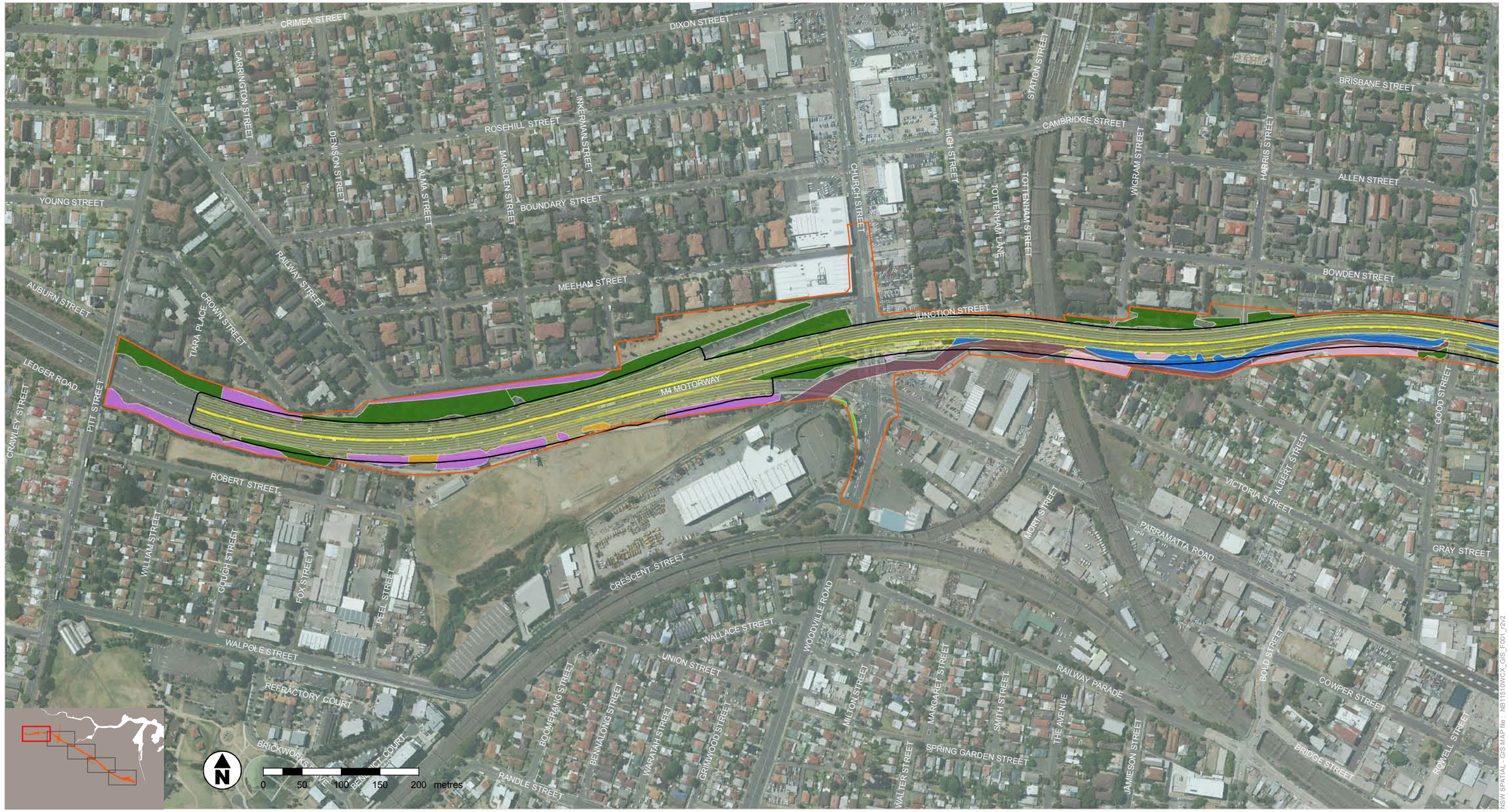
Map Unit	Biometric Vegetation Type	Description	Status	Condition	Area in study area (ha)	Cleared estimate #	Fauna habitat type and characteristics
		Common native species include Cumbungi (*Typha orientalis*), Common Rush (*Juncus usitatus*), *Schoenoplectus validus*, Common Reed (*Phragmites australis*) and Knotweeds (*Persicaria* spp.). There is also a high density of exotic flora usually present such as Umbrella Sedge (*Cyperus eragrostis*), Wandering Dew (*Tradescantia fluminensis*), Dock (*Rumex* spp.), Rhodes Grass (*Chloris gayana*) and Parramatta Grass (*Sporobolus africanus*).There are also and colonising exotic trees and shrubs on the edges of drainage lines such as Privet (*Ligustrum* spp.) and Mulberry (*Morus alba*). This map unit occurs along non-tidal drainage lines of the study area including the A'Becketts Creek and several smaller concrete lined drainage channels.					*modesta*) and White-faced Heron (*Egretta novaehollandiae*). Planted vegetation adjacent to drainage lines supported several additional bird species such as honeyeaters and Superb Fairy-wren (*Malurus cyaneus*).
Map Unit 5: Estuarine Drainage Lines	N/A	This map unit comprises concrete lined tidal channels in the study area including Haslam's Creek and Duck Creek. There is generally no aquatic or riparian vegetation associated with these areas being restricted to a concrete-lined channel	N/A	Low	0.5	N/A	Estuarine Wetland provide limited habitat for fauna species considering the presence of a concrete channels with an absence of mangrove and saltmarsh vegetation including mud flats. These drainage lines still provide foraging habitats for water bird species such as White-faced Heron.
Map Unit 6: Planted Monocultures (6a Casuarina species; 6b	N/A	This map unit comprises monoculture plantings of various species including Swamp Oak and River Oak (*Casuarina cunninghamii*) (Map Unit 5a), Hill's Weeping Fig (*Ficus microcarpa var. hillii*) and Moreton Bay Fig (*Ficus macrophylla*) (Map Unit 5b), Spotted Gum	N/A	Low	6a: 2.6 6b: 3.7 6c: 0.5 6d: 0.1 6e: 0.6	N/A	Planted forest/woodland habitats rarely support any native groundcovers and often have a sparse planted shrub layer. The understorey is dominated by dense

Map Unit	Biometric Vegetation Type	Description	Status	Condition	Area in study area (ha)	Cleared estimate #	Fauna habitat type and characteristics
Ficus species; 6c Spotted Gum; 6d Native Shrubs; 6e Tallowwood)		(*Corymbia maculata*) (Map Unit 5c), native shrubs including Weeping Bottlebrush (*Callistemon viminalis*) and Flax-leaved Paperbark (*Melaleuca linariifolia*) and Tallowwood (*Eucalyptus microcorys*). This map unit is distributed throughout the study area. The understorey is dominated by exotic flora including a wide range of environmental and noxious weed species. This map unit is distributed throughout the study area.					tall exotic grasses, such that there is little to no open areas in the ground cover and minimal leaf litter present. The habitat structure is simplified and lacks structural maturity or important features such as hollows, timber on the ground and shrubs or tall canopy. Habitat for Cumberland Plain Snail is typically low to very low and influenced by the dense cover of exotic grasses; lack of microhabitat features, small patch size and lack of connectivity. Common fauna species include the introduced Spotted Turtle-dove (*Streptopelia chinensis*) and Common Myna (*Acridotheres tristis*) as well as Australian Magpie, Crested Pigeon (*Ocyphaps lophotes*) and Garden Sunskink (*Lampropholis guichenoti*).
Map Unit 7: Mixed Plantings	N/A	This map unit consists of mixed plantings of Eucalypt species, Figs (*Ficus* spp.), She-oaks (*Casuarina* spp.) and various native shrub species including Wattles (*Acacia* spp.), Paperbarks and Bottlebrush (*Callistemon* spp.). This map unit is the most dominant in the study area including a range of planted native species, exotic weeds and horticultural species. The species composition varies throughout the distribution of this unit being subject to planting mixes of landscaping activities during the time of construction.	N/A	Low	19.3	N/A	Planted forest/woodland habitats as per Map Unit 6

Map Unit	Biometric Vegetation Type	Description	Status	Condition	Area in study area (ha)	Cleared estimate #	Fauna habitat type and characteristics
		Flora species include local native species and native flora not naturally occurring in local vegetation communities and native species from other regions of NSW. Tree species planted include all those recorded in Map Unit 5 in addition to Forest Red Gum (*Eucalyptus tereticornis*), Lemon-scented Gum (*Corymbia citriodora*), Brush Box (*Lophostemon confertus*), Cabbage Gum (*Eucalyptus amplifolia*), Yellow Box (*Eucalyptus melliodora*), Flooded Gum (*Eucalyptus grandis*), Grey Box (*Eucalyptus moluccana*), Narrow-leaved Ironbark (*eucalyptus crebra*), Silky Oak (*Grevillea robusta*), Mugga Ironbark (*Eucalyptus sideroxylon*), Smooth-barked Apple (*Angophora costata*), Rough-barked Apple (*Angophora floribunda*) and Grey Gum (*Eucalyptus punctata*). Native shrub species in addition to those listed under Map Unit 5 include Fringed Wattle (*Acacia fimbriata*), Coast Myall (*Acacia binervia*), Sickle Wattle (*Acacia falcata*), Broad-leaved Paperbark (*Melaleuca quinquenervia*) Bracelet Honey-myrtle (*Melaleuca armillaris*), Prickly Paperbark (*Melaleuca styphelioides*), Crimson Bottlebrush (*Callistemon citrinus*), Narrow-leaved Bottlebrush (*Callistemon linearis*), Stiff Bottlebrush (*Callistemon rigidus*), Coastal Rosemary (*Westringia fruticosa*) and Lemon-scented Tea-tree (*Leptospermum petersonii*). The understorey is dominated by exotic flora including a wide range of environmental and noxious weed species.					

Map Unit	Biometric Vegetation Type	Description	Status	Condition	Area in study area (ha)	Cleared estimate #	Fauna habitat type and characteristics
		This map unit is distributed throughout the study area.					
Map Unit 8: Exotic Vegetation	N/A	This map unit includes areas dominated by exotic trees, shrubs and groundcovers. Dominant species vary although common species include: trees such as Camphor Laurel (*Cinnamomum camphora*), Jacaranda (*Jacaranda mimosifolia*), Privet species (*Ligustrum spp.*) and African Olive (*Olea europaea subsp. africana*); shrubs such as Paddy's Lucerne (*Sida rhombifolia*), Green Cestrum (*Cestrum parqui*) and the non-indigenous native species from Western Australia Golden Wreath Wattle (*Acacia saligna*); exotic groundcovers mainly include grass species such as Rhodes Grass, African Lovegrass (*Eragrostis curvula*) and Green Panic (*Panicum maximum var. trichoglume*); and exotic vines and scramblers species dominate some areas including Balloon Vine (*Cardiospermum grandiflorum*) and Morning Glory (*Ipomoea indica*).	N/A	Very low	1.0	N/A	Exotic vegetation provides poor habitat value for fauna. These areas generally have a lack of food resources to attract foragers and limited nesting/roosting habitat. May be used by a range of introduced fauna and wide-ranging common fauna only. A small hollow was observed in a large Pepper Tree (*Schinus areira*) east of Church Street. This hollow is unlikely to be important for local fauna species considering the size and height from the ground (2.5 metres).

Cleared estimate from the Biometric Vegetation Types database (OEH 2012).



WestConnex study area
Design
Indicative construction footprint

Vegetation communities

- Map Unit 1: Mangrove Forest
- Map Unit 2: Swamp Oak Floodplain Forest
- Map Unit 3: Shale-Gravel Transition Forest
- Map Unit 4: Freshwater Drainage Lines
- Map Unit 5: Estuarine Drainage Lines
- Map Unit 6a: Planted Monocultures - Casuarina
- Map Unit 6b: Planted Monocultures - Figs
- Map Unit 6c: Planted Monocultures - Spotted Gum
- Map Unit 6d: Planted Monocultures - Native Shrubs
- Map Unit 6e: Planted Monocultures - Tallowwood
- Map Unit 7: Mixed Plantings
- Map Unit 8: Exotic vegetation

SCALE 1:5,000
A3
SHEET 1 of 5
COORDINATE SYSTEM GDA 1994 MGA Zone 56

TITLE
Figure 3-1 a
Distribution of vegetation communities in the study area

PROJECT
WestConnex Stage 1 - M4 Widening

CLIENT
ROADS AND MARITIME SERVICES

DRAWN	PROJECT #	MAP #	REV VER
KM	NB11510		
CHECK	DATE	F001	2 1
CT	17/05/2014		

NSW SPATIAL - GIS MAP file : NB11510WCX_GIS_F001_r2r2

WestConnex study area
Design
Indicative construction footprint

Vegetation communities

- Map Unit 1: Mangrove Forest
- Map Unit 2: Swamp Oak Floodplain Forest
- Map Unit 3: Shale-Gravel Transition Forest
- Map Unit 4: Freshwater Drainage Lines
- Map Unit 5: Estuarine Drainage Lines
- Map Unit 6a: Planted Monocultures - Casuarina
- Map Unit 6b: Planted Monocultures - Figs
- Map Unit 6c: Planted Monocultures - Spotted Gum
- Map Unit 6d: Planted Monocultures - Native Shrubs
- Map Unit 6e: Planted Monocultures - Tallowwood
- Map Unit 7: Mixed Plantings
- Map Unit 8: Exotic vegetation

SCALE 1:5,000 | A3
SHEET 2 of 5 | COORDINATE SYSTEM GDA 1994 MGA Zone 56

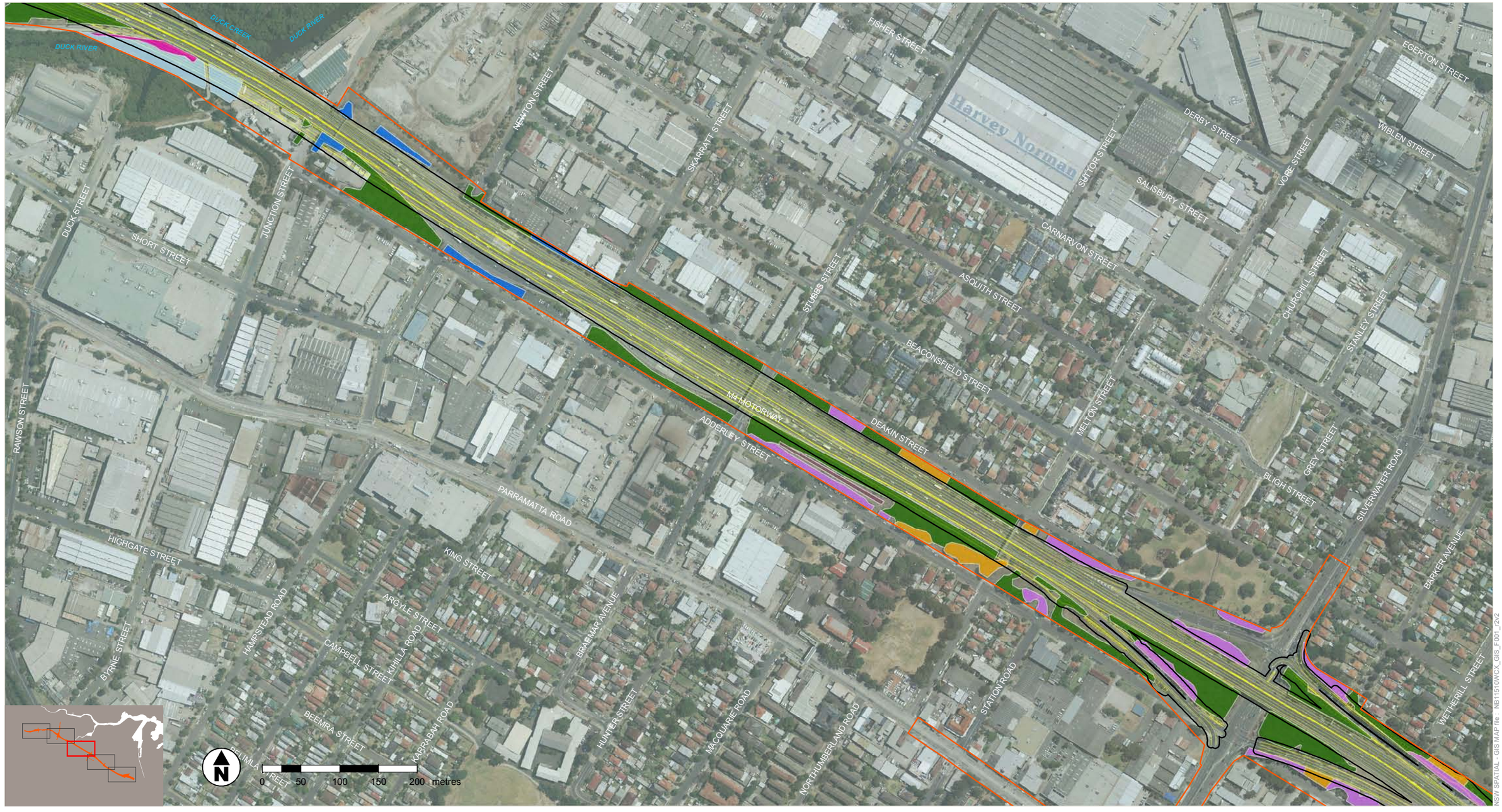
TITLE
Figure 3-1 b
Distribution of vegetation communities in the study area

PROJECT
WestConnex Stage 1 - M4 Widening

CLIENT
ROADS AND MARITIME SERVICES

DRAWN	PROJECT #	MAP #	REV VER
KM	NB11510	F001	2 1
CHECK CT	DATE 17/05/2014		

NSW SPATIAL GIS MAP file : NB11510WCX_GIS_F001_r2v2



WestConnex study area
Design
Indicative construction footprint

Vegetation communities

- Map Unit 1: Mangrove Forest
- Map Unit 2: Swamp Oak Floodplain Forest
- Map Unit 3: Shale-Gravel Transition Forest
- Map Unit 4: Freshwater Drainage Lines
- Map Unit 5: Estuarine Drainage Lines
- Map Unit 6a: Planted Monocultures - Casuarina
- Map Unit 6b: Planted Monocultures - Figs
- Map Unit 6c: Planted Monocultures - Spotted Gum
- Map Unit 6d: Planted Monocultures - Native Shrubs
- Map Unit 6e: Planted Monocultures - Tallowwood
- Map Unit 7: Mixed Plantings
- Map Unit 8: Exotic vegetation

SINCLAIR KNIGHT MERZ SKM

SCALE 1:5,000 | A3
SHEET 3 of 5 | COORDINATE SYSTEM GDA 1994 MGA Zone 56

TITLE
Figure 3-1 c
Distribution of vegetation communities in the study area

PROJECT
WestConnex Stage 1 - M4 Widening

CLIENT
ROADS AND MARITIME SERVICES

DRAWN	PROJECT #	MAP #	REV	VER
KM	NB11510	F001	2	1
CHECK CT	DATE 17/05/2014			

NSW SPATIAL - GIS MAP file - NB11510WCX_GIS_F001_r2v2

WestConnex study area
Design
Indicative construction footprint

Vegetation communities

- Map Unit 1: Mangrove Forest
- Map Unit 2: Swamp Oak Floodplain Forest
- Map Unit 3: Shale-Gravel Transition Forest
- Map Unit 4: Freshwater Drainage Lines
- Map Unit 5: Estuarine Drainage Lines
- Map Unit 6a: Planted Monocultures - Casuarina
- Map Unit 6b: Planted Monocultures - Figs
- Map Unit 6c: Planted Monocultures - Spotted Gum
- Map Unit 6d: Planted Monocultures - Native Shrubs
- Map Unit 6e: Planted Monocultures - Tallowwood
- Map Unit 7: Mixed Plantings
- Map Unit 8: Exotic vegetation

SCALE 1:5,000 | A3
SHEET 4 of 5 | COORDINATE SYSTEM GDA 1994 MGA Zone 56

TITLE
Figure 3-1 d
Distribution of vegetation communities in the study area

PROJECT
WestConnex Stage 1 - M4 Widening

CLIENT
ROADS AND MARITIME SERVICES

DRAWN	PROJECT #	MAP #	REV	VER
KM	NB11510			
CHECK	DATE			
CT	17/05/2014	F001	2	1

NSW SPATIAL - GIS MAP file : NB11510WCX_GIS_F001_r2r2

WestConnex study area

Design

Indicative construction footprint

Vegetation communities

- Map Unit 1: Mangrove Forest
- Map Unit 2: Swamp Oak Floodplain Forest
- Map Unit 3: Shale-Gravel Transition Forest
- Map Unit 4: Freshwater Drainage Lines
- Map Unit 5: Estuarine Drainage Lines
- Map Unit 6a: Planted Monocultures - Casuarina
- Map Unit 6b: Planted Monocultures - Figs
- Map Unit 6c: Planted Monocultures - Spotted Gum
- Map Unit 6d: Planted Monocultures - Native Shrubs
- Map Unit 6e: Planted Monocultures - Tallowwood
- Map Unit 7: Mixed Plantings
- Map Unit 8: Exotic vegetation

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SCALE 1:5,000 | A3

SHEET 5 of 5 | COORDINATE SYSTEM GDA 1994 MGA Zone 56

TITLE

Figure 3-1 e
Distribution of vegetation communities in the study area

PROJECT
WestConnex Stage 1 - M4 Widening

CLIENT
ROADS AND MARITIME SERVICES

DRAWN	PROJECT #	MAP #	REV VER
KM	NB11510	F001	2 1
CHECK CT	DATE 17/05/2014		

Plate 3-1 Mangrove Forest on southern bank of Duck River showing mud flat area

Plate 3-2 Swamp Oak Floodplain Forest showing planted trees on the top of river bank and larger remnant tree to left of photo on the edge of Duck River. Photo shows dense groundcover of exotic weeds common in the riparian areas

3.3.2 Fauna habitat

Natural habitats for fauna have been extensively removed or modified for commercial, industrial and residential development and are now largely confined to narrow, linear strips of planted trees and degraded riparian habitats. Fauna habitats are mapped in **Figure 3-2a** to **Figure 3-2e,** including hollow-bearing trees and dead-standing trees which are scarce. Remaining patches of habitat are small and fragmented and can be described as:

- Narrow linear strips of Grey Mangrove (*Avicennia marina*) and Swamp Oak (*Casuarina glauca*) occurring along the edges of Duck River. These habitats have a high proportion of exotic vegetation.
- A small patch of remnant woodland with disturbed groundcover of dense exotic grasses.
- Narrow corridors of immature planted vegetation with an absence of tree hollows and logs and a dense groundcover of exotic grasses.
- Cleared and modified landscapes with occasional planted trees.

Areas of Grey Mangrove are restricted to the banks and tidal flats of Duck River, and have naturally low floristic diversity. Areas of Swamp Oak forest are present on river-flat areas above the river banks adjacent to the bike path comprising a mix of planted and remnant Swamp Oak trees with a mix of native and exotic flora in the understorey. These habitats provide potential foraging and nesting/roosting opportunities for semi-aquatic bird species, such as cormorants, ducks and ibis.

The woodland habitat type is restricted to several small patches and trees at the intersection of Hill Road and the M4 Motorway and a small patch near Rawson Road. One patch was isolated by the westbound on ramp at this location and also included are about six remnant *Melaleuca decora* on the northern side of the M4 Motorway adjacent to Hill Road. This area is dominated by exotic flora in the understorey, however native canopy, sub-canopy and mid-storey layers are present. This area is currently being used by Sacred Ibis (*Threskiornis aethiopica*) as a rookery (nesting and roosting), with hatchlings observed in one nest during the survey. A small hollow was observed in one of the Woollybutt (*Eucalyptus longifolia*) trees in this community, which may be used by hollow-dependent microbats. This habitat provides foraging resources for threatened bird species and the Grey-headed Flying-fox.

With the exception of Duck River all other major drainage lines are highly disturbed being

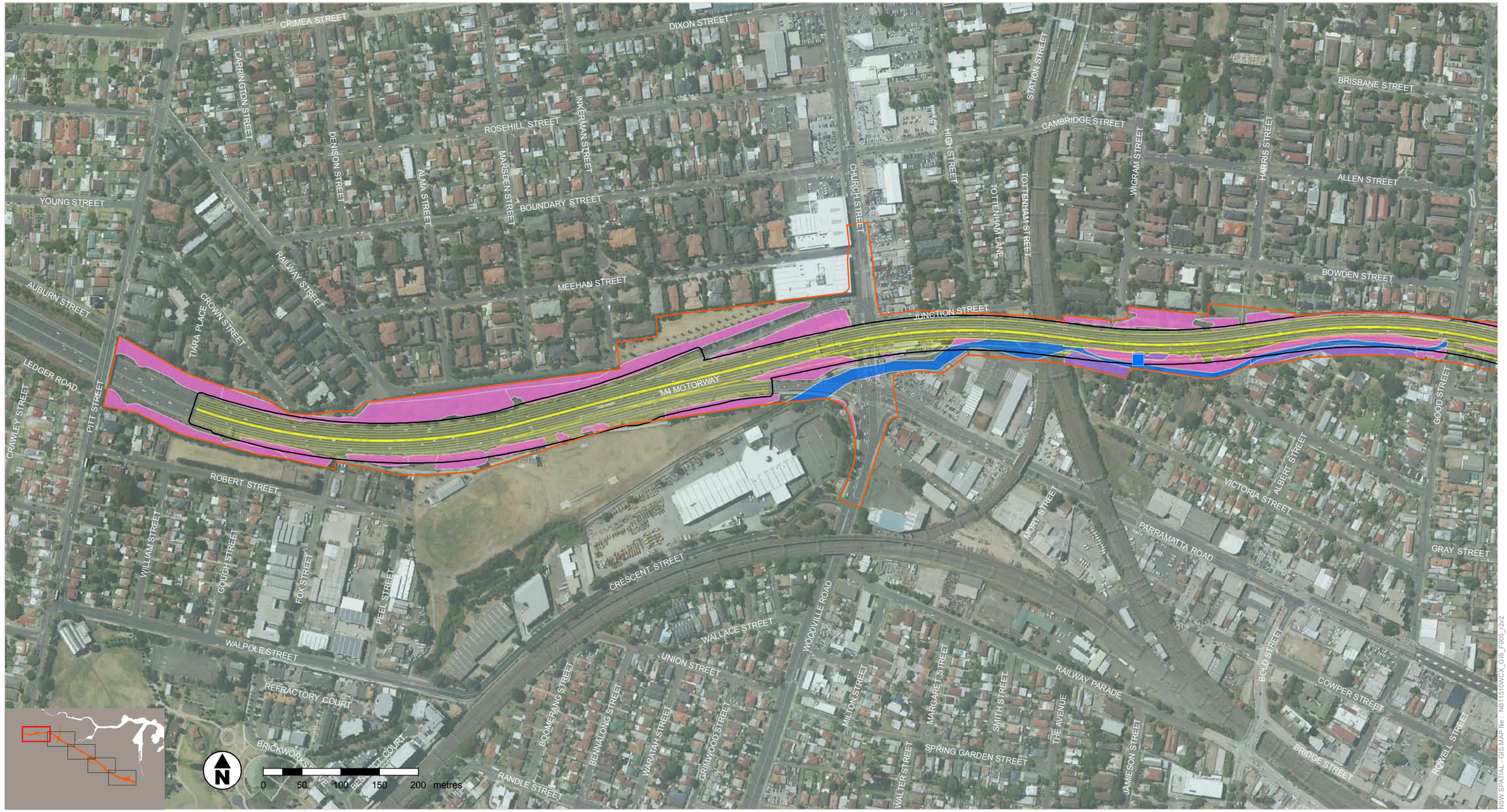
mostly concrete lined channels devoid of any native or planted riparian vegetation. Where riparian vegetation is present it is dominated by exotic flora species. The edges of some concrete channels have been planted with Swamp Oak providing some riparian vegetation cover. The highest bird diversity was recorded along the edges of concrete lined creeks with planted Swamp Oak and *Eucalyptus* species along the edges. These habitats provide potential although marginal foraging opportunities for birds and bats.

The remainder and majority of the road corridor landscape is a mix of young and semi-mature planted vegetation. These areas rarely support any native groundcovers and often have a sparse planted shrub layer dominated by exotic shrubs, grasses, herbs, vines and scramblers such that there is little to no patchiness in the ground cover and no leaf litter present. There is an absence of structural maturity and no tree hollows or logs, reducing the value of the habitat as sheltering or refuge areas for larger or hollow dependent fauna. These areas provide foraging habitat for common urban species. Some sheltering habitat is provided for reptiles and invertebrates through rubbish dumping and dense groundcovers. The overall habitat condition was considered low.

A low density of trees in the study area support small hollow cavities, cracks and fissures as well as decorticating bark which may be utilised by hollow-dependent fauna including threatened microbat species (**Plate 3-3**). However the relative habitat value of these is considered low in the context of the urban landscape and potentially suitable only to smaller species such as microbats, reptiles and amphibians and it is unlikely that these microhabitats support large populations of hollow-dependent fauna. There are limited other potential roost sites present for microbat species in the form of cavities under concrete bridges and culverts and no evidence of roosting by microbats was recorded at the time of the survey. The Eastern Bentwing-bat (*Miniopterus schreibersii*) is known to roost in artificial structures under other sections of the M4 Motorway, however no evidence was reported in this study area. A small number of Fairy Martin (*Petrochelidon ariel*) nests were observed (**Plate 3-4**) under existing M4 Motorway bridges and viaducts, as well as numerous culverts, buildings and other structures which may provide roosting habitat. Several bat species are known to roost in the mud nests of Fairy Martins (Schulz 1997).

Plate 3-3 Small hollows and fissures in a senescent mangrove tree

Plate 3-4 Fairy-martin nests beneath the existing M4 Motorway viaduct which provides potential roosting habitat for threatened microbat species



WestConnex study area
Design
Indicative construction footprint

Vegetation communities
- Estuarine Wetland
- Exotic vegetation
- Freshwater Wetland
- Grassy Woodland
- Mangrove Forest
- Planted forest/woodland habitats
- Swamp Oak Forest

Fauna habitats
- Dead-standing Trees
- Hollow Tree

SCALE 1:5,000 | A3
SHEET 1 of 5 | COORDINATE SYSTEM GDA 1994 MGA Zone 56

TITLE
Figure 3-2 a
Distribution of fauna habitats in the study area

PROJECT
WestConnex Stage 1 - M4 Widening

CLIENT
ROADS AND MARITIME SERVICES

DRAWN	PROJECT #	MAP #	REV	VER
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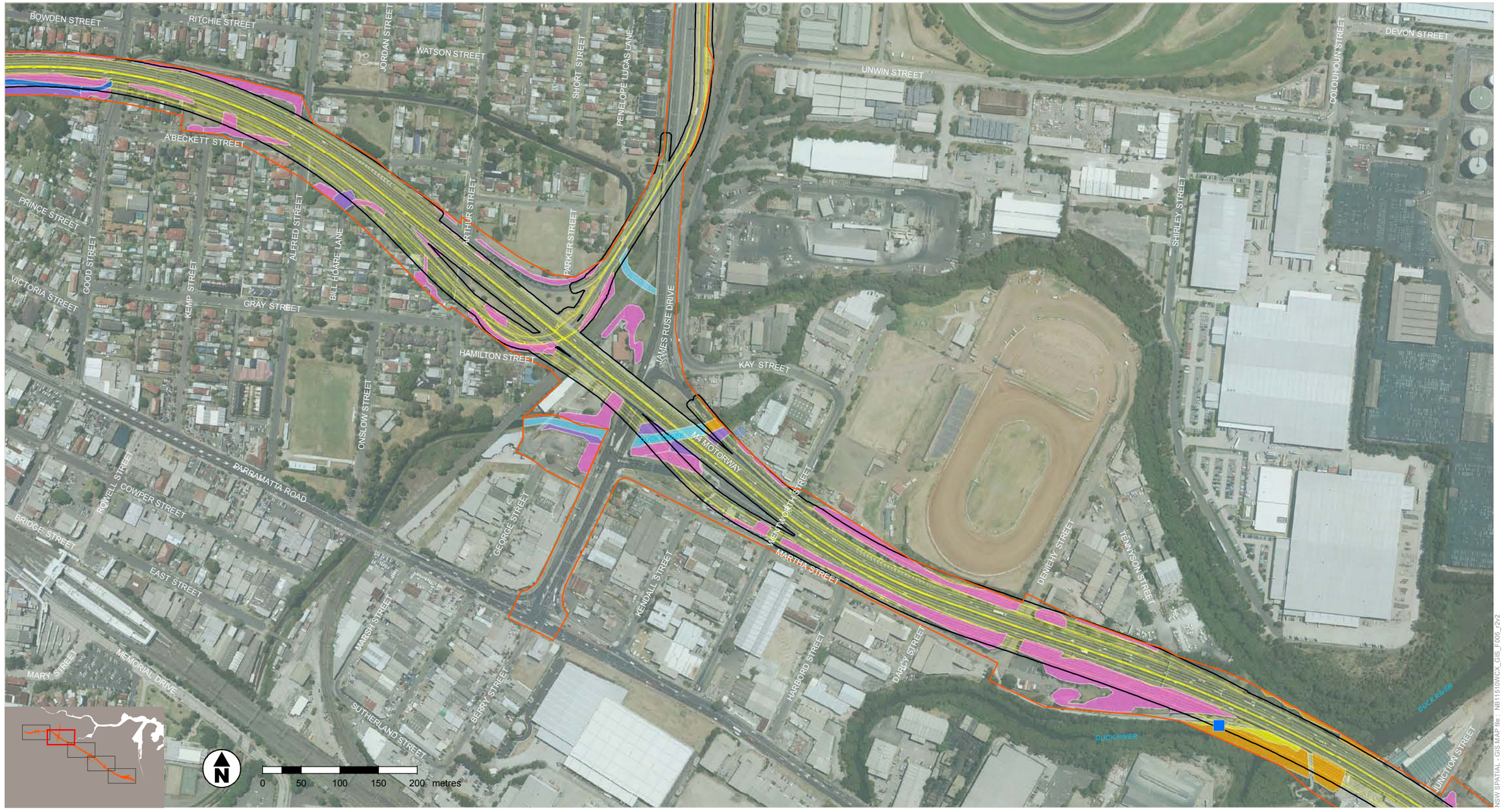
CHECK	DATE			
CT	17/05/2014	F005	2	1

NSW SPATIAL - GIS MAP file : NB11510WCX_GIS_F005_r2r2



WestConnex study area
Design
Indicative construction footprint

Vegetation communities
- Estuarine Wetland
- Exotic vegetation
- Freshwater Wetland
- Grassy Woodland
- Mangrove Forest
- Planted forest/woodland habitats
- Swamp Oak Forest

Fauna habitats
- Dead-standing Trees
- Hollow Tree

SCALE 1:5,000 | A3
SHEET 2 of 5 | COORDINATE SYSTEM GDA 1994 MGA Zone 56

TITLE
Figure 3-2 b
Distribution of fauna habitats in the study area

PROJECT
WestConnex Stage 1 - M4 Widening

CLIENT
ROADS AND MARITIME SERVICES

DRAWN	PROJECT #	MAP #	REV	VER
KM	NB11510	F005	2	1
CHECK CT	DATE 17/05/2014			

NSW SPATIAL - GIS MAP file - NB11510WCX_GIS_F005_r2v2

NSW SPATIAL - GIS MAP File : NB11510WCX_GIS_F005_r2v2

WestConnex study area
Design
Indicative construction footprint

Vegetation communities
- Estuarine Wetland
- Exotic vegetation
- Freshwater Wetland
- Grassy Woodland
- Mangrove Forest
- Planted forest/woodland habitats
- Swamp Oak Forest

Fauna habitats
- Dead-standing Trees
- Hollow Tree

SCALE 1:5,000 | A3
SHEET 3 of 5 | COORDINATE SYSTEM GDA 1994 MGA Zone 56

TITLE
Figure 3-2 c
Distribution of fauna habitats in the study area

PROJECT
WestConnex Stage 1 - M4 Widening

CLIENT
ROADS AND MARITIME SERVICES

DRAWN	PROJECT #	MAP #	REV	VER
KM	NB11510			
CHECK	DATE			
CT	17/05/2014	F005	2	1

NSW SPATIAL - GIS MAP file : NB11510WCX_GIS_F005_r2v2

WestConnex study area
Design
Indicative construction footprint

Vegetation communities
- Estuarine Wetland
- Exotic vegetation
- Freshwater Wetland
- Grassy Woodland
- Mangrove Forest
- Planted forest/woodland habitats
- Swamp Oak Forest

Fauna habitats
- Dead-standing Trees
- Hollow Tree

SCALE 1:5,000 | A3
SHEET 4 of 5 | COORDINATE SYSTEM GDA 1994 MGA Zone 56

TITLE
Figure 3-2 d
Distribution of fauna habitats in the study area

PROJECT
WestConnex Stage 1 - M4 Widening

CLIENT
ROADS AND MARITIME SERVICES

DRAWN	PROJECT #	MAP #	REV	VER
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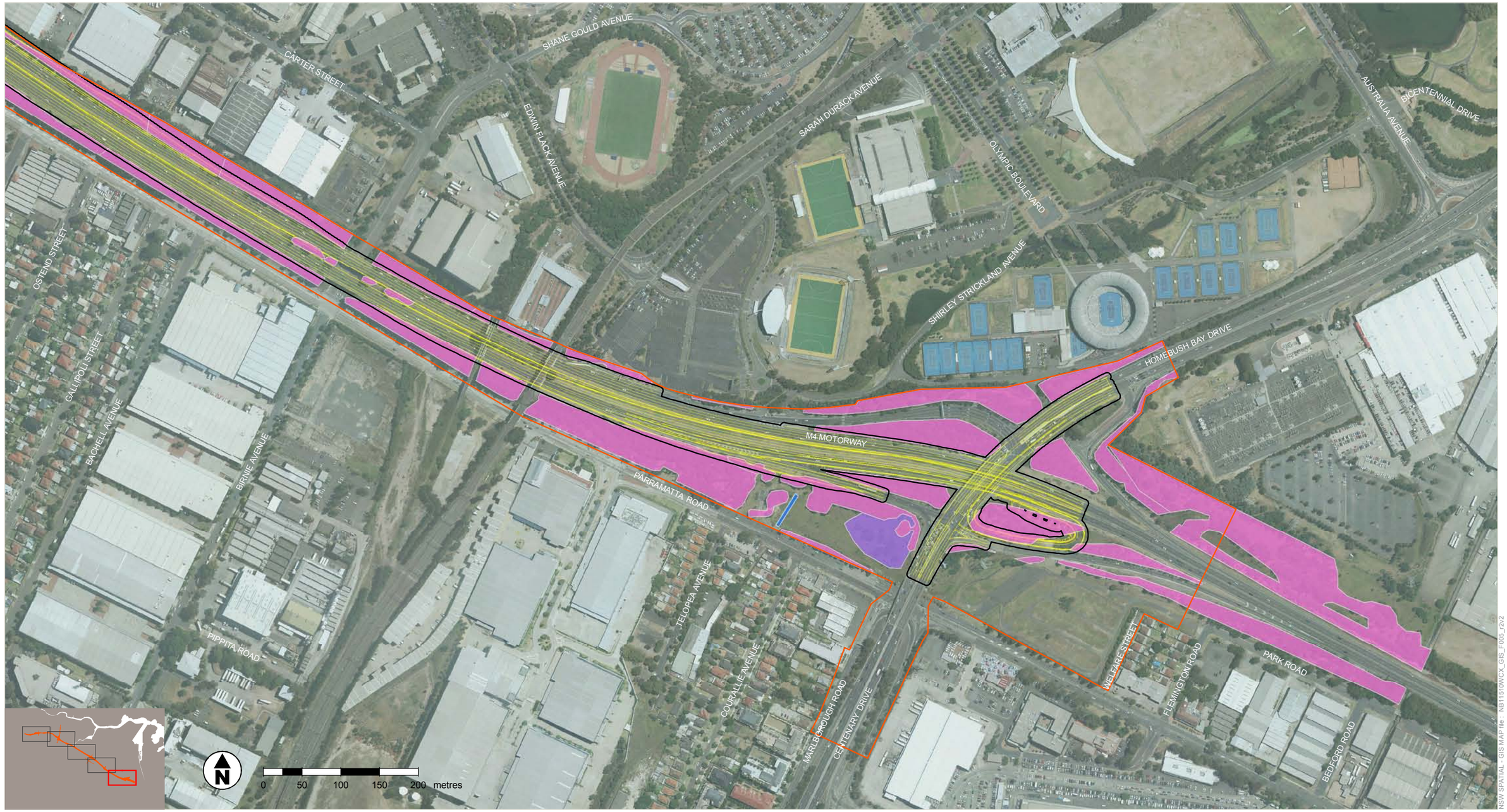
CHECK	DATE			
CT	17/05/2014			



WestConnex study area
Design
Indicative construction footprint

Vegetation communities
- Estuarine Wetland
- Exotic vegetation
- Freshwater Wetland
- Grassy Woodland
- Mangrove Forest
- Planted forest/woodland habitats
- Swamp Oak Forest

Fauna habitats
- Dead-standing Trees
- Hollow Tree

SCALE 1:5,000 | A3
SHEET 5 of 5 | COORDINATE SYSTEM GDA 1994 MGA Zone 56

TITLE
Figure 3-2 e
Distribution of fauna habitats in the study area

PROJECT
WestConnex Stage 1 - M4 Widening

CLIENT
ROADS AND MARITIME SERVICES

DRAWN	PROJECT #	MAP #	REV	VER
KM	NB11510	F005	2	1
CHECK	DATE			
CT	17/05/2014			

NSW SPATIAL - GIS MAP file : NB11510WCX_GIS_F005_r2v2

3.3.3 Aquatic habitat

The M4 Motorway is located on the southern side of the Parramatta River within the A'Becketts Creek, Duck Creek, Duck River, Haslams Creek and Powells Creek subcatchments, which all drain to the Parramatta River. These catchments are highly urbanised with much of the surrounding landuse being industrial and resulting in about 90 per cent of land surfaces being impervious (Hackney *et al.* 2010). The widening corridor crosses all these waterways with the exception of Powells Creek. Large sections of open channels have been replaced with concrete lined channels and the remaining natural channels are affected by erosion and sedimentation. The water quality of creeks is largely influenced by stormwater, aquatic weeds and erosion which are attributable to the catchment which drains to these creeks. Sewer overflows, particularly during high rainfall events, influence water quality in these subcatchments, providing additional sources of nitrogen, phosphorus, suspended solids and faecal coliforms (SKM 1999). Modelling of nutrient loads suggests that subcatchments contribute about 14 per cent of the total nitrogen (TN), total phosphorus (TP) and total suspended solids (TSS) entering Sydney Estuary per year (Birch *et al*. 2010). High pollutant loads including cadmium, copper and zinc have been recorded in Powells Creek. Duck River has elevated concentrations of lead, iron, chromium, mercury, zinc, chlordane, dieldrin, PCBs, DDT and oils and grease, which reflects the highly urbanised nature of the catchments found near the M4 Motorway corridor (SKM 1999, Birch and Rochford 2010).

There is the potential for contaminated sites to occur within the vicinity of the project due to old industrial areas and numerous contaminated sites located along the Parramatta River (Cardno 2008). Acid sulphate soils (ASS) are common in Australian estuaries. Therefore there is a potential for ASS to occur along the M4 Motorway corridor due to its proximity to the Parramatta River estuary. Mapping has also identified a high probability of the occurrence for ASS around Haslam's and Powells Creeks (Cardno 2008). Given the likelihood of ASS, more detailed information on the extent will be required where works that disturb these soils are to be undertaken. Salinity is part of the natural landscape of the Parramatta River subcatchments with salt being found in the rocks, soils and the estuarine sections of the subcatchments. These salts can potentially be mobilised during construction.

The M4 Motorway crosses Haslams Creek at the eastern end of the corridor, Duck River at Weird Bridge and Duck Creek at James Ruse Drive. James Ruse Drive also crosses A'Becketts Creek at the junction with the M4 Motorway and within the corridor widening. A'Becketts Creek then runs west along the northern edge of the M4 Motorway until Good Street Parramatta where it continues running adjacent to the M4 Motorway on its southern side. At Church Street, the creek deviates in a south-west direction away from the M4 Motorway.

The waterways assessed showed signs of impairment which is common for such a highly urbanised catchment. The habitat assessment and water quality for each site is detailed in **Appendix D**. Duck River had a natural channel with a mangrove riparian strip on both banks (**Plate 3-5**). Other sites had a thin strip (less than five metres) of riparian vegetation and partially or completely concrete-lined channels. The concrete lined channelling extended upstream and downstream, beyond the existing M4 Motorway waterway crossings. Sites were typically shallow with a width to depth ratio greater than eight to one. Stormwater drains discharge directly into several sites.

Plate 3-5 Duck River with natural channel and mangrove lined banks

Plate 3-6 Duck Creek near Kay Street with high volumes of rubbish

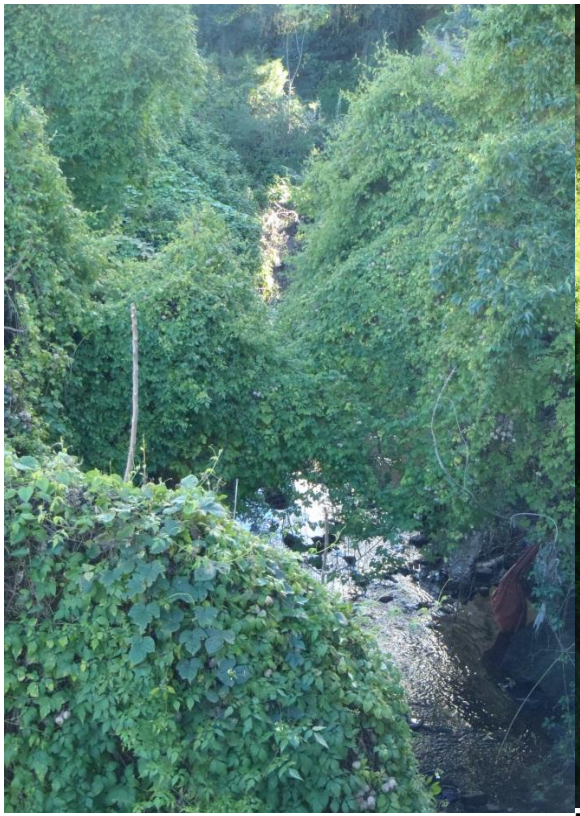


Plate 3-7 One of the small sections of A'Becketts Creek that is not concrete lined showing very dense weed infestation

Plate 3-8 Concrete-lined Duck Creek under the existing M4, with a nearby culvert at James Ruse Drive

Accumulated rubbish was observed within all waterways either in-stream or on the banks (**Plate 3-6**). Some aquatic macrophytes were observed at A'Becketts Creek although this site was thickly choked with riparian weeds (**Plate 3-7**). Generally all sites were heavily silted, with little in-stream habitat. Although A'Becketts Creek had small gravel beds in the few locations where the stream had a natural base, much of the channel contained fragments of large concrete blocks and bricks. The existing M4 Motorway crossings at the sites were primarily bridges, although culverts were observed in close proximity of the M4 Widening project corridor at adjacent roads (**Plate 3-8**).

Once the habitat of the sites was assessed, their sensitivity and functionality as fish habitat were classified according DPI (2013) (**Table 3-3**). Duck River was classed as moderately sensitive due to its muddy intertidal habitat and mangroves. Duck Creek and A'Becketts Creek were minimally sensitive based on the small area of habitat that wasn't concrete-lined. Haslam's Creek could not be classified because its entire length upstream and downstream of the corridor was concrete lined. The large estuarine waterways were classified as major key fish habitat (**Table 3-3**).

Table 3-3 Classification of waterways in the M4 Motorway corridor and preferred waterway crossing types as recommended by DPI (2013)

Waterway	Type	Classification	Minimum recommended crossing type#
Haslam's Creek	n/a^	Class 1 Major key fish habitat	Bridge, arch structure or tunnel. Bridges are preferred to arch structures.
Duck River	Type 2 Moderately sensitive		
Duck Creek	Type 3* Minimally sensitive		
A'Becketts Creek	Type 3* Minimally sensitive	Class 3 Minimal key fish habitat	Culvert or ford (box culverts are preferred to fords and pipe culverts – in that order).

^ concrete lined waterway in the vicinity of, and within, the corridor and therefore not considered key habitat
* 'type' has been classified on the small areas of natural base near the corridor in an otherwise concrete lined waterway
# crossing type is based on waterway class

The waterways were generally very turbid and two to four times higher than the upper threshold of ANZECC guidelines for estuarine waters in South East Australia. Although turbidity is not always a useful indicator for estuarine waters, nine days of continuous rainfall totalling 201 millimetres preceded the field survey. The catchment run-off may have contributed to high turbidity values. Dissolved oxygen only complied within the ANZECC guidelines at Haslam's Creek and was beneath the lower threshold value at Duck Creek and Duck River. Temperatures and salinities were higher in Duck River, presumably because it is (a) more tidally influenced and (b) there was greater infiltration of antecedent rainfall than the concrete lined channels.

The aquatic habitat assessment and water quality indicate that the ecosystem health of these creeks is poor, as a result of the urban development and the high proportion of impervious surfaces. The riparian zones are very fragmented, there is little in-stream habitat and high levels of siltation. Mangroves, which are protected in NSW under the FM Act provide the best habitat in the study area. Generally however, creeks lacked habitat diversity and are unlikely to provide significant or important fish habitat.

3.4 Threatened ecological communities

Based on the background review a number of other potentially occurring Threatened Ecological Communities (TECs) are noted for the region as listed **Table A-3** of **Appendix A**. Targeted follow-up survey confirmed the presence or absence of these communities as identified in **Table 3-4**.

A brief description of the TECs recorded in the study area is provided in **Table 3-4** and these are mapped in **Figure 3-3a** to **Figure 3-3e**. Detailed descriptions of threatened ecological communities are provided in Final Determinations for state listed communities on the OEH website (OEH 2012).

WestConnex study area

Design

Indicative construction footprint

Threatened ecological communities

- Freshwater wetlands on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions
- Shale gravel transition forest in the Sydney Basin Bioregion
- Swamp Oak floodplain forest of the NSW North Coast, Sydney Basin and South East Corner bioregions

SCALE 1:5,000 | A3

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TITLE

Figure 3-3 a
Threatened ecological communities in the study area

PROJECT
WestConnex Stage 1 - M4 Widening

CLIENT
ROADS AND MARITIME SERVICES

DRAWN	PROJECT #	MAP #	REV	VER
KM	NB11510			
CHECK	DATE			
CT	17/05/2014	F002	2	1

NSW SPATIAL - GIS MAP file : NB11510WCX_GIS_F002_r2r2

WestConnex study area
Design
Indicative construction footprint

Threatened ecological communities
- Freshwater wetlands on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions
- Shale gravel transition forest in the Sydney Basin Bioregion
- Swamp Oak floodplain forest of the NSW North Coast, Sydney Basin and South East Corner bioregions

SCALE 1:5,000 | A3
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TITLE
Figure 3-3 b
Threatened ecological communities in the study area

PROJECT
WestConnex Stage 1 - M4 Widening

CLIENT
ROADS AND MARITIME SERVICES

DRAWN	PROJECT #	MAP #	REV	VER
KM	NB11510	F002	2	1
CHECK	DATE			
CT	17/05/2014			

NSW SPATIAL GIS MAP file : NB11510WCX_GIS_F002_r2v2

NSW SPATIAL - GIS MAP file : NB11510WCX_GIS_F002_2v2

WestConnex study area
Design
Indicative construction footprint

Threatened ecological communities
- Freshwater wetlands on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions
- Shale gravel transition forest in the Sydney Basin Bioregion
- Swamp Oak floodplain forest of the NSW North Coast, Sydney Basin and South East Corner bioregions

SCALE 1:5,000 | A3
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TITLE
Figure 3-3 c
Threatened ecological communities in the study area

PROJECT
WestConnex Stage 1 - M4 Widening

CLIENT
ROADS AND MARITIME SERVICES

DRAWN	PROJECT #	MAP #	REV	VER
KM	NB11510			
CHECK	DATE			
CT	17/05/2014	F002	2	1

WestConnex study area

Design

Indicative construction footprint

Threatened ecological communities

- Freshwater wetlands on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions
- Shale gravel transition forest in the Sydney Basin Bioregion
- Swamp Oak floodplain forest of the NSW North Coast, Sydney Basin and South East Corner bioregions

SCALE 1:5,000 | A3

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TITLE

Figure 3-3 d
Threatened ecological communities in the study area

PROJECT
WestConnex Stage 1 - M4 Widening

CLIENT
ROADS AND MARITIME SERVICES

DRAWN	PROJECT #	MAP #	REV	VER
KM	NB11510			
CHECK	DATE			
CT	17/05/2014	F002	2	1

WestConnex study area
Design
Indicative construction footprint

Threatened ecological communities
- Freshwater wetlands on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions
- Shale gravel transition forest in the Sydney Basin Bioregion
- Swamp Oak floodplain forest of the NSW North Coast, Sydney Basin and South East Corner bioregions

SCALE 1:5,000 | A3
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TITLE
Figure 3-3 e
Threatened ecological communities in the study area

PROJECT
WestConnex Stage 1 - M4 Widening

CLIENT
ROADS AND MARITIME SERVICES

DRAWN	PROJECT #	MAP #	REV	VER
KM	NB11510			
CHECK	DATE	F002	2	1
CT	17/05/2014			

NSW SPATIAL - GIS MAP file : NB11510WCX_GIS_F002_r2v2

Table 3-4 Description threatened ecological communities recorded in the study area

Threatened ecological community	Status	Description	Area in study area (ha)
Swamp Oak Floodplain Forest of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	Endangered, TSC Act	This community in the study area consists of a small area dominated by Swamp Oak on the river-flats of Duck River. The canopy includes mainly planted Swamp Oak, however several remnant trees are also present suggesting Swamp Oak dominated forest was once present in this area. The understorey is dominated by exotic flora, however several diagnostic native groundcovers are also present.	0.1
Shale Gravel Transition Forest in the Sydney Basin Bioregion	Endangered, TSC Act Critically Endangered, EPBC Act	The woodland habitat type is restricted to a small patch on the corner of Hill Road and Parramatta Road along with about six remnant *Melaleuca decora* on the northern side of the M4 Motorway adjacent to Hill Road. This patch of vegetation has been subject to significant disturbances as evidenced by the highly depleted floristic diversity and dominance of exotic flora in understorey. However the upper structural layers of this community have been retained despite these disturbances. This area may have been subject to restoration practices in the past.	0.4
Freshwater wetlands on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions	Endangered, TSC Act	This map unit occurs in natural and constructed freshwater drainage channels where there is continuous moisture. This community varies throughout the study area from areas of open water to areas with low to moderate densities of macrophyte vegetation. This map unit occurs mostly as thin strips along modified drainage lines. Riparian vegetation is generally absent or dominated by exotic vegetation. These areas are considered to be in a low condition due to the highly modified nature of these areas mainly comprising concrete lined channels with a small area of natural-substrate creek lines along A'Becketts Creek dominated by exotic vegetation.	1.0

3.5 Groundwater dependant ecosystems

The level of water dependence of vegetation communities on the Cumberland Plain have been identified in the *'Risk Assessment Guidelines for Groundwater Dependant Ecosystems'* released by DPI (Kuginis *et al.* 2012). The level of groundwater dependence identified for ecological communities in the study area is identified in **Table 3-5**.

Table 3-5 Level of groundwater dependence of vegetation in study area

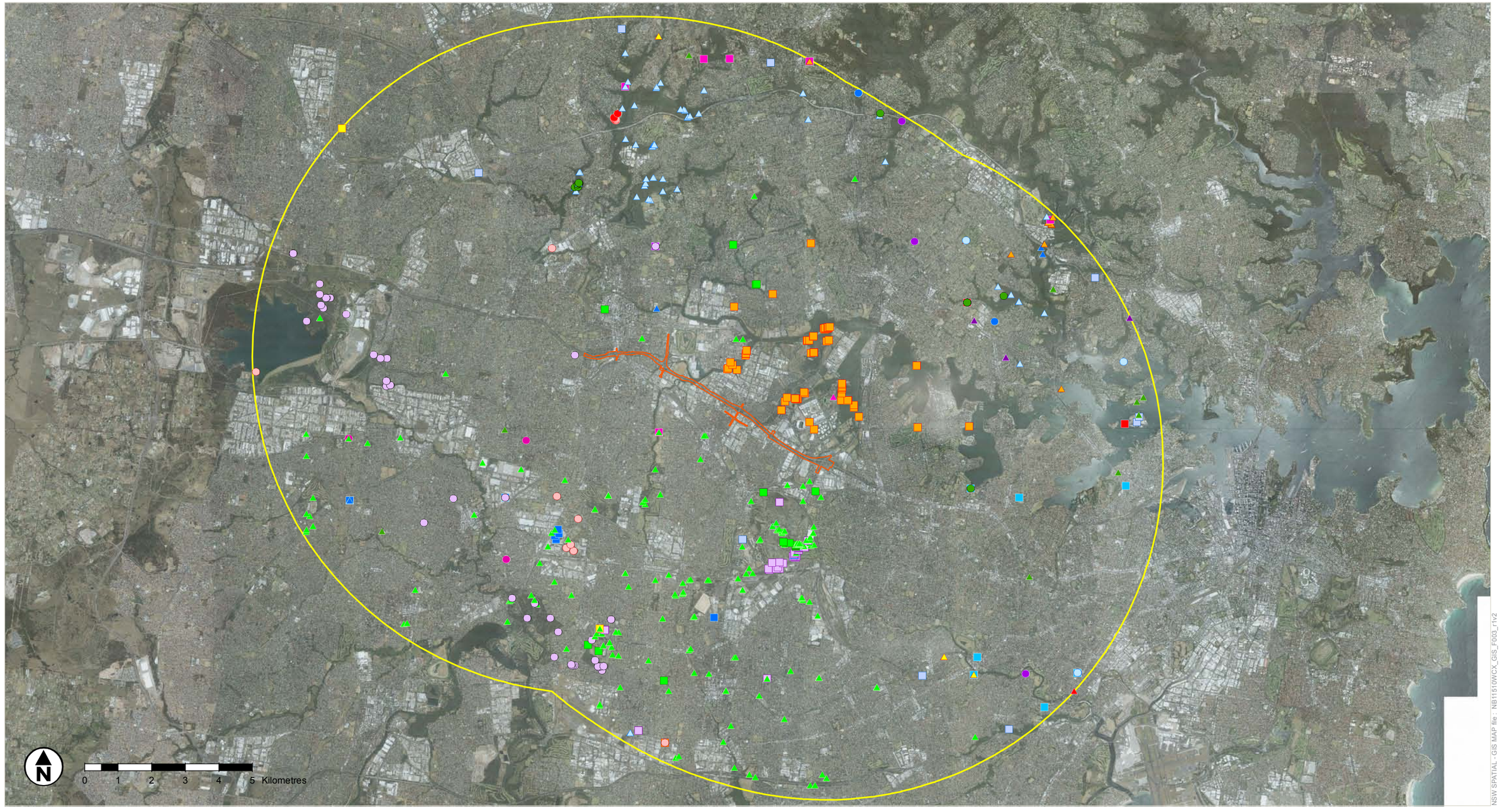
Map Unit	Level of groundwater dependence (Kuginis *et al.* 2012)
Map Unit 1: Mangrove Forest	Obligate
Map Unit 2: Swamp Oak Floodplain Forest	Obligate/High
Map Unit 3: Shale-Gravel Transition Forest	High
Map Unit 4: Freshwater Drainage Lines (freshwater)	Obligate
Map Unit 5: Estuarine Drainage Lines	Obligate
Map Unit 6: Planted Monocultures (6a Casuarina species; 6b Ficus species; 6c Spotted Gum; 6d Native Shrubs; 6e Tallowwood)	Unlikely
Map Unit 7: Mixed Plantings	Unlikely
Map Unit 8: Exotic Vegetation	Unlikely

The remnant vegetation communities in the study area are considered to have an obligate or high level of potential groundwater dependence (**Table 3-5**). Areas of Mangrove forest, Swamp Oak forest and drainage lines (Map Units 1, 2, 4 and 5) are considered to obligate level of groundwater dependence considering the presence in low-lying areas with direct access to groundwater. Shale Gravel transition Forest (Map Unit 2) potentially has a high-level of groundwater dependence as identified by Kuginis *et al.* (2012). The remaining planted and exotic map units are considered unlikely to be dependent on groundwater.

3.6 Threatened flora

On the basis of regional records and reports and the presence of suitable habitat, a total of 42 threatened flora species have been previously recorded or listed as having potential to occur in the locality. Of these 42 species, four are considered to have a moderate chance of occurring in the study area (**Table 4-3**), 17 species with a low potential of occurring and the remaining 21 species are considered unlikely to occur. The full list of flora species considered in this assessment is provided in **Table A-1** of **Appendix A** and the distribution of threatened flora species records in the study area is provided in **Figure 3-4**.

The field surveys resulted in the identification of no threatened flora species listed under the TSC Act or EPBC Act. Habitat assessment confirmed the presence of potential habitat for four threatened flora species considered to have a moderate potential to occur (**Table 4-3**) based on their distribution and presence of potential habitat. Potential habitat for these species in the study area comprises estuarine mud-flats on Duck River, aquatic and riparian habitats along creeks, and disturbed and planted vegetation.



WestConnex study area

10 kilometre radius

Threatened flora

- Acacia bynoeana
- Acacia pubescens
- Caladenia tessellata
- Callistemon linearifolius
- Darwinia biflora
- Dillwynia tenuifolia
- Epacris purpurascens var. purpurascens
- Eucalyptus nicholii
- Eucalyptus scoparia
- Genoplesium baueri
- Grammitis stenophylla
- Hibbertia superans
- Hypsela sessiliflora
- Leptospermum deanei
- Marsdenia viridiflora subsp. viridiflora
- Melaleuca deanei
- Persoonia hirsuta
- Persoonia nutans
- Pimelea curviflora var. curviflora
- Pimelea spicata
- Pomaderris prunifolia
- Prostanthera marifolia
- Pultenaea parviflora
- Pultenaea pedunculata
- Syzygium paniculatum
- Tetratheca glandulosa
- Tetratheca juncea
- Triplarina imbricata
- Wahlenbergia multicaulis
- Wilsonia backhousei

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SHEET 1 of 1 COORDINATE SYSTEM GDA 1994 MGA Zone 56

TITLE

Figure 3-4
Threatened flora records within a 10km radius of the study area

PROJECT
WestConnex Stage 1 - M4 Widening

CLIENT
ROADS AND MARITIME SERVICES

DRAWN	PROJECT #	MAP #	REV	VER
LW	NB11553			
CHECK	DATE			
AC	1/08/2013	F003	1	2

NSW SPATIAL - GIS MAP file : NB11510WCX_GIS_F003_r1v2

3.7 Threatened fauna

On the basis of regional records, reports and the presence of suitable habitat, a total of 68 threatened fauna species have been identified within a 10 kilometre radius of the study area (Figure 3-5). These species are listed in **Table A-2** of **Appendix A**, along with an assessment of their likelihood of occurrence in the study area using the criteria described in section 2.6.1. Many of these species favour habitats that are not represented in the study area and these were considered unlikely to occur (n=20) or have a low likelihood of occurring (n=21). From the review, 23 species were considered to have a moderate chance of occurring and one species the Grey-headed Flying-fox was observed foraging in the study area during the spotlight survey. There were no signs of roosting in the study area by the Grey-headed Flying-fox. There are two known Grey-headed Flying-fox camp sites in the locality, one on the Parramatta River, at Parramatta Park around two kilometres north of the M4 Motorway and a second one along the Duck River at Clyde around 800 metres south of the M4 Motorway. The Parramatta River camp is about 1 hectare in area and spreads across both sides of the river, comprising 5000-6000 bats (in 2008) (ELA 2008). Neither camp site would be directly impacted by the proposed M4 Widening activities. Grey-headed Flying-fox are known to forage up to 50 km from a camp site and therefore bats are expected to utilise available feeding resources throughout the study area which may include planted or remnant trees adjoining the M4 corridor, including eucalypts, non-indigenous and exotic trees.

There are three Green and Golden Bell Frog (*Litoria aurea*) populations known from proximity to the study area, at Homebush Bay, Clyde/Rosehill and Merrylands (incorporating Holroyd Gardens and Walpole Street Park along A'Becketts Creek) (DECC 2008). These three populations were once a single population, but they are now effectively isolated from one another, and are managed as separate entities (DECC 2008). The latest Atlas of NSW Wildlife records for bell frogs in the study area are from 2010. These are clustered close to the Parramatta River in Sydney Olympic Park and Bicentennial Park, Millennium Parklands, and in the industrial complex at Camellia. The few records closer to the M4 Motorway (in Holroyd, Granville and Lidcombe) are from 1965 and 1999. The majority of wetland habitat areas for Green and Golden Bell Frog is at the Sydney Olympic Park, and at the tip of the Rosehill/Camelia peninsula (DECC 2008). Artificial or altered freshwater wetlands, waterbodies and ponds in public reserves, playing fields and residential developments, and along drainage lines also provide habitat for the species in the area (DECC 2008). All of these locations are a considerable distance from the M4 Motorway corridor

The threatened species, *Litoria aurea* was not positively detected during surveys within the M4 Motorway corridor areas or adjacent habitat and no suitable habitat for this species was found to be present

A summary of the findings of the targeted frog survey sites for the M4 Motorway corridor, and their habitat value for frogs in general is discussed in **Table 3-6.**

- **Table 3-6 Details of frog survey sites**

Survey Site	Description	Habitat value
1.	Shallow concrete line creek with some native vegetation elements although very overgrown and high weed abundance. Steep banks with abundant algae growth and shallow pools. Surrounding habitat open grassland, planted trees and weeds.	Poor frog habitat, considered very low quality for *Litoria aurea*
2.	Vertical concrete banks and substrate concrete (0.3 m wide and 0.2 m deep). Extensive accumulation of rubbish. Riparian zone grass, weeds or isolated trees.	Poor frog habitat, considered very unlikely for *Litoria aurea*

Survey Site	Description	Habitat value
3.	Duck Creek. Concrete vertical banks and substrate. Petro-chemical odour and colour. Rubbish accumulation in channel. Riparian mix of native, planted and parklands.	Poor frog habitat, considered very unlikely for *Litoria aurea*.
4.	Estuarine – Grey Mangroves lining banks with Casuarina upslope. Two streams adjacent, narrow (0.3 m) and shallow (0.2 m), cobble substrate with Phragmites growing instream and Casuarina in riparian zone. Abundant algae and poor water quality	Poor frog habitat, too wide, deep and salty for *Litoria aurea*.
5.	Haslams Creek. Concrete vertical banks and substrate, shallow with no riparian or instream vegetation.	Poor frog habitat, considered very unlikely for *Litoria aurea.*
6.	Concrete culvert with sloping banks. Surrounding landscape pasture and industrial. Riparian edges dominated by dense weed growth.	Poor frog habitat, considered very unlikely for *Litoria aurea.*

A comparison of the known habitat features required by *Litoria aurea*, in relation to the representation of such features at each of the survey sites, has been undertaken to provide an assessment of its potential presence of *Litoria aurea* as provided in Table 3-7. Reference to known habitat features for *Litoria aurea* follows Pyke and White (1996). It is evident from the results of the surveys that there is a very low likelihood that *Litoria aurea* occurs in the project area.

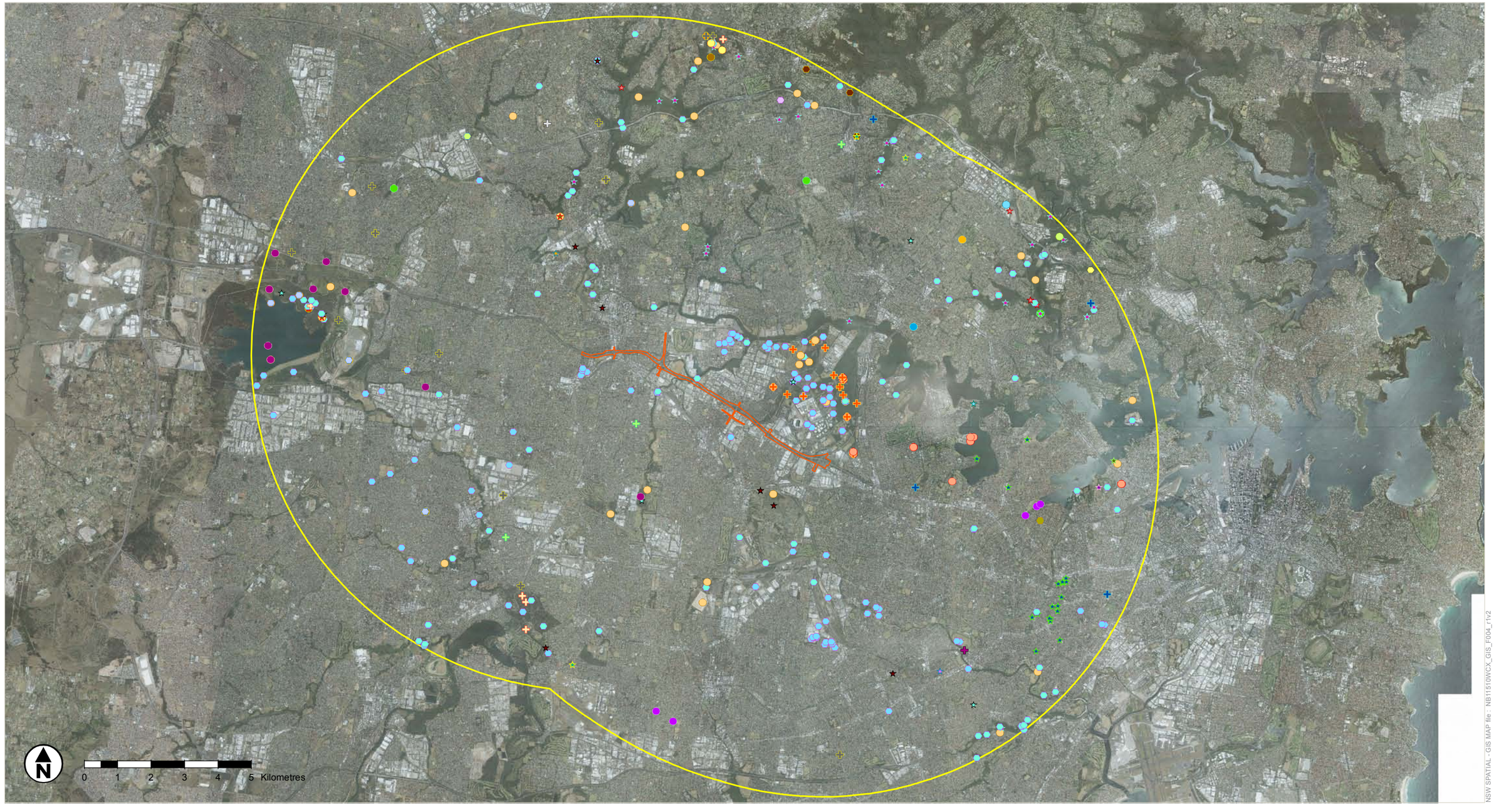
- **Table 3-7 Site habitat analysis**

Critical habitat feature	Presence at site					
	1	**2**	**3**	**4**	**5**	**6**
Nearby vegetation is low and open (grassy, woodland or lower)	√	√	√	x	x	x
Substrate should be sand or rock	x	x	x	√	x	X
Ephemeral or fluctuating water level, shallow, with still or slow moving water and no pollution	x	x	x	x	x	X
Unshaded and absence of predatory fish (in particular *Gambusia* sp.)	x	x	x	x	x	x
Diurnal shelter sites are present (debris, rocks, logs, vegetation)	x	x	x	x	x	x
Site has emergent and submerged aquatic plants present preferably Typha spp.	√	x	x	√	x	x

Based on the habitat analysis, only some elements of the preferred habitat for *Litoria aurea* are present and none of the sites near the corridor emerge as potential sites for the endangered *Litoria aurea*. It is concluded by this investigation that the freshwater habitats in the study area that are potentially impacted by the project are considered sub-optimal and unlikely to provide sufficient resources to sustain any individuals from the local *Litoria aurea* populations known from the wider locality.

One threatened fauna species was observed during the surveys (Grey-headed Flying-fox). No other threatened fauna species were recorded from the surveys in July 2013 or February 2014. Potential habitat for some wetland birds, microchiropteran bats and nectar-feeding birds

was recorded along Duck River and in areas of planted/landscaped vegetation. The list of species with a moderate potential to occur is provided in section 4.1.2. Potential habitat has been highly modified for threatened fauna species in the study area, and is limited to planted vegetation and a thin strip of Grey Mangrove and Swamp Oak trees along Duck River.



WestConnex study area

10 kilometre radius

Threatened fauna

- Australasian Bittern
- Barking Owl
- Black Bittern
- Black-necked Stork
- Black-tailed Godwit
- Broad-billed Sandpiper
- Bush Stone-curlew
- Cumberland Plain Land Snail
- Curlew Sandpiper
- Eastern Bentwing-bat
- Eastern False Pipistrelle
- Eastern Freetail-bat
- Eastern Grass Owl
- Eastern Osprey
- Eastern Pygmy-possum
- Eastern Quoll
- Flame Robin
- Freckled Duck
- Gang-gang Cockatoo
- Gang-gang Cockatoo population in the Hornsby and Ku-ring-gai Local Government Areas
- Glossy Black-Cockatoo
- Great Knot
- Greater Broad-nosed Bat
- Greater Sand-plover
- Green and Golden Bell Frog
- Grey-headed Flying-fox
- Large-eared Pied Bat
- Little Bentwing-bat
- Little Eagle
- Little Lorikeet
- Little Tern
- Long-nosed Bandicoot population in inner western Sydney
- Masked Owl
- Pied Oystercatcher
- Powerful Owl
- Red-crowned Toadlet
- Regent Honeyeater
- Scarlet Robin
- Southern Myotis
- Spotted-tailed Quoll
- Superb Fruit-Dove
- Superb Parrot
- Swift Parrot
- Terek Sandpiper
- Turquoise Parrot
- Varied Sittella
- White-fronted Chat
- White-fronted Chat population in the Sydney Metropolitan Catchment Management Area
- Yellow-bellied Sheathtail-bat

SCALE 1:115,000 A3

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TITLE

Figure 3-5
Threatened fauna records within a 10km radius of the study area

PROJECT WestConnex Stage 1 - M4 Widening

CLIENT ROADS AND MARITIME SERVICES

DRAWN	PROJECT #	MAP #	REV	VER
LW	NB11553	F004	1	2
CHECK AC	DATE 1/08/2013			

NSW SPATIAL - GIS MAP file : NB11510WCX_GIS_F004_r1v2

3.8 Migratory species

A total of 22 migratory fauna species were identified in the EPBC Act Protected Matters Search Tool Report as potentially occurring in the locality based on the distributional range of the species. These migratory species, along with their preferred habitat requirements and an assessment of their likely presence in the study area are listed in **Table A-2** of **Appendix A**. From this review one species was recorded and 17 migratory species are considered to have a moderate likelihood of occurring in the study area (**Table 3-7**). The main area of potential habitat for migratory species is the estuarine habitats along Duck River, comprising several small areas of mud-flats dominated by Grey Mangrove.

Table 3-7 Migratory species considered to have a moderate likelihood of occurring

Species	Potential habitat in the study area
Fork-tailed Swift (*Apus pacificus*)	Potential habitat widespread
Cattle Egret (*Ardea ibis*)	Potential habitat widespread
White-bellied Sea-eagle (*Haliaeetus leucogaster*)	Map Unit 1
White-throated Needletail (*Hirundapus caudacutus*)	Potential habitat widespread
Bar-tailed Godwit (*Limosa lapponica*)	Map Unit 1
Double-banded Plover (*Charadrius bicinctus*)	Map Unit 1
Eastern Curlew (*Numensis madagascariensis*)	Map Unit 1
Grey-tailed Tattler (*Heteroscelus brevipes*)	Map Unit 1
Great Egret (*Ardea alba*)	Recorded. Potential habitat widespread
Latham's snipe (*Gallinago hardwickii*)	Map Unit 1
Little Curlew (*Numensis minutus*)	Map Unit 1
Marsh Sandpiper (*Tringa stagnatilis*)	Map Unit 1
Pacific Golden Plover (*Pluvialis fulva*)	Map Unit 1
Red Knot (*Calidris canutus*)	Map Unit 1
Ruddy Turnstone (*Arenaria interpres*)	Map Unit 1
Sharp-tailed Sandpiper (*Calidris acuminata*)	Map Unit 1
Whimbrel (*Numensis phaeopus*)	Map Unit 1
Swift Parrot (*Lathamus discolour*)	Planted areas with Eucalypt feed trees

3.9 General flora and fauna

A complete list of flora and fauna including common and threatened species identified from the field surveys is provided in **Appendix B** for flora species and **Appendix C** for fauna species.

Native floral species richness was low in the naturally vegetated portions of the study area. The disturbed areas support plantings and open grassland areas, and are low in native species diversity and richness due primarily to the long term effects of significant soil disturbance and removal of the native seed bank.

Of the total 175 species of flora recorded, 87 are introduced species including 15 noxious weed species and 26 non-indigenous native flora were identified, collectively representing about 65 per cent of the total species richness. The remaining 62 species include 28 local native species that have been planted in the study area and 34 local native species which are naturally occurring in some areas of the study area. The total list of flora species recorded in the study area is provided in **Appendix B**.

A total of 26 vertebrate fauna species were recorded in the study area during this survey. This includes 23 bird species, one introduced mammal species, one reptile species and one frog species. The list of fauna species recorded is provided in **Appendix C**. All species were directly seen or heard calling during the survey, with the exception of the Red Fox which was observed through the presence of scats and trails.

Bat call analysis

No microchiropteran bat calls were recorded from the targeted survey of six sites.

3.10 Wildlife connectivity corridors

Landscape connectivity in the study area is limited to aquatic habitat along creeks or narrow linear strips of riparian vegetation where present. These linear corridors may provide important links in the otherwise cleared landscape and connect larger habitat patches. Duck River constitutes the main intact fauna corridor within the study area linking habitats upstream to the south of the study area and areas of habitat to the north.

3.11 Critical habitat

No areas of declared critical habitat under the TSC Act or EPBC Act occur in the study area.

4 Potential impacts

4.1 Loss of vegetation and habitat

The potential loss of vegetation and habitat associated with the M4 Widening project is summarised in **Table 4-1**. The construction footprint would impact on up to 8.86 hectares of planted and remnant vegetation in various states of condition. This total area of clearing includes 0.43 hectares of remnant vegetation (Map Units 1, 2, and 3).

Table 4-1 Direct impacts on vegetation and fauna habitat

Vegetation Community Type	Fauna Habitat Type	Biometric Vegetation Type	Conservation Status	Condition	Area (ha)
Map Unit 1: Mangrove Forest	Mangrove Forest	Mangrove forest in estuaries of the Sydney Basin and South East Corner	Fish habitat including mangroves are protected under the FM Act	High	0.28
Map Unit 2: Swamp Oak Floodplain Forest	Disturbed Swamp Oak Forest	Swamp Oak - Prickly Tea-tree - Swamp Paperbark swamp forest on coastal floodplains, Sydney Basin and South East Corner	Endangered, TSC Act	Moderate	0.08
Map Unit 3: Shale-Gravel Transition Forest	Disturbed Grassy Woodland	Broad-leaved Ironbark - Grey Box - *Melaleuca decora* grassy open forest on clay/gravel soils of the Cumberland Plain, Sydney Basin	Endangered, TSC Act	Moderate	0.09
Map Unit 4: Freshwater Drainage Lines	Disturbed Freshwater Wetland	(in part) *Phragmites australis* and *Typha orientalis* coastal freshwater wetlands of the Sydney Basin	Endangered, TSC Act	Low	0.35
Map Unit 5: Estuarine Drainage Lines	Disturbed Estuarine Wetland	N/A	N/A	Low	0.23
Map Unit 6: Planted Monocultures (6a Casuarina species; 6b Ficus species; 6c Spotted Gum; 6d Native Shrubs; 6e Tallowwood)	Planted Forest/ Woodland Habitats	N/A	N/A	Low	Total: 2.79 6a: 1.32 6b: 1.11 6c: 0.13 6d: 0.08 6e: 0.15

Vegetation Community Type	Fauna Habitat Type	Biometric Vegetation Type	Conservation Status	Condition	Area (ha)
Map Unit 7: Mixed Plantings		N/A	N/A	Low	4.85
Map Unit 8: Exotic Vegetation	Exotic vegetation	N/A	N/A	Very Low	0.17
TOTAL				8.84 hectares	

These impacts are quantified on the basis of the widening design with an added five metre buffer to account for potential disturbance during construction as well as communications infrastructure likely to be trenched along edges of the M4 Motorway. However not all areas are likely to be impacted considering the majority of the design is for a viaduct and so large areas of existing vegetation would be avoided.

Where existing vegetation would be retained beneath the new viaduct structures there is potential for impacts associated with introducing shading. Impacts to drainage lines (Map Units 4 and 5) would largely be avoided considering that new bridge structures would span across these drainage lines.

The proposed impacts include about 0.43 hectares of remnant vegetation, 0.59 hectares of drainage lines that would be overshaded and/or include pier construction, 7.68 hectares of planted vegetation and 0.17 hectares of exotic vegetation. Impacts to TECs are limited to about 0.11 hectares of moderate condition vegetation (Map Units 2 and 3) and 0.28 hectares of low condition habitat (Map Unit 4). This loss of native vegetation is a Key Threatening Process listed as 'Clearing of native vegetation' under Schedule 3 of the TSC Act and listed as 'Land Clearance' under the EPBC Act.

Direct impacts to aquatic habitats would include 0.25 hectares of Mangrove Forest which is classified as fish habitat under the FM Act, as well as freshwater drainage lines 0.28 hectares and 0.24 hectares of estuarine drainage lines.

4.1.1 Threatened ecological communities

Impacts to TECs are limited to about 0.17 hectares of moderate condition vegetation (Map Units 2 and 3) and 0.35 hectares of low condition habitat (Map Unit 4). These occur as highly disturbed remnants within an urban landscape and have minimal ecological importance in terms of floristic diversity, fauna habitat values and threatened flora habitat. The impacts to TECs are summarised in **Table 4-2**, comprising a collective impact to 0.52 hectares of these three communities.

Table 4-2 Impacts on threatened ecological communities (TSC Act)

Vegetation Community Type	TEC	Conservation Status	Condition	Area (ha)
Map Unit 2: Swamp Oak Floodplain Forest	Swamp Oak floodplain forest of the NSW North Coast, Sydney Basin and South East Corner bioregions	Endangered, TSC Act	Moderate	0.08
Map Unit 3: Shale-Gravel Transition Forest	Shale gravel transition forest in the Sydney Basin Bioregion	Endangered, TSC Act	Moderate	0.09
Map Unit 4: Freshwater Drainage Lines	Freshwater wetlands on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions	Endangered, TSC Act	Low	0.35
TOTAL				**0.52 hectares**

Impacts to Swamp Oak floodplain forest will be limited to several senescent remnant trees on the edge of Duck River and numerous planted Swamp Oak trees which are beneath the proposed bridge over Duck River (**Plate 3-2**). There is potential to retain some of the Swamp Oak cover through heavy lopping or pollarding of trunk and branches to provide sufficient clearance for construction. This will provide an opportunity for trees to regrow and maintain the root system of these trees for soil stability on the edge of Duck River.

Impacts to Shale Gravel Transition Forest will be limited to several *Melaleuca decora* trees which are within the footprint of the proposed eastbound on-ramp at Hill Road. These trees are suspected to be remnant, due to their size and that their position occur within a maintained landscape including planted trees and parkland areas (**Plate 4-1**).

Plate 4-1 Several remnant trees in parkland adjacent to Hill Road

Highly-disturbed areas of these freshwater wetlands would be impacted from the project. Impacts would be restricted to areas of A'Becketts Creek which runs parallel to the M4 Motorway, mainly consisting of a concrete-lined drainage channel (**Plate 3-8**). A small area of natural based creek line is present east of Church Street on A'Becketts Creek (**Plate 3-7**). Impacts to freshwater wetlands would be limited to over-shading from the viaduct structure or potential in-stream structures.

4.1.2 Threatened species

Impacts to threatened species would generally be limited to potential foraging resources for a range of common fauna species adapted to the heavily urbanised environment. No threatened flora species have been confirmed and there is a low likelihood that threatened plant populations would occur.

Potentially occurring threatened fauna are restricted to highly mobile species which may forage across spatially separated resources such as flowering and fruiting trees, such as the Grey-headed Flying-fox, or hunt for insects such as threatened microbats including the Eastern Bentwing-Bat. There are a range of waterbirds which may use estuarine habitats

along Duck River and nectar-feeding bird and bat species such as Little Lorikeet and Grey-headed Flying-fox.

Table 4-3 Threatened species considered to have a moderate to high likelihood of occurring

Species	Status		Likelihood of occurrence
	EPBC Act	TSC Act	
FLORA			
Hypsela sessiflora	-	E	Moderate
Marsdenia viridiflora subsp. *viridiflora* (endangered population)	-	E2	Moderate
Tadgell's Bluebell (*Wahlenbergia multicaulis*)	-	E2	Moderate
Narrow-leaved Wilsonia (*Wilsonia backhousei*)	-	V	Moderate
MAMMALS			
Eastern Bent-wing Bat (*Miniopterus schreibersii oceanensis*)	-	V	Moderate
Eastern False Pipistrelle (*Falsistrellus tasmaniensis*)	-	V	Moderate
Eastern Freetail Bat (*Mormopterus norfolkensis*)	-	V	Moderate
Greater Broad-nosed Bat (*Scoteanax rueppellii*)	-	V	Moderate
Grey-headed Flying-fox (*Pteropus poliocephalus*)*	V	V	High
Large-eared Pied Bat (*Chalinolobus dwyeri*)	V	V	Moderate
Little Bent-wing Bat (*Miniopterus australis*)	-	V	Moderate
Long-nosed Bandicoot (*Perameles nasuta*)	-	E2	Moderate
Southern Myotis (*Myotis macropus*)	-	V	Moderate
Yellow-bellied Sheathtail-bat (*Saccolaimus flaviventris*)	-	V	Moderate
BIRDS			
Black Bittern (*Ixobrychus flavicollis*)	-	V	Moderate
Black-tailed Godwit (*Limosa limosa*)	M	V	Moderate
Broad-billed Sandpiper (*Limicola falcinellus*)	-	V	Moderate
Curlew Sandpiper (*Calidris ferruginea*)	M	E	Moderate
Eastern Osprey (*Pandion haliaetus*)	M	V	Moderate
Great Knot (*Calidris tenuirostris*)	M	V	Moderate
Greater Sand Plover (*Charadrius leschenaultii*)	M	V	Moderate
Little Lorikeet (*Glossopsitta pusilla*)	-	V	Moderate
Little Tern (*Sterna albifrons*)	-	E	Moderate
Pied Oystercatcher (*Haematopus longirostris*)	-	V	Moderate
Swift Parrot (*Lathamus discolour*)	E, M	E	Moderate
Terek Sandpiper (*Xenus cinereus*)	-	V	Moderate
White-fronted Chat (*Epthianura albifrons*)	-	E2	Moderate

V- vulnerable; E – endangered; E2 – endangered population; M – migratory species

* species recorded from the survey (refer section 3.7.2)

4.2 Wildlife connectivity and habitat fragmentation

Duck River constitutes the main intact fauna corridor within the study area linking habitats upstream to the south of the study area and areas of habitat to the north. In the study area the mangrove canopy is currently fragmented by the existing M4 Motorway bridges. There is some regrowth of mangroves beneath Weird Bridge (**Plate 4-2**), however this is likely to have been limited by the low light levels and similar effects are anticipated for the new bridge structure over Duck River. Connectivity of aquatic habitats would be maintained along Duck River with impacts limited to areas of mangrove and swamp oak forest. Impacts to the mangrove canopy would be a further increase of the fragmentation from the existing bridges by about 20 metres.

Plate 4-2 Mangrove regrowth on Duck River under Weird Bridge.

4.3 Injury and mortality

Fauna injury or death can occur during the clearing phase of construction via the removal of habitat trees, as well as throughout the life-time of the road operation as a result of collision with vehicles. There is also potential for increased fauna injury and mortality as a result of further habitat fragmentation, degradation and loss.

There is potential for injury and mortality to fauna species during vegetation clearing activities. The most vulnerable species are those who take refuge in trees (eg hollows, under bark, in nests, and in fallen logs) and in the ground, and/or have low agility. Mainly common species such as possums, reptiles, birds (particularly fledglings) and frogs are likely to be affected considering the highly urbanised environment and limited sheltering opportunities such as hollow trees and fallen timber.

4.3.1 Construction impacts

While some diurnal and mobile species, such as birds, may be able to move away from the path of clearing, other species that are less mobile or those that are nocturnal, or have smaller home ranges and/or strong site fidelity, are less inclined to move rapidly or disperse large distances away from the activity. This includes species such roosting microchiropteran bats, arboreal mammals, small reptiles and frogs. Roads and Maritime has developed biodiversity guidelines to protect and manage biodiversity on Roads and Maritime projects (RTA 2011). Further details on the procedures to be implemented are outlined in Chapter 5.

4.3.2 Operation impacts

Mortality due to vehicle strike during operation of the upgraded section of the M4 Motorway is considered to be rare considering the low abundance of fauna species prone to vehicle strike being present in the study area and the majority of the proposed road would be on viaduct structures above ground level. Impacts to mobile species such as Grey-headed Flying-fox and bird species are not considered to be substantially increased from existing levels associated with the M4 Motorway.

Some indirect impacts to adjacent vegetation could be expected and typically involved weed invasion, which is common in all existing vegetated areas. Dieback of mangroves surrounding the construction footprint or bridge pylons around Duck Creek could occur until such time as the stabilisation has been reached at the site. Other areas of planted and remnant vegetation in road corridor have a high proportion of weeds (50 per cent) indicative of existing edge effects. The potential indirect impacts from weeds are discussed further below.

4.4 Weeds

Of the total 175 species of flora recorded, 87 (50 per cent) are introduced species including 15 noxious weed species (**Table 4-4**) and 26 non-indigenous native flora were identified, collectively representing about 65 per cent of the total species richness. All areas of the study area support some level of noxious weed abundance with the exception of Map Unit 1. These results are consistent with previous work in the area (Environmental Partnership Pty Ltd 2002, RailCorp 2010).

Table 4-4 Noxious weed species listed in the Holroyd, Parramatta, Auburn, Strathfield, Canada Bay and Burwood control areas

Species	Prevalence on Site	Noxious Class
African Olive *Olea europaea* subsp. *cuspidata*	Low to high abundance throughout the study area. Widespread	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 and the plant must not be sold propagated or knowingly distributed
Asparagus Fern *Asparagus aethiopicus*	Recorded in low to moderate abundance. Seed spread by bird species	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 and the plant must not be sold propagated or knowingly distributed Weed of national significance
Balloon Vine *Cardiospermum grandiflorum*	High abundance mainly along drainage line areas. Common and widespread throughout study	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 and the plant must not be sold propagated or knowingly distributed

Species	Prevalence on Site	Noxious Class
	area	
Bathurst Burr *Xanthium occidentale*	Low abundance at a single location on A'Becketts Creek. Not widespread	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
Bridal Creeper *Asparagus asparagoides*	Low to high abundance throughout the corridor. Seed spread by bird species. Common and Widespread	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 and the plant must not be sold propagated or knowingly distributed Weed of national significance
Castor Oil Plant *Ricinus communis*	Moderate abundance in several areas of the study area mainly along drainage lines. Common	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
Crofton Weed *Ageratina adenophora*	Moderate abundance at several locations in study area. Not widespread	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
Green Cestrum *Cestrum parqui*	Low to high abundance throughout the study area. Common and Widespread	Class 3: The plant must be fully and continuously suppressed and destroyed
Johnson Grass *Sorghum halepense*	Moderate abundance at several locations in study area. Not widespread	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
Lantana *Lantana camara*	Moderate abundance throughout the study area. Widespread	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 and the plant must not be sold propagated or knowingly distributed. Weed of national significance
Madeira Vine *Anredera cordifolia*	Low to moderate abundance throughout study area. Common and widespread	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 and the plant must not be sold propagated or knowingly distributed
Morning Glory *Ipomoea indica*	High abundance a several locations. Not widespread	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 and the plant must not be sold propagated or knowingly distributed

Species	Prevalence on Site	Noxious Class
Pampas Grass *Cortaderia* species	Moderate abundance at several locations in study area. Not widespread	Class 3: The plant must be fully suppressed and destroyed
Privet species *Ligustrum sinense* *L. lucidum*	Low to high abundance throughout the study area, with dense thickets occurring along drainage lines. Common and widespread	Class 4: The growth of the plant must be managed in a manner that reduces its numbers spread and incidence and continuously inhibits its flowering and reproduction

There are currently five key threatening processes listed under the TSC Act and EPBC Act that relate to the invasion and establishment of weeds. Each of these has potential to be exacerbated by construction and operation of the project, and includes the following:

- Invasion and establishment of exotic vines and scramblers.
- Invasion of native plant communities by Bitou Bush and Boneseed.
- Invasion of native plant communities by exotic perennial grasses.
- Invasion of native plant communities by African Olive (*Olea europaea L.* subsp. *cuspidata*).
- Invasion, establishment and spread of Lantana (*Lantana camara*).

The noxious species recorded in the study area are relatively common in roadside habitats along the M4 Motorway. During construction there is potential to disperse weed seeds and plant material into adjoining areas where weed species do not currently occur. The most likely causes of weed dispersal are associated with clearing of vegetation and stockpile of contaminated mulch and topsoil during earthworks, and movement of soil and attachment of seed (and other propagules) to construction vehicles and machinery.

There is a risk these species could be spread during construction of the project. However, mitigation measures undertaken in accordance with those outlined in Roads and Maritime Biodiversity Guidelines (RTA 2011) would limit the spread and germination of noxious weeds (section 5.2.4). Further, landscaping of surrounding disturbed areas including weed management would limit the establishment and spread of weed species during operation.

4.5 Pests and pathogens

4.5.1 Pests

There are currently five key threatening processes listed under the TSC Act and three under the EPBC Act that relate to the invasion and establishment of pests. Each of these has potential to be exacerbated by construction and operation of the project, which includes:

- Competition and grazing by the feral European Rabbit (TSC Act and EPBC Act).
- Competition from feral honeybees (TSC Act).
- Predation by feral cats (TSC Act and EPBC Act).
- Predation by the European Red Fox (TSC Act and EPBC Act).

- Predation by the Plague Minnow (*Gambusia holbrooki*) (TSC Act).

The clearing of vegetation is unlikely to significantly increase the value of the habitat for rabbits (*Oryctolagus cuniculus*) in the study area over the long-term. As rabbits tend to colonise more disturbed and modified open habitats, any increase in the population of this pest species is more likely to impact on native fauna tolerant of modified habitats. After construction of the project, revegetation of redundant sections would assist in reducing potential habitat for rabbits in the project area.

Feral honeybees are introduced bees which originally escaped from hives and have subsequently established in the wild. While the project would not directly increase bee numbers, the removal of hollow-bearing trees would indirectly increase competition for hollows with native fauna. Where tree hollows are occupied by feral honeybees, this would reduce the number of hollows available for native animals to breed and shelter. This is of particular concern for species which are threatened and include tree-roosting microbats, and several bird, reptile and frog species. Feral honey bees were observed in the study area, comprising a hive on an open branch on a *Melaleuca decora* tree adjacent to Hill Road (Map Unit 2).

The project is unlikely to contribute to increased levels of predation on native fauna from foxes and cats. The M4 Motorway currently presents limited fauna habitat in a fragmented and highly urbanised landscape. Fauna populations residing in these habitats are restricted to species modified to this disturbed landscape and highly mobile transient species. While some fox scats were reported beneath Weird Bridge, it is unlikely that the widening of the road would create a more favourable habitat for foxes and there are not purpose designed fauna structures on this project.

4.5.2 Pathogens

Pathogens are agents that cause disease in flora and fauna and are usually living organisms such as bacterium, virus or fungus. Several pathogens known from NSW have potential to impact on biodiversity as a result their movement and infection during construction of the project. Of these, three are listed as a key threatening process under either the EPBC Act and/or TSC Act including:

- Dieback caused by Phytophthora (Root Rot; EPBC Act and TSC Act).
- Infection of frogs by amphibian chytrid fungus causing the disease chytridiomycosis (EPBC Act and TSC Act).
- Introduction and establishment of exotic Rust Fungi of the order Pucciniales on plants of the family Myrtaceae (TSC Act).

While these pathogens were not observed or tested in the study area the potential for pathogens to occur should be treated as a risk during construction. The risk is especially high in construction areas affecting waterways (**Table 4-5**).

Table 4-5 Pathogens that may affect flora and fauna during construction

Pathogen	Description	Potential disease transmission
Phytophthora (*Phytophthora cinnamomi*)	A soil-borne fungus that causes tree death (dieback). Attacks the roots of a wide range of native plant species.	Spores can be dispersed over relatively large distances by surface and sub-surface water flows. Infected soil/root material may be dispersed by vehicles (eg earth moving equipment)

Pathogen	Description	Potential disease transmission
Myrtle rust (*Uredo rangelli*)	An introduced fungus that attacks the young leaves, short tips and stems of Myrtaceous plants eventually killing the plant.	Myrtle rust is an air-borne fungus that may be spread by moving infected plant material, contaminated clothing, equipment and vehicles.
Chytrid fungus (*Batrachocytrium dendrobatidis*).	A soil and water-borne fungus which attacks keratin in frog skin and organs, causing death.	Chytrid is a water-borne fungus that may be spread as a result of handling frogs or through cross contamination of water bodies by vehicles and workers.

4.6 Changed hydrology

Hydrology regimes in the study area are currently highly modified from the construction of numerous concrete-lined drainage channels and the highly urbanised environment with large areas of impervious ground conditions limiting absorption of surface water. The proposed construction of the bridges over all creeks and rivers would limit any further impacts to hydrology regimes. The current stream flow regime or velocities or the depths of the waterways in the study area are unlikely to be substantially modified. Where possible structures would aim to span the entire waterway channel and avoid the placement of piers within the waterway. The presence of A'Becketts Creek parallel to the M4 Motorway would limit the potential to avoid the placement of piers in the waterway and several piers may be required within concrete-lined and more natural-based sections of this waterway east of Church Street.

4.7 Groundwater-dependent ecosystems

The remnant vegetation communities in the study area are considered to have an obligate or high level of potential groundwater dependence (**Table 3-5**). Areas of Mangrove forest, Swamp Oak floodplain forest and drainage lines (Map Units 1, 2, 4 and 5) are considered to have an obligate level of groundwater dependence considering the presence in low-lying areas with direct access to groundwater. Shale Gravel Transition Forest (Map Unit 2) potentially has a high-level of groundwater dependence as identified by Kuginis *et al*. (2012). The remaining planted and exotic map units are considered unlikely to be dependent on groundwater.

Hydrological regimes including groundwater levels and flooding regimes are unlikely to be substantially altered from the project. The construction of piers may include the intersection of the groundwater table however no substantial dewatering or depletion of ground water levels are expected. Intersection of the water table on elevated lands is considered unlikely. It is considered unlikely that there would be any groundwater drawdown as a result of the project. Potential for contamination of groundwater where groundwater intersection occurs during construction would be low.

Considering groundwater levels are unlikely to be altered as a result of the project, potential groundwater-dependant ecosystems are considered unlikely to be impacted.

4.8 Aquatic impacts

The potential impact on soil, water and aquatic habitat during the project is detailed in **Table 4-6**.

Table 4-6 Potential impacts on aquatic habitats during construction and operation

Stage	Description
Construction	• Direct impacts aquatic habitat availability through the removal of mangroves at Duck River • Direct impacts to bank stability (where not already concrete lined) due to the clearing of riparian vegetation, and the construction of bridges. • Direct erosion impacts due to the exposure and mobilisation of soils during construction. This may potentially impact on water quality Haslams Creek, Duck River, Duck Creek and A'Becketts Creek. • Direct impacts to water quality from accidental chemical spills or materials during construction or improper management of run-off, sediment control and discharge from the construction site. • Low potential for contamination of groundwater where groundwater intersection occurs during construction. • Potential disturbance and exposure of acid sulphate soils to the air as a result of excavation and construction works, resulting in the potential for sulphuric acid to impact groundwater, soils and waterways in addition to the built environment. • Potential impact on salinity as a result of changes to the local landscape, which affects the way salt and water move through the environment and where they concentrate. • Potential for disruption to stream flow and isolation of pools as a result of in-stream construction of bridge piers, particularly in A'Becketts Creek.
Operation	• Loss of riparian and in-stream vegetation as a result of shading from bridge piers and the new viaduct. • Indirect loss of mangroves at Duck River through increased shading by the new widened road. • Contamination of local waterways as a result of any spills that may occur during operation from maintenance activities or vehicle crashes. • Increase in sediment and pollution loads in stormwater due to the removal of buffer vegetation, increase in road surface and increase in vehicular traffic. This has the potential to impact on water quality through road runoff containing suspended solids, nutrients from atmospheric fallout and other pollutants from vehicle, tyre and pavement wear. • Potential changes to flow patterns in the creeks that the motorway crosses due to the construction of bridges and culverts. This could lead to increased scour and/or sedimentation which impacts on water quality. • Potential for changes to flow conditions from in-stream bridge piers which may result in result of (a) increased bank erosion, (b) collection of debris and sediment (c) disruption of flow (d) reduced water quality and (e) reduced fish passage.

4.9 Noise, vibration and light

Considering the existing levels of noise, vibration and light from the M4 Motorway and surrounding roads, industrial and commercial properties, it is unlikely there would be a significant increase in these impacting factors resulting in any increased impacts to flora and fauna species. There is potential for impacts to locally common fauna from noise and vibration during construction, which may result in fauna temporarily avoiding habitats adjacent to the project, however traffic noise on the existing M4 motorway is likely to be significant deterrent to fauna already.

The light levels beneath the proposed viaduct widening areas would be relatively low similar to existing conditions beneath viaducts and bridges of the M4 Motorway and may limit the growth of any plantings associated with landscaping activities. The low light levels are not envisaged to substantially deter fauna movements or foraging activities in this area.

Areas of pedestrian access beneath the existing M4 Motorway are lit during the night and there is potential for additional lighting to be installed with the project. It is considered unlikely there would be any additional impacts to native flora and fauna from any additional lighting installed as part of the project.

4.10 Impact on relevant key threatening processes

Key threatening processes identified as being a result of the project would comprise those associated with habitat degradation including vegetation clearing and removal of hollow-bearing trees. Mitigation measures would be implemented to minimise the extent of vegetation clearing and habitat disturbance (refer section 5.2). There is also potential for other key threatening processes to be further increased from their current condition (eg weed invasion, introduction of pests and diseases and alteration of hydrological regimes), however, mitigation measures would be implemented to minimise their effect.

Table 4-7 Key threatening processes enacted by the project

Threatening Process	Relevant legislation	Increased by the project?	Proposed Mitigation
Habitat Degradation			
Bushrock removal	TSC Act	No	section 5.2
Land clearance/Clearing of native vegetation	EPBC Act, TSC Act	Yes	
Loss of hollow-bearing trees	TSC Act	Yes	
Removal of dead wood and dead trees	TSC Act	Yes	
Forest Eucalypt dieback associated with over-abundant psyllids and bell miners	TSC Act	No	
Feral Invertebrate Fauna			
Competition from feral honey bees (*Apis mellifera*)	TSC Act	Potential	
Feral Vertebrate Fauna			
Predation by feral cats / Predation by the feral cat (*Felis catus*)	EPBC Act, TSC Act	Unlikely	section 5.2
Predation, Habitat Degradation, Competition and Disease Transmission by Feral Pigs / Predation, habitat degradation, competition and disease transmission by feral pigs (*Sus scrofa*)	EPBC Act, TSC Act	Unlikely	

Threatening Process	Relevant legislation	Increased by the project?	Proposed Mitigation
Competition and land degradation by rabbits / Competition and grazing by the feral European rabbit (*Oryctolagus cuniculus*)	EPBC Act, TSC Act	Potential	
Predation and hybridisation of feral dogs (*Canis lupus* familiaris)	TSC Act	Unlikely	
Herbivory and environmental degradation caused by feral deer	TSC Act	Unlikely	
Predation by European red fox / Predation by the European red fox (*Vulpes vulpes*)	EPBC Act, TSC Act	Unlikely	
Hydrology and Riparian Zones			
Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands	TSC Act	Unlikely	section 5.2
The degradation of native riparian vegetation along NSW water courses	FM Act	Potential	section 5.2
Removal of large woody debris from NSW rivers and streams	FM Act	Unlikely	section 5.2
Installation and operation of in-stream structures and other mechanisms that alter natural flow regimes of rivers and streams	FM Act	Yes	section 5.2
Pathogens			
Infection of amphibians with chytrid fungus resulting in chytridiomycosis/Infection of frogs by amphibian chytrid causing the disease chytridiomycosis	EPBC Act, TSC Act	Potential	section 5.2
Dieback caused by the root-rot fungus (*Phytophthora cinnamomi*)/Infection of native plants by *Phytophthora cinnamomi*	EPBC Act, TSC Act	Potential	
Introduction and Establishment of Exotic Rust Fungi of the order Pucciniales pathogenic on plants of the family Myrtaceae	TSC Act	Potential	
Weeds			
Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants	EPBC Act	Potential	section 5.2
Invasion of native plant communities by exotic perennial grasses	TSC Act	Potential	
Invasion and establishment of exotic vines and scramblers	TSC Act	Potential	
Invasion of native plant communities by African Olive (*Olea europaea L. subsp. cuspidata*)	TSC Act	Potential	
Invasion, establishment and spread of *Lantana camara*	TSC Act	Potential	
Climate Change			
Loss of terrestrial climatic habitat caused by anthropogenic emissions of greenhouse gases	EPBC Act	Potential	n/a
Anthropogenic climate change	TSC Act	Potential	n/a

4.11 Cumulative impacts

The project would increase the existing area of disturbance created by the M4 Motorway as well as surrounding urban development. There would also be cumulative impacts from potential future upgrades.

5 Avoidance and mitigation measures

In managing biodiversity, the M4 Widening project aim to:

- Avoid and minimise impacts first.
- Mitigate impacts where avoidance is not possible.
- Offset where residual impacts cannot be avoided.

5.1 Avoid and minimise

There is limited scope to avoid areas of remnant vegetation along the Duck River considering the highly urbanised areas surrounding the M4 Motorway and the engineering constraints. Specific avoidance and minimisation measures associated with the design of the project would generally comprise avoidance of vegetation clearance during construction. Indeed the proposed raised design of the works in several locations would avoid the need to remove vegetation in a number of locations. Further the placement of proposed construction compounds has been selected to avoid impacts to native vegetation.

Specific avoidance and minimisation measures associated with the design comprise the piers for bridges and viaducts which have been designed to avoid in-stream areas of drainage lines where possible and the design is being developed with the aim of avoiding alteration of stream/tidal flows.

5.2 Recommended construction mitigation measures

It is recommended that the following mitigation measures as outlined in the Roads and Maritime Biodiversity Guidelines: Protecting and managing biodiversity of RTA projects (RTA 2011) are implemented.

5.2.1 Pre-clearing

- A construction environmental management plan (CEMP) should include details regarding pre-clearance surveys. The plan should include a clearing procedure, which in turn would specify the requirements for pre-clearing.
- The construction footprint should be identified and marked before construction and exclusion zones established in retained areas of habitat particularly in riparian areas such as Duck Creek.
- Nearby habitats should be identified on both sides of the existing highway along the length of the project suitable for the release of fauna that may be encountered during the pre-clearing process or habitat removal.

5.2.2 Management of unexpected species finds (particularly roosting microbats and Green and Golden Bell Frog)

- Pre-clearing surveys should be undertaken by an experienced ecologist to identify any nesting/roosting animals present in the project area. In particular it would be important to conduct a pre-clearing inspection for any artificial structures such as bridges and culverts which are proposed to be physically demolished or upgraded. The inspection is required to identify if threatened bat species are present and are using the structure for roosting and/or breeding habitat. The inspection would be conducted during the day and would ensure that all cracks, fissures, scuppers, lifting holes, etc, within concrete structures are inspected for microbats prior to any works commencing.

Because no structures are proposed to be demolished, it is unlikely that works will have a significant impact on any microbats roosting in adjacent structures. However, if bats are found, an appropriately qualified ecologist will be engaged and provide advice on work methods and timing to minimise impacts on the bats. If exclusions are required, these will be done in accordance with a Bat Management Plan prepared by an appropriately qualified ecologist.

- While the study area has been assessed as containing sub-optimal habitat for Green and Golden Bell Frog, this species is known in proximal areas. Because of this, the unexpected threatened species finds procedure should be followed as outlined in the Roads and Maritime Biodiversity Guidelines (RTA 2011). This procedure is particularly relevant to the potential presence of microbats in artificial structures and the Green and Golden Bell Frog in freshwater aquatic habitats disturbed. The procedure is to be adopted through the construction phase of the project.

  As a first step photos and descriptions of roosting bats and the Green and Golden Bell Frog would be included in the CEMP and/or the flora and fauna management sub-plan. All personnel are to be inducted on the potential for these threatened species occurring on site and the unexpected threatened species finds procedure.

5.2.3 Exclusion zones

The location of exclusion zones should be established to avoid damage to native vegetation and fauna habitats and prevent the distribution of pests, weeds and disease. Basic temporary fencing would need to be installed to indicate the limits of clearing. The location of exclusion fencing to be installed should be identified on plans in the CEMP and the function and importance of the exclusion zones communicated to construction personnel.

5.2.4 Minimising fauna injury and mortality

To prevent injury and mortality of fauna during the clearing of vegetation an experienced and licensed wildlife carer and/or ecologist should be present to supervise vegetation clearing and capture and relocate fauna where required. Further details regarding fauna handling and vegetation clearing procedures are provided in the Roads and Maritime Biodiversity Guidelines (RTA 2011). The following should be implemented to avoid injury and mortality of fauna:

- Allow fauna to leave an area without intervention as much as possible.
- In circumstances where the handling of fauna is completely unavoidable, best practice methods need to be followed as outlined in the Roads and Maritime Biodiversity Guidelines – Guide 9 Fauna Handling (RTA 2011).
- Include the procedures in project inductions for construction staff to implement if fauna is found or injured on site and also the importance of not feeding any wildlife that may be encountered on construction sites.
- Never deliberately kill any native fauna, including snakes, as all native species are protected under the *National Parks and Wildlife Act 1974*.
- Keep records of fauna captured and relocated.
- Report any injury to or death of a threatened species to WDA environmental staff.

The Sacred Ibis breeding colony located in the Shale Gravel transition forest on the edge of the M4 Motorway near Hill Road requires specific management actions during construction to minimise impacts. Sacred Ibis breed from August to November, laying two or three eggs which are incubated for about three weeks (Brandis *et al*. 2009). Once hatched the young are dependent on their parents for a further five to six weeks (Brandis *et al*. 2009). A 40 metre buffer should be implemented around the colony during the breeding season to mitigate disturbance to adults and young. Actions which are likely to affect hydrology at the breeding site should also be avoided, because ibis are sensitive to declines in water levels during the

breeding season (Brandis *et al*. 2011).

5.2.5 Weed management

A weed management plan should be developed as part of the CEMP with reference to the Urban Design Report. The Roads and Maritime Biodiversity Guidelines (RTA 2011) and the Introductory Weed Management Manual (Natural Heritage Trust 2004) provide guidance for developing weed management plans. As part of the weed management plan a site assessment by an ecologist or person trained in weed identification and management would be required to assess the extent and severity of weed species in the construction footprint with particular emphasis on noxious weed species. A weed management plan should also be consistent with other plans of management for the area, such as the RailCorp (2010) '*Management Plan for Restoration and Rehabilitation of the Riparian Zone of Duck River in RailCorp Managed Lands at Clyde-Auburn'*, and the Environmental Partnership Pty Ltd (2002) '*Lower Duck River Riparian Management Plan*' prepared for Auburn Council.

The weed management plan would include descriptions and mapping of major weed infestations during pre-clearing surveys and appropriate management actions to be undertaken for each infestation. The details of the weed management plan would vary for each site but would include:

- Taxa and potential sources of the weed species.
- Weed management priorities and objectives.
- Sensitive environmental areas within or adjacent to the site.
- Location of weed infested areas.
- Mechanical weed control methods such as slashing or mowing, as well as a range of herbicides to avoid the development of herbicide resistance.
- Measures to prevent the spread of weeds.
- A monitoring program to measure the success of weed management.
- Strategic management with adjacent landowners.
- Appropriate disposal of weed infested materials and soils to be identified in the CEMP.
- Communication strategies to improve contractor awareness of weeds and weed management.

5.2.6 Pest and disease management

No pests and diseases are currently known from the project footprint but could potentially be present. Measures to prevent the introduction and/or spread of pests and disease causing agents such as bacteria and fungi need to be incorporated into the CEMP for the project.

Measures to confirm the presence of pathogens/disease causing agents such as bacteria and fungi may be undertaken before construction. This includes a background search of government-maintained websites for the most recent known locations of contamination and for the most up-to-date hygiene protocols for each pathogen. If risks are identified in the vicinity of the project, testing from a National Association of Testing Authorities (NATA) approved laboratory may be required to confirm the presence of pathogens in the soil and/or water.

If pathogens/disease causing agents are found to be present, measures to prevent the introduction and/or spread of these pathogens/disease causing agents are to be incorporated into the CEMP for the project. If pathogens are identified exclusion zones with fencing and signage to restrict access into contaminated areas would be required. The pest and disease management plan should be developed in accordance with Guide 7 Pathogen Management of the Roads and Maritime Biodiversity Guidelines (RTA 2011), including:

- Providing vehicle and boot wash down facilities and ensuring vehicles and footwear are free of soil before entering or exiting the site.
- Regular communication to staff and contractors during inductions and toolbox talks, of the risk of spreading pathogens and the mitigation measures required on site.
- Programming construction works to move from uninfected areas to any known infected areas.
- Restricting vehicles to designated tracks, trails and parking areas.

5.3 Habitat re-establishment

A landscape management plan should be developed which provides specific details for the re-establishment of native vegetation on batters, surrounding sediment basins and other areas disturbed during construction. The landscape management plan would need to consider a range of constraints and opportunities associated with the project and be developed in conjunction with the Urban Design Report.

Detailed guidelines for the re-establishment of native vegetation on road projects are provided in Guide 3 Re-establishment of Native Vegetation of the Roads and Maritime Biodiversity Guidelines (RTA 2011) and supporting documentation, those of relevance to the project include the following:

- Ensure areas to be revegetated have an appropriate level of natural drainage.
- Avoid compaction of soils in areas identified for revegetation and where compaction has occurred, the soil would be loosened.
- When planting consider seasonal risks of frost, drought, flooding and sun exposure to avoid damaging plants and to encourage growth.
- Adhere to relevant specifications and guidelines including but not limited to the RTA Landscape Planting QA Specification R179, RTA Seed Collection QA Specification R176, the Florabank Guidelines, Model Code of Practice and Construction Quality Technical Direction 007, Quality Alert 7 – Hydro-seeding, hydro-mulching and other slope stabilisation methods.
- Inspection, monitoring and maintenance of revegetated areas would be conducted biannually for a minimum of two years after the completion of construction in accordance with the landscape management plan. Outline the roles and responsibilities in landscape management and revegetation plans including the schedule for monitoring and maintenance activities.

Because of their importance as habitat for fish, mangroves are protected in NSW under the FM Act. Direct impacts to mangroves would include 0.25 hectares. Under the FM Act, habitat compensation may be required where mangroves and other fish habitats would be impacted on a minimum ratio of 2:1 offset impacts to fish habitat.

5.4 Wildlife connectivity

The main zone of potential impact to habitat connectivity is around the Duck River area comprising removal of Grey Mangrove and Swamp Oak trees further fragmenting the canopy cover along this drainage line.

The project provides wildlife crossing functions through the construction of bridges and viaducts allowing fauna to effectively cross beneath the M4 Motorway. The eastern end of the project would include widening of the existing M4 Motorway and the existing levels connectivity would be maintained in this area along Haslams Creek.

The existing levels of habitat connectivity can be enhanced through appropriate habitat re-establishment and protection of existing habitats where possible. Landscaping should use

locally indigenous species either side of the viaduct and bridge structures and thus provide for some level of habitat linkage. Riparian vegetation along the main wildlife corridor (Duck River) is to be protected during construction works where possible and any areas of riparian vegetation impacted by construction are to be rehabilitated. Heavy pruning or pollarding of existing trees instead of complete removal of trees would maintain some cover and habitat structure for fauna.

5.5 Aquatic habitats and riparian zones

Potential impacts to water quality, aquatic habitat and fish passage can be mitigated through the measures outlined in **Table 5-1**.

Table 5-1 Mitigation measures for water quality and aquatic ecology.

Mitigation measures	Description
Water quality management and prevention	• Construction traffic would be restricted to access tracks, fenced before the start of construction and maintained until construction is complete. • Chemicals and fuels would be appropriately stored and bunded. • Appropriate sediment and erosion control measures would be put in place during the construction process and may include sediment and erosion control curtains to control turbidity generated during the construction and restoration process. • No turbid water generated from the construction area would be discharged into any waterway. • The need for water quality monitoring during construction is addressed in the Soils, Water, Waste and Contamination Working Paper. • All construction materials (rocks and gravel) would be clean before being used for construction to minimise turbidity. • Lateral flow (ie stormwater) should be managed to avoid flow over exposed soils which may result in erosion and impacts to water quality.
Riparian and aquatic habitat management	• Minimise disturbance to riparian vegetation where possible with trimming or 'lopping' of branches would be considered as a first option before removing. • Minimise harm to mangroves. • Riparian vegetation and wetlands along the main wildlife corridor (Duck River) will be protected during construction works where possible with any affected areas to be rehabilitated.
Sedimentation and erosion management	• All standard sediment and erosion control measures for water quality management would be implemented. • Develop and conduct water quality monitoring.
Fish passage and habitat	• If construction works result in the temporary isolation of pools for any period of time and they become susceptible to drying or poor water quality then any resident native fish that are trapped are to be relocated to areas not being disturbed away from impacts. • Large woody debris, where existing, would be retained to the greatest extent possible or salvaged and reused or relocated. • Any woody debris in-stream during construction is to be replaced at the completion of the works. This would ensure that

Mitigation measures	Description
	there is no net loss of woody debris structural habitat. • Limit further concreting of waterways channels. • Follow the DPI guidelines for the design and construction of waterway crossings to limit barriers to fish. • Where possible avoid the construction of bridge piers in-stream. • Where in-stream construction is necessary, diversion of natural waterways is required to maintain similar depth and width of the stream for fish passage. • Monitoring during and post-construction for (a) build-up of debris and sediment near bridge piers and (b) bank erosion from change in flow conditions.

If required, instream structures such as bridges and culverts are to be designed and managed to minimise any potential impact to flow regimes and fish passage. The preferred structure for crossing waterways would be consistent with Witheridge (2002). All major creeks would be crossed by a bridge, thereby minimising the impact to flow regimes and fish passage.

The following design and management measures are applicable for bridge crossings:

- Piers not to be placed in waterways where possible.
- Where piers are required in waterways these would be constructed and designed appropriately to avoid interruption to fish passage and natural stream flow and velocity.
- Stockpiles to be located above the 1:100 year flood level with appropriate management control measures in place such as bunding.

As a precautionary measure, flow should not be disconnected or disrupted as a result of in-stream bridge pier construction provided the environmental benefit gained by the stream diversion works exceeds the potential harm caused by these works.

As a general principle the Department of Primary Industries (Fisheries) requires that proponents should, as a first priority, aim to avoid impacts upon key fish habitats. Where avoidance is impossible or impractical, proponents should then aim to minimise impacts and any remaining impacts should then be offset with compensatory works (section 5.6).

5.6 Offsetting

A number of documents were reviewed to identify the need for biodiversity offsets for this project. This included the:

- EPBC Act Environmental Offsets Policy (DSEWPaC 2012).
- Principles for the Use of Biodiversity Offsets in NSW (Department of Environment, Climate Change and Water 2008) as noted in the DGRs. Note that the NSW Government recently announced a new set of draft offset principles for major projects which are applicable to State Significant Infrastructure. At the time of writing the EIS, these principles were released in draft form and were entering a transitional phase. As such the original principles for use of biodiversity offsets have not been considered in this assessment.
- Roads and Maritime Guideline for Biodiversity Offsets (Roads and Maritime 2011b)

This biodiversity assessment identifies that the project would not have a significant impact on a MNES listed under the EPBC Act. Accordingly there is no requirement for a referral under the EPBC Act and it is likely that the project would be deemed as ‘not a controlled action’. In

this instance the EPBC Act environmental offsets policy does not apply.

The ecological values of the study area were considered at the preliminary environmental and planning stages of the project and ecological data gathered from the background review and field surveys was considered as a guide to the refinement of the development footprint, and to devise appropriate design features and mitigation measures to avoid and minimise long-term impacts on biodiversity.

The approach adopted has considered the Principals for the use of biodiversity offsets in NSW (DECCW, 2008). The assessment has identified and quantified the impact on biodiversity, including the loss of endangered ecological communities in keeping with Principal number 5 (DECCW 2008). In this regard the report recognises that impacts on threatened ecological communities and habitat for threatened flora and fauna species would be negligible and not significant. The greatest extent of impact likely is on planted roadside vegetation of low ecological value. In terms of remnant or native regrowth vegetation, these impacts relate to the potential loss of 0.52 hectares of low to moderate condition vegetation listed as endangered under the TSC Act.

It is recognised that the project should aim to ensure a net improvement in biodiversity over time (Principal number 6; DECCW; 2008).

Portions of three threatened ecological communities (TSC Act) would be impacted. Each of these communities is recognised as being a vegetation type that is more than 70 per cent cleared in NSW according to the OEH NSW Biometric database. Although the potential amount to be cleared for each is less than one hectare and each is in a low to moderate condition. The total loss of low to moderate condition TEC is less than 0.05 ha. Given the proposed impact on TECs from this project and the intent to be apply principle number 6 (ie. net improvement on biodiversity over time) these direct and indirect impacts should be appropriately offset. It would be reasonable when determining the adequacy of the offset, to take into account the small area and isolated and fragmented nature of the areas to be directly and indirectly impacted. Principle 6 of the OEH Offset Principles includes a number of offset options, of these the following are to be considered:

- Enhancing habitat.
- Reconstructing habitat in strategic areas to link areas of conservation value.
- Increasing buffer zones.

Mangroves are considered as key fish habitat according to the *Policy and Guidelines for Fish Habitat Conservation and Management* (DPI 2013). This report recognises the likely impacts to 0.25 hectares of mangroves alongside Duck River. In consideration of the current disturbed aquatic environment in the study area, it would be appropriate to consult with DPI concerning an appropriate form of biodiversity offset for the proposed loss of mangroves.

6 Significance assessments

Significance assessments have been conducted for threatened biodiversity that have been positively identified or that have a moderate or high likelihood of occurring in the study area.

6.1 (NSW) *Environmental Planning and Assessment Act 1979*

For threatened species and ecological communities listed under the TSC Act, this section details the heads of consideration as listed under Part 5.1 of the EP&A Act in assessing the significance of the impacts.

Species with similar taxonomy or ecological requirements have been assessed together, for example tree-roosting microchiropteran bats. Full details of assessment of significance under the EP&A Act are presented in **Appendix E**. The conclusions of the EP&A Act are provided in **Table 6-1**, which indicates that a significant impact is considered unlikely on any biota listed under the TSC Act.

Table 6-6-1 Summary of EP&A Act assessments of significance

Species	Status (TSC Act)	Sect 5a EP&A Act (heads of consideration*)						Likely Significant Impact	Potential to occur in the Study area
		a	b	c	d	e	f		
THREATENED ECOLOGICAL COMMUNITIES									
Swamp Oak Floodplain Forest	E	X	N	X	N	N	N	No	Present
Shale-Gravel Transition Forest	E	X	N	X	N	N	N	No	Present
Freshwater Wetlands	E	X	N	X	N	N	N	No	Present
Cumberland Plain Woodland	E	X	N	X	N	N	N	No	Present
FLORA									
Hypsela sessiflora	E	N	N	N	N	N	N	No	Moderate
Marsdenia viridiflora subsp. viridiflora (endangered population)	E2	N	N	N	N	N	N	No	Moderate
Tadgell's Bluebell (*Wahlenbergia multicaulis*)	E2	N	N	N	N	N	N	No	Moderate
Narrow-leaved Wilsonia (*Wilsonia backhousei*)	V	N	N	N	N	N	N	No	Moderate
FAUNA									
Grey-headed Flying-fox (*Pteropus poliocephalus*)	V	N	N	N	N	N	N	No	Present
Long-nosed Bandicoot (*Perameles nasuta*)	E2	N	N	N	N	N	N	No	High
Little Lorikeet (*Glossopsitta pusilla*)	V	N	N	N	Y	N	N	No	High
Swift Parrot (*Lathamus discolour*)	E	N	N	N	N	N	N	No	Moderate
White-fronted Chat (*Epthianura albifrons*)	E2	N	N	N	N	N	N	No	Moderate
WETLAND BIRDS									

Species	Status (TSC Act)	Sect 5a EP&A Act (heads of consideration*)						Likely Significant Impact	Potential to occur in the Study area
		a	b	c	d	e	f		
Black Bittern (*Ixobrychus flavicollis*)	V	N	N	N	N	N	N	No	Moderate
Black-tailed Godwit (*Limosa limosa*)	V								Moderate
Broad-billed Sandpiper (*Limicola falcinellus*)	V								Moderate
Curlew Sandpiper (*Calidris ferruginea*)	E								Moderate
Eastern Osprey (*Pandion haliaetus*)	V								Moderate
Great Knot (*Calidris tenuirostris*)	V								Moderate
Greater Sand Plover (*Charadrius leschenaultii*)	V								Moderate
Little Tern (*Sterna albifrons*)	E								Moderate
Pied Oystercatcher (*Haematopus longirostris*)	V								Moderate
Terek Sandpiper (Xenus cinereus)	V								Moderate
CAVE-ROOSTING BATS									
Large-eared Pied Bat (*Chalinolobus dwyeri*)	V	N	N	N	N	N	N	No	Moderate
Eastern Bent-wing Bat (*Miniopterus schreibersii oceanensis*)	V								High
Southern Myotis (*Myotis macropus*)	V								Moderate
TREE-ROOSTING BATS									
Eastern False Pipistrelle (*Falsistrellus tasmaniensis*)	V	N	N	N	N	N	N	No	High
Eastern Freetail-bat (*Mormopterus norfolkensis*)	V								High
Greater Broad-nosed Bat (*Scoteanax rueppellii*)	V								High
Yellow-bellied Sheathtail-bat (*Saccolaimus flaviventris*)	V								High

* Y= Yes (negative impact), N = No (no or positive impact), X = not applicable,

Significance assessment questions (heads of consideration) as detailed in Section 5a of the EP&A Act

a How is the project likely to affect the lifecycle of a threatened species and/or population?

b How is the project likely to affect the habitat of a threatened species, population or ecological community?

c Does the project affect any threatened species or populations that are at the limit of its known distribution?

d How is the project likely to affect current disturbance regimes?

e How is the project likely to affect habitat connectivity?

Species	Status (TSC Act)	Sect 5a EP&A Act (heads of consideration*)						Likely Significant Impact	Potential to occur in the Study area
		a	b	c	d	e	f		
f How is the project likely to affect critical habitat?									

6.2 (Commonwealth) *Environment Protection and Biodiversity Conservation Act 1999*

6.2.1 Threatened species

Full details of the assessment of significance for threatened species under the EPBC Act are presented in **Appendix E**. The conclusions of the EPBC Act assessment of significance are provided in **Table 6-2** which indicates that a significant impact is considered unlikely for any Matter of NES.

Table 6-2 Summary of Commonwealth EPBC Act assessments of significance

Species/Ecological Community	*Assessment of significance questions (EPBC Act)									Likely Significant Impact	Important Population +
	1	2	3	4	5	6	7	8	9		
Vulnerable fauna											
Grey-headed Flying-fox (*Pteropus poliocephalus*)	N	N	N	N	N	N	N	N	N	No	No
Large-eared Pied Bat (*Chalinolobus dwyeri*)	N	N	N	N	N	N	N	N	N	No	No
Endangered fauna											
Swift Parrot (*Lathamus discolour*)	N	N	N	N	N	N	N	N	N	No	No

* Assessment of significance questions

1) Lead to a long-term decrease in the size of a population
2) Reduce the area of occupancy of the species
3) Fragment an existing population into two or more populations
4) Adversely affect habitat critical to the survival of a species
5) Disrupt the breeding cycle of a population
6) Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline
7) Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat
8) Introduce disease that may cause the species to decline
9) Interfere with the recovery of the species.

+ Important population as determined by the EPBC Act is a population of a vulnerable species that:

is likely to be key source populations either for breeding or dispersal

is likely to be necessary for maintaining genetic diversity

is at or near the limit of the species range

6.2.2 Migratory species

Full details of the assessment of significance under the EPBC Act are presented in **Appendix E**. The conclusions of the assessments of significance on migratory species are provided in **Table 6-3** and indicate that the project is considered unlikely to significantly impact on migratory birds.

Table 6-3 Summary of Commonwealth significance assessment for migratory species

Migratory species	EPBC Act status	Important population* in project area	Likely significant impact
Black-faced Monarch (*Monarcha melanopsis*)	Marine; Migratory (BONN)	No	No
Bar-tailed Godwit (*Limosa lapponica*)	Marine; Migratory (CAMBA, JAMBA, ROKAMBA)	No	No
Black-tailed Godwit (*Limosa limosa*)	Marine; Migratory (CAMBA, JAMBA, ROKAMBA)	No	No
Cattle Egret (*Ardea ibis*)	Marine; Migratory (CAMBA, JAMBA)	No	No
Double-banded Plover (*Charadrius bicinctus*)	Marine; Migratory (BONN)	No	No
Curlew Sandpiper (*Calidris ferruginea*)	Marine; Migratory (CAMBA, JAMBA, ROKAMBA)	No	No
Eastern Curlew (*Numensis madagascariensis)*	Marine; Migratory (CAMBA, JAMBA, ROKAMBA)	No	No

Migratory species	EPBC Act status	Important population* in project area	Likely significant impact
Fork-tailed Swift (*Apus pacificus*)	Marine; Migratory (CAMBA, JAMBA, ROKAMBA)	No	No
Great Egret (*Egretta alba*)	Marine; Migratory (CAMBA, JAMBA)	No	No
Great Knot (*Calidris tenuirostris*)	Marine; Migratory (CAMBA, JAMBA, ROKAMBA)	No	No
Greater Sand Plover (*Charadrius leschenaultii*)	Marine; Migratory (CAMBA, JAMBA, ROKAMBA)	No	No
Grey-tailed Tattler (*Heteroscelus brevipes*)	Marine; Migratory (CAMBA, JAMBA, ROKAMBA)	No	No
Latham's Snipe (*Galliago hardwickii*)	Marine; Migratory (CAMBA, JAMBA, ROKAMBA)	No	No
Little Curlew (*Numensis minutus*)	Marine; Migratory (CAMBA, JAMBA, ROKAMBA)	No	No
Eastern Osprey (*Pandion haliaetus*)	Marine; Migratory (BONN)	No	No
Marsh Sandpiper (*Tringa stagnatilis*)	Marine; Migratory (CAMBA, JAMBA, ROKAMBA)	No	No
Pacific Golden Plover (*Pluvialis fulva*)	Marine; Migratory (CAMBA, JAMBA, ROKAMBA)	No	No
Rainbow Bee-eater (*Merops ornatus*)	Marine; Migratory (JAMBA)	No	No
Red Knot *(Calidris canutus*)	Marine; Migratory (CAMBA, JAMBA, ROKAMBA)	No	No
Ruddy Turnstone (*Arenaria interpres*)	Marine; Migratory (CAMBA, JAMBA, ROKAMBA)	No	No
Rufous Fantail (*Rhipidura rufifrons*)	Marine; Migratory (BONN)	No	No
Satin Flycatcher (*Myiagra cyanoleuca*)	Marine; Migratory (BONN)	No	No
Sharp-tailed Sandpiper (*Calidris acuminata*)	Marine; Migratory (CAMBA, JAMBA, ROKAMBA)	No	No
Spectacled Monarch (*Monarcha trivirgatus*)	Marine; Migratory (BONN)	No	No
Swift Parrot (*Lathamus discolour*)	Marine	No	No
Whimbrel (*Numensis phaeopus*)	Marine; Migratory (CAMBA, JAMBA, ROKAMBA)	No	No
White-bellied Sea-Eagle (*Haliaeetus leucogaster*)	Marine; Migratory (CAMBA)	No	No
White Throated Needletail (*Hirundapus caudacutus*)	Marine; Migratory(CAMBA, JAMBA, ROKAMBA)	No	No

Migratory species	EPBC Act status	Important population* in project area	Likely significant impact
* Important population as determined by the Environment Protection and Biodiversity Conservation Act 1999, is one that for a vulnerable species: is likely to be key source populations either for breeding or dispersal is likely to be necessary for maintaining genetic diversity is at or near the limit of the species range.			

7 Conclusion

The biodiversity assessment identifies the following key factors associated with the proposed M4 Widening project:

- The project would not have a significant impact on a MNES listed under the EPBC Act or species, population or community listed under the TSC Act and FM Act.
- The small scale of the impacts predicted and the condition of the vegetation in the project area was considered in assessing the need for biodiversity offsets according to the principles for use of biodiversity offsets in NSW and the EPBC Act environmental offsets policy.
- The removal of around 0.28 hectares of mangrove forest which is classified as important fish habitat under the FM Act and a Type 2 sensitive fish habitat according to DPI (2013). Considering the limited opportunities to avoid and minimise impacts to these areas of fish habitat, it is proposed to consider offsetting this impact, in consultation with DPI.
- The removal of small isolated and fragmented areas of low to moderate condition threatened ecological communities listed under the TSC Act equating to a total loss of 0.52 hectares. Further impacts to these communities should be avoided where possible.
- The project is unlikely to substantially contribute to further fragmentation of habitats and impacts to wildlife connectivity considering the existing high levels of fragmentation limiting fauna species to highly mobile species, and existing bridge and viaduct structures would be duplicated allowing for movements beneath the project.

Key mitigation measures to minimise and avoid biodiversity impacts include but are not limited to:

- Placement of piers in waterways would be avoided where possible and any piers required in waterways would be designed to allow for fish passage.
- Undertaking pre-clearing surveys.
- Employing a staged habitat removal process.
- Avoidance and minimisation of vegetation removal where possible.
- Management of invasive species, pests and diseases.
- A threatened species unexpected finds procedure.

8 References

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Appendix A Threatened subject species assessment

The following assessment identifies the list of threatened flora and fauna species recorded from a 10 kilometre radius of the project and compares the preferred habitat of these species with the habitats identified in the study area to make an assessment of the likelihood of the species being present in the project study area (ie subject species). The criteria used in the assessment are detailed below.

Likelihood of Occurrence	Criteria
Unlikely	▪ Species highly restricted to certain geographical areas not within the project footprint ▪ Specific habitat requirements are not present in the study area
Low	Species not recorded during field surveys and fit one or more of the following criteria: ▪ Have not been recorded previously in the study area/surrounds and for which the study area is beyond the current distribution range ▪ Use specific habitats or resources not present in the study area ▪ Are a non-cryptic perennial flora species that were specifically targeted by surveys and not recorded
Moderate	Species not recorded during the field surveys that fit one or more of the following criteria: ▪ Have infrequently been recorded previously in the study area/surrounds ▪ Use specific habitats or resources present in the study area but in a poor or modified condition ▪ Are unlikely to maintain sedentary populations, however may seasonally use resources within the study area opportunistically or during migration ▪ Are cryptic flowering flora species that were not seasonally targeted by surveys and that have not been recorded
High	Species recorded during the field surveys or species not recorded that fit one or more of the following criteria: ▪ Have frequently been recorded previously in the study area/surrounds ▪ Use habitat types or resources that are present in the study area that are abundance and/or in good condition within the study area ▪ Are known or likely to maintain resident populations surrounding the study area ▪ Are known or likely to visit the site during regular seasonal movements or migration

Table A-8-1 Known or potentially occurring threatened flora species

Species	Status		Distribution and habitat requirements*	Data source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC Act	TSC Act				
Bynoe's Wattles *Acacia bynoeana*	V	E	Found in central eastern NSW, from the Hunter District south to the Southern Highlands and west to the Blue Mountains. It has recently been found in the Colymea and Parma Creek areas west of Nowra. Occurs in heath or dry sclerophyll forest on sandy soils. Seems to prefer open, sometimes slightly disturbed sites such as trail margins, edges of roadside spoil mounds and in recently burnt patches. Associated overstorey species include Red Bloodwood (*Corymbia gummifera),* Scribbly Gum *(Eucalyptus haemastoma),*Drooping Red Gum *(E. parramattensis),* Old Man Banksia *(Banksia serrata)* and Small-leaved Apple *(Angophora bakeri).*	3	Absent	Unlikely
Downy Wattle *Acacia pubescens*	V	V	Concentrated around the Bankstown-Fairfield-Rookwood area and the Pitt Town area, with outliers occurring at Barden Ridge, Oakdale and Mountain Lagoon. Occurs in open woodland and forest, in a variety of plant communities, including Cooks River/ Castlereagh Ironbark Forest, Shale/Gravel Transition Forest and Cumberland Plain Woodland. Occurs on alluviums, shales and at the intergrade between shales and sandstones. The soils are characteristically gravely soils, often with ironstone.	226 PMST	Map Unit 3	Low
Sunshine Wattle *Acacia terminalis subsp. terminalis*	E	E	Very limited distribution between Botany Bay to the northern foreshore of Port Jackson. Recent collections have only been made from the Quarantine Station, Clifton Gardens, Dover Heights, Parsely Bay, Nielson Park, Cooper Park, Chifley and Watsons Bays. Coastal scrub and dry sclerophyll woodland on sandy soils. Habitat is generally sparse and scattered. Most areas of habitat or potential habitat are small and isolated.	0 PMST	Absent	Unlikely
Allocasuarina glareicola	E	E	Primarily restricted to the Richmond (NW Cumberland Plain) district, but with an outlier population found at Voyager Point, Liverpool. Grows in Castlereagh woodland on lateritic soil. Found in open woodland with *Eucalyptus parramattensis, Eucalyptus fibrosa, Angophora bakeri, Eucalyptus sclerophylla* and *Melaleuca decora*. Common associated understorey species include *Melaleuca nodosa, Hakea dactyloides, Hakea sericea, Dillwynia tenuifolia,*	0 PMST	Map Unit 3	Low

Species	Status EPBC Act	Status TSC Act	Distribution and habitat requirements*	Data source+	Potential habitat in the study area	Likelihood of occurrence in the study area
			Micromyrtus minutiflora, Acacia elongata, Acacia brownei, Themeda australis and *Xanthorrhoea minor.*			
Asterolasia elegans	E	E	Occurs north of Sydney, in the Baulkham Hills, Hawkesbury and Hornsby local government areas. Also likely to occur in the western part of Gosford local government area. Known from only seven populations, only one of which is wholly within a conservation reserve. Occurs on Hawkesbury sandstone. Found in sheltered forests on mid- to lower slopes and valleys, eg in or adjacent to gullies which support sheltered forest. The canopy at known sites includes Turpentine (*Syncarpia glomulifera subsp. glomulifera*), Smooth-barked Apple (*Angophora costata*), Sydney Peppermint (*Eucalyptus piperita*), Forest Oak (*Allocasuarina torulosa*) and Christmas Bush (*Ceratopetalum gummiferum*).	0 PMST	Absent	Unlikely
Bothriochloa biloba	E	-	Grows in woodland on poorer soils.	0 PMST	Absent or limited	Low
Thick Lip Spider Orchid *Caladenia tesselata*	V	E	Occurs in the Sydney area, Wyong, Ulladulla and Braidwood. Populations in Kiama and Queanbeyan are presumed extinct. Has been recorded in the Huskisson area in the 1930s. Generally found in grassy sclerophyll woodland on clay loam or sandy soils, however the population near Braidwood is in low woodland with stony soil.	1 PMST	Map Unit 3	Low
Netted Bottlebrush *Callistemon linearifolius*	-	V	Recorded from the Georges River to Hawkesbury River in the Sydney area, and north to the Nelson Bay area of NSW. Was more widespread across its distribution in the past. Some populations are reserved in Ku-ring-gai Chase National Park, Lion Island Nature Reserve, and Spectacle Island Nature Reserve. Further north it has been recorded from Yengo National Park and Werakata National Park. Grows in dry sclerophyll forest on the coast and adjacent ranges.	7	Map Unit 3	Low
Darwinia biflora	V	V	Occurs at 129 sites in the northern and north-western suburbs of Sydney, in	10	Absent	Unlikely

Species	Status		Distribution and habitat requirements*	Data source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC Act	TSC Act				
			the Ryde, Baulkham Hills, Hornsby and Ku-Ring-Gai Local government Areas (LGAs). Occurs on the edges of weathered shale-capped ridges, where these intergrade with Hawkesbury Sandstone. Associated overstorey species include *Eucalyptus haemastoma, Corymbia gummifera* and/or *E. squamosa*. The vegetation structure is usually woodland, open forest or scrub-heath.	PMST		
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 PMST	Map Unit 1 and 2	Low
Dillwynia tenuifolia	V	V	Core distribution is the Cumberland Plain from Windsor to Penrith east to Deans Park. Other populations in Western Sydney are recorded at Voyger Point and Kemps Creek in the Liverpool LGA, Luddenham in the Penrith LGA and South Maroota in the Baulkham Hills Shire. Disjunct localities include the Bulga Mountains at Yengo in the north, and Kurrajong Heights and Woodford in the Lower Blue Mountains. In western Sydney, it may be locally abundant particularly within scrubby/dry heath areas within Castlereagh Ironbark Forest and Shale Gravel Transition Forest on tertiary alluvium or laterised clays. May also be common in transitional areas where these communities adjoin Castlereagh Scribbly Gum Woodland. At Yengo, is reported to occur in disturbed escarpment woodland on Narrabeen sandstone.	1	Map Unit 3	Low
Epacris purpurascens var. purpurascens	-	V	Recorded from Gosford in the north, to Narrabeen in the east, Silverdale in the west and Avon Dam vicinity in the South. Found in a range of habitat types, most of which have a strong shale soil influence.	88	Map Unit 3	Low
Narrow-leaved Black Peppermint *Eucalyptus nicholii*	V	V	This species is sparsely distributed but widespread on the New England Tablelands from Nundle to north of Tenterfield, being most common in central portions of its range. Found largely on private property and roadsides, and occasionally conservation reserves. Planted as urban trees, windbreaks and	1PMST	Natural habitat absent. Potentially	Low

Species	Status EPBC Act	Status TSC Act	Distribution and habitat requirements*	Data source+	Potential habitat in the study area	Likelihood of occurrence in the study area
			corridors. Typically grows in dry grassy woodland, on shallow soils of slopes and ridges. Found primarily on infertile soils derived from granite or metasedimentary rock. This species has been planted in the locality.		planted in the study area	
Wallangarra White Gum *Eucalyptus scoparia*	V	E	In NSW it is known from only three locations near Tenterfield, including Bald Rock National Park. In Queensland it is equally rare, occurring at three sites of which only one has more than a dozen trees. In NSW it is known from only three locations near Tenterfield, including Bald Rock National Park. In Queensland it is equally rare, occurring at three sites of which only one has more than a dozen trees. This species has been planted in the locality.	1	Natural habitat absent. Potentially planted in the study area	Low
Bauer's Midge Orchid *Genoplesium baureri*	-	V	Recorded from locations between Nowra and Pittwater and may occur as far north as Port Stephens. About half the records were made before 1960 with most of the older records being from Sydney suburbs including Asquith, Cowan, Gladesville, Longueville and Wahroonga. No collections have been made from those sites in recent years. The species has been recorded at locations now likely to be within the several conservation reserves including Berowra Valley Regional Park, Royal National Park and Lane Cove National Park. May occur in the Woronora, O'Hares, Metropolitan and Warragamba Catchments. Found in sparse sclerophyll forest and moss gardens over sandstone	10	Absent	Unlikely
Narrow-leaf Finger Fern *Grammitis stenophylla*	-	E	In NSW it has been found on the south, central and north coasts and as far west as Mount Kaputar National Park near Narrabrai. Inhabits moist places, usually near streams, on rocks or in trees, in rainforest and moist eucalypt forest.	1	Absent	Unlikely
Small-flower Grevillea *Grevillea parviflora subsp. parviflora*	V	V	Sporadically distributed throughout the Sydney Basin with the main occurrence centred around Picton, Appin and Bargo. Separate populations are also known further north from Putty to Wyong and Lake Macquarie on the Central Coast, and Cessnock and Kurri Kurri in the Lower Hunter. Grows in sandy or light clay soils usually over thin shales. Occurs in a range of vegetation types from heath	PMST	Absent	Unlikely

Species	Status EPBC Act	Status TSC Act	Distribution and habitat requirements*	Data source+	Potential habitat in the study area	Likelihood of occurrence in the study area
			and shrubby woodland to open forest. Found over a range of altitudes from flat, low-lying areas to upper slopes and ridge crests. Often occurs in open, slightly disturbed sites such as along tracks.			
Hibbertia sp. Bankstown	CE	CE	Is currently known to occur in only one population at Bankstown Airport in Sydney's southern suburbs. The airport site is very heavily modified from the natural state, now largely lacks canopy species, and is currently a low grass/shrub association with many pasture grasses and other introduced herbaceous weeds.	0 PMST	Potential habitat widespread	Low
Hibbertia superans	-	E	Occurs from Baulkham Hills to South Maroota in the northern outskirts of Sydney and at one locality at Mount Boss inland from Kempsey. Occurs in both open woodland and heathland, and appears to prefer open disturbed areas, such as tracksides.	43	Absent	Unlikely
Hypsela sessiflora	X	E	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. Known to grow in damp places, on the Cumberland Plain, including freshwater wetland, grassland/alluvial woodland and an alluvial woodland/shale plains woodland ecotone.	1	Map Unit 4	Moderate
Leptospermum deanei	V	V	Known from the Hornsby, Warringah, Ku-ring-gai and Ryde LGAs. Occurs in woodland on lower hill slopes or near creeks, sandy alluvial soil or sand over sandstone, riparian scrub woodland and open forest.	4 PMST	Absent	Unlikely
Marsdenia viridifolia subsp. viridifolia (endangered population)	-	E2	Endangered population in the Bankstown, Blacktown, Camden, Campbelltown, Fairfield, Holroyd, Liverpool and Penrith local government areas. Recent records are from Prospect, Bankstown, Smithfield, Cabramatta Creek and St Marys. Grows in vine thickets and open shale woodland.	5	Potential habitat widespread	Moderate
Biconvex Paperbark (*Melaleuca biconvexa*)	V	V	Found only in NSW, with scattered and dispersed populations found in the Jervis Bay area in the south and the Gosford-Wyong area in the north. Generally grows in damp places, often near streams or low-lying areas on alluvial soils of low slopes or sheltered aspects.	0 PMST	Absent	Unlikely

Species	Status EPBC Act	Status TSC Act	Distribution and habitat requirements*	Data source+	Potential habitat in the study area	Likelihood of occurrence in the study area
Deane's Paperbark *Melaleuca deanei*	V	V	Deane's Paperbark occurs in two distinct areas, in the Ku-ring-gai, Berowra, Holsworthy and Wedderburn areas, and there are also more isolated occurrences at Springwood, Wollemi National Park, Yalwal and the Central Coast areas. The species grows in heath on sandstone	5 PMST	Absent	Unlikely
Omeo Storksbill (*Pelargonium* sp. G.W. Carr 10345)	E	E	Known from only 3 locations in NSW, with two on lake-beds on the basalt plains of the Monaro and one at Lake Bathurst. A population at a fourth known site on the Monaro has not been seen in recent years. The only other known population is at Lake Omeo, Victoria. It occurs at altitudes between 680 to 1030 m. It is known to occur in the local government areas of Goulburn-Mulwaree, Cooma-Monaro, and Snowy River, but may occur in other areas with suitable habitat; these may include Bombala, Eurobodalla, Palerang, Tumbarumba, Tumut, Upper Lachlan, and Yass Valley local government areas. It has a narrow habitat that is usually just above the high-water level of irregularly inundated or ephemeral lakes, in the transition zone between surrounding grasslands or pasture and the wetland or aquatic communities. It sometimes colonises exposed lake beds during dry periods.	0 PMST	Map Unit 4	Low
Hairy Geebung *Persoonia hirsuta*	E	E	The Hairy Geebung has been recorded in the Sydney coastal area, the Blue Mountains area and the Southern Highlands. Found in sandy soils in dry sclerophyll open forest, woodland and heath on sandstone.	4	Absent	Unlikely
Nodding Geebung *Persoonia nutans*	E	E	Restricted to the Cumberland Plain in western Sydney, between Richmond in the north and Macquarie Fields in the south. Core distribution occurs within the Penrith, and to a lesser extent, Hawkesbury LGAs, with isolated and relatively small populations also occurring in the Liverpool, Campbelltown, Bankstown and Blacktown LGAs. Confined to aeolian and alluvial sediments and occurs in a range of sclerophyll forest and woodland vegetation communities, with the majority of individuals occurring within Agnes Banks Woodland or Castlereagh Scribbly Gum Woodland.	11 PMST	Map Unit 3	Low
Slender Curved Rice Flowers	V	V	Confined to the coastal area of Sydney between northern Sydney in the south and Maroota in the north-west. Former range extended south to the Parramatta	12 PMST	Absent	Unlikely

Species	Status EPBC Act	Status TSC Act	Distribution and habitat requirements*	Data source+	Potential habitat in the study area	Likelihood of occurrence in the study area
Pimelea curviflora var. curviflora			River and Port Jackson region including Five Dock, Bellevue Hill and Manly. Occurs on shaley/lateritic soils over sandstone and shale/sandstone transition soils on ridgetops and upper slopes amongst woodlands.			
Spiked-rice Flower *Pimelea spicata*	E	E	Broad distribution in western Sydney, occurring on the Cumberland Plain (Narellan, Marayong, Prospect Reservoir areas). Another smaller population is recorded in districts (Landsdowne to Shellharbour to northern Kiama) Illawarra. It grows on well-structured clay soils. On the inland Cumberland Plain sites it is associated with Grey Box and Ironbark. In the coastal Illawarra it occurs commonly in Coastal Banksia open woodland with a more well developed shrub and grass understorey.	47 PMST	Absent	Low
Pomaderris prunifolia (endangered population)	-	E2	Endangered population in the Parramatta, Auburn, Strathfield and Bankstown Local government Areas. Known from only three sites within the listed local government areas, at Rydalmere, within Rookwood Cemetery and at The Crest of Bankstown. At Rydalmere it occurs along a road reserve near a creek, among grass species on sandstone. At Rookwood Cemetery it occurs in a small gully of degraded Cooks River / Castlereagh Ironbark Forest on shale soils.	19	Absent	Unlikely
Seaforth Mintbush *Prostanthera marifolia*	E	E	Prostanthera marifolia is currently only known from the northern Sydney suburb of Seaforth and has a very highly restricted distribution within the Sydney Basin Bioregion. The single population is fragmented by urbanisation into three small sites. All known sites are within an area of 2x2 km. Two of the sites are within the local government area of Manly and one site is in the LGA of Warringah. 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.	2 PMST	Absent	Unlikely
Illawarra Greenhood	E	E	Known from a small number of populations in the Hunter region (Milbrodale), the Illawarra region (Albion Park and Yallah) and the Shoalhaven region (near	0 PMST	Map Unit 3	Low

Species	Status EPBC Act	Status TSC Act	Distribution and habitat requirements*	Data source+	Potential habitat in the study area	Likelihood of occurrence in the study area
Pterostylis gibbosa			Nowra). It is apparently extinct in western Sydney which is the area where it was first collected (1803). All known populations grow in open forest or woodland, on flat or gently sloping land with poor drainage. In the Hunter region, the species grows in open woodland dominated by Narrow-leaved Ironbark (*Eucalyptus crebra*), Forest Red Gum (*Eucalyptus tereticornis*) and Black Cypress Pine (*Callitris endlicheri*).			
Sydney Plains Greenhood *Pterostylis saxicola*	E	E	Restricted to western Sydney between Freemans Reach in the north and Picton in the south. There are very few known populations and they are all very small and isolated. Only one population occurs within a conservation reserve at Georges River National Park. Most commonly found growing in small pockets of shallow soil in depressions on sandstone rock shelves above cliff lines. The vegetation communities above the shelves where it occurs are sclerophyll forest or woodland on shale/sandstone transition soils or shale soils.	0 PMST	Absent	Unlikely
Sydney-bush Pea *Pultenaea parviflora*	E	E	Endemic to the Cumberland Plain the 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 of Castlereagh Ironbark Forest and Shale Gravel Transition Forest on tertiary alluvium or laterised clays. May also be common in transitional areas where these communities adjoin Castlereagh Scribbly Gum Woodland. *Eucalyptus fibrosa* is usually the dominant canopy species. *Eucalyptus globoidea, E. longifolia, E. parramattensis, E. sclerophylla* and *E. sideroxylon* may also be present or co-dominant, with *Melaleuca decora* frequently forming a secondary canopy layer. Associated species may include *Allocasuarina littoralis, Angophora bakeri, Aristida* spp. *Banksia spinulosa*, *Cryptandra* spp., *Daviesia ulicifolia*, *Entolasia stricta, Hakea sericea, Lissanthe strigosa, Melaleuca nodosa, Ozothamnus diosmifolius* and *Themeda australis*.	2	Map Unit	Low
Matted Bush-pea *Pultenaea*	-	V	Widespread in Victoria, Tasmania, and south-eastern South Australia, However in NSW it is represented by just three disjunct populations on the	13	Map Unit 3	Low

Species	Status EPBC Act	Status TSC Act	Distribution and habitat requirements*	Data source+	Potential habitat in the study area	Likelihood of occurrence in the study area
pedunculata			Cumberland Plains in Sydney, the coast between Tathra and Bermagui and the Windellama area south of Goulburn. 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.			
Whalebone Tree *Streblus brunonianus* (syn. *Streblus pendulinus*)	E	-	In warmer rainforest, chiefly along watercourses, north from Milton.	0 PMST	Absent	Unlikely
Magenta Lilly Pilly *Syzygium paniculatum*	V	V	The Magenta Lilly Pilly is found only in NSW, in a narrow, linear coastal strip from Bulahdelah to Conjola State Forest. On the south coast the Magenta Lilly Pilly occurs on grey soils over sandstone, restricted mainly to remnant stands of littoral rainforest. On the central coast Magenta Lilly Pilly occurs on gravels, sands, silts and clays in riverside gallery rainforests and remnant littoral rainforest communities.	9 PMST	Absent	Unlikely
Glandular-pink Bell *Tetratheca glandulosa*	V	V	Endemic to NSW, with around about 150 populations from Yengo National Park to Lane Cove National Park. Associates in areas with shale cappings over sandstone. Occurs in heath, scrublands to woodlands and open forest. Common woodland tree species include: *Corymbia gummifera, C. eximia, Eucalyptus haemastoma, E. punctata, E. racemosa*, and/or *E. sparsifolia,* with an understorey dominated by species from the families Proteaceae, Fabaceae, and Epacridaceae.	7 PMST	Absent	Unlikely
Black-eyed Susan *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. The majority of populations occur on low nutrient	13	Absent	Unlikely

Species	Status EPBC Act	Status TSC Act	Distribution and habitat requirements*	Data source+	Potential habitat in the study area	Likelihood of occurrence in the study area
			soils associated with the Awaba Soil Landscape. While the species has a preference for cooler southerly aspects, it has been found on slopes with a variety of aspects. It generally prefers well-drained sites and occurs on ridges, although it has also been found on upper slopes, mid-slopes and occasionally in gullies.			
Creek Triplarina *Triplarina imbricata*	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*).	4	Absent	Unlikely
Tadgell's Bluebell *Wahlenbergia multicaulis* (endangered population)	-	E2	Endnagered population in the in the local government areas of Auburn, Bankstown, Baulkham Hills, Canterbury, Hornsby, Parramatta and Strathfield LGAs. There are 13 known sites, two of which are in northern Sydney (ie Thornleigh and Mt Ku-Ring-Gai) with the remainder in western Sydney (eg at Rookwood, Chullora, Bass Hill, Bankstown, Georges Hall, Campsie, South Granville and Greenacre). 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 Hornsby LGA it occurs in or adjacent to sandstone gully forest. In Western Sydney it is found in remnants of Cooks River/ Castlereagh Ironbark Forest.	61	Potential habitat widespread	Moderate
Narrow-leaved Wilsonia *Wilsonia backhousei*	-	V	Found on the coast between Mimosa Rocks National Park and Wamberal north of Sydney. It grows in all southern states. This is a species of the margins of salt marshes and lakes, both coastal and inland.	95	Map Unit 1	Moderate
* Distribution and habitat requirement information adapted from:						

Species	Status EPBC Act	Status TSC Act	Distribution and habitat requirements*	Data source+	Potential habitat in the study area	Likelihood of occurrence in the study area
• Commonwealth Government Department of Sustainability, Environment, Water, Populations and Community http://www.environment.gov.au/biodiversity/threatened/index.html • NSW Office of Environment and Heritage http://www.environment.nsw.gov.au/threatenedspecies/ • Department of Primary Industries – Threatened Fish and Marine Vegetation http://pas.dpi.nsw.gov.au/Species/All_Species.aspx + Data source includes • Number of records from the NSW Office of Environment and Heritage Wildlife Atlas record data (Accessed November 2012); and • Identified from the Protected Matters Search Tool (PMST) Australian Government Department of Sustainability, Environment, Water, Populations and Community http://www.environment.gov.au/epbc/pmst/index.html						

Table A-8-2 Known or potentially occurring threatened and migratory fauna species

Species	Status EPBC Act	Status TSC Act/ FM Act	Distribution and habitat requirements*	Source+	Potential habitat in the study area	Likelihood of occurrence in the study area
MAMMALS						
Brush-tailed Rock Wallaby (*Petrogale penicillilata*)	E	E	Open forest habitats on steep terrain with exposed rocks, rock overhangs and platforms.	0 PMST	Absent	Unlikely
Eastern Bent-wing Bat (*Miniopterus schreibersii oceanensis*)	-	V	Occurs on east and north west coasts of Australia. Caves are the primary roosting habitat, but also use derelict mines, storm-water tunnels, buildings and other man-made structures.	46	Potential habitat widespread	Moderate
Eastern False Pipistrelle (*Falsistrellus tasmaniensis*)	-	V	Occurs in a variety of open forest and woodland habitats with hollow-bearing trees. Requires hollows for roosting. May forage in re-growth and modified environments.	5	Potential habitat widespread	Moderate

Species	Status		Distribution and habitat requirements*	Source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC Act	TSC Act/ FM Act				
Eastern Freetail Bat (*Mormopterus norfolkensis*)	-	V	Occur in dry sclerophyll forest and woodland east of the Great Dividing Range. Roosts mainly in tree hollows but will also roost under bark or in human-made structures.	12	Potential habitat widespread	Moderate
Eastern Pygmy Possum (*Cercartetus nanus*)	-	V	Found in a broad range of habitats from rainforest through to wet and dry sclerophyll forest and woodland to heath, but in most areas woodlands and heath appear to be preferred.	2	Absent	Unlikely
Greater Broad-nosed Bat (*Scoteanax rueppellii*)	-	V	Utilises a variety of habitats from woodland through to moist and dry eucalypt forest and rainforest, though it is most commonly found in tall wet forest. Although this species usually roosts in tree hollows, it has also been found in buildings.	6	Potential habitat widespread	Moderate
Grey-headed Flying-fox (*Pteropus poliocephalus*)	V	V	Forages on nectar and pollen in sclerophyll forests and on rainforest fruits and vines, orchards, gardens.	196 PMST	Potential habitat widespread	Moderate
Koala (*Phascolarctos cinereus*)	V	V	Open forests and woodlands with favoured food tree species.	0 PMST	Absent	Unlikely
Large-eared Pied Bat (*Chalinolobus dwyeri*)	V	V	Forages over a broad range of open forest and woodland habitats, this species is a cave roosting bat which favours sandstone escarpment habitats for roosting, in the form of shallow overhangs, crevices and caves.	1 PMST	Potential habitat widespread	Moderate
Little Bent-wing Bat (*Miniopterus australis*)	-	V	Moist eucalypt forest, rainforest, vine thicket, wet and dry sclerophyll forest	1	Potential habitat widespread	Moderate
Long-nosed Bandicoot (*perameles nasuta*) – endangered population	-	E2	An endangered population in inner western Sydney. The exact area occupied by the population is not clearly defined, and includes the local government areas (LGA) of Marrickville and Canada Bay, with the likelihood that it also includes Canterbury, Ashfield and Leichhardt LGAs. Future research may better define the population and possibly indicate a wider distribution. This population is disjunct from the nearest	23	Potential habitat present	Moderate

Species	Status		Distribution and habitat requirements*	Source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC Act	TSC Act/ FM Act				
			records of the Long-nosed Bandicoot, which occur north of the Parramatta River or much further south at Holsworthy Military Reserve. Shelter mostly under older houses and buildings Forage in parkland and back-yards There are apparently no large blocks of suitable habitat, likely to support a large source population, on the Cooks River to the south, or along the southern foreshore of Parramatta River and Sydney Harbour to the north.			
Long-nosed Potoroo (*Potorous tridactylus*)	V	V	Inhabits coastal heaths and dry and wet sclerophyll forests. Dense understorey with occasional open areas is an essential part of habitat, and may consist of grass-trees, sedges, ferns or heath, or of low shrubs of tea-trees or melaleucas. A sandy loam soil is also a common feature.	0 PMST	Absent	Unlikely
New Holland Mouse (*Psuedomys novaehollandiae*)	V	-	Distribution is fragmented across all eastern states of Australia, where it inhabits open heath lands, open woodlands with heath understorey and vegetated sand dunes.	0 PMST	Absent	Unlikely
Southern Brown Bandicoot (*Isoodon o. obesulus*)	E	E	Typically associated with coastal heaths or open forest habitats with a heathy understorey on sandy soils.	0 PMST	Absent	Unlikely
Southern Myotis (*Myotis macropus*)	-	V	Generally roost in groups close to water in caves, mine shafts, hollow-bearing trees, storm water channels, buildings, under bridges and in dense foliage. Forages over streams and pools catching insects and small fish.	5	Potential habitat widespread	Moderate
Spotted-tailed Quoll (*Dasyurus maculatus*)	E	V	Wet and dry sclerophyll forests and rainforests, and adjacent open agricultural areas. Generally associated with large expansive areas of habitat to sustain territory size. Requires hollow-bearing trees, fallen logs, small caves, rock crevices, boulder fields and rocky-cliff faces as den sites.	3 PMST	Potential habitat widespread	Low
Yellow-bellied Sheathtail-	-	V	Forages in most habitats across its very wide range, with and	3	Potential	Moderate

Species	Status EPBC Act	Status TSC Act/ FM Act	Distribution and habitat requirements*	Source+	Potential habitat in the study area	Likelihood of occurrence in the study area
bat (*Saccolaimus flaviventris*)			without trees; appears to defend an aerial territory. Roost in tree hollows and buildings.		habitat widespread	
BIRDS						
Australasian Bittern (*Botaurus poiciloptilus*)	E	E	They are widespread but uncommon over south-eastern Australia. It extends mainly along the coasts of eastern Australia and is found all over NSW except for the far north west. It inhabits freshwater wetlands with tall dense vegetation where it feeds in shallow waters.	3 PMST	Absent	Low
Australian Fairy Tern (*Sternula nereis nereis*)	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. The Fairy Tern (Australian) nests on sheltered sandy beaches, spits and banks above the high tide line and below vegetation. The subspecies has been found in embayments of a variety of habitats including offshore, estuarine or lacustrine (lake) islands, wetlands and mainland coastline. The bird roosts on beaches at night.	0 PMST	Map Unit 1	Low
Australian Painted Snipe (*Rostratula benghalensis australis*)	V, M	E	Prefers fringes of swamps, dams and nearby marshy areas where there is a cover of grasses, lignum, low scrub or open timber.	0 PMST	Absent	Low
Barking Owl (*Ninox connivens*)	-	V	Forest and woodland habitats, particularly drier western slopes and riverine areas, hunts for birds and small mammals.	5	Absent	Low
Black Bittern (*Ixobrychus flavicollis*)	-	V	Occurs from south NSW to Cape York, and extends to the Kimberley region. Inhabits terrestrial and estuarine wetlands, preferring permanent water and dense vegetation.	1	Map Unit 1	Moderate
Black-necked Stork	-	E	Open wetlands & adjoining agricultural areas.	1	Absent	Low

Species	Status		Distribution and habitat requirements*	Source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC Act	TSC Act/ FM Act				
(*Ephippiorhynchus asiaticus*)						
Black-tailed Godwit (*Limosa limosa*)	M	V	A migratory wading bird that breeds in Mongolia and Eastern Siberia and flies to Australia for the southern summer, arriving in August and leaving in March. In NSW, it is most frequently found at Kooragang Island (Hunter River estuary). Occurs in sheltered bays, estuaries and lagoons with large intertidal mudflats and sand flats. Also found at inland mudflats, swamps.	13	Map Unit 1	Moderate
Broad-billed Sandpiper (*Limicola falcinellus*)	-	V	Oceanic, marine and estuarine	1	Map Unit 1	Moderate
Bush-stone Curlew (*Burhinus grallarius*)	V	E	Open forests and woodlands with a sparse grassy ground layer and fallen timber. Largely nocturnal, being especially active on moonlit nights. Feed on insects and small vertebrates, such as frogs, lizards and snakes. Nest on the ground in a scrape or small bare patch.	5	Absent	Low
Curlew Sandpiper (*Calidris ferruginea*)	M	E	It is distributed along most of the Australian coastline. It occurs in littoral and estuarine habitats and intertidal mudflats and also non tidal lakes, swamps and lagoons. Sometimes found at inland freshwater wetlands.	354	Map Unit 1	Moderate
Eastern Bristlebird (*Dasyornis brachypterus*)	E	E	Habitat is characterised by dense, low vegetation including heath and open woodland with a heathy understorey; in northern NSW occurs in open forest with tussocky grass understorey; all of these vegetation types are fire prone.	0 PMST	Absent	Unlikely
Eastern Grass Owl (*Tyto longimembris*)	-	V	Eastern Grass Owls have been recorded occasionally in all mainland states of Australia but are most common in northern and north-eastern Australia. In NSW they are more likely to be resident in the north-east. Eastern Grass Owl numbers can fluctuate greatly, increasing especially during rodent plagues.	1	Absent	Unlikely

Species	Status		Distribution and habitat requirements*	Source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC Act	TSC Act/ FM Act				
			Eastern Grass Owls are found in areas of tall grass, including grass tussocks, in swampy areas, grassy plains, swampy heath, and in cane grass or sedges on flood plains.			
Eastern Osprey (*Pandion haliaetus*)	-	V	Favour coastal areas, especially the mouths of large rivers, lagoons and lakes	2	Map Unit 1	Moderate
Flame Robin (*Petroica phoenicea*)	-	V	Breeds in upland tall moist eucalypt forests and woodlands, often on ridges and slopes. Prefers clearings or areas with an open understorey.	1	Absent	Unlikely
Freckled Duck (*Stictonetta naevosa*)	-	V	Open wetlands & adjoining agricultural areas.	1	Absent	Unlikely
Gang-gang Cockatoo (*Callocephalon fimbriatum*)	-	V, E2	Occurs within a variety of forest and woodland types. Usually frequents forested areas with old growth attributes required for nesting and roosting purposes.	6	Absent	Low
Glossy Black-Cockatoo (*Calyptorhynchus lathami*)	-	V	Open forest habitats with She-oak species (*Allocasuarina* spp.) required for food.	1	Absent	Low
Great Knot (*Calidris tenuirostris*)	M	V	Oceanic, marine and estuarine	1	Map Unit 1	Moderate
Greater Sand Plover (*Charadrius leschenaultii*)	M	V	Oceanic, marine and estuarine	1	Map Unit 1	Moderate
Little Eagle (*Hieraaetus morphnoides*)	-	V	Occupies open eucalypt forest, woodland or open woodland. Sheoak or acacia woodlands and riparian woodlands of interior NSW are also used.	9	Absent	Low
Little Lorikeet (*Glossopsitta pusilla*)	-	V	Forages primarily in the canopy of open Eucalyptus forest and woodland, yet also finds food in apples (*Angophora* sp.), paperbarks (*melaleuca* sp.) and other tree species. Riparian habitats are particularly used, due to higher soil fertility and hence greater productivity. Isolated flowering trees in open	10	Planted Eucalypts	Moderate

Species	Status		Distribution and habitat requirements*	Source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC Act	TSC Act/ FM Act				
			country (eg paddocks, roadside remnants) and urban trees also help sustain viable populations of the species.			
Little Tern (*Sterna albifrons*)	E	E	Oceanic, marine and estuarine	3	Map Unit 1	Moderate
Masked Owl (*Tyto novaehollandiae*)	-	V	Dry eucalypt forests and woodland, typically prefers open forest with low shrub density. Requires old trees for roosting and nesting	2	Absent	Low
Orange-bellied Parrot (*Neophema chrysogaster*)	CE, M	CE	Coastal saltmarsh and strandline/foredune vegetation communities as well as pasture and weedy areas on the coast.	0 PMST	Absent	Low
Pied Oystercatcher (*Haematopus longirostris*)	-	V	Oceanic, marine and estuarine	1	Map Unit 1	Moderate
Powerful Owl (*Ninox strenua*)	-	V	Open forests with dense wet gullies and creek areas, requires large mature trees with hollows for breeding and dense areas of vegetation for prey and roosting	40	Absent	Low
Red Goshawk (*Erythrotriorchis radiatus*)	V	CE	This unique Australian endemic raptor is distributed sparsely through northern and eastern Australia, from the western Kimberley Division of northern Western Australia to north-eastern Queensland and south to far north-eastern NSW, and with scattered records in central Australia. The species is very rare in NSW, extending south to about 30°S, with most records north of this, in the Clarence River Catchment, and a few around the lower Richmond and Tweed Rivers. Formerly, it was at least occasionally reported as far south as Port Stephens. Red Goshawks inhabit open woodland and forest, preferring a mosaic of vegetation types, a large population of birds as a source of food, and permanent water, and are often found in riparian habitats along or near watercourses or	0 PMST	Absent	Low

Species	Status		Distribution and habitat requirements*	Source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC Act	TSC Act/ FM Act				
			wetlands. In NSW, preferred habitats include mixed subtropical rainforest, Melaleuca swamp forest and riparian Eucalyptus forest of coastal rivers.			
Regent Honeyeater (*Xanthomyza phrygia*)	E, M	E	A nomadic species typically associated with forest and woodland habitats with the presence of suitable foraging species such as Yellow Box (*Eucalyptus melliodora*) and Red Ironbark (*Eucalyptus sideroxylon*).	8 PMST	Absent	Low
Scarlet Robin (*Petroica boodang*)	-	V	The Scarlet Robin lives in dry eucalypt forests and woodlands. The understorey is usually open and grassy with few scattered shrubs. This species lives in both mature and re-growth vegetation. It occasionally occurs in mallee or wet forest communities, or in wetlands and tea-tree swamps.	1	Absent	Low
Superb Fruit-dove (*Ptilinopus superbus*)	-	V	Inhabits rainforest and similar closed forests where it forages high in the canopy, eating the fruits of many tree species such as figs and palms	5	Absent	Low
Superb Parrot (*Polytelis swainsonii*)	V	V	Occurs in eastern inland NSW. Inhabit Box-Gum, Box-Cypress-pine and Boree Woodlands and River Red Gum Forest	2	Absent	Unlikely
Swift Parrot	E, M	E	On the mainland they occur in areas where eucalypts are	22	Planted	Moderate

Species	Status		Distribution and habitat requirements*	Source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC Act	TSC Act/ FM Act				
(*Lathamus discolour*)			flowering profusely or where there are abundant lerp (from sap-sucking bugs) infestations. Favoured feed trees include winter flowering species such as Swamp Mahogany (*Eucalyptus robusta*), Spotted Gum (*Corymbia maculate)*, Red Bloodwood (*C. gummifera),* Red Ironbark (*E. sideroxylon*), and White Box (*E. albens*).	PMST	Eucalypts	
Terek Sandpiper (*Xenus cinereus*)	-	V	Oceanic, marine and estuarine	1	Map Unit 1	Moderate
Turquoise Parrot (*Neophema pulchella*)	-	V	Lives on the edges of eucalypt woodland adjoining clearings, timbered ridges and creeks in farmland.	1	Absent	Low
Varied Sittella (*Daphoenositta chrysoptera)*	-	V	Inhabits eucalypt forests and woodlands, especially those containing rough-barked species and mature smooth-barked gums with dead branches, mallee and acacia woodland.	6	Planted Eucalypts	Low
White-fronted Chat (*Epthianura albifrons*) – endangered population	-	E2	An endangered population in the Sydney Metropolitan Catchment Management Area. Regularly observed in the saltmarsh of Newington Nature Reserve (with occasional sightings from other parts of Sydney Olympic Park and in grassland on the northern bank of the Parramatta River). Current estimates suggest this population consists of 8 individuals. Regularly observed in the saltmarsh and on the sandy shoreline of a small island of Towra Point Nature Reserve. This population is around 19-50 individuals.	208	Map Unit 1	Moderate
REPTILES						
Broad-headed Snake (*Hoplocephalus bungaroides*)	V	V	Shelters in rock crevices and under flat sandstone rocks on exposed cliff edges during autumn, winter and spring. Moves from the sandstone rocks to shelters in hollows in large trees within 200 m of escarpments in summer.	0 PMST	Absent	Unlikely

Species	Status EPBC Act	Status TSC Act/ FM Act	Distribution and habitat requirements*	Source+	Potential habitat in the study area	Likelihood of occurrence in the study area
AMPHIBIANS						
Southern Barred Frog (*Mixophyes iteratus*)	E	E	Forages and lives amongst deep, damp leaf litter in rainforests, moist eucalypt forest and nearby dry eucalypt forest, at elevations below 1000 m. They breed around shallow, flowing rocky streams from late spring to summer.	0 PMST	Absent	Unlikely
Giant Burrowing Frog (*Heleioporus australiacus*)	V	V	Found in heath, woodland and open forest with sandy soils.	0 PMST	Absent	Unlikely
Green and Golden Bell Frog (*Litoria aurea*)	E	E	Ephemeral and permanent freshwater wetlands, ponds, dams with an open aspect and fringed by Typha and other aquatics, free from predatory fish.	11832 PMST	Absent	Low
Red-crowned Toadlet (*Pseudophryne australis*)	-	V	It has restricted distribution from Pokolbin to Nowra and west to Mt Victoria. Occurs in open forests and wet drainage lines below sandstone ridges that often have shale lenses or cappings in the Hawkesbury and Narrabeen Sandstones.	9	Absent	Unlikely
Southern Bell Frog (*Litoria raniformis*)	V	E	In NSW the species was once distributed along the Murray and Murrumbidgee Rivers and their tributaries, the southern slopes of the Monaro district and the central southern tablelands as far north as Tarana, near Bathurst. Currently, the species is known to exist only in isolated populations in the Coleambally Irrigation Area, the Lowbidgee floodplain and around Lake Victoria. A few yet unconfirmed records have also been made in the Murray Irrigation Area in recent years. The species is also found in Victoria, Tasmania and South Australia, where it has also become endangered. Usually found in or around permanent or ephemeral Black Box/Lignum/Nitre Goosefoot swamps, Lignum/Typha swamps and River Red Gum swamps or billabongs along floodplains and river valleys. They are also found in irrigated rice crops, particularly where there is no	0 PMST	Absent	Unlikely

Species	Status		Distribution and habitat requirements*	Source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC Act	TSC Act/ FM Act				
			available natural habitat.			
Stuttering Frog (*Mixophyes balbus*)	-	E	Permanent streams in moist and wet sclerophyll forests.	0 PMST	Absent	Unlikely
INVERTEBRATE						
Cumberland Land Snail (*Meridolum corneovirens*)	-	E	Primarily inhabits Cumberland Plain Woodland (an endangered ecological community). This community is grassy, open woodland with occasional dense patches of shrubs. Lives under litter of bark, leaves and logs, or shelters in loose soil around grass clumps. Occasionally shelters under rubbish.	9	Map Unit 3	Low
Sydney Hawk Dragonfly (*Austrocordulia leonardi*)		E (FM Act)	Has been in Picton, the Hawkesbury-Nepean, George's River and Port Hacking drainages. The freshwater larvae require deep and shady river pools with cool water where they live underneath rocks. Not tolerant to catchment development.	8	Absent	Unlikely
Adam's Emerald Dragonfly (*Archaeophya adamsi*)		E (FM Act)	One of Australia's rarest dragonflies. Only 5 specimens ever collected from the greater Sydney region. Larvae require freshwater creeks with shaded riffle zones, gravel or sandy bottoms and riparian vegetation. Impacted by catchment development.	5	Absent	Low
FISH						
Australian Grayling (*Prototroctes maraena*)	V		The Australian Grayling has been recorded within the upper reaches of the Hawkesbury-Nepean River Catchment. It inhabits clear, flowing waters.	0 PMST	Map Unit 4	Unlikely
Black Cod (*Epinephelus daemelii*)	V	V	In Australia, the distribution of black cod ranges from southern Queensland through NSW to northern Victoria. However, records from Queensland and Victoria are rare, and the NSW coastline forms the species' main range, both in Australia and internationally. The use of estuaries may be an important part of the ecology of juvenile black cod in NSW waters.	0 PMST	Map Unit 1	low

Species	Status EPBC Act	Status TSC Act/ FM Act	Distribution and habitat requirements*	Source+	Potential habitat in the study area	Likelihood of occurrence in the study area
Macquarie Perch (*Macquaria australasica*)	E	E (FM Act)	Macquarie Perch has been recorded within the upper Reaches of the Hawkesbury –Nepean System.	0 PMST	Map Unit 3 and 4	Unlikely
Trout Cod (*Maccullochella macquariensis*)	E	E (FM Act)	The Trout Cod is a freshwater fish endemic to the southern Murray Darling Basin. Two specimens have been recorded in Appin in the early 1980's. They are reliant on woody snags for cover and prefer deeper holes close to the bank. They are territorial and have a small home range.	78	Absent	Unlikely
Silver Perch (*Bidyanus bidyanus*)		V (FM Act)	Large freshwater fish native to the Murray-Darling Basin. The closest record near Sydney was Appin in 1980. Prefers fast flowing open waters with rapids or will inhabit slow waters with cover (snags, macrphytes).	91	Absent	Unlikely
Murray Cod (*Maccullochella peelii*)	V		The Murray Cod is a freshwater fish occurring in the Murray Darling Basin. It has not been recorded in the Sydney catchments. It is a territorial, sedentary fish which is highly reliant on woody debris, debris piles and in-stream vegetation for habitat.	78	Absent	Unlikely
MIGRATORY MARINE SPECIES						
Fork-tailed Swift (*Apus pacificus*)	M	-	The species breeds in Asia and migrate to Australia in the summer from which they spend their entire life-cycle on the wing, hunting, resting and sleeping.	PMST	Potential habitat widespread	Moderate
Cattle Egret (*Ardea ibis*)	M	-	Grasslands, woodlands and wetlands, and is not common in arid areas. It also uses pastures and croplands, especially where drainage is poor. Often seen with cattle.	PMST	Potential habitat widespread	Moderate
MIGRATORY TERRESTRIAL SPECIES						
Black-faced Monarch (*Monarcha melanopsis*)	M	-	Rainforests, moist eucalypt forests and coastal scrubs.	PMST	Absent	Low
Rainbow Bee-eater (*Merops ornatus*)	M	-	Predominantly woodland and timbered plains.	PMST	Absent	Low

Species	Status		Distribution and habitat requirements*	Source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC Act	TSC Act/ FM Act				
Rufous Fantail (*Rhipidura rufifrons*)	M	-	Predominantly rainforests and wetter forests.	PMST	Absent	Low
Satin Flycatcher (*Myagra cyanoleuca*)	M	-	Predominantly forests, in particular thick vegetation in gullies.	PMST	Absent	Low
Spectacled Monarch (*Monarchia trivirgatus*)	M	-	Found in rainforest, mangroves and moist gullies of wet sclerophyll forest	PMST	Absent	Low
White-bellied Sea-eagle (*Haliaeetus leucogaster*)	M	-	Predominantly ocean shores and estuaries, occasionally inland rivers and streams.	PMST	Map Unit 1	Moderate
White-throated Needletail (*Hirundapus caudacutus*)	M	-	An aerial foraging species which occupies a range of habitats from open modified landscapes to woodland and forest.	PMST	Potential habitat widespread	Moderate
MIGRATORY WETLAND SPECIES						
Bar-tailed Godwit (*Limosa lapponica*)	M	-	Mudflats and beaches.	PMST	Map Unit 1	Moderate
Double-banded Plover (*Charadrius bicinctus*)	M	-	Coastal beaches, mudflats, sewage farms, river banks, fields, dunes, upland tussock grasses and shingle.	PMST	Map Unit 1	Moderate
Eastern Curlew (*Numensis madagascariensis*)	M	-	Intertidal mudflats and sandflats, often with beds of seagrass, on sheltered coasts, especially estuaries, mangrove swamps, bays, harbours and lagoons.	PMST	Map Unit 1	Moderate
Great Egret (*Ardea alba*)	M	-	Grasslands and wetlands such as pastures and croplands, especially where drainage is poor.	PMST	Potential habitat widespread	Present
Grey-tailed Tattler (*Heteroscelus brevipes*)	M	-	Sheltered coasts with reefs and rock platforms or with intertidal mudflats	PMST	Map Unit 1	Moderate
Latham's snipe (*Gallinago hardwickii*)	M	-	Wetlands, wet meadows, flooded grassy paddocks, open grassland and drainage areas.	PMST	Potential habitat widespread	Moderate

Species	Status		Distribution and habitat requirements*	Source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC Act	TSC Act/ FM Act				
Little Curlew (*Numensis minutus*)	M	-	Coastal and inland grasslands and black soil plains in northern Australia, near swamps and flooded areas. They also feed on playing fields, paddocks and urban lawns.	PMST	Potential habitat widespread	Moderate
Marsh Sandpiper (*Tringa stagnatilis*)	M	-	Fresh or brackish (slightly salty) wetlands such as rivers, water meadows, sewage farms, drains, lagoons and swamps.	PMST	Map Unit 1	Moderate
Pacific Golden Plover (*Pluvialis fulva*)	M	-	Fields, beaches and tidal flats.	PMST	Map Unit 1	Moderate
Red Knot (*Calidris canutus*)	M	-	Coastal mudfalts.	PMST	Map Unit 1	Moderate
Ruddy Turnstone (*Arenaria interpres*)	M	-	Coastline and only occasionally inland. They are mainly found on exposed rocks or reefs, often with shallow pools, and on beaches.	PMST	Map Unit 1	Moderate
Sharp-tailed Sandpiper (*Calidris acuminata*)	M	-	Grasslands and mudflats.	PMST	Map Unit 1	Moderate
Whimbrel (*Numensis phaeopus*)	M	-	Mudflats and beaches.	PMST	Map Unit 1	Moderate

* Distribution and habitat requirement information adapted from:

- Australian Government Department of Sustainability, Environment, Water, Populations and Community http://www.environment.gov.au/biodiversity/threatened/index.html
- NSW Office of Environment and Heritage http://www.environment.nsw.gov.au/threatenedspecies/
- Department of Primary Industries – Threatened Fish and Marine Vegetation http://pas.dpi.nsw.gov.au/Species/All_Species.aspx

+ Data source includes

- Number of records from the NSW Office of Environment and Heritage Wildlife Atlas record data (Accessed November 2012); and
- Identified from the Protected Matters Search Tool (PMST) Australian Government Department of Sustainability, Environment, Water, Populations and Community http://www.environment.gov.au/epbc/pmst/index.html

Key

Species	Status		Distribution and habitat requirements*	Source+	Potential habitat in the study area	Likelihood of occurrence in the study area
	EPBC Act	TSC Act/ FM Act				
E = endangered species E2 = endangered population V = vulnerable species M = migratory species						

Table A-3 Threatened ecological communities known from the region and recorded in the study area

TSC Act Listed Community	EPBC Act Listed Community	Confirmed occurrence in the study area
Castlereagh Swamp Woodland Community (Endangered)	-	No
Coastal Saltmarsh in the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (Endangered)	-	No
Cooks River/ Castlereagh Ironbark Forest in the Sydney Basin Bioregion (Endangered)	-	No
Cumberland Plain Woodland in the Sydney basin Bioregion (Critically Endangered)	Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest (Critically Endangered)	Present (TSC Act listed only)
Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (Endangered)	-	No
Moist Shale Woodland in the Sydney Basin Bioregion (Endangered)	-	No
River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (Endangered)	-	No
Shale Gravel Transition Forest in the Sydney Basin Bioregion (Endangered)	Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest (Critically Endangered)	Present
Shale Sandstone Transition Forest in the Sydney Basin Bioregion (Endangered)	Shale/Sandstone Transition Forest (Endangered)	No

TSC Act Listed Community	EPBC Act Listed Community	Confirmed occurrence in the study area
Swamp Oak Floodplain Forest of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (Endangered)	-	Present
Western Sydney Dry Rainforest in the Sydney Basin Bioregion	-	No

Appendix B Flora species list

Abbreviations

i = introduced (ie not indigenous to Australia)

ix = Noxious species listed under the *Noxious Weeds Act 1993*.

n = native Australian species not considered to be indigenous to the site

t = threatened species

Notes

A sample flora assemblage obtained from a short term survey, such as the present one, cannot be considered to be comprehensive, but rather indicative of the actual flora assemblage. It can take many years of flora surveys to record all of the plant species occurring within any area, especially species that are only apparent in some seasons. Not all species can be accurately identified in a 'snapshot' survey due to absence of flowering or fruiting material, etc.

Group	Family	Scientific name	Common name	Status
Flowering Plants - Dicotyledons				
	ARAUCARIACEAE	*Araucaria cunninghamii*	Hoop Pine	n
Flowering Plants - Dicotyledons				
	ACANTHACEAE	*Avicennia marina*	Grey Mangrove	
	AIZOACEAE	*Tetragonia tetragonioides*	New Zealand Spinach	
	ANACARDIACEAE	*Schinus areira*	Pepper tree	i
	APOCYNACEAE	*Araujia hortorum*	Moth Vine	i
	ASTERACEAE	*Ageratina adenophora*	Crofton Weed	ix
	ASTERACEAE	*Ambrosia* spp.	Ragweed	i
	ASTERACEAE	*Bidens pilosa*	Cobblers Peg	i
	ASTERACEAE	*Cirsium vulgare*	Spear Thistle	i
	ASTERACEAE	*Conyza spp.*	Fleabane	i

Group	Family	Scientific name	Common name	Status
	ASTERACEAE	*Facelis retusa*	Facelis	i
	ASTERACEAE	*Gamochaeta purpurea*	Cudweed	i
	ASTERACEAE	*Hypochoeris microcephala* var. *albiflora*	White Flatweed	i
	ASTERACEAE	*Hypochoeris radicata*	Catsear	i
	ASTERACEAE	*Lactuca serriola*	Prickly Lettuce	i
	ASTERACEAE	*Ozothamnus diosmifolius*	Tall Paperdaisy	p
	ASTERACEAE	*Senecio madagascariensis*	Fireweed	i
	ASTERACEAE	*Sonchus oleraceus*	Common Sow-thistle	i
	ASTERACEAE	*Tagetes minuta*	Stinking Roger	i
	ASTERACEAE	*Taraxacum officinale*	Dandelion	i
	ASTERACEAE	*Xanthium occidentale*	Noogoora Burr	ix
	BASELLACEAE	*Anredera cordifolia*	Madeira Vine	ix
	BIGNONIACEAE	*Jacaranda mimosifolia*	Jacaranda	i
	BIGNONIACEAE	*Tecoma stans*	Yellowbells	i
	BRASSICACEAE	*Brassica* sp.		i
	BRASSICACEAE	*Capsella bursa-pastoris*	Shepherds Purse	i
	BRASSICACEAE	*Lepidium bonariense*	Peppercress	i
	CARYOPHYLLACEAE	*Cerastium glomeratum*	Mouse-ear Chickweed	i
	CARYOPHYLLACEAE	*Stellaria media*	Common Chickweed	i
	CASUARINACEAE	*Allocasuarina littoralis*	Black She-oak	p
	CASUARINACEAE	*Casuarina cunninghamiana*	River Oak	n
	CASUARINACEAE	*Casuarina glauca*	Swamp Oak	
	CHENOPODIACEAE	*Atriplex prostrata*	Saltbush	i
	CHENOPODIACEAE	*Suaeda australis*	Seablite	
	CONVOLVULACEAE	*Ipomoea indica*	Blue Morning Glory	ix

Group	Family	Scientific name	Common name	Status
	EUPHORBIACEAE	*Euphorbia peplus*	Petty Spurge	i
	PHYLLANTHACEAE	*Phyylanthus tennellus*	Hen and Chicken	i
	EUPHORBIACEAE	*Ricinus communis*	Castor Oil Plant	ix
	FABACEAE-CAESALPINIOIDEAE	*Senna pendula* var. *glabrata*	Cassia	i
	FABACEAE-FABOIDEAE	*Canavalia rosea*	Coastal Jack Bean	
	FABACEAE-FABOIDEAE	*Erythrina cristi-galli*	Cockspur Coral Tree	i
	FABACEAE-FABOIDEAE	*Erythrina* x *sykesii*	Coral Tree	i
	FABACEAE-FABOIDEAE	*Glycine clandestina* agg.	Twining Glycine	
	FABACEAE-FABOIDEAE	*Indigofera australis*	Native Indigo	n
	FABACEAE-FABOIDEAE	*Lotus angustissimus*	Slender Birds-foot Trefoil	i
	FABACEAE-FABOIDEAE	*Trifolium repens*	White Clover	i
	FABACEAE-FABOIDEAE	*Vicia sativa* subsp. *sativa*	Common Vetch	i
	FABACEAE-MIMOSOIDEAE	*Acacia baileyana*	Cootamundra Wattle	n
	FABACEAE-MIMOSOIDEAE	*Acacia binervia*	Coast Myall	n
	FABACEAE-MIMOSOIDEAE	*Acacia decurrens*	Fine-leaf Green Wattle	p
	FABACEAE-MIMOSOIDEAE	*Acacia falcata*	Sickle Wattle	p
	FABACEAE-MIMOSOIDEAE	*Acacia fimbriata*	Fringed Wattle	n
	FABACEAE-MIMOSOIDEAE	*Acacia floribunda*	Sally Wattle	p
	FABACEAE-MIMOSOIDEAE	*Acacia implexa*	Hickory	p
	FABACEAE-MIMOSOIDEAE	*Acacia longifolia*	Sydney Golden Wattle	p
	FABACEAE-MIMOSOIDEAE	*Acacia parramattensis*	Sydney Green Wattle	
	FABACEAE-MIMOSOIDEAE	*Acacia podalyriifolia*	Queensland Silver Wattle	i
	FABACEAE-MIMOSOIDEAE	*Acacia saligna*	Golden-wreath Wattle	i
	LAMIACEAE	*Stachys arvensis*	Stagger Weed	i

Group	Family	Scientific name	Common name	Status
	LAMIACEAE	*Westringia fruticosa*	Coast Rosemary	n
	LAURACEAE	*Cinnamomum camphora*	Camphor Laurel	i
	MALACEAE	*Cotoneaster glaucophyllus*	Cotoneaster	i
	MALVACEAE	*Abutilon grandifolium*		i
	MALVACEAE	*Lagunaria patersonii*	Norfolk Island Hibiscus	i
	MALVACEAE	*Modiola caroliniana*	Red-flowered Mallow	i
	MALVACEAE	*Sida rhombifolia*	Paddys Lucerene	i
	MORACEAE	*Ficus macrophylla*	Moreton Bay Fig	p
	MORACEAE	*Ficus microcarpa var. hillii*	Hill's Weeping Fig	n
	MORACEAE	*Ficus rubiginosa*	Port Jackson Fig	
	MORACEAE	*Morus alba*	Mulberry	i
	MYRSINACEAE	*Anagallis arvensis*	Pimpernell	i
	MYRTACEAE	*Angophora costata*	Smooth-barked Apple	n
	MYRTACEAE	*Angophora floribunda*	Rough-barked Apple	p
	MYRTACEAE	*Callistemon citrinus*	Crimson Bottlebrush	n
	MYRTACEAE	*Callistemon linearis*	Narrow-leaved Bottlebrush	p
	MYRTACEAE	*Callistemon salignus*	Willow Bottlebrush	
	MYRTACEAE	*Callistemon viminalis*	Weeping Bottlebrush	n
	MYRTACEAE	*Callisteon rigidus*	Stiff Bottlebrush	p
	MYRTACEAE	*Corymbia citriodora*	Lemon-scented Gum	n
	MYRTACEAE	*Corymbia maculata*	Spotted Gum	p
	MYRTACEAE	*Eucalyptus amplifolia*	Cabbage Gum	p
	MYRTACEAE	*Eucalyptus botryoides*	Bangalay	n
	MYRTACEAE	*Eucalyptus crebra*	Narrow-leaf Ironbark	p
	MYRTACEAE	*Eucalyptus fibrosa*	Broad-leaf Ironbark	

Group	Family	Scientific name	Common name	Status
	MYRTACEAE	*Eucalyptus grandis*	Flooded Gum	n
	MYRTACEAE	*Eucalyptus longifolia*	Woollybutt	
	MYRTACEAE	*Eucalyptus melliodora*	Yellow Box	n
	MYRTACEAE	*Eucalyptus microcorys*	Tallowwood	n
	MYRTACEAE	*Eucalyptus moluccana*	Grey Box	p
	MYRTACEAE	*Eucalyptus punctata*	Common Grey Gum	p
	MYRTACEAE	*Eucalyptus siderophloia*	Northern Grey Ironbark	p
	MYRTACEAE	*Eucalyptus sideroxylon*	Mugga Ironbark	n
	MYRTACEAE	*Eucalyptus tereticornis*	Forest Red Gum	p
	MYRTACEAE	*Leptospermum pertersonii*	Lemon-scented Tea-tree	n
	MYRTACEAE	*Leptospermum polygalifolium*	Yellow Tea-tree	p
	MYRTACEAE	*Lophostemon confertus*	Brush Box	n
	MYRTACEAE	*Melaleuca armillaris*	Bracelet Honey-myrtle	n
	MYRTACEAE	*Melaleuca decora*	White Feather Honey-myrtle	
	MYRTACEAE	*Melaleuca linariifolia*	Snow-in-Summer	p
	MYRTACEAE	*Melaleuca nodosa*	Ball Honey-myrtle	
	MYRTACEAE	*Melaleuca quinquenervia*	Broad-leaved Paperbark	p
	MYRTACEAE	*Melaleuca styphelioides*	Prickly Paperbark	p
	MYRTACEAE	*Syncarpia glomulifera*	Turpentine	p
	OCHNACEAE	*Ochna serrulata*	Ochna	i
	OLEACEAE	*Ligustrum lucidum*	Large-leaf Privet	ix
	OLEACEAE	*Ligustrum sinense*	Small-leaf Privet	ix
	OLEACEAE	*Olea europaea* subsp. *africana*	African Olive	ix
	ONAGRACEAE	*Ludwigia peploides* subsp. *montevidensis*	Water Primrose	
	PITTOSPORACEAE	*Bursaria spinosa*	Blackthorn	p

Group	Family	Scientific name	Common name	Status
	PITTOSPORACEAE	*Pittosporum revolutum*	Yellow Pittosporum	p
	PITTOSPORACEAE	*Pittosporum undulatum*	Native Daphne	
	PLANTAGINACEAE	*Plantago lanceolata*	Plantain	i
	POLYGONACEAE	*Acetosa sagittata*	Rambling Dock	i
	POLYGONACEAE	*Persicaria decipiens*	Slender Knotweed	
	POLYGONACEAE	*Persicaria hydropiper*	Water Pepper	
	POLYGONACEAE	*Rumex brownii*	Swamp Dock	
	POLYGONACEAE	*Rumex conglomeratus*	Clustered Dock	i
	PROTEACEAE	*Banksia integrifolia*	Coastal Banksia	n
	PROTEACEAE	*Grevillea robusta*	Silky Oak	n
	PROTEACEAE	*Grevillea spp.*	A Grevillea Cultivar/Hybrid	n
	RANUNCULACEAE	*Clematis glycinoides*	Entire-leaf Clematis	
	RUBIACEAE	*Galium asparine*	Cleavers	i
	RUTACEAE	*Murraya paniculata*	Mock Orange	i
	SALICACEAE	*Salix babylonica*	Weeping Willow	i
	SAPINDACEAE	*Cardiospermum grandiflorum*	Balloon Vine	ix
	SOLANACEAE	*Cestrum parqui*	Green Cestrum	ix
	SOLANACEAE	*Solanum nigrum*	Black Nightshade	i
	THEAPHRASTRACEAE	*Samolus repens*	Creeping Brookweed	
	TROPAEOLACEAE	*Tropaeolum majus*	Nasturtium	i
	ULMACEAE	*Ulmus spp*	Elm	i
	VERBENACEAE	*Lantana camara*	Lantana	ix
	VERBENACEAE	*Verbena bonariensis*	Purple Top	i
	VERBENACEAE	*Verbena rigidus*	Creeping Verbena	i
	VIOLACEAE	*Viola banksii*	Wild Violet	

Group	Family	Scientific name	Common name	Status
Flowering Plants - Monocotyledons				
	ARECACEAE	*Livistona australis*	Cabbage Tree Palm	n
	ARECACEAE	*Phoenix canarienis*	Canary Island Date Palm	i
	ASPARAGACEAE	*Asparagus asparagoides*	Bridal Creeper	ix
	ASPARAGACEAE	*Asparagus aethiopicus*	Asparagus Fern	ix
	COMMELINACEAE	*Commelina cyanea*	Scurvy Weed	
	COMMELINACEAE	*Tradescantia fluminensis*	Wandering Jew	i
	CYPERACEAE	*Bolboschoenus fluviatilis*	Marsh Club-rush	
	CYPERACEAE	*Cyperus eragrostis*	Umbrella Sedge	i
	CYPERACEAE	*Cyperus gracilis*	Slender Flat Sedge	
	CYPERACEAE	*Eleocharis sphacelata*	Tall Spike-rush	
	CYPERACEAE	*Schoenoplectus validus*	River Club-rush	
	DORYANTHACEAE	*Doryanthes excelsa*	Gymea Lily	n
	JUNCACEAE	*Juncus usitatus*	Common Rush	
	JUNCAGINACEAE	*Triglochin striatum*	Streaked Arrowgrass	
	LOMANDRACEAE	*Lomandra longifolia* subsp. *longifolia*	Spiny Mat-rush	p
	PHILYDRACEAE	*Philydrum lanuginosum*	Frogsmouth	
	PHORMIACEAE	*Dianella caerulea* var. *caerulea*	Leafy Blue Flax Lily	p
	POACEAE	*Axonopus fissifolius*	Narrow-leaved Carpet Grass	i
	POACEAE	*Briza subaristata*		i
	POACEAE	*Bromus catharticus*	Prarie Grass	i
	POACEAE	*Chloris gayana*	Rhodes Grass	i
	POACEAE	*Cortadieria selloana*	Pampas Grass	ix
	POACEAE	*Cynodon dactylon*	Common Couch	n
	POACEAE	*Ehrharta erecta*	Panic Veldtgrass	i

Group	Family	Scientific name	Common name	Status
	POACEAE	*Eleusine tristachya*	Crab Grass	i
	POACEAE	*Eragrostis curvula*	African Lovegrass	i
	POACEAE	*Hyparrhenia hirta*	Coolatai Grass	i
	POACEAE	*Microlaena stipoides* var. *stipoides*	Weeping Grass	
	POACEAE	*Oplismenus aemulus*	Broad-leaf Beard-grass	
	POACEAE	*Panicum maximum* var. *trichoglume*	Green Panic	i
	POACEAE	*Paspalum dilatatum*	Paspalum	i
	POACEAE	*Paspalum urvillei*	Vasey Grass	i
	POACEAE	*Pennisetum clandestinum*	Kikuyu	i
	POACEAE	*Phragmites australis*	Common Reed	
	POACEAE	*Setaria gracilis*	Slender Pigeon Grass	i
	POACEAE	*Setaria sphaceulata*	South African Pigeon Grass	i
	POACEAE	*Sorghum halepense*	Johnson Grass	ix
	POACEAE	*Sporobolus africanus*	Parramatta Grass	i
	POACEAE	*Sporobolus virginicus* var. *minor*	Saltmarsh Couch	
	POACEAE	*Themeda australis*	Kangaroo Grass	p
	TYPHACEAE	*Typha orientalis*	Broad-leaf Cumbungi	

Appendix C Fauna species

NOTES ON SYMBOLS USED IN THE TABLE
V = Vulnerable species M = Migratory species listed in the EPBC Act P = Protected speies U = Introduced species

	Family/Scientific name	Common name	Status
AMPHIBIANS			
	Myobatrachidae		
	Crinia signifera	Common Eastern Froglet	P
BIRDS			
	Phalacrocoracidae		
	Phalacrocorax carbo	Great Cormorant	P
	Ardeidae		
	Ardea alba	Great Egret	M
	Egretta novaehollandiae	White-faced Heron	P
	Threskiornithidae		
	Threskiornis molucca	Australian White Ibis	P
	Columbidae		
	Columba livia	Feral Pigeon	U
	Streptopelia chinensis	Spotted Turtle-Dove	U
	Psittacidae		
	Trichoglossus haematodus	Rainbow Lorikeet	P
	Maluridae		
	Malurus pulcherrimus	Suberb Fairy-wren	P
	Meliphagidae		
	Lichenostomus penicillatus	White-plumed Honeyeater	P
	Phylidonyris niger	White-cheeked Honeyeater	P
	Manorina melanocephala	Noisy Miner	P
	Anthochaera carunculata	Red Wattlebird	P
	Dicruridae		
	Rhipidura leucophrys	Willie Wagtail	P
	Oriolidae		
	Oriolus sagittatus	Olive-backed Oriole	P
	Artamidae		
	Strepera graculina	Pied Currawong	P
	Cracticus torquatus	Grey Butcherbird	P
	Gymnorhina tibicen	Australian Magpie	P
	Corvidae		
	Corvus coronoides	Australian Raven	P
	Hirundinidae		
	Hirundo neoxena	Welcome Swallow	P
	Petrochelidon ariel	Fairy Martin	P
	Passeridae		
	Passer domesticus	House Sparrow	U
	Sturnidae		
	Acridotheres tristis	Common Myna	U
	Sturnus vulgaris	Common Starling	U
MAMMALS			

	Family/Scientific name	Common name	Status
	Pteropodidae		
	Pteropus poliocephalus	Grey-headed Flying-fox	V
	Canidae		
	Vulpes vulpes	Red Fox	U
REPTILES			
	Scincidae		
	Lampropholis delicata	Dark-flecked Garden Sunskink	P

Appendix D Aquatic habitat and water quality

Mean water quality measurements taken at each site (n=3)

Parameter	Duck River	Duck Creek (Kay St)	Haslam's Creek
Depth (m)	0.4	0.3	0.25
Temp (˚C)	14.04	11.90	11.70
Turbidity (NTU)	37.1	24.1	38.8
Dissolved Oxygen (mg/l)	4.9	7.4	9.6
Dissolved Oxygen (%)	49.2	67.3	87.9
Conductivity (mS/cm)	7.00	1.42	1.02
Salinity (ppt)	3.67	0.71	0.50
ORP (mV)	295	262	241
pH	7.50	7.98	7.72

Site	RCE Score (max score 52)	Width of Waterway	Water Depth	Flow characteristics	Substrate	Existing Infrastructure	Riparian Strip	Notes
Haslam's Creek	15	25 m	<1 m	slow flow, low water level.	Silt/mud	Pylons from M4 bridge, stormwater drains, gross pollutant trap. Channel completely concrete lined	<1 m (left bank) and <3 m (right bank) within corridor.	Industrial/commercial, no in-stream-habitat or vegetation, rubbish (shopping trolley); litter
Duck River	28	30 m	2.1 m	Low flow, moderate height. At low tide	Silt mud	Pylons from existing M4 bridge. Pedestrian walkway and associate infrastructure	< 5 m (left bank) and 10-15 m (right bank). Mostly mangroves. Under M4 riparian strip <2 m wide; fragmented	Very turbid. Nearby drainage line coming into Duck River – mostly concrete, too shallow for WQ measurements. Litter on the banks
Duck Creek	21	25 m	<1 m (~0.5 m)	Incoming tide, low water level	Silt/mud	Culvert at James Ruse Drive, Existing M4 bridge pylons, pedestrian walkway across waterway. 75% concrete lined channel	Weedy, little woody vegetation, <5 m wide	Lots of litter
A'Becketts Creek (Church St)	25	1-5 m	<30 cm	Low, but flowing	Some gravel bars, mud and sand	90% concrete lined channel. Bridge (M4) and railway infrastructure	Very steep banks choked with vegetation	Some oily slicks observed, lots of litter, fragments of concrete and bricks in-stream
A'Becketts Creek (Kay St)	24	1 m	10-20 cm	Low water level, no flow	mud	Culvert (Kay Street), M4 bridge pylons 150m upstream	Mostly grasses, herbs, and weeds, fragmented (<5 m wide)	Very impaired – lots of rubbish. Evidence of recent high flows. Industrial area

Appendix E Assessments of significance

Significance assessments have been conducted for species, populations and communities that were identified as having a moderate or high potential to occur in the study area. These species are listed in **Table 6-1** for states listed species, **Table 6-2** for federal listed species and **Table 6-3** for federally listed migratory species.

Significance assessments have been divided into:

- State listed species (under the TSC Act or the FM Act (**Appendix E.1**)
- Commonwealth listed species (under the EPBC Act (**Appendix E.2**).

For threatened biodiversity listed under the TSC Act, the assessment considered the heads of consideration for Threatened species assessment as suggested in the Department of Environment and Conservation/Department of Primary Industries (2005) draft '*Guidelines for Threatened Species Assessment*'. The guidelines present methods to consider the impacts on biodiversity of projects, including presenting heads of consideration for determining the significance of impacts.

For threatened biodiversity listed under the EPBC Act significance assessments have been completed in accordance with the Matters of National Environmental Significance Significant Impact Guidelines 1.1 (Department of the Environment, Water, Heritage and the Arts 2009).

Species with similar taxonomy or ecological requirements have been assessed together, for example wetland birds, tree-roosting microchiropteran bats and cave-roosting microchiropteran bats.

E.1 Environmental Planning & Assessment Act, 1979

Threatened ecological communities

Swamp Oak Floodplain Forest

How is the project likely to affect the lifecycle of a threatened species and/or population?

Swamp Oak Floodplain Forest is not a threatened species or a population.

How is the project likely to affect the habitat of a threatened species, population or ecological community?

A total of 0.08 hectares of Swamp Oak Floodplain Forest has been identified within and surrounding the study area, of which the project would impact the majority. This community occurs as a thin strip on the upper bank of Duck River between the existing M4 Motorway and mangrove forest vegetation on Duck River. This community in the study area constitutes an area of planted Swamp Oak with several larger remnant trees along the edges of Duck River.

Habitat for this ecological community in the study area comprises lower elevated areas with saline sub-soils usually adjoining estuarine communities such as mangroves and saltmarsh. The Parramatta estuary to the north of the study area includes areas of intact Swamp Oak Floodplain Forest (SOPA 2011). Broad-scale mapping in the locality (Tozer *et al*. 2010) has identified 7.7 hectares of vegetation with affinities to this community (not including areas of the Parramatta estuary) comprising about one per cent of this distribution, and less when considering the distribution in Sydney Olympic Park and the Parramatta estuary.

Does the project affect any threatened species or populations that are at the limit of its known distribution?

Swamp Oak Floodplain Forest is not a threatened species or a population.

How is the project likely to affect current disturbance regimes?

Current disturbance regimes in Swamp Oak Floodplain Forest mainly comprise weed invasion and shading from the existing M4 Motorway bridge. Numerous exotic flora species were recorded in this community in the study area.

The project is likely to contribute to further invasion of noxious weeds. However shading from the proposed bridge structure is likely to limit the potential and vigour of weed invasions in this area. Mitigation measures to limit the spread and establishment of weeds will be implemented with the project.

How is the project likely to affect habitat connectivity?

Duck River constitutes the main intact area of habitat connectivity within the study area linking habitats upstream to the south of the study area and areas of habitat to the north. There is limited direct connectivity to other areas of swamp oak forest, however this community is generally present along the Duck River corridor. There are thin strips of this community present to the north along the western bank of Duck River behind mangroves based on aerial photography interpretation Connectivity of aquatic habitats will be maintained along Duck River with impacts limited to areas of mangrove and swamp oak forest. Impacts to the mangrove and Swamp Oak canopy will further increase the fragmentation from the existing bridges by about 20 metres.

How is the project likely to affect critical habitat?

No critical habitat has been identified for this community.

Freshwater Wetlands

How is the project likely to affect the lifecycle of a threatened species and/or population?

Freshwater wetland is not a threatened species or a population.

How is the project likely to affect the habitat of a threatened species, population or ecological community?

This community in the study area occurs in natural and constructed freshwater drainage channels where there is continuous moisture. It varies throughout the study area from areas of open water to areas with low to moderate densities of macrophyte vegetation. This map unit occurs mostly as thin strips along modified drainage lines. Riparian vegetation is generally absent or dominated by exotic vegetation. These areas are considered to be in a low condition due to the highly modified nature of these areas. This map unit occurs along non-tidal drainage lines of the study area including the A'Becketts Creek and several smaller concrete lined drainage channels.

About one hectare of Freshwater Wetlands has been identified within the study area of which the project would impact around 0.38 hectares through shading and the construction of piers in several locations. The main impacts include areas of A'Becketts Creek which runs parallel to the southern side of the existing M4 Motorway viaduct and are already being somewhat impacted from shading effects from autumn to spring. Impacts from the construction of piers will be limited to several piers in concrete channels and disturbed drainage lines.

There is potential for the project to alter habitat attributes of surrounding areas through indirect impacts such as altering hydrological and nutrient regimes in habitats downstream of the proposed development, however these impacts will generally be limited to the construction period. Mitigation measures during construction and the implementation of specific design features into the proposed development are likely to minimise these indirect impacts.

Does the project affect any threatened species or populations that are at the limit of its known distribution?

Freshwater wetland is not a threatened species or a population.

How is the project likely to affect current disturbance regimes?

Current disturbance regimes in Freshwater Wetlands mainly comprise weed invasion, sedimentation, altered hydrology regimes and high nutrient levels. The natural flows of A'Becketts Creek have been highly altered from surrounding urban developments within the catchment and the channelisation of the drainage line, resulting in high flows during storm events with minimal recharging of groundwater levels resulting in lower sustained flows.

There is potential for the project to alter habitat attributes of surrounding areas through indirect impacts such as altering hydrological and nutrient regimes in habitats downstream of the proposed development, however these impacts will generally be limited to the construction period. Mitigation measures during construction and the implementation of specific design features into the proposed development are likely to minimise these indirect impacts.

How is the project likely to affect habitat connectivity?

Aquatic habitats will not be substantially fragmented by the project considering all major drainage lines will be spanned by bridges. There may be some temporary impacts to connectivity during construction of piers within waterways however mitigation measures will be implemented to limit the potential for fish passage to be impacted. Any piers that need to be located within this community will be designed to maintain fish passage and flows.

How is the project likely to affect critical habitat?

None of the habitats present in the study area are registered on the current list of recommended or declared critical habitat in NSW.

Shale Gravel Transition Forest

How is the project likely to affect the lifecycle of a threatened species and/or population?

Shale Gravel Transition Forest is not a threatened species or a population.

How is the project likely to affect the habitat of a threatened species, population or ecological community?

There is a very small patch of remnant vegetation with affinities to Shale-Gravel Transition Forest. This vegetation type is restricted to several small patches and trees at the intersection of Hill Road and the M4 Motorway. Impacts are limited to up to 0.08 hectares of this community comprising six *Melaleuca decora* suspected to be remnant on the northern side of the M4 Motorway adjacent to Hill Road in maintained parkland. A total of 0.45 hectares of this community have been identified in the study area on the southern side of the M4 Motorway including better quality examples than those being impacted. The potential impact represents a very small and low quality example of this community representing a very small proportion of the overall distribution, however the community is very rare in inner western Sydney and about 11 per cent of the community in the study area will be impacted.

Does the project affect any threatened species or populations that are at the limit of its known distribution?

Shale Gravel Transition Forest is not a threatened species or a population.

How is the project likely to affect current disturbance regimes?

The main disturbance regimes effecting this community in the study area is weed invasion, fragmentation and edge effects and slashing of the understorey. The project is unlikely to result in further exacerbation of any of these impacts in the remaining areas of this community in the study area.

How is the project likely to affect habitat connectivity?

The community is currently highly fragmented in the study area, being very small patches present on opposite sides of the M4 Motorway and Hill Road, and one patch is isolated by the westbound on-ramp. The project will not substantially alter existing habitat connectivity for this community.

How is the project likely to affect critical habitat?

None of the habitats present in the study area are registered on the current list of recommended or declared critical habitat in NSW.

Threatened flora

Species	Status – TSC Act
Hypsela sessiflora	E
Marsdenia viridifolia subsp. viridifolia (endangered population)	E2
Tadgell's Bluebell (*Wahlenbergia multicaulis*)	E2
Narrow-leaved Wilsonia (*Wilsonia backhousei*)	V

How is the project likely to affect the lifecycle of a threatened species and/or population?

None of these threatened flora species were recorded during the surveys, however these have some potential to occur based on the presence of natural habitats and/or the potential to occur in disturbed habitats. The life cycle of these species is unlikely to be substantially impacted by the project considering the relatively low-moderate potential to occur, the marginal nature of the natural habitats and the potential for some species to occur in disturbed habitats which are widespread in the study area.

How is the project likely to affect the habitat of a threatened species, population or ecological community?

Hypsela sessiflora occurs in damp places including drainage lines and freshwater wetlands. About 0.35 hectares of drainage lines will be impacted from shading impacts and pier construction in several locations. However the majority of this area comprises concrete-lined drainage channels which are generally unsuitable for the species with suitable habitat limited to a small stretch of A'Becketts Creek east of Church Street. There were some small areas of sediment which may be suitable habitat for this species however the high flows during storm events are likely to substantially modify sedimentation processes and impact small herbs such as this species.

Marsdenia viridifolia subsp. *viridifolia* is known to occur in disturbed habitats and seeds can be dispersed by wind over relatively long distances. The species natural habitat comprises vine thickets and open shale woodland. There is a high level of competition in the study area from exotic vines and scramblers, and any establishing seedlings of this species will potentially be out competed by the larger and vigorous exotic species.

Tadgell's Bluebell (*Wahlenbergia multicaulis*) typically occurs in damp, disturbed sites (with natural or human disturbance of various forms), typically amongst other herbs rather than in the open. This habitat type is generally widespread throughout the study area and the species could potentially occur in numerous areas, however no Wahlenbergia species were observed during the surveys. All records for this species occur to the south of the study area and this endangered population has a relatively restricted range and the study area is potentially outside of the existing extant of the species.

Narrow-leaved Wilsonia (*Wilsonia backhousei*) occurs on the margins of estuarine habitats mainly including open sites such as saltmarsh and rocky shores. As the project traverses a portion of Duck River, this would result in direct impacts to around 0.23 hectares of estuarine wetland habitats comprising Mangrove Forest including small areas of mudflats and the aquatic habitats within Duck Creek. Habitats impacted by the project are likely to be marginal for the species being shaded by mangroves and the existing Weird Bridge of the M4 Motorway.

Does the project affect any threatened species or populations that are at the limit of its known distribution?

Hypsela sessiflora is 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. This species would be a the limit of its known distribution if present in the study area.

The endangered populations if present in the study area would potentially be at the limit of the distribution if present in the study area. There are populations of Tadgell's Bluebell (*Wahlenbergia multicaulis*) in the Hornsby area however the study area would be the northern limit for the western Sydney population. The *Marsdenia viridifolia* subsp. *viridifolia* endangered population would be towards the eastern limit for the population if present in the study area.

Narrow-leaved Wilsonia (*Wilsonia backhousei*) is found on the coast between Mimosa Rocks National Park and Wamberal north of Sydney. This species would not be a t the limit of its known distribution if present in the study area.

How is the project likely to affect current disturbance regimes?

The main disturbance regimes affecting these species in the study area are weed invasion, fragmentation and edge effects and maintenance regimes such as slashing and pruning. Mitigation measures will be implemented to limit the exacerbation of these current disturbance regimes.

How is the project likely to affect habitat connectivity?

Habitats in the locality are currently highly fragmented, comprising very small patches of natural habitats and areas of disturbed habitats dominated by exotic vegetation. The project will not substantially alter the existing levels of habitat connectivity for these species in the study area.

How is the project likely to affect critical habitat?

None of the habitats present in the study area are registered on the current list of recommended or declared critical habitat in NSW.

Threatened Fauna

Grey-headed Flying-fox (*Pteropus poliocephalus*)

How is the project likely to affect the lifecycle of a threatened species and/or population?

There have been no roost camps identified in the project boundary to date and at the time of the environmental impact statement the project would not directly impact on any known breeding / maternity site. This species was observed flying over the study area during dusk. The nearest known camps are on the Duck River and Parramatta River over 800 metres and 2000 metres from the M4 respectively.

Therefore it is likely that the impacts of construction and operation of the project would be confined to loss of feeding habitat caused by 1) direct clearing or damage to native vegetation during the construction phase and 2) edge effects during operation related to degradation of foraging habitat from shading.

The project would directly remove up to 8.84 hectares of potential foraging habitat however vegetation will be avoided where possible. Foraging habitat mainly comprises nectar resources from planted native trees and shrubs as well as fruit resources from planted fig trees and some exotic trees. This area of habitat may be defined as a portion of the potential area of occupancy for feeding life-cycle attributes of the population. The affected area of foraging habitat would represent a small percentage of the total extent of important foraging vegetation types present within a 50 kilometre radius of the project boundary. Given the relative widespread nature of similar planted vegetation in the locality and abundance of higher quality foraging habitat within the feeding range of regional populations, the project is not expected to significantly affect the life cycle of the species.

How is the project likely to affect the habitat of a threatened species, population or ecological community?

The project would directly remove up to 8.84 hectares of potential foraging habitat however vegetation will be avoided where possible. Foraging habitat mainly comprises nectar resources from planted native trees and shrubs as well as fruit resources from planted fig trees and some exotic trees. This area of habitat may be defined as a portion of the potential area of occupancy for feeding life-cycle attributes of the population. The affected area of foraging habitat would represent a small percentage of the total extent of important foraging vegetation types present within a 50 kilometre radius of the project boundary. Given the relative widespread nature of similar planted vegetation in the locality and abundance of higher quality foraging habitat within the feeding range of regional populations, the project is not expected to significantly affect the life cycle of the species.

Does the project affect any threatened species or populations that are at the limit of its known distribution?

The species occurs from Bundaberg in Queensland to Melbourne in Victoria and is not at the limit of its distribution in the study area.

How is the project likely to affect current disturbance regimes?

The main disturbance regimes effecting habitats in the study area are weed invasion, fragmentation and edge effects and maintenance regimes such as slashing and pruning. Mitigation measures will be implemented to limit the exacerbation of these current disturbance regimes.

Any impacts from change of habitat condition associated with altering disturbance regimes in proximity to the road may be offset by their ability to move widely throughout the landscape and access disturbed and fragmented habitats.

How is the project likely to affect habitat connectivity?

There is currently a high degree of habitat fragmentation across the study area. These highly mobile species are adapted to moving across forest clearings such as roads to access foraging and roosting habitat and are unlikely to be significantly impacted by the barrier effect of the road.

How is the project likely to affect critical habitat?

None of the habitats present in the study area are registered on the current list of recommended or declared critical habitat in NSW.

Long-nosed Bandicoot (*Perameles nasuta*)

How is the project likely to affect the lifecycle of a threatened species and/or population?

An endangered population of Long-nosed Bandicoot (*Perameles nasuta*) is present in inner western Sydney. The exact area occupied by the population is not clearly defined. This population shelters mostly under older houses and buildings and forages in parkland and back-yards. Potential foraging and sheltering habitat is present throughout areas of the study area and generally include all identified map units as well as maintained lawns and areas of bare ground beneath the existing viaduct and bridge structures. Considering the widespread nature of potential foraging habitat and any potential sheltering habitat will be subject to prior-disturbance surveys there is unlikely to be a significant impact to the life cycle of this population.

How is the project likely to affect the habitat of a threatened species, population or ecological community?

The project would directly remove up to 8.84 hectares of vegetation comprising potential foraging habitat however vegetation removal will be avoided where possible. Foraging habitat also includes maintained lawns and areas of bare ground beneath the existing viaduct and bridge structures. Considering the widespread nature of potential foraging habitat and any potential sheltering habitat will be subject to prior-disturbance surveys there is unlikely to be a significant impact habitat of this population.

Does the project affect any threatened species or populations that are at the limit of its known distribution?

The species would be at the limit of the known population distribution if present in the study area considering the limited and largely unknown distribution of the population.

How is the project likely to affect current disturbance regimes?

The main disturbance regimes effecting habitats in the study area are weed invasion, fragmentation and edge effects and maintenance regimes such as slashing and pruning. Mitigation measures will be implemented to limit the exacerbation of these current disturbance regimes.

Any impacts from change of habitat condition associated with altering disturbance regimes in proximity to the road are likely to be minimal given the populations known foraging in disturbed habitats.

How is the project likely to affect habitat connectivity?

There is currently a high degree of habitat fragmentation across the study area. Connectivity for this population will be maintained across the M4 Motorway corridor through the replicating of existing bridge and viaduct structures.

How is the project likely to affect critical habitat?

None of the habitats present in the study area are registered on the current list of recommended or declared critical habitat in NSW.

Swift Parrot (*Lathamus discolour*)

How is the project likely to affect the lifecycle of a threatened species and/or population?

The species is an occasional visitor to the region during peak flowering events of the dominant trees, particularly the winter flowering Spotted Gum (*Corymbia maculata*) and Swamp Mahogany (*Eucalyptus robusta*). There are no breeding records in the study area and the extent of habitat remaining in the study area would provide sufficient resources to sustain future visitation.

How is the project likely to affect the habitat of a threatened species, population or ecological community?

The species is an occasional visitor to the region during peak flowering events of the dominant trees, particularly the winter flowering Spotted Gum (*Corymbia maculata*) which have been planted in the study area. The project would remove up to 8.84 hectares of planted and native vegetation including planted Spotted Gum which provide potential foraging habitat

Does the project affect any threatened species or populations that are at the limit of its known distribution?

No, the species is an occasional visitor to the region and its distribution extends from Tasmania to south-eat Queensland.

How is the project likely to affect current disturbance regimes?

The main disturbance regimes effecting habitats in the study area are weed invasion, fragmentation and edge effects and maintenance regimes such as slashing and pruning. Mitigation measures will be implemented to limit the exacerbation of these current disturbance regimes.

Any impacts from change of habitat condition associated with altering disturbance regimes in proximity to the road may be offset by their ability to move widely throughout the landscape and access disturbed and fragmented habitats.

How is the project likely to affect habitat connectivity?

There is currently a high degree of habitat fragmentation across the study area. These highly mobile species are adapted to moving across forest clearings such as roads to access foraging and roosting habitat and are unlikely to be significantly impacted by the barrier effect of the road.

How is the project likely to affect critical habitat?

None of the habitats present in the study area are registered on the current list of recommended or declared critical habitat in NSW.

Little Lorikeet (*Glossopsitta pusilla*)

How is the project likely to affect the lifecycle of a threatened species and/or population?

Little lorikeets are known to occupy a diversity of forest and woodland habitats, including old-growth and logged forests, and remnant woodland patches and roadside vegetation (Pizzey & Knight 1997, DECC 2008). The species is generally considered to be nomadic, with irregular large or small influxes of individuals occurring at any time of year, apparently related to food availability (DECC 2008). However, they do exhibit some site fidelity, with breeding pairs resident from April to December, and even during their non-resident period some individuals will return to the nest area for short periods if there is some tree-flowering in the vicinity.

They feed in small flocks, often with other species of lorikeet, primarily on nectar and pollen in the tree canopy. They prefer profusely flowering eucalypts but will also feed in other species such as melaleucas and mistletoes. The species breeds in tree hollows in living trees, during May to September, raising clutches of three to five eggs (DECC 2008). They likely start breeding at one year, and live for around 10 years in the wild.

Major threats to little lorikeets are loss of breeding sites and food resources from ongoing land clearing. Loss of nest trees from road-side verges, often associated with road works, remains an ongoing threat (DECC 2008).

The study area would constitute non-breeding habitat for the species as no trees supporting suitable hollows will be impacted. The loss of feed trees would directly affect the species opportunity to feed and breed in the area, however the study area is not considered a critical area for the Little Lorikeet as extensive areas of suitable habitat occur elsewhere in the region. The current potential for the species to occur based on the presence of potential foraging habitat is expected to remain after completion of the project such that foraging, movement and other life-cycle attributes would not be impacted.

How is the project likely to affect the habitat of a threatened species, population or ecological community?

The project would remove up to 5 hectares including a mix of nectar-producing native shrubs and trees which provide potential foraging habitat. The large majority of this potentially impacted foraging habitat comprises planted vegetation and potential impacts will be avoided where possible during construction.

Does the project affect any threatened species or populations that are at the limit of its known distribution?

The distribution of the little lorikeet extends from just north of Cairns, around the east of Australia, to Adelaide. In NSW the species is distributed in forests and woodlands from the coast to the western slopes of the Great Dividing Range. Hence the study area is not at the limit of the species known distribution.

How is the project likely to affect current disturbance regimes?

The main disturbance regimes effecting habitats in the study area are weed invasion, fragmentation and edge effects and maintenance regimes such as slashing and pruning. Mitigation measures will be implemented to limit the exacerbation of these current disturbance regimes.

Any impacts from change of habitat condition associated with altering disturbance regimes in proximity to the road may be offset by their ability to move widely throughout the landscape and access disturbed and fragmented habitats.

How is the project likely to affect habitat connectivity?

There is currently a high degree of habitat fragmentation across the study area. These highly mobile species are adapted to moving across forest clearings such as roads to access foraging and roosting habitat and are unlikely to be significantly impacted by the barrier effect of the road.

How is the project likely to affect critical habitat?

None of the habitats present in the study area are registered on the current list of recommended or declared critical habitat in NSW.

White-fronted Chat (*Epthianura albifrons*)

How is the project likely to affect the lifecycle of a threatened species and/or population?

An endangered population of White-fronted Chat is present in the Sydney Metropolitan Catchment Management Area. This species is regularly observed north of the study area in the saltmarsh of Newington Nature Reserve with occasional sightings from other parts of Sydney Olympic Park and in grassland on the northern bank of the Parramatta River (OEH 2013). Current estimates suggest this population consists of 8 individuals (OEH 2013).

It is found predominantly in saltmarsh vegetation but also in open grasslands and sometimes in low shrubs bordering wetland areas. Open-cup type nests are built in low vegetation and nests in the Sydney region have also been seen in low isolated mangroves with nests usually built about 23 centimetres above the ground, but have been found up to 2.5 metres above the ground (OEH 2013).

Habitat in the study area comprise the estuarine habitats surrounding Duck River which are generally marginal considering the preference for the species to occur in more open habitats. There is a higher potential for more open sunny edges of Duck Creek to be utilised to the north of the study area. However considering the limited knowledge about the population there is some potential for the species to occur.

The current potential for the species to occur based on the presence of marginal foraging and nesting habitats is expected to remain after completion of the project such that foraging, movement and other life-cycle attributes would not be impacted.

How is the project likely to affect the habitat of a threatened species, population or ecological community?

It is found predominantly in saltmarsh vegetation but also in open grasslands and sometimes in low shrubs bordering wetland areas. Open-cup type nests are built in low vegetation and nests in the Sydney region have also been seen in low isolated mangroves with nests usually built about 23 centimetres above the ground, but have been found up to 2.5 metres above the ground (OEH 2013).

Habitat in the study area comprise the estuarine habitats surrounding Duck River which are generally marginal considering the preference for the species to occur in more open habitats. There is a higher potential for more open sunny edges of Duck Creek to be

utilised to the north of the study area. However considering the limited knowledge about the population there is some potential for the species to occur.

The project would impact up to 0.33 hectares of marginal habitat including mangrove forest and swamp oak forest.

Does the project affect any threatened species or populations that are at the limit of its known distribution?

The species would be at the limit of the known population distribution if present in the study area considering the limited and largely unknown distribution of the population.

How is the project likely to affect current disturbance regimes?

The main disturbance regimes effecting habitats in the study area are weed invasion, fragmentation and edge effects and maintenance regimes such as slashing and pruning. Mitigation measures will be implemented to limit the exacerbation of these current disturbance regimes.

Any impacts from change of habitat condition associated with altering disturbance regimes in proximity to the road may be offset by their ability to move widely throughout the landscape and access disturbed and fragmented habitats.

How is the project likely to affect habitat connectivity?

There is currently a high degree of habitat fragmentation across the study area. These highly mobile species are adapted to moving across forest clearings such as roads to access foraging and roosting habitat and are unlikely to be significantly impacted by the barrier effect of the road.

How is the project likely to affect critical habitat?

None of the habitats present in the study area are registered on the current list of recommended or declared critical habitat in NSW.

Wetland/estuarine birds

Species	Status – TSC Act
Black Bittern (*Ixobrychus flavicollis*)	V
Black-tailed Godwit (*Limosa limosa*)	V
Broad-billed Sandpiper (Limicola falcinellus)	V
Curlew Sandpiper (*Calidris ferruginea*)	E
Eastern Osprey (*Pandion haliaetus*)	V
Great Knot (*Calidris tenuirostris*)	V
Greater Sand Plover (*Charadrius leschenaultii*)	V
Little Tern (*Sterna albifrons*)	E
Pied Oystercatcher (*Haematopus longirostris*)	V
Terek Sandpiper (*Xenus cinereus*)	V

How is the project likely to affect the lifecycle of a threatened species and/or population?

As the project traverses a portion of Duck River, this would result in direct impacts to around 0.23 hectares of estuarine wetland habitats comprising Mangrove Forest including small areas of mudflats and the aquatic habitats within Duck Creek. There will also be some minor impacts to larger estuarine drainage lines which could also potentially be used for foraging by wetland bird species.

The project may directly and indirectly affect the life-cycle of localised populations by displacing or disturbing individuals or established pairs. This may include nesting, foraging and roosting life-cycle activities within the home range of established pairs. These species are not restricted to the study area and extend across other states and territories.

There are known populations of several species from the Parramatta estuary including Black-tailed Godwit and Curlew Sandpiper (SOPA 2011). There are also several records for some species in the locality including Black-tailed Godwit (13), Curlew Sandpiper (354), Eastern Osprey (2) and Little Tern (3), and the remaining six species (Black Bittern, Broad-billed Sandpiper, Greater Knot, Greater Sand Plover, Pied Oystercatcher and Terek Sandpiper) have a single record from the locality.

Potential habitat for these wetland bird species' is present throughout the locality including Prospect reservoir to the west, the Parramatta estuary to the north, and beach and estuary habitats along the coastline.

Considering the small area of habitat being impacted by the project and the presence of better quality habitats in the locality the project is unlikely to have a negative effect on the life cycle of these species.

How is the project likely to affect the habitat of a threatened species, population or ecological community?

As the project traverses a portion of Duck River, this would result in direct impacts to around 0.23 hectares of estuarine wetland habitats comprising Mangrove Forest including small areas of mudflats and the aquatic habitats within Duck Creek. There will also be some minor impacts to larger estuarine drainage lines which could also potentially be used for foraging by wetland bird species.

The proposed impacts will not remove all habitat features for these species, considering all drainage lines will be spanned by the project. Impacts to riparian vegetation along Duck River will be minimised where possible with trees proposed to be heavily pruned maintaining some habitat structure and cover for fauna. There will be impacts from shading to any trees that will be retained beneath the proposed bridge structure, which may result in death to trees over a period of time. Shading of the waterway will potentially have minor effect on primary production in these habitats, making them less productive for foraging.

Potential habitat for these wetland bird species' is present throughout the locality including Prospect reservoir to the west, the Parramatta estuary to the north, and beach and estuary habitats along the coastline.

Considering the low-level of impact to potential habitat for these species including proposed avoidance and minimisation of vegetation clearing and the presence of better quality habitats in the locality the project is unlikely to have a significant impact to habitat for these species.

Does the project affect any threatened species or populations that are at the limit of its known distribution?

These species are not restricted to the study area with their distribution extending across other states and territories. None of these species are at the limit of the known distribution.

How is the project likely to affect current disturbance regimes?

The range of disturbance regimes that currently exists in the study area are substantial considering the presence of the study area in a highly urbanised environment. This includes removal of mangrove and wetland habitats along drainage lines and estuaries (ie Duck Creek and Haslams Creek). There are also high levels of weed invasion in the study area, however weed invasion is minimal in estuarine habitats of the study area.

The project will further contribute to habitat removal and fragmentation including direct removal and indirect impacts from shading. There is potential for the project to exacerbate weed invasion in the study area, however this is not anticipated for estuarine environments.

How is the project likely to affect habitat connectivity?

Duck River constitutes the main intact fauna corridor within the study area linking habitats upstream to the south of the study area and areas of habitat to the north. In the study area the mangrove canopy is currently fragmented by the existing M4 Motorway bridges. There is some regrowth of mangroves beneath Weird Bridge, however this is likely to have been limited by the low light levels and similar effects are anticipated for the new bridge structure over Duck River. Connectivity of aquatic habitats will be maintained along Duck River with impacts limited to areas of mangrove and swamp oak forest. Impacts to the mangrove canopy will further increase the fragmentation from the existing bridges by about 20 metres.

How is the project likely to affect critical habitat?

None of the habitats present in the study area are registered on the current list of recommended or declared critical habitat in NSW.

Tree-roosting microbats

Species	Status – TSC Act
Eastern False Pipistrelle (*Falsistrellus tasmaniensis*)	V
Eastern Freetail-bat (*Mormopterus norfolkensis*)	V
Greater Broad-nosed Bat (*Scoteanax rueppellii*)	V
Yellow-bellied Sheathtail-bat (*Saccolaimus flaviventris*)	V

How is the project likely to affect the lifecycle of a threatened species and/or population?

Vegetation in the study area provides potential foraging and roosting habitat for the assessed species. These bat species frequent a variety of habitat types including mangrove forests, disturbed habitats, forests and woodlands. Important life-cycle activities include roosting and breeding and both are typically associated with tree hollows as well as foraging for insect prey which occurs in a variety of habitat types. Breeding habitat for insect prey includes a very diverse range of wetlands, swamps and open modified and artificial landscapes.

The size of local populations is not known, although expected to not to be considerably large considering the highly urbanised and modified habitats I the locality and limited tree hollows. Potential foraging habitat in the study area is generally widespread including natural habitats such as mangrove forest, swamp forest and wetlands, as well as planted vegetation and exotic dominated vegetation. Impacts to these habitats would impact on the potential breeding habitat for prey species (invertebrates), however any potential overall reductions to the abundance of prey species is likely to be minimal, considering the widespread nature of these habitats in the locality.

The project would have some level of impact to up to 8.84 hectares of foraging habitat comprising a combination of all identified map units. This includes indirect impacts from shading and removal of vegetation where required, however foraging attributes are unlikely to be substantial modified throughout much of this 8.84 hectare area. Maintained lawns and various structures throughout the study area also provide potential foraging opportunities, which have not been delineated and quantified throughout the study area.

Potential impacts to the life-cycle activities of these bat species mainly relates to disruption of breeding activities and shelter or dormancy activities and removal of roosting habitats leading to increased competition for hollows. Potential roost sites are limited in the study area to several small hollows and fissures, and decorticating bark observed in several trees in the study area. These potential roosting habitats are considered to have relatively limited habitat value, however in a landscape of limited roosting resources may be utilised by these species on occasion. There is also some potential for these species to utilise other habitats for roosting in the study area, such as Fairy-martin nests and cavities in the viaduct structure which potentially offer more favourable roosting conditions.

Mitigation measures will include avoiding clearance of potential roosting habitats, pre-clearance surveys and staged habitat removal. Considering the limited presence of preferred roosting habitat attributes, and the proposed mitigation measures the project is

unlikely to result in a negative impact to the life cycle of these species.

How is the project likely to affect the habitat of a threatened species, population or ecological community?

The project would have some level of impact to up to 8.84 hectares of foraging habitat comprising a combination of all identified map units. This includes indirect impacts from shading and removal of vegetation where required, however foraging attributes are unlikely to be substantial modified throughout much of this 8.84 hectare area. Maintained lawns and various structures throughout the study area also provide potential foraging opportunities, which have not been delineated and quantified throughout the study area.

Potential roost sites are limited in the study area to several small hollows and fissures, and decorticating bark observed in several trees in the study area. These potential roosting habitats are considered to have relatively limited habitat value, however in a landscape of limited roosting resources may be utilised by these species on occasion. There is also some potential for these species to utilise other habitats for roosting in the study area, such as Fairy-martin nests and cavities in the viaduct structure which potentially offer more favourable roosting conditions.

Does the project affect any threatened species or populations that are at the limit of its known distribution?

None of these tree roosting threatened bat species are at the limit of their distribution in the project study area. Habitats are widespread throughout the region particularly further west of the study area.

How is the project likely to affect current disturbance regimes?

The range of disturbance regimes that currently exists in the study area, and the evolutionary adaption of species to these disturbances, has been influenced by the historical and current land-uses. For example processes such as seasonal weed invasions, interruption to surface and groundwater flow, nutrient inputs into aquatic systems can result in the creation of habitat for insect prey species creating potential foraging habitat resources for microbat species. The project has potential to affect these current disturbance regimes, however considering the existing high levels of human disturbance in the locality, the project is unlikely to substantially exacerbate these disturbance regimes.

Insectivorous bats are wide-ranging species adapted to moving across fragmented landscapes to find prey. Any impacts from change of habitat condition associated with altering disturbance regimes in proximity to the road may be offset by their ability to move widely throughout the landscape and access disturbed and fragmented habitats.

How is the project likely to affect habitat connectivity?

There is currently a high degree of habitat fragmentation across the study area. These highly mobile species are adapted to moving across forest clearings such as roads to access foraging and roosting habitat and are unlikely to be significantly impacted by the barrier effect of the road.

How is the project likely to affect critical habitat?

None of the habitats present in the study area are registered on the current list of recommended or declared critical habitat in NSW.

Cave-roosting microbats

Species	Status – TSC Act
Large-eared Pied Bat (*Chalinolobus dwyeri*)	V
Eastern Bent-wing Bat (*Miniopterus schreibersii oceanensis*)	V
Southern Myotis (*Myotis macropus*)	V

How is the project likely to affect the lifecycle of a threatened species and/or population?

Vegetation in the study area provides potential foraging habitat for the assessed species. Some potential roosting habitats are also present including cavities in the existing viaduct and bridge structures of the M4 motorway, culverts, buildings, Fairy-martin nests and other structures.

These bat species frequent a variety of habitat types including mangrove forests, disturbed habitats, forests and woodlands. Important life-cycle activities include roosting and breeding and both are typically associated with caves, as well as foraging for insect prey which occurs in a variety of habitat types. Breeding habitat for insect prey includes a very diverse range of wetlands, swamps and open modified and artificial landscapes.

The size of local populations is not known, although expected to not to be considerably large considering the highly urbanised and modified habitats in the locality. Potential foraging habitat in the study area is generally widespread including natural habitats such as mangrove forest, swamp forest and wetlands, as well as planted vegetation and exotic dominated vegetation. Impacts to these habitats would impact on the potential breeding habitat for prey species (invertebrates), however any potential overall reductions to the abundance of prey species is likely to be minimal, considering the widespread nature of these habitats in the locality.

The project would have some level of impact to up to 8.84 hectares of foraging habitat comprising a combination of all identified map units. This includes indirect impacts from shading and removal of vegetation where required, however foraging attributes are unlikely to be substantial modified throughout much of this 8.84 hectare area. Maintained lawns and various structures throughout the study area also provide potential foraging opportunities, which have not been delineated and quantified throughout the study area.

Potential impacts to the life-cycle activities of these bat species mainly relates to disruption of breeding activities and shelter or dormancy activities and removal of roosting habitats. Potential roost sites include cavities in the existing viaduct and bridge structures of the M4 motorway, culverts, buildings, Fairy-martin nests and other structures. Impacts to these potential roosting habitats are not expected and any potential impacts to these impacts from construction will be identified during the pre-clearance surveys.

Mitigation measures will include avoiding disturance of potential roosting habitats, pre-clearance surveys and staged habitat removal. Considering the limited potential impact to preferred roosting habitats, and the proposed mitigation measures the project is unlikely to result in a negative impact to the life cycle of these species.

How is the project likely to affect the habitat of a threatened species, population or ecological community?

The project would have some level of impact to up to 8.84 hectares of foraging habitat

comprising a combination of all identified map units. This includes indirect impacts from shading and removal of vegetation where required, however foraging attributes are unlikely to be substantial modified throughout much of this 8.84 hectare area. Maintained lawns and various structures throughout the study area also provide potential foraging opportunities, which have not been delineated and quantified throughout the study area.

Potential roost sites include cavities in the existing viaduct and bridge structures of the M4 motorway, culverts, buildings, Fairy-martin nests and other structures. Impacts to these potential roosting habitats are not expected and any potential impacts to these impacts from construction will be identified during the pre-clearance surveys.

Does the project affect any threatened species or populations that are at the limit of its known distribution?

None of these threatened bat species are at the limit of their distribution in the project study area. Habitats are widespread throughout the region particularly further west of the study area.

How is the project likely to affect current disturbance regimes?

The range of disturbance regimes that currently exists in the study area, and the evolutionary adaption of species to these disturbances, has been influenced by the historical and current land-uses. For example processes such as seasonal weed invasions, interruption to surface and groundwater flow, nutrient inputs into aquatic systems can result in the creation of habitat for insect prey species creating potential foraging habitat resources for microbat species. The project has potential to affect these current disturbance regimes, however considering the existing high levels of human disturbance in the locality, the project is unlikely to substantially exacerbate these disturbance regimes.

Insectivorous bats are wide-ranging species adapted to moving across fragmented landscapes to find prey. Any impacts from change of habitat condition associated with altering disturbance regimes in proximity to the road may be offset by their ability to move widely throughout the landscape and access disturbed and fragmented habitats.

How is the project likely to affect habitat connectivity?

There is currently a high degree of habitat fragmentation across the study area. These highly mobile species are adapted to moving across forest clearings such as roads to access foraging and roosting habitat and are unlikely to be significantly impacted by the barrier effect of the road.

How is the project likely to affect critical habitat?

None of the habitats present in the study area are registered on the current list of recommended or declared critical habitat in NSW.

E.2 Environment Protection and Biodiversity Conservation Act, 1999

Endangered Fauna

Swift Parrot (*Lathamus discolour*)

Lead to a long-term decrease in the size of a population

The species is an occasional visitor to the region during peak flowering events of the dominant trees, particularly the winter flowering Spotted Gum (*Corymbia maculata*) and Swamp Mahogany (*Eucalyptus robusta*). The project would remove up to 0.13 hectares of planted Spotted Gum which provide potential winter food resources. There are no breeding records in the study area and the extent of habitat remaining in the study area would provide sufficient resources to sustain future visitation, such that the project is unlikely to lead to a long-term decrease in the size of a population.

Reduce the area of occupancy of the species

The species is an occasional visitor to the region and there are no known permanent populations. The project would contribute to the loss of potential foraging habitat throughout the distributional range of the Swift Parrot and therefore reduce the area of habitat available.

Fragment an existing population into two or more populations

The species is an occasional visitor to the region and there are no known permanent populations within the study area. The foraging range of the Swift parrot population occurs across Victoria, NSW and southern Queensland and the species has evolved to disperse over great distances.

Adversely affect habitat critical to the survival of a species

Any use of the site habitats by this migratory and nomadic bird is likely to be sporadic and during peak flowering events of the dominant mature trees. The habitat within the project boundary is not recognised as a critical breeding area for this species however the project would contribute to the loss of suitable foraging habitat throughout the distributional range of the Swift Parrot. In particularly the loss of habitat that is dominated by winter flowering eucalyptus species is considered critical for this species. In this instance the project will remove critical foraging habitat. Indirect impacts on adjacent areas of critical habitat may results from edge effects.

Disrupt the breeding cycle of a population

There are no breeding records of Swift Parrot in the study area.

Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

There are no permanent populations in the region although the study area is known to contain important winter foraging habitat for this species. The project would contribute to the loss of potential foraging habitat including critical habitat throughout the distributional range of the Swift Parrot in NSW. This loss is a recognised threat to the species.

Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat

The main disturbance regimes effecting habitats in the study area are weed invasion,

fragmentation and edge effects and maintenance regimes such as slashing and pruning. Mitigation measures will be implemented to limit the exacerbation of these current disturbance regimes.

Any impacts from change of habitat condition associated with altering disturbance regimes in proximity to the road may be offset by their ability to move widely throughout the landscape and access disturbed and fragmented habitats.

The management of invasive species would be managed under the construction environmental management plan and during operation of the highway.

Introduce disease that may cause the species to decline

Infection of native plants by *Phytophthora cinnamomi* has been identified as being spread by construction machinery. This water-borne fungus infects the roots of plants and has the potential to cause dieback. Machinery associated with vegetation clearance and subsequent construction for the project has the potential to transmit the fungus to remaining native vegetation remnants of the species. This is a potential indirect impact to the species through the transmission of pathogens into retained habitat near the road. This can be mitigated through the development and implementation of suitable control measures for vehicle and plant hygiene and is unlikely to have a significant impact. It is the intention to use current best practice hygiene protocols as detailed in RTA (2011) on this project as part of the CEMP to prevent the introduction or spread of pathogens.

The project mitigation strategy and environmental management procedures would include guidance for preventing the introduction and/or spread of disease causing agents such as bacteria and fungi.

Interfere with the recovery of the species.

The project and proposed highway construction would not conflict with the recovery of this species. Impacts to foraging habitats will be minimise where possible, and mitigation measures would target replacement of removed foraging resources in future landscaping. There are no priority sites for conservation of this species within the project boundary.

Vulnerable Fauna

Grey-headed Flying-fox (*Pteropus poliocephalus*)

Lead to a long-term decrease in the size of an important population

There have been no roost camps identified in the project boundary to date and at the time of the EIS the project would not directly impact on any known breeding / maternity site. This species was observed flying over the study area during dusk.

Therefore it is likely that the impacts of construction and operation of the project would be confined to loss of feeding habitat caused by 1) direct clearing or damage to native vegetation during the construction phase and 2) edge effects during operation related to degradation of foraging habitat from shading.

The project would directly remove up to 8.84 hectares of potential foraging habitat however vegetation will be avoided where possible. Foraging habitat mainly comprises nectar resources from planted native trees and shrubs as well as fruit resources from planted fig trees and some exotic trees. This area of habitat may be defined as a portion of the potential area of occupancy for feeding life-cycle attributes of the population. The affected area of foraging habitat would represent a small percentage of the total extent of important foraging vegetation types present within a 50 kilometre radius of the project boundary. Given the relative widespread nature of similar planted vegetation in the locality and abundance of higher quality foraging habitat within the feeding range of regional populations, the project is not expected to lead to a long-term decrease in the size of an important population.

Reduce the area of occupancy of an important population

The project would directly remove up to 8.84 hectares of foraging habitat however vegetation will be avoided where possible. Foraging habitat mainly comprises nectar resources from planted native trees and shrubs as well as fruit resources from planted fig trees and some exotic trees. This area of habitat may be defined as a portion of the potential area of occupancy for feeding life-cycle attributes of the population. The project will reduce the area of habitat available to the species.

Fragment an existing important population into two or more populations

There is currently a high degree of habitat fragmentation across the study area. Highly mobile species such as bats are expected to be less impacted by fragmentation and the grey-headed flying-fox is particularly well adapted to accessing widely spaced habitat resources given its mobility and preference for seasonal fruits and blossom. The project would not fragment an important population of the Grey-headed Flying-fox.

Adversely affect habitat critical to the survival of the species

Habitat critical to the survival of a species refers to areas that are necessary for activities such as:

- *Foraging, breeding, roosting, or dispersal*
- *For the long-term maintenance of the species including the maintenance of other species essential to the survival of the species, such as pollinators*
- *To maintain genetic diversity and long-term evolutionary development*

- *For the reintroduction of populations or recovery of the species.*

The proposed area of habitat loss represents a small percentage of the potential foraging habitat for the Grey-headed Flying-fox within a 50 kilometre radius of the project boundary and know roost camps in the region. This species typically exhibits very large home ranges and Grey-headed Flying-fox are known to travel distances of at least 50 kilometres from roost sites to access seasonal foraging resources (Eby 1996). No evidence of a camp site has been identified from the footprint of the upgrade.

The draft recovery plan for the Grey-headed Flying-fox (DECCW 2009) identifies critical foraging habitat for this species as:

- Productive during winter and spring, when food bottlenecks have been identified
- Known to support populations of >30,000 individuals, within an area of 50 kilometre radius
- Productive during the final weeks of gestation, and during the weeks of birth, lactation and conception (Sept-May)
- Productive during the final stages of fruit development and ripening in commercial crops affected by Grey-headed Flying-foxes
- Known to be continuously occupied as a camp site.

The project would directly remove up to 8.84 hectares of foraging habitat however vegetation will be avoided where possible. Foraging habitat mainly comprises nectar resources from planted native trees and shrubs as well as fruit resources from planted fig trees and some exotic trees. This area of habitat may be defined as a portion of the potential area of occupancy for feeding life-cycle attributes of the population. The affected area of foraging habitat would represent a small percentage of the total extent of important foraging vegetation types present within a 50 kilometre radius of the project boundary. Given the relative widespread nature of similar planted vegetation in the locality and abundance of higher quality foraging habitat within the feeding range of regional populations, the project is not expected to adversely affect habitat critical to the survival of the species

Disrupt the breeding cycle of an important population

As stated above there would be a minor impact on critical habitat identified as important during the breeding cycle of the species. The upgrade would not directly impact on a known roost camp / breeding or maternity site.

Modify, destroy, remove, or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

No evidence of a roost camp has been identified from the footprint of the upgrade. Further there would be a relatively minor impact on critical foraging habitat associated with the upgrade and contained with a 50 kilometre radius of known camp sites. This impact is not expected to lead to a decline in the species in this region.

Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species habitat

The potential for weed invasion was considered possible with a project of this nature and appropriate controls are required during construction and operation of the road to reduce

this threat. The management of invasive species would be managed under the construction environmental management plan and during operation of the highway using best practice methods as outlined in RTA (2011).

Introduce disease that may cause the species to decline

There are no known disease issues affecting this species in relation to the project. The project would be unlikely to increase feral animal abundance or the potential for significant disease vectors to affect local populations.

Infection of native plants by *Phytophthora cinnamomi* has been identified as being spread by construction machinery. This water-borne fungus infects the roots of plants and has the potential to cause dieback. Machinery associated with vegetation clearance and subsequent construction for the project has the potential to transmit the fungus to remaining native vegetation remnants of the species. This is a potential indirect impact to the species through the transmission of pathogens into retained habitat near the road. This can be mitigated through the development and implementation of suitable control measures for vehicle and plant hygiene and is unlikely to have a significant impact. It is the intention to use current best practice hygiene protocols as detailed in RTA (2011) on this project as part of the Construction Environmental Management Plan to prevent the introduction or spread of pathogens.

Interferes substantially with the recovery of the species

Given the relative widespread nature of similar planted vegetation in the locality and abundance of higher quality foraging habitat within the feeding range of regional populations, the project is not expected to interfere substantially with the recovery of the species.

Large-eared Pied Bat (Chalinolobus dwyeri)

Lead to a long-term decrease in the size of an important population

Vegetation in the study area provides potential foraging habitat for this species. Some potential roosting habitats are also present including cavities in the existing viaduct and bridge structures of the M4 Motorway, culverts, buildings, Fairy-martin nests and other structures.

This species frequent a variety of habitat types including mangrove forests, disturbed habitats, forests and woodlands. Important life-cycle activities include roosting and breeding and both are typically associated with caves, as well as foraging for insect prey which occurs in a variety of habitat types. Breeding habitat for insect prey includes a very diverse range of wetlands, swamps and open modified and artificial landscapes.

The size of local population is not known, although expected to not to be considerably large considering the highly urbanised and modified habitats in the locality and absence of caves. Potential foraging habitat in the study area is generally widespread including natural habitats such as mangrove forest, swamp forest and wetlands, as well as planted vegetation and exotic dominated vegetation. Impacts to these habitats would impact on the potential breeding habitat for prey species (invertebrates), however any potential overall reductions to the abundance of prey species is likely to be minimal, considering the widespread nature of these habitats in the locality.

The project would have some level of impact to up to 8.84hectares of foraging habitat

comprising a combination of all identified map units. This includes indirect impacts from shading and removal of vegetation where required, however foraging attributes are unlikely to be substantial modified throughout much of this 8.84 hectare area. Maintained lawns and various structures throughout the study area also provide potential foraging opportunities, which have not been delineated and quantified throughout the study area.

Potential impacts to the life-cycle activities of this species mainly relates to disruption of breeding activities and shelter or dormancy activities and removal of roosting habitats. Potential roost sites include cavities in the existing viaduct and bridge structures of the M4 Motorway, culverts, buildings, Fairy-martin nests and other structures. Impacts to these potential roosting habitats are not expected and any potential impacts to these impacts from construction will be identified during the pre-clearance surveys.

Mitigation measures will include avoiding disturbance of potential roosting habitats, pre-clearance surveys and staged habitat removal. Considering the limited potential impact to preferred roosting habitats, and the proposed mitigation measures the project is unlikely to lead to a long-term decrease in the size of an important population.

Reduce the area of occupancy of an important population

The project would have some level of impact to up to 8.84 hectares of foraging habitat comprising a combination of all identified map units. This includes indirect impacts from shading and removal of vegetation where required, however foraging attributes are unlikely to be substantial modified throughout much of this 8.84 hectare area. Maintained lawns and various structures throughout the study area also provide potential foraging opportunities, which have not been delineated and quantified throughout the study area. The project will reduce the area of habitat available to the species.

Fragment an existing important population into two or more populations

There is currently a high degree of habitat fragmentation across the study area. Highly mobile species such as bats are expected to be less impacted by fragmentation. The project would not fragment an important population of this species.

Adversely affect habitat critical to the survival of the species

Habitat critical to the survival of a species refers to areas that are necessary for activities such as:

- *Foraging, breeding, roosting, or dispersal*
- *For the long-term maintenance of the species including the maintenance of other species essential to the survival of the species, such as pollinators*
- *To maintain genetic diversity and long-term evolutionary development*
- *For the reintroduction of populations or recovery of the species.*

The project would have some level of impact to up to 8.84 hectares of foraging habitat comprising a combination of all identified map units. This includes indirect impacts from shading and removal of vegetation where required, however foraging attributes are unlikely to be substantial modified throughout much of this 8.84 hectare area. Maintained lawns and various structures throughout the study area also provide potential foraging opportunities, which have not been delineated and quantified throughout the study area.

The proposed area of disturbance represents a very small fraction of the potential

foraging habitat for the Large-eared Pied-bat. Impacts to areas of roosting habitat are not anticipated. The project is unlikely to impact habitat critical to the survival of the species.

Disrupt the breeding cycle of an important population

The proposed area of disturbance represents a very small fraction of the potential foraging habitat for the Large-eared Pied-bat. The upgrade would not directly impact on a known roost or maternity site and such as unlikely to disrupt the breeding cycle of this species.

Modify, destroy, remove, or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

The project would have some level of impact to up to 8.84 hectares of foraging habitat comprising a combination of all identified map units. This includes indirect impacts from shading and removal of vegetation where required, however foraging attributes are unlikely to be substantial modified throughout much of this 8.84 hectare area. Maintained lawns and various structures throughout the study area also provide potential foraging opportunities, which have not been delineated and quantified throughout the study area. The proposed area of disturbance represents a very small fraction of the potential foraging habitat for the Large-eared Pied-bat, and it is considered unlikely the species will decline a result of the project.

Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species habitat

The potential for weed invasion was considered possible with a project of this nature and appropriate controls are required during construction and operation of the road to reduce this threat. The management of invasive species would be managed under the construction environmental management plan and during operation of the highway using best practice methods as outlined in RTA (2011).

Introduce disease that may cause the species to decline

There are no known disease issues affecting this species in relation to the project. The project would be unlikely to increase feral animal abundance or the potential for significant disease vectors to affect local populations.

Infection of native plants by *Phytophthora cinnamomi* has been identified as being spread by construction machinery. This water-borne fungus infects the roots of plants and has the potential to cause dieback. Machinery associated with vegetation clearance and subsequent construction for the project has the potential to transmit the fungus to remaining native vegetation remnants of the species. This is a potential indirect impact to the species through the transmission of pathogens into retained habitat near the road. This can be mitigated through the development and implementation of suitable control measures for vehicle and plant hygiene and is unlikely to have a significant impact. It is the intention to use current best practice hygiene protocols as detailed in RTA (2011) on this project as part of the CEMP to prevent the introduction or spread of pathogens.

Interferes substantially with the recovery of the species

Given the relative widespread nature of similar planted vegetation in the locality and abundance of higher quality foraging habitat in the region and locality, the project is not expected to interfere substantially with the recovery of the species.

Migratory species

An area of 'important habitat' for a migratory species is:

- habitat used by a migratory species occasionally or periodically within a region that supports an ecologically significant proportion of the population of the species, and/or
- habitat that is of critical importance to the species at particular life-cycle stages, and/or
- habitat used by a migratory species which is at the limit of the species range, and/or
- habitat within an area where the species is declining.

Listed migratory species cover a broad range of species with different life cycles and population sizes. Therefore, what is an 'ecologically significant proportion' of the population varies with the species. Some factors that would be considered include the species' population status, genetic distinctiveness and species specific behavioural patterns (for example, site fidelity and dispersal rates). These factors have been considered in the following assessment.

Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species

There is no evidence to suggest that an ecologically significant proportion of the population of any identified migratory species exists within the project boundary.

Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species

The potential for weed invasion has been considered highly likely with a proposal of this nature and appropriate controls have been provided during the construction and operation of the road to reduce this threat as it may have long term implications for the habitat of threatened and migratory species. The management of invasive species would be managed under the construction environmental management plan.

Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.

As discussed there is no evidence to suggest that an ecologically significant proportion of the population of a migratory species exists within the project boundary.