

# Species Impact Statement

**Mona Vale Road West Upgrade**  
**McCarrs Creek Road, Terrey Hills to Powder Works Road, Ingleside**

Report prepared for Roads and Maritime Services

February 2017



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## Glossary and Acronyms

Acronym	Definition
Activity	The same meaning as in the EP&A Act
CAMBA	China-Australia Migratory Birds Agreement
cm	Centimetres
Development	The same meaning as in the EP&A Act
DGRs	Director General's Requirements
DoE	Department of the Environment
EEC	Endangered Ecological Community
EP&A Act	<i>Environmental Planning and Assessment Act 1979</i>
EPBC Act	<i>Environmental Protection and Biodiversity Conservation Act 1999</i>
FM Act	<i>Fisheries Management Act 1994</i>
ha	hectare
JAMBA	Japan-Australia Migratory Birds Agreement
KTP	Key Threatening Process
LEP	Local Environmental Plan
LGA	Local Government Area
Locality	The area within a 5 kilometres radius of the subject site
MNES	Matters of National Environmental Significance
MSW	Moist Shale Woodland
NPWS	National Parks and Wildlife Service, NSW
NP	National Park
NSW	New South Wales
OEH	Office of Environment and Heritage, NSW.
PCT	Plant Community Type
Proposal	The development, activity or action proposed



<b>Acronym</b>	<b>Definition</b>
ROTAP	Rare or Threatened Australian Plants
SEPP	State Environmental Planning Policy
SGTF	Shale Gravel Transition Forest
Study area	The subject site and any additional areas likely to be affected by the proposal, either directly or indirectly
Subject site	The area directly affected by the proposal
Subject Species	Threatened species that are known or considered likely to occur in the study area
TEC	Threatened Ecological Community
Threatened species, populations and ecological communities	The same meaning as in the TSC Act
TSC Act	<i>Threatened Species Conservation Act 1995 (NSW)</i>
WoNS	Weeds of National Significance

## Executive Summary

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This Species Impact Statement (SIS) has been prepared by SMEC for Roads and Maritime Services (Roads and Maritime) for the proposed upgrade of Mona Vale Road between McCarrs Creek Road, Terrey Hills and Powder Works Road, Ingleside (Mona Vale Road West), approximately 30 kilometres north of Sydney.

This SIS has been prepared in accordance with the Director General's Requirements (DGRs) issued by the NSW Office of Environment and Heritage (OEH) on 25 May 2015 and amended DGRs on 21 July 2015. The DGRs identified 23 fauna, 11 flora, one endangered population and two endangered ecological communities as subject species to be assessed through the SIS. Database searches identified 43 flora and 102 fauna species with the potential to occur within ten kilometres of the subject site. Desktop assessments determined that additional species may be directly or indirectly affected by this proposal and that others listed in the DGRs would not be affected, therefore the list of subject species was amended to a final total of 23 fauna, 11 flora species, two endangered ecological communities and one endangered population.

Background information for this SIS was gathered from various sources, including relevant previous studies, scientific literature, databases, aerial photography and maps. Field surveys were also undertaken following the guidelines set out in the relevant threatened species survey guidelines (DEC 2004) and the DGRs.

Flora surveys were carried out between September 2013 and July 2016, incorporating surveys undertaken by SMEC (2016), Ecosure (2015) Smith and Smith (2011), reported herein. This included 128 person hours of flora survey effort with surveys undertaken to meet survey seasonal requirements for targeted flora. Existing vegetation mapping was validated and remapped as required using a combination of ground-truthing (rapid data points and flora survey plots which incorporated plot and transect and full floristic quadrats – 24 flora survey plots completed) and GIS updating of maps and vegetation types (including calculation of type extent and attribution of types to local, regional and Plant Community Types). Vegetation condition was also assessed as being in good, moderate or low condition according to the quality and intactness of the structure, the number and dominance of native species present, and the number of exotic species present.

Fauna surveys were undertaken between August 2010 and January 2016 by Ecosure and SMEC. Standard survey techniques were used to target threatened fauna, including Elliot traps, cage traps, hair funnels, diurnal bird census, pitfall traps, diurnal reptile searches, nocturnal call playback, spotlighting, frog searches, harp trapping, stag watches, remote cameras and ultrasonic bat recording. Assessments of fauna habitat were also undertaken at various locations throughout the study area and a survey of the hollow-bearing trees was undertaken.

Each of the final subject species, populations and communities were considered in relation to the proposal. The assessment took into account a review of previous records in the study area and locality, species database searches, other surveys in the locality and the results of surveys conducted to address the DGRs for the proposal.

Forty-three threatened flora species were assessed as potentially occurring within the general locality of the study area, ten of these had a moderate or high probability of occurring in the study area. Of

these ten species, two were confirmed as present within the study area and three others were previously recorded within the study area. Hence, ten flora species were determined to be subject species for this assessment. One threatened ecological community (Duffys Forest EEC) was assessed as potentially affected by this proposal. The remaining threatened ecological community requested by the DGRs, Coastal Upland Swamp in the Sydney Basin Bioregion, was excluded as it does not occur in the study area.

One hundred and two threatened or migratory fauna species have been recorded within 10 kilometres of the subject site. An assessment of the likelihood of occurrence of these species was made based on database and other records, habitat availability, targeted survey (Ecosure 2015 and SMEC 2015), preliminary field inspection and professional knowledge. Twelve species were considered to have a moderate or greater likelihood of occurrence or have been previously identified within the study area. No listed endangered fauna populations are known to occur within the study area and are not considered further.

For each of the subject species, communities or populations the SIS generates an assessment of likely impacts based on the consideration of several factors. These include distribution, abundance, habitat values and utilisation, conservation status and the context of these species, population and communities in the locale and region. Feasible alternatives and ameliorative strategies were considered in generating the final impact assessments.

The proposal (before a consideration of mitigation/amelioration measures) would remove about 18 hectares of native vegetation, resulting in the loss of threatened plants and habitat for the threatened species *Grevillea caleyi* and *Microtis angusii* and about 3.4 hectares of DFEC.

Removal of vegetation generally will reduce habitat available to numerous threatened fauna species that have the potential or are known to occupy the study area. In addition to vegetation, the proposal will require the removal of 135 hollow-bearing trees and 22 termite mounds. These habitat features are important to threatened species such as the Powerful Owl, Eastern Pygmy-possum, Rosenberg's Goanna some microchiropteran bats. Indirect impacts arising from the proposal may also include eventual increases to fauna collision and mortality due to increased traffic speeds and volumes.

A number of amelioration measures have been developed to mitigate the potential impacts of the proposal on subject species. The amelioration measures are designed to reduce impacts on threatened species as well as general flora and fauna species in the study area and include:

- Implementing the RMS Biodiversity Guidelines (2011a) for the pre-clearing process, establishment of exclusion zones, clearing of vegetation, re-establishment of native vegetation and re-use of habitat features (eg bush rock)
- Construction of a fauna landbridge to connect Ku-ring-gai Chase and Garigal National Parks over Mona Vale Road, near Kimbriki Tip
- Two fauna underpasses; one between Bungendore Street and Addison Road and one on Mona Vale Road in the vicinity of the Tumburra Street intersection
- Fauna-proof fencing to direct fauna towards crossing structures and to reduce roadkill for common species i.e Swamp Wallaby
- Targeted rehabilitation and revegetation to encourage fauna to use the connectivity measures

- Preparation of a weed management plan to be implemented before and during construction and during operation

A re-assessment of the ten subject flora, 12 subject fauna species and one threatened community with the potential to be impacted by the proposal using the EP&A Act. Assessments of significance concluded that, even after implementation of all proposed ameliorative measures, the proposal would have residual significant impacts on Duffy's Forest EEC, *Microtis angusii*, *Grevillea caleyi* and Red-crowned Toadlet.

Residual impacts that cannot be avoided or ameliorated will be further compensated through the acquisition and retirement of BioBanking Credits in line with the OEH *Principles for the Use of Biodiversity Offsetting*. Compensatory measures for impacts that cannot be avoided or mitigated have been calculated using the Framework for Biodiversity Assessment (FBA) linear assessment methodology.

The following quantum of BioBanking credits have been calculated to compensate the residual impacts to these threatened species and communities:

- 225 ecosystem credits for DFEC (BVT ID: ME98)
- 26 species credits for *Microtis angusii* (subject to resolution of the taxonomic and conservation status of the species)
- 462 species credits for *Grevillea caleyi*
- 19 species credits for Red-crowned Toadlet

An additional 654 ecosystem credits for BVT ID ME106 will be considered to offset the impacts on habitat with the potential to support all other threatened species in accordance with the Roads and Maritime Guideline for Biodiversity Offsets (RMS 2016).

The acquisition and retirement of the required ecosystem and species credits are currently under consideration by Roads and Maritime which will be the subject of a Biodiversity Offset Strategy.



# 1 PURPOSE AND CONTENT OF THE SPECIES IMPACT STATEMENT

---

## 1.1 PURPOSE

This Species Impact Statement (SIS) has been prepared by SMEC on behalf of Roads and Maritime Services (Roads and Maritime) to consider potential impacts on threatened species, populations and ecological communities associated with the proposed Mona Vale Road West Upgrade (the proposal).

The purpose of the SIS is to:

- Allow the proponent to identify threatened species issues and provide appropriate amelioration for adverse impacts resulting from the proposal
- Assist consent and determining authorities in the assessment of a request for Part 5 approval under the EP&A Act
- Assist the Director-General in deciding whether or not concurrence should be granted under Part 5 of the EP&A Act
- Assist the Director-General or the Minister for the Environment when consulted for the purposes of Part 5 of the EP&A Act.

## 1.2 DIRECTOR GENERAL'S REQUIREMENTS

The Director General's Requirements (DGRs) for this SIS were issued by the NSW Office of Environment and Heritage (OEH) on 25 May 2015 and amended DGRs on 21 July 2015 (Appendix A).

## 1.3 MATTERS WHICH HAVE BEEN LIMITED

The following Section 110 matters need only be addressed where relevant:

### *Threat abatement plans*

- Predation by the Red Fox (*Vulpes vulpes*)
- Predation by *Gambusia holbrooki* – The Plague Minnow

### *Recovery plans*

- Recovery plan for *Grevillea caleyi* R. Br. (Proteaceae)
- Southern Brown Bandicoot *Isodon obesulus* Recovery Plan
- Large Forest Owls Recovery Plan
- The national recovery plans for the *Microtis angusii* and Large-eared Pied Bat *Chalinolobus dwyeri*

### *Key threatening processes*

- Aggressive exclusion of birds from woodland and forest habitat by abundant Noisy Miner *Manoria melanocephala*
- Alteration of natural flow regimes of rivers and streams and their floodplains and wetlands
- Anthropogenic climate change
- Bushrock removal
- Clearing of native vegetation
- Competition and grazing by the Feral European Rabbit *Oryctolagus cuniculus*
- Competition from feral honey bees *Apis mellifera*
- Forest eucalypt dieback associated with overabundant psyllids and Bell Miners
- High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition
- Infection of frogs by amphibian chytrid causing the disease *chytridiomycosis*
- Infection of native plants by *Phytophthora cinnamomi*
- Introduction and establishment of Exotic Rust Fungi of the order Pucciniales pathogenic on plants of the family Myrtaceae
- Invasion and establishment of exotic vines and scramblers
- Invasion of native plant communities by exotic perennial grasses
- Invasion, establishment and spread of Lantana (*Lantana camara* L. sens. Lat)
- Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants
- Loss of hollow-bearing trees
- Predation by the European Red Fox *Vulpes vulpes* (Linnaeus, 1758)
- Predation by the Feral Cat *Felis catus* (Linnaeus, 1758)
- Removal of dead wood and dead trees

### *Critical habitat*

At the time of preparing this SIS no areas of declared critical habitat were relevant to this proposal.

## **1.4 MATTERS TO BE ADDRESSED**

The TSC Act provides that the SIS must meet all the matters specified in Sections 109 and 110 of the TSC Act except where those matters have been limited above. The specific requirements of the DGRs are addressed in the SIS as indicated in Table 1.

**Table 1: Compliance table showing where sections of the DGRs are addressed in the SIS**

<b>DGR's section and heading</b>	<b>SIS section and heading</b>
<b>1 - Form of the Species Impact Statement</b>	Section 1 of this SIS
1.1 A species impact statement must be in writing	As required by Section 109(1) of the TSC Act, this SIS is in writing.
1.2 A species impact statement must be signed	Section 1.5 of this SIS.
<b>2 - Contextual Information</b>	
2.1 Description of proposal, subject site and study area	2.1 Background information, 2.2 The proposal 2.3 Subject site and study area Appendix B: the proposal – detail figures
2.2 Land tenure information	2.4 Land tenure
2.3 Vegetation	2.5 Vegetation
2.4 Plans and maps	2.6 Plans and Maps
<b>3 - Initial Assessment</b>	
3.1 Identifying subject threatened species, populations and ecological communities	3.1 Subject species, population and ecological communities as listed in the DGRs 3.1.1 Assessment of available information and data sources 3.1.2 Flora 3.1.3 Fauna Appendix C: Threatened Flora and fauna species with the potential to occur in the study area
<b>4 - Survey</b>	
4.1 Requirement to survey	Section 4.1
4.2 Documentation	4.2 documentation 4.2.1 Description of survey techniques and survey locations: flora 4.2.2 Description of survey techniques and survey locations: flora 4.2.3 Documenting survey effort and results 4.2.4 Description and mapping of results of vegetation, flora and fauna surveys Appendix E: Field data sheets

DGR's section and heading	SIS section and heading
4.3 Specific survey requirements	4.3 Specific survey requirements 4.3.1 Endangered ecological communities 4.3.2 Flora species 4.3.3 Fauna species
<b>5 - Assessment of likely impacts on threatened species and populations</b>	
5.1 Assessment of species likely to be affected	5.1 Assessment of species likely to be affected 5.1.1 Flora species 5.1.2 Fauna species
5.2 Discussion of local and regional abundance and distribution	5.2 Discussion of local and regional abundance and distribution 5.2.1 Discussion of other known local populations – Flora 5.2.2 Discussion of other known local populations – Fauna
5.3 Assessment of habitat	5.3 Assessment of habitat 5.3.1 Description of habitat values 5.3.2 Discussion of habitat utilisation
5.4 Discussion of conservation status	5.4 Discussion of conservation status 5.4.1 Flora 5.4.2 Fauna
5.5 Discussion of likely effect of the proposal at local and regional scales	5.5 Discussion of likely effect of the proposal at local and regional scales 5.5.1 Significance within a local context 5.5.2 Discussion of connectivity 5.5.3 Consideration of threatening processes
5.6 Description of feasible alternatives	5.6 Description of feasible alternatives
<b>6 – Assessment of Likely Impacts on Endangered Ecological Communities</b>	
6.1 Assessment of endangered ecological communities likely to be affected	6.1 Assessment of endangered ecological communities likely to be affected 6.1.3 Direct impacts 6.1.4 Indirect impacts
6.2 Description of habitat	6.2 Description of habitat 6.2.1 Study area 6.2.2 Locality



<b>DGR's section and heading</b>	<b>SIS section and heading</b>
6.3 Discussion of conservation status	6.3 Discussion of conservation status
6.4 Discussion of the likely effect of the proposal at local and regional scales	6.4 Discussion of the likely effect of the proposal at local and regional scales 6.4.1 Significance within a local context 6.4.2 Extent of habitat removal or modification 6.4.3 Discussion of connectivity 6.4.4 consideration of threatening processes
6.5 Description of feasible alternatives	6.5 Description of feasible alternatives
<b>7 – Ameliorative measures</b>	
7.1 Description of ameliorative measures	7.1 Description of ameliorative measures 7.1.1 Long term management strategies 7.1.2 Compensatory strategies 7.1.2.1 Biodiversity offsetting 7.1.2.2 Identification of Potential Offset Sites 7.1.2.3 Supplementary measures 7.1.2.4 Ongoing monitoring
<b>8 – Assessment of Significance of likely effect or proposed action</b>	Section 8.1 Summary of Assessments Appendix D: EP&A Act Assessment of Significance
<b>9 – Additional Information</b>	
9.1 Qualifications and experience	9.1 Qualifications and experience
9.2 Other approvals required for the development or activity	9.2 Other approvals required for the development or activity
9.3 Licencing matters relating to conducting surveys	9.3 Licencing matters relating to conducting surveys
9.4 Section 110 (5) reports	9.4 Section 110 (5) reports

**Table 2: Checklist for determining if an SIS has met the requirements of the Director General of OEH**

Matter	Met requirements of DGRs?	Comments
Has the SIS been signed by both its author and the applicant for consent/approval?	Yes	The SIS has been signed by one of the chief report author's (Liam Hogg, SMEC Ecology Team Lead) and the Roads and Maritime Project development Manager.
Has the description of the proposal included all associated activities and works, such as hazard reduction zones, access roads and road upgrades, utilities, etc.?	Yes	The SIS provides a summary of the description of the proposal. The reader is referred to the REF for a full description of the proposal.
Have all requested plans, maps and aerial photographs been provided? This includes any A1 or A0 sized proper survey plans prepared by a registered surveyor that clearly shows the location and boundaries of any proposed offsets.	Yes	The SIS provides plans and maps showing the subject site, study area, proposal, land use, threatened species records, vegetation types and topographical contours overlaid onto aerial imagery at varying scales (refer Figures 1-27).
Has the SIS determined the subject species by reviewing the suggested list in the DGRs, other available information and survey results and assessing which species, populations and ecological communities are to be affected by the development	Yes	The SIS has determined a list of subject species and EECs through desktop assessment and field survey (refer Section 3). The subject species and EEC have been assessed against the proposal through Section 5A Assessments (Appendix D) and EPBC Assessments (Appendix E).
Has the survey undertaken provided sufficient information to determine the likely impacts of the proposal on threatened species, populations and ecological communities?	Yes	The SIS has relied on four baseline and targeted flora and fauna survey datasets to adequately assess the impacts, these being: <ul style="list-style-type: none"> <li>▪ Smith and Smith (2011);</li> <li>▪ Ecosure (2015);</li> <li>▪ EcoLogical Australia (2015); and</li> <li>▪ SMEC (2016) for Eastern Pygmy-possum and <i>Grevillea caleyi</i> surveys</li> </ul>

Matter	Met requirements of DGRs?	Comments
Have surveys been undertaken during the appropriate seasons for the detection of the species that may possibly occur on the site?	Yes	The seasonal survey requirements for all subject species have been taken into consideration as part of the SIS surveys. Details on the timing and methods of seasonal surveys for subject species are provided in Section 5.
Have surveys been undertaken during appropriate weather conditions?	Yes	The weather requirements for all subject species have been taken into consideration as part of the SIS surveys. Details on the weather conditions experienced during the SIS surveys for subject species are provided in Section 5.
Have climatic conditions preceding the surveys (e.g. drought) affected the possibility of subject species being detected?	Yes	Neither Smith and Smith (2011) nor Ecosure (2015) provided comment on any weather related flora or fauna survey limitations as part of their field surveys of the study area.  Ecosure surveys were conducted throughout the year to maximise the chance of detecting as many species as possible, they also surveyed different microhabitat areas within 1 kilometre of the survey area to maximise species detected.
Have all specific survey methods, techniques and intensities requested in the DGRs been followed completely?	Yes	Both specific and general survey requirements prescribed in the DGRs have been met through both third party survey datasets and recent SMEC surveys in spring/summer 2015/2016.
Has the documentation of survey effort, locations and techniques provided sufficient information to determine the above?	Yes	Survey effort, locations and methods are outlined in Section 5 and are of sufficient detail to determine compliance with the DGRs.
Has the assessment of impacts included the impacts of all activities associated with the development, including fire hazard reduction requirements, access road upgrades, downstream and downslope impacts, detention basins, severing of fauna movement corridors, etc.	Yes	Both the Section 5A and EPBC Assessments for all subject species and EEC address both direct and indirect impacts, where possible. Where information on, for example, hydrology changes and post development nutrient levels were not available at the time of report preparation, the assessments were based on assumptions made regarding such potential indirect impacts.

Matter	Met requirements of DGRs?	Comments
Has the SIS discussed the extent, conservation significance and security of other occurrences of the subject species' in the locality?	Yes	Section 4 of the SIS is devoted to describing the habitats, distribution, local occurrences and conservation status of all subject species and EEC.
Has the SIS discussed the significance of the population/remnant to be affected, relative to others in the locality?	Yes	Both Section 4 and the Section 5A/EPBC Assessments (Appendices D and E) provide a discussion regarding the importance of the habitat of all subject species and EEC to be affected relative to others in the locality.
Has the SIS discussed the extent, conservation significance and security of other occurrences of the subject species in the region?	Yes	Section 4 of the SIS is devoted to describing the habitats, distribution, local and regional occurrences and conservation status (including security) of all subject species and EEC.
Has the SIS discussed the significance of the population/remnant to be affected, relative to others in the region?	Yes	Both Section 4 and the Section 5A/EPBC Assessments (Appendices D and E) provide a discussion regarding the importance of the habitat of all subject species and EEC to be affected relative to others in the locality and region.
Have alternatives to the proposal been discussed? Alternatives may include relocation of infrastructure or, for example, reducing minimum lot size so that a similar number of lots may be realised whilst retaining a larger conservation lot within a subdivision, or changing mining techniques.	Yes	A description of feasible alternatives to the proposal is addressed in Section 6.6 of the SIS (which have been reproduced from the REF).
Has the discussion of alternatives included assessment of the social and economic (not merely financial) aspects of these alternatives (particularly, of not proceeding)?	Yes	A description of feasible alternatives to the proposal is addressed in Section 6.6 of the SIS (which have been reproduced from the REF). A discussion of the social and economic aspects of these alternatives are provided in the REF.
Does the proposal use biodiversity offsets to compensate for the loss or impact to threatened species, populations, ecological communities and their habitat? Have these	Yes	Residual impacts on subject species, EECs (and their habitats) that cannot be avoided or ameliorated will be further compensated through the acquisition and retirement of BioBanking Credits in line with the <i>OEH Principles for the</i>



Matter	Met requirements of DGRs?	Comments
offsets been determined in accordance with either: (i) OEH's Principles for the use of biodiversity offsets in NSW, or (ii) a biodiversity assessment using BioBanking Assessment Methodology under Biodiversity Banking and Offsets Scheme, as outlined in the BioBanking Assessment Methodology 2014 (OEH BBAM 2014)?		<i>Use of Biodiversity Offsetting.</i> Compensatory measures for impacts that cannot be avoided or mitigated have been calculated using the Framework for Biodiversity Assessment (FBA) linear assessment methodology.
Has the discussion included an assessment of how the project meets the principles of Ecological Sustainable Development (ESD), as defined in section 6(2) of the <i>Protection of the Environment Administration Act 1991</i> ?	Yes	A discussion of ESD in relation to the proposal is addressed in the REF.
Have all proposals for compensatory actions (e.g. purchase of similar vegetation/habitat or revegetation of habitat, where appropriate) been discussed with the relevant landowners/manager?	Yes	Roads and Maritime have entered into discussions with relevant landowners with a view to establishing Biobank sites to offset the loss of biodiversity as a result of the proposal.
Is there documented agreement for sale or revegetation activities?	No	No formal Biobank agreement applications have been submitted to OEH to date. Biobank assessments are currently being undertaken on a number of potentially suitable offset properties.
Is there agreement to change zoning or enter into a covenant on title in order to secure the conservation of the properties being purchased or revegetated?	Yes	Roads and Maritime is committed to securing suitable offset properties with a view to conservation in perpetuity. As noted above, no Biobank agreements or other conservation mechanisms have been formally established at present.
If translocation is proposed, has the impact of the translocation on the recipient site(s) been assessed?	No	Duffys Forest translocation (of a portion of the soil seedbank earmarked for removal) is a recommended supplementary measure. Potentially suitable recipient (host) sites would be identified and assessed following proposal approval, where reasonable and feasible.

Matter	Met requirements of DGRs?	Comments
Is there a Plan of Management or similar titled document?	No	Plans of Management for offset sites subject to a formal Biobank agreement (or other conservation mechanism) would be prepared following project approval.
Has the SIS utilised relevant information from published draft and final recovery plans? If no plan has been published, but it is known that one is being prepared, has the SIS utilised advice from NPWS as to the likely contents of that recovery plan (liaison to obtain this advice may have been specified in the DGRs)? For example, would the proposal result in the loss of a local population or remnant that a recovery plan describes as being of particular importance to the conservation of the species, population or ecological community?	Yes	Recovery Plans for <i>Grevillea caleyi</i> , <i>Microtis angusii</i> , the large forest owls, Southern Brown Bandicoot, Swift Parrot, Large eared Pied Bat and Spotted-tailed Quoll have been utilised in the SIS preparation.
If a BioBanking assessment has been done for the proposal, have the following been provided: copies of BioBanking Credit reports, copies of field datasheets, copies of a checklist that includes all data used in the credit calculator and the underlying assumptions, such as how local vegetation communities were assigned to Biometric vegetation types (Plant Community Types) and has the Credit Calculator files been submitted via the OEH portal?	Yes	To date, a Biobank assessment has been undertaken for the development proposal to determine offsetting requirements for the proposal. Biobank survey field data sheets (Ecosure 2015 and SMEC) have been provided as Appendix E. A copy of the Biobank Credit Report for the linear-based development is provided as Appendix F. Biobank files for the development assessment will be submitted to the OEH portal. An outline of the methods and assumptions used in the Biobank assessment is provided in Section 8 of the SIS.
Has the SIS discussed the relationship of the proposal to any listed Key Threatening Processes (e.g. does the proposal result in the need for High Frequency Fire as a fire hazard reduction measure, or does it result in the clearing of native vegetation)?	Yes	Key Threatening Processes (KTPs) as they relate to each subject species and EEC are discussed in Sections 6.5 and Appendix D of the SIS.


Matter	Met requirements of DGRs?	Comments
Has the SIS discussed the relationship of the proposal to any published Threat Abatement Plan (e.g. does the proposal result in an increased threat in a manner that is specifically at odds with a published plan)?	Yes	The SIS provides a discussion of the Red Fox and <i>Gambusia</i> threat abatement plans as they relate to relevant subject fauna species (refer Appendix D).
Has a revised Part 5A assessment of significance been included?	Yes	Revised Part 5A Assessments (which take into account SIS mitigation measures) for subject species and subject EEC are provided in Appendix D.
Has the 'additional information' specified in Section 9 of the DGRs been provided?	Yes	Additional information including licences, qualifications and approvals are provided in Section 10 of the SIS.
Have the qualifications and experience of those involved in the surveys been included?	Yes	Additional information including qualifications of SIS team members are provided in Section 10 of the SIS.
Have other approvals which are required for the development or activity been documented?	Yes	Additional information including approvals required for the proposal is provided in Section 10 of the SIS.
Any licensing requirements (e.g. s91 TSC Act).	Yes	Additional information including licences needed to prepare the SIS is provided in Section 10 of the SIS.

## FORM OF THIS SIS AND DECLARATION

This Species Impact Statement is in writing in accordance with Section 109(1) of the TSC Act.

The declaration below has been signed by the principal author and by the proponent in accordance with Section 109(2).

*I Matty Mathivanar of 27-31 Argyle Street Parramatta NSW 2150, being the applicant for the proposed Mona Vale Road Upgrade between McCarrs Creek Road and Powderworks Road have read and understood this species impact statement. I understand the implications of the recommendations made in the statement and accept that they may be placed as conditions of consent or concurrence for the proposal.*



Matty Mathivanar

Project Manager

*I Liam Hogg of SMEC Australia, being the principal author for the Species Impact Statement for the proposed Mona Vale Road Upgrade between McCarrs Creek Road and Powderworks Road have read and understood this species impact statement. I understand the implications of the recommendations made in the statement and accept that they may be placed as conditions of consent or concurrence for the proposal.*



Liam Hogg

Senior Associated Scientist – Ecology Team Lead

## 2 CONTEXTUAL INFORMATION

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### 2.1 BACKGROUND INFORMATION

The NSW Roads and Maritime Services (Roads and Maritime) propose to upgrade Mona Vale Road between McCarrs Creek Road, Terrey Hills and Powder Works Road, Ingleside (the proposal).

A Biodiversity Investigation report was prepared for the proposal (Ecosure 2015). Initial impact assessments by SMEC concluded that a significant impact was likely for two flora species and one endangered ecological community listed under the *Threatened Species Conservation Act 1995* (TSC Act) and that a Species Impact Statement (SIS) would be required.

Roads and Maritime applied to the NSW Office of Environment and Heritage (OEH) for Director General's Requirements (DGRs) for a Species Impact Statement on April 16 2015. OEH issued the DGR's on 25 May 2015 and amended DGRs on 21 July 2015. The DGRs identified 23 fauna, 11 flora, one endangered population and two endangered ecological communities as subject species to be assessed through the SIS.

### 2.2 THE PROPOSAL

Mona Vale Road is the main east-west link between the Pacific Highway, Pymble and Pittwater Road at Mona Vale totalling about 20 kilometres in length and carrying about 22,000 vehicles per day in both directions.

Roads and Maritime Services (Roads and Maritime) proposes to upgrade and widen about 3.4 kilometres of Mona Vale Road between McCarrs Creek Road, Terrey Hills and Powder Works Road, Ingleside, from a two lane (one in each direction) undivided road to a four lane (two lanes in each direction) divided road. The proposal includes:

- Widening to provide an additional two traffic lanes (one in each direction) on Mona Vale Road between McCarrs Creek Road and Powder Works Road
  - Widening on the southern side of the existing carriageway between McCarrs Creek Road to Kimbriki Road
  - Deviation of the entire dual carriageway from the current road to the north of a rock outcrop between Kimbriki Road and Tumburra Street
  - Widening on the northern side of the existing carriageway from about 700 metres west of Tumburra Street to Addison Road
  - Widening on both sides of the existing carriageway between Addison Road and Powder Works Road.
- Provision of a new traffic signal intersection at Kimbriki Road including additional dedicated turning lanes and a truck climbing lane
- Restricting traffic movements at the intersection of Mona Vale Road and Tumburra Street to left-in and left-out only
- Deviating the Mona Vale Road and Tumburra Street intersection locally to the west by about 40 metres to improve the existing steep grade on Tumburra Street

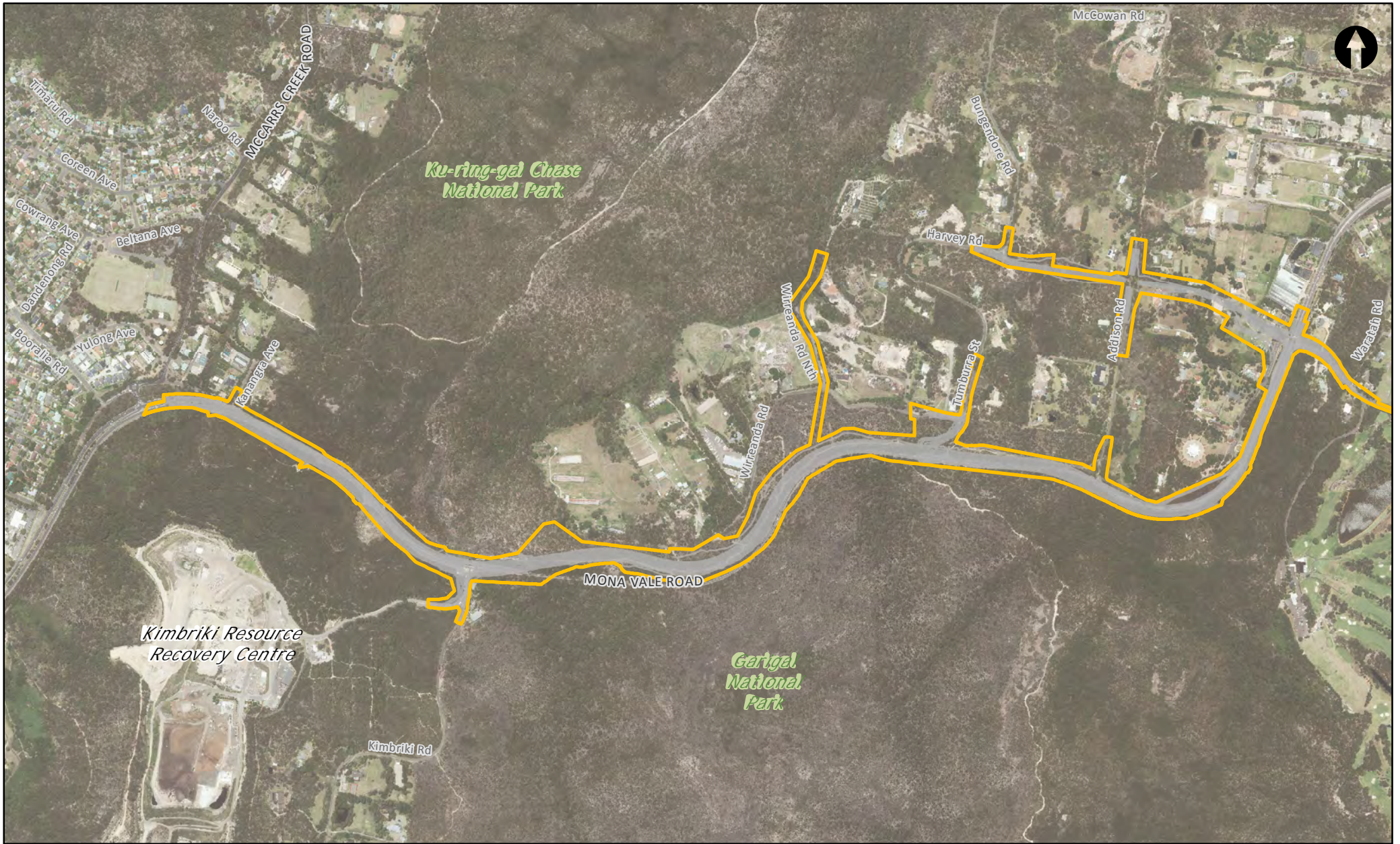
- Providing a new local road connection between Bungendore Street and Powder Works Road utilising the existing Harvey Road corridor and extending the new local road east of Addison Road to meet with the intersection of Mona Vale Road and Powder Works Road
- Relocating the existing access to the National Baha'i Centre by about 120 metres west along the new road
- Installing concrete jersey kerbs in the median for road safety
- Providing new and improved fauna connectivity between Mona Vale Road and the new local road connection by way of two fauna underpasses; one between Bungendore Street and Addison Road and one on Mona Vale Road in the vicinity of the Tumburra Street intersection
- Closing the existing intersection at Mona Vale Road and Addison Road to general traffic and making future access at this intersection restricted to emergency vehicles only
- Minor widening of Powder Works Road for a distance of about 80 metres east from the intersection with Mona Vale Road
- Providing a 40 metre wide fauna landbridge over Mona Vale Road, east of Kimbriki Road, linking Ku-ring-gai and Garigal National Parks enabling new and improved fauna connectivity between the National Parks by way of unimpeded passage
- Providing significant fauna-proof fencing to direct fauna toward connectivity mitigation measures
- Constructing retaining walls and/or sandstone cuttings at various locations along the alignment
- Constructing a shared use path on the northern side of Mona Vale Road for the full upgrade length
- Relocating and and/or adjusting underground and above ground utilities where required including the upgrade of street lighting for the full upgrade length
- Upgrading of the existing pavement and cross drainage structures including the construction, reconstruction and extension of pavement drainage lines. This includes a piped drainage connection from Mona Vale Road along Wirreanda Road discharging to the existing channel within the road reserve
- Landscaping over the length of the proposal
- Installing traffic monitoring cameras at all signalised intersections to assist with traffic management.


The proposal would be funded by the NSW Government. Subject to approval and funding, construction works are expected to commence in 2018, and construction is expected to take a minimum of 2.5 years to complete (including preliminary works).

Figure 1 shows the overall concept design and illustrates the key features of the proposal (detailed concept design maps are provided in Appendix B).

The reader is referred to the accompanying REF for a full description of the proposal.





 Construction Boundary

**Proposed Mona Vale Road West Alignment Figure 1**

Vector base dataset RoadNet © MDS 2015

0 200 400 m

Last updated by: RC10721 on 6/02/2017 at 12:57



## 2.3 SUBJECT SITE AND STUDY AREA

The subject site is defined in the DGRs as the area directly affected by the proposal and corresponds to the construction impact area for the proposal (Figure 2 and Figure 3). The construction impact area includes a six metre buffer that was applied to the road design.

The study area is defined in the DGRs as the subject site and additional areas that are likely to be affected by the proposal, either directly or indirectly (Figure 2 and Figure 3). The study area for vegetation includes a 20 metre buffer from the edge of the proposed construction footprint. For fauna, the study area included habitat up to 500 metres from the construction footprint.

The locality, as defined in the DGRs for the proposal, is the area within a five kilometre radius of the subject site (Figure 4).

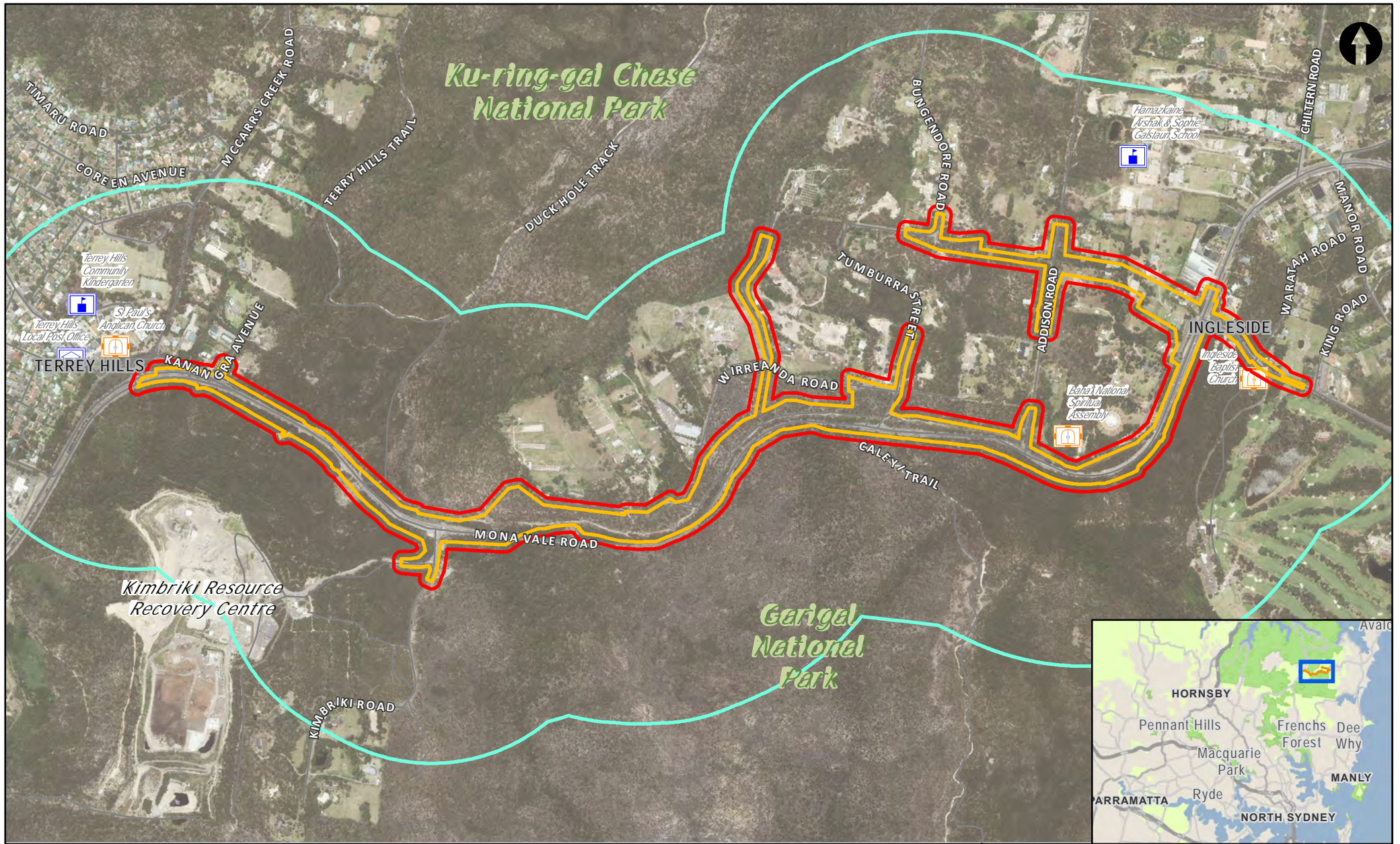
The 3.4 kilometre long section of Mona Vale Road within the proposal area is primarily within a bushland setting with Ku-ring-gai Chase National Park adjacent to the road corridor to the north and Garigal National Park adjacent to the road corridor to the south. The Kimbriki Resource Recovery Centre is located to the south of Mona Vale Road near western extent of the proposal and the Baha'i Temple is located to the north of the road near the eastern extent of the proposal.

Other land uses in the vicinity of the proposal area include the Monash Country Club near the Powderworks Road intersection, the Ingleside Baptist Church located off Powderworks Road, residential development in Terrey Hills and also on the northern side of the road at Addison Road and commercial, business and residential development at Tumburra Road.

The proposal is located within the Northern Beaches local government area (LGA) (formerly the Pittwater and Warringah LGAs) and is within the Roads and Maritime Sydney Region.

Figure 5 shows the location of the proposal in a regional context.





□ Study Area - fauna | Revised Construction Boundary Rev 03 (Aug 2016)

□ Construction Footprint | Revised Construction Boundary (Nov 2016)

□ Study Area - flora | Revised Construction Boundary (Nov 2016)

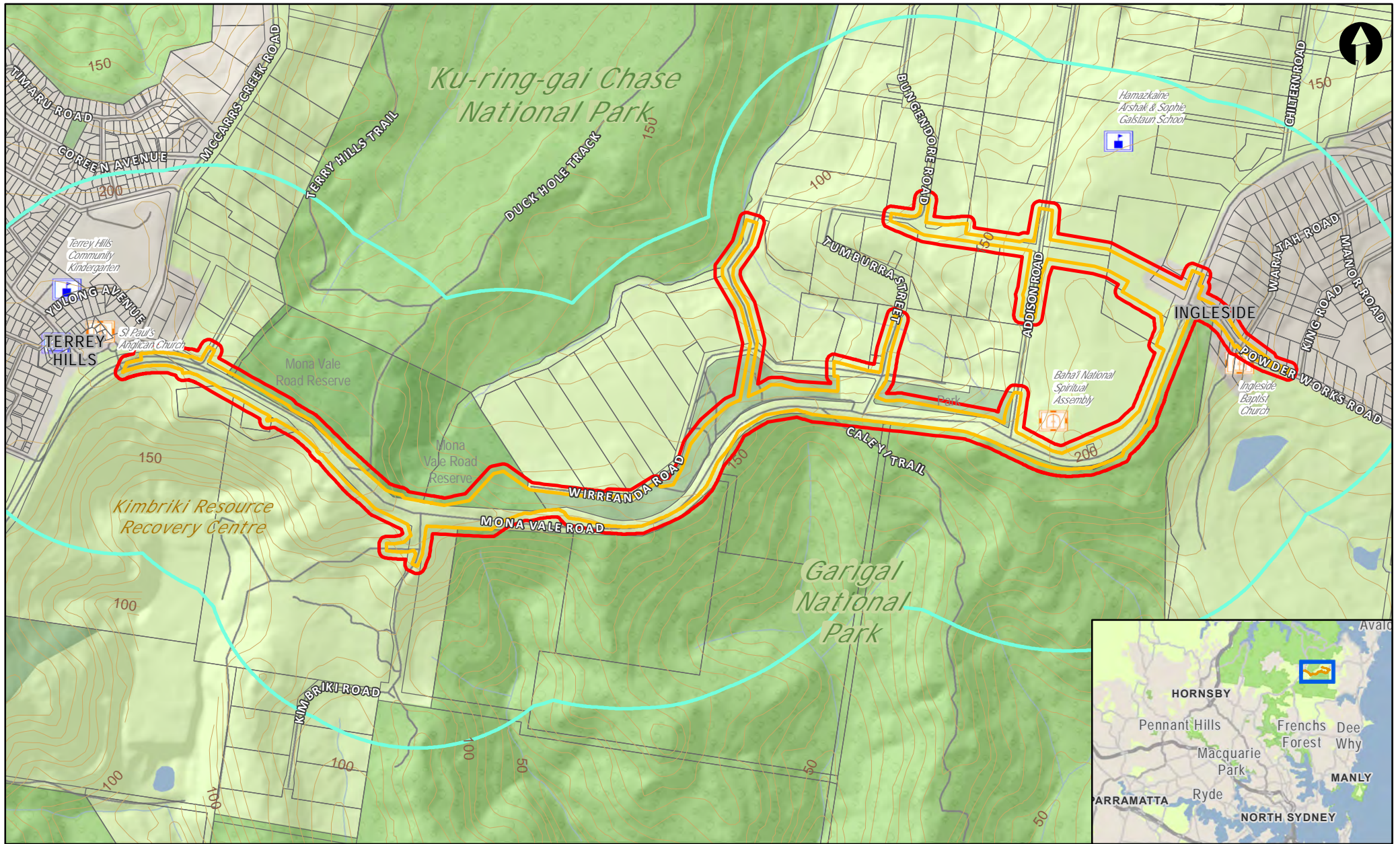
**Location of Study Area and Subject Site Figure 2**

Vector base dataset RoadNet © MDS 2016

0 0.25 0.5 km

Last updated by: DW13219 on 12/01/2017 at 15:34





- ▭ Study Area - fauna | Revised Construction Boundary Rev 03 (Aug 2016)
- ▭ Study Area - flora | Revised Construction Boundary (Nov 2016)
- Construction Footprint | Revised Construction Boundary (Nov 2016)
- 10m contour
- Cadastral Boundaries

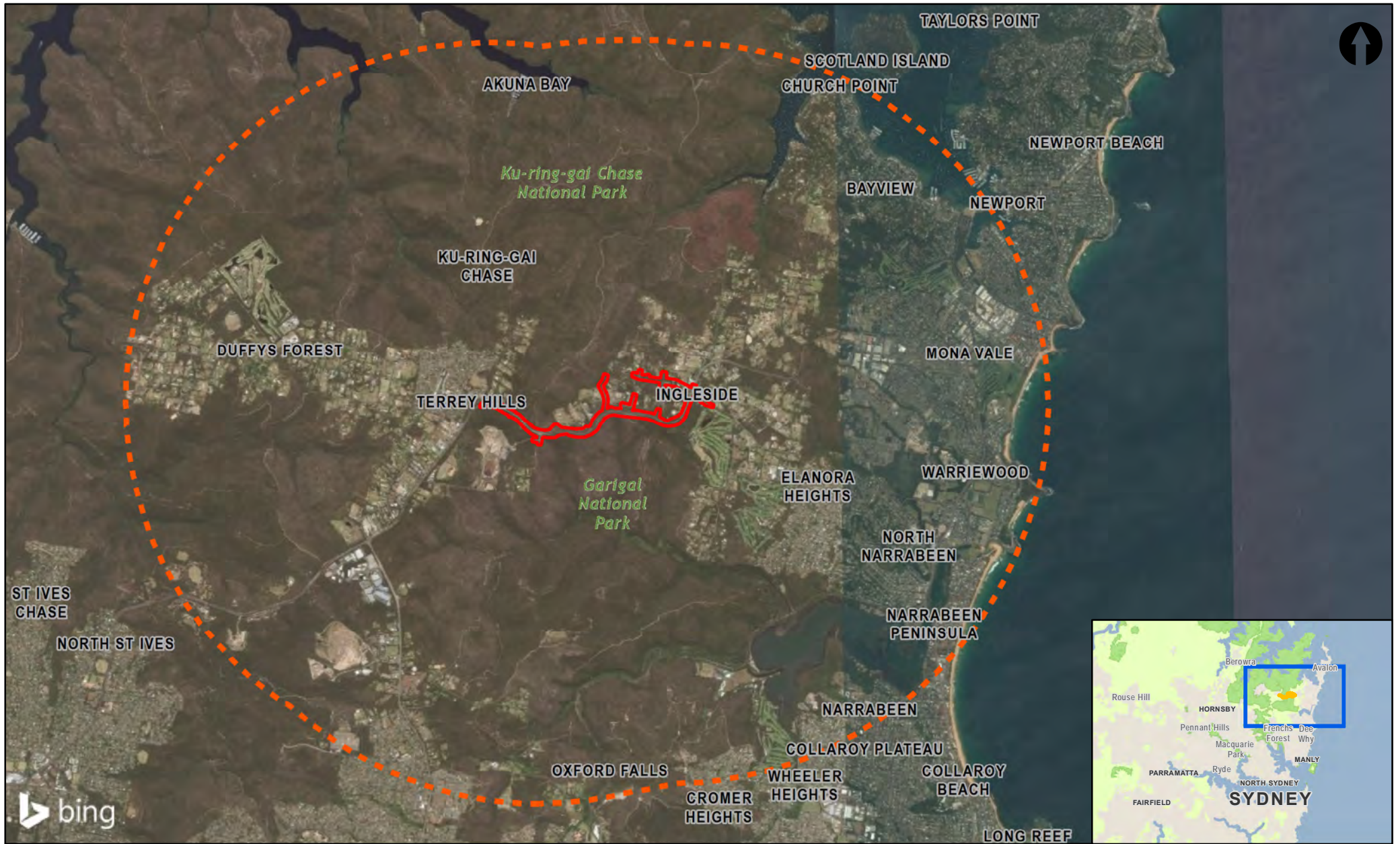
**Location of Study Area and Subject Site on a Topographic Base Figure 3**

Vector base dataset RoadNet © MDS 2016

0 250 500 m

Last updated by: DW113219 on 12/01/2017 at 15:38

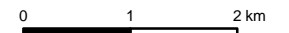




- ▭ Study Area | Revised Construction Boundary (Nov 2016)
- - - Locality (5km radius)

Locality Map **Figure 4**

Vector base dataset RoadNet © MDS 2016



Last updated by: DW113219 on 12/01/2017 at 15:41

## 2.4 LAND TENURE

The proposal would generally be undertaken within the road reserve (Crown Land) managed by Roads and Maritime. The proposal would have an impact on the local community through the acquisition of land. This includes strip acquisition of ten private properties and ten properties owned by government agencies (Table 3). In addition, one total acquisition is required from land owned by The Metropolitan Water, Sewerage and Drainage Board. Land required to construct the proposed fauna overpass has been acquired from Ku-ring-gai Chase National Park through a revocation process.

Zoning is mainly Infrastructure with small areas of Environmental Management, Public Recreation, National Parks and Nature Reserves and Primary Production (small lots). Land use within the study area and locality is shown in Figure 6 and Figure 7.

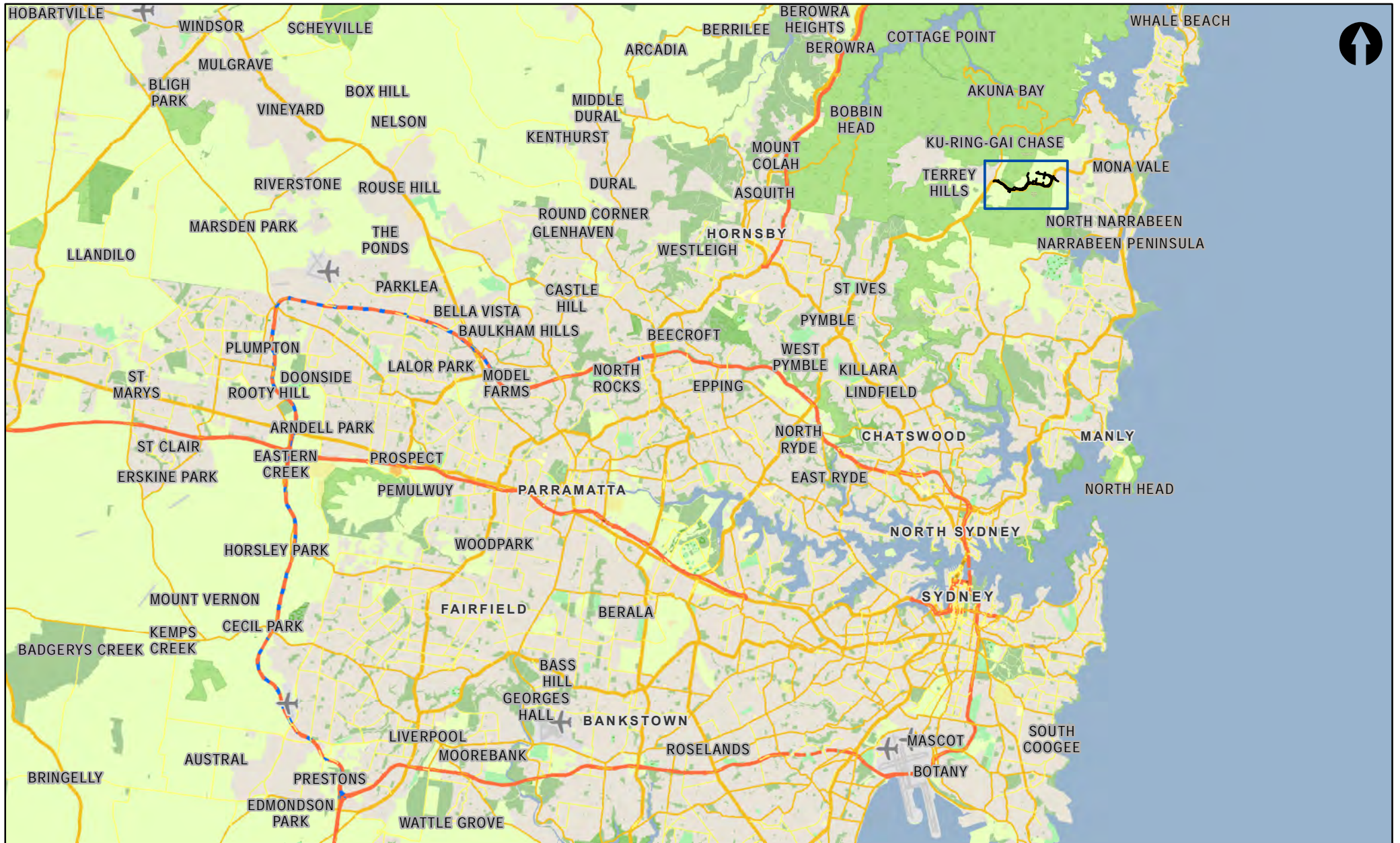
The lots in Table 3 may be affected by the proposal.

**Table 3: Property ownership**

Lot	DP	Owner
5	846223	XINGSHEN PTY. LIMITED
109	752017	TROYAL-PETBRU PTY LIMITED
171	752017	L. J. CARISTO
179	752017	P. J. J. & J. D. VENDRELL
7010	1059241	LANDS DEPT
7064	1051232	LANDS DEPT
83	752046	CROWN LAND
7307	1132678	THE STATE OF NEW SOUTH WALES
7308	1132678	THE STATE OF NEW SOUTH WALES
51	1053225	NATIONAL SPIRITUAL ASSEMBLY OF BAHA'IS OF AUSTRALIA INCORPORATED
202	1054875	MINISTER OF EDUCATION
201	1054875	MINISTER OF EDUCATION
4	1039775	F. M. CARR
38	114318	S. TAN & S. KHUN
4	792962	THE MINISTER ADMINISTERING THE NATIONAL PARKS AND WILDLIFE ACT 1974
7066	93811	THE STATE OF NEW SOUTH WALES
3	799321	THE MINISTER ADMINISTERING THE NATIONAL PARKS AND WILDLIFE ACT 1974

Lot	DP	Owner
2	799321	THE MINISTER ADMINISTERING THE NATIONAL PARKS AND WILDLIFE ACT 1974
1	799321	THE MINISTER ADMINISTERING THE NATIONAL PARKS AND WILDLIFE ACT 1974
1	381755	R. J. & M. V. RUSHBY & G. D. STEVENSON
4	255466	THE COUNCIL OF THE SHIRE OF WARRINGAH
3	255466	THE METROPOLITAN WATER SEWERAGE AND DRAINAGE BOARD
1	545696	WATER BOARD
5	255466	THE METROPOLITAN WATER SEWERAGE AND DRAINAGE BOARD
1	255466	THE METROPOLITAN WATER SEWERAGE AND DRAINAGE BOARD
2	255466	THE COUNCIL OF THE SHIRE OF WARRINGAH
2	565232	JAMES MANAVERIS & HELEN MANAVERIS
20	708360	JOSEPHINE EVERSON & CHRISTINE YEOMANS
40	114318	MINISTER ADMINISTERING THE ENVIRONMENTAL PLANNING AND ASSESSMENT ACT, 1979
5	1053738	JOSEPHINE EVERSON-TREMAIN





- Construction Footprint | Revised
- Construction Boundary (Nov 2016)
- Location of Study Area

**Regional Location Figure 5**

Vector base dataset RoadNet © MDS 2016



Last updated by: DW13219 on 12/01/2017 at 15:44





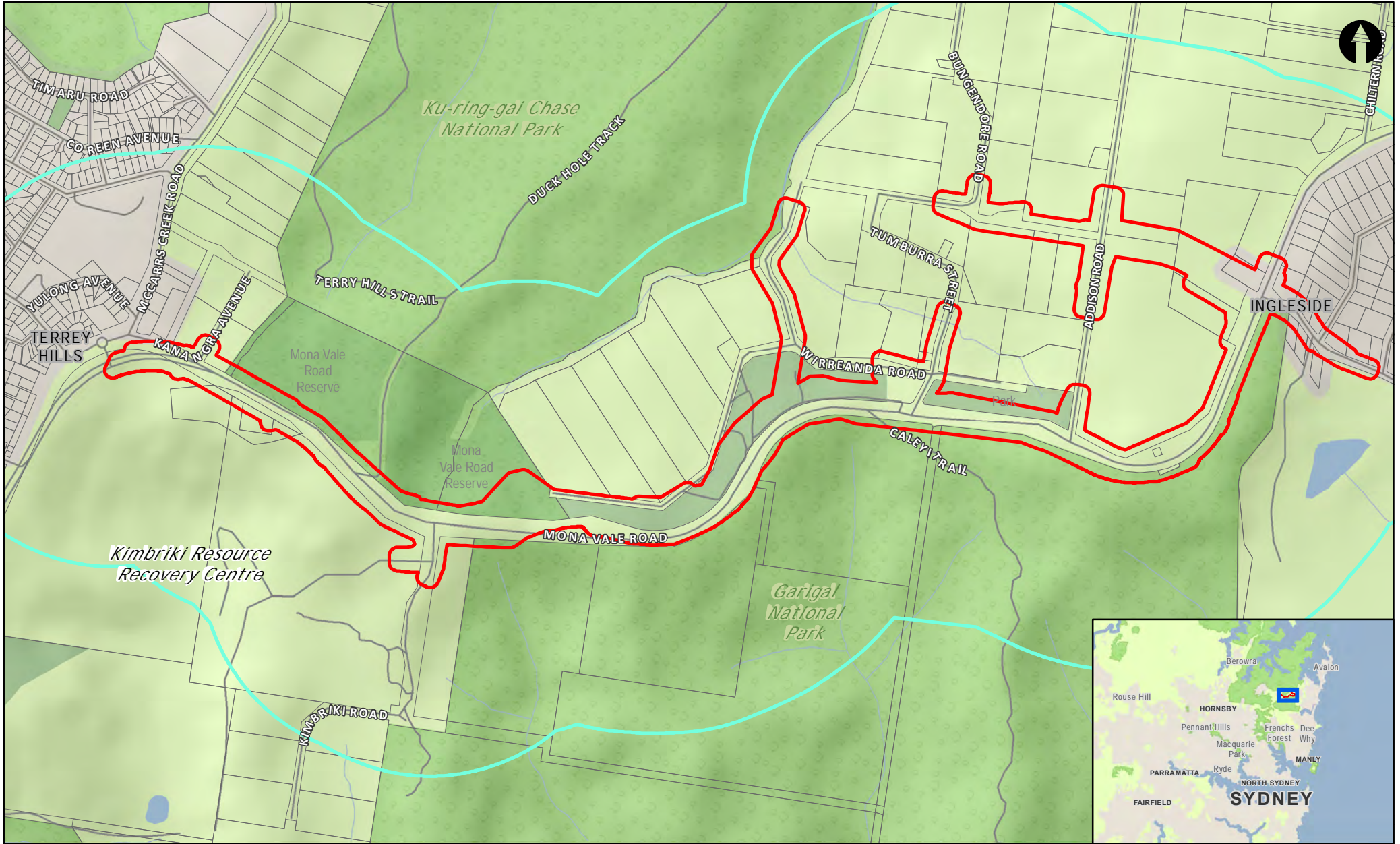
Land Uses in the Locality **Figure 6**

Vector base dataset RoadNet © MDS 2016



Last updated by: DW13219 on 12/01/2017 at 15:48





- Study Area - fauna | Revised Construction Boundary Rev 03 (Aug 2016)
- Study Area - flora | Revised Construction Boundary (Nov 2016)
- Cadastral Boundaries
- National Parks
- Park and Garden
- Built Up Areas

**Land Uses in the Study Area Figure 7**

Vector base dataset RoadNet © MDS 2016

0 250 500 m

Last updated by: DW113219 on 12/01/2017 at 17:08

## 2.5 VEGETATION

### 2.5.1 *Locality*

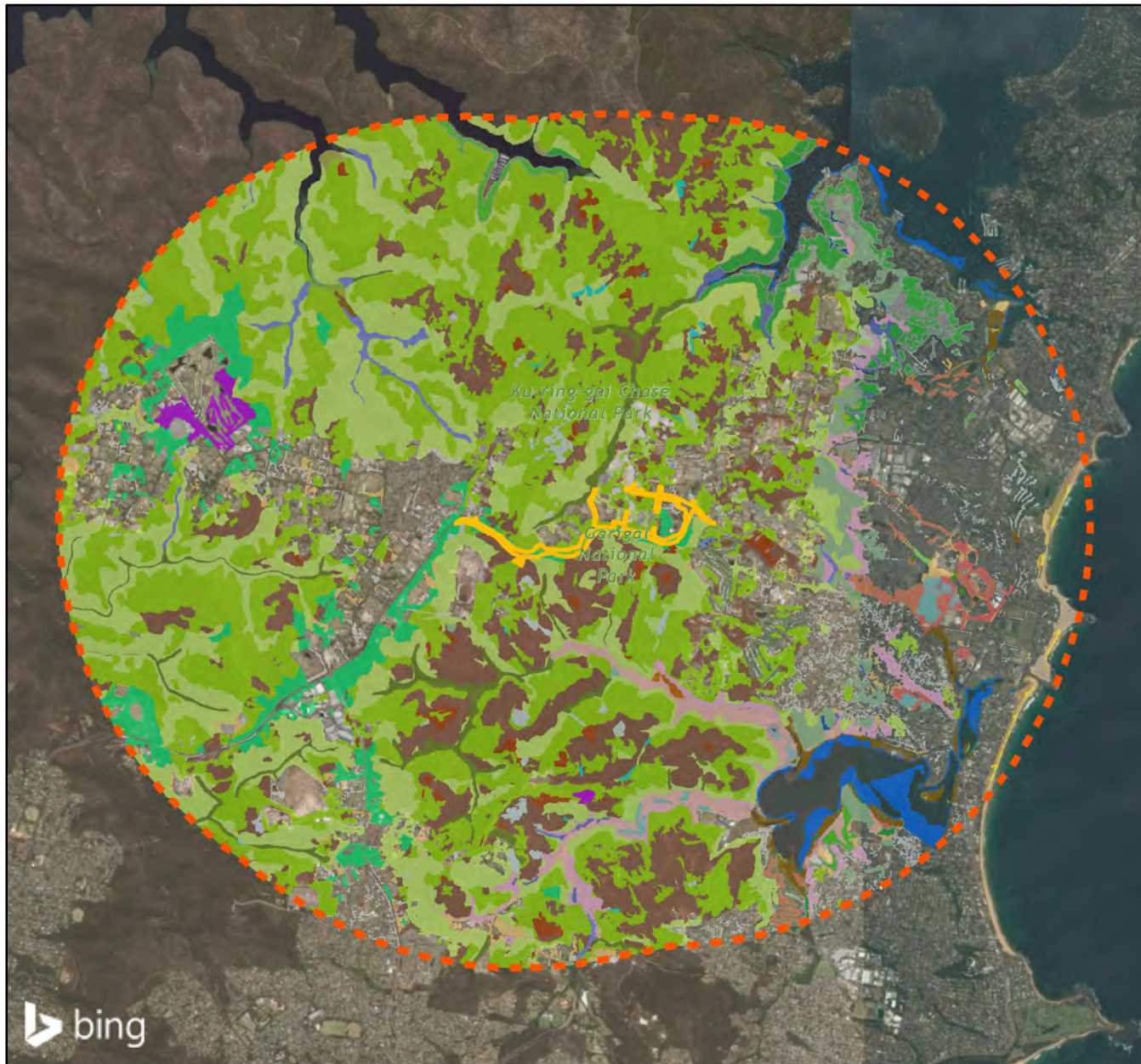
The study area along Mona Vale Road occupies a ridgeline on undulating terrain within a highly dissected sandstone plateau landscape. The geology of the site and adjoining areas is Triassic Hawkesbury Sandstone. The locality is well vegetated with a diversity of native vegetation communities and includes areas within Ku-ring-gai Chase National Park to the north and Garigal National Park to the south. The ridge-line separates the drainage catchments of McCarrs Creek and Wirreanda Creek to the north (Hawkesbury Nepean Catchment) and Deep Creek and Mullet Creek to the south (Sydney Metropolitan Catchment).

Vegetation within the locality (5 kilometre radius) has been mapped and described by OEH (2013) The Native Vegetation of the Sydney Metropolitan Area (Figure 8). Thirty-eight native vegetation types are mapped totalling an area of approximately 6,500 ha. Many of the communities, however, are restricted to the coastal lowlands (e.g. Swamp Oak Floodplain Forest, Littoral Rainforest and Coastal Saltmarsh) and unrepresentative of the higher sandstone plateau location and the subject site.

About 30% of the mapped vegetation types are listed as threatened ecological communities at state and/or national levels. The most extensively occurring communities occur on sandstone and include Coastal Sandstone Gully Forest, Coastal Sandstone Heath-Mallee and Sydney North Exposed Sandstone Woodland.

A summary of the vegetation types occurring within the locality is provided in Table 4.





### Vegetation Mapping Unit (OEH 2013)



#### Rainforests

- S\_RF02 Coastal Sandstone Gallery Rainforest
- S\_RF03 Coastal Warm Temperate Rainforest
- S\_RF07 Coastal Escarpment Littoral Rainforest

#### Wet Sclerophyll Forests

- S\_WSF01 Blue Gum High Forest
- S\_WSF02 Coastal Enriched Sandstone Moist Forest
- S\_WSF06 Coastal Shale-Sandstone Forest
- S\_WSF11 Pittwater Spotted Gum Forest
- S\_WSF33 Central Coast Escarpment Moist Forest
- S\_WSF34 Central Coast Escarpment Dry Forest
- S\_WSF36 Coastal Flats Tall Moist Forest

#### Dry Sclerophyll Forests

- S\_DSF04 Coastal Enriched Sandstone Dry Forest
- S\_DSF06 Coastal Sandstone Foreshores Forest
- S\_DSF08 Coastal Sandstone Riparian Forest
- S\_DSF09 Coastal Sandstone Gully Forest
- S\_DSF11 Sydney North Exposed Sandstone Woodland
- S\_DSF14 Sydney Ironstone Bloodwood-Silvertop Ash Forest
- S\_DSF21 Coastal Sand Bangalay Forest
- S\_DSF69 Hawkesbury River Escarpment Dry Forest

#### Forested Wetlands

- S\_FOW01 Coastal Alluvial Bangalay Forest
- S\_FOW02 Coastal Flats Swamp Mahogany Forest
- S\_FOW03 Coastal Freshwater Swamp Forest

- S\_FOW05 Riverflat Paperbark Swamp Forest
- S\_FOW08 Estuarine Swamp Oak Forest
- S\_FOW12 Coastal Swamp Paperbark-Swamp Oak Scrub
- S\_FOW21 Sandstone Cliff-face Soak

#### Heathlands

- S\_HL01 Coastal Headland Clay Heath
- S\_HL02 Coastal Sand Tea-tree-Banksia Scrub
- S\_HL05 Coastal Fore-dune Wattle Scrub
- S\_HL08 Coastal Sandstone Heath-Mallee
- S\_HL09 Coastal Sandstone Rock Plate Heath

#### Grasslands

- S\_GL01 Beach Spinifex Grassland
- S\_GL02 Coastal Headland Grassland

#### Freshwater Wetlands

- S\_FRW01 Coastal Upland Damp Heath Swamp
- S\_FRW02 Coastal Upland Wet Heath Swamp
- S\_FRW03 Coastal Freshwater Wetland
- S\_FRW06 Estuarine Reedland

#### Saline Wetlands

- S\_SW01 Estuarine Mangrove Forest
- S\_SW02 Estuarine Saltmarsh
- S\_SW03 Seagrass Meadows

#### Other

- PLNTN Plantations
- URE/N Urban Native and Exotic Cover
- LF Rock, Sand, Built Landscapes
- WEX Weeds and Exotics
- Water

- Subject Site | Revised Construction Boundary (Nov 2016)
- Locality (5km radius)

Vegetation Types in the Locality **Figure 8**

Vector base dataset RoadNet © MDS 2016

0 1 2 km

Last updated by: DW113219 on 12/01/2017 at 15:55

**Table 4: Vegetation types of the locality**

<b>Sydney Metro (OEH 2013)</b>	<b>SM Veg Code</b>	<b>NSW PCT</b>	<b>TSC Act</b>	<b>EPBC Act</b>	<b>Area within the locality (5 kilometres<sup>2</sup>)</b>
Beach Spinifex Grassland	S_GL01	1204	Not listed	Not listed	3.19 ha
Blue Gum High Forest	S_WSF01	1840	Blue Gum High Forest	Blue Gum High Forest	0.02 ha
Central Coast Escarpment Dry Forest	S_WSF34	1557	Not listed	Not listed	37.29 ha
Central Coast Escarpment Moist Forest	S_WSF33	1565	Not listed	Not listed	118.97 ha
Coastal Alluvial Bangalay Forest	S_FoW01	1794	River-flat Eucalypt Forest on Coastal Floodplains	Not listed	83.71 ha
Coastal Enriched Sandstone Dry Forest	S_DSF04	1181	Not listed	Not listed	124.31 ha
Coastal Enriched Sandstone Moist Forest	S_WSF02	1841	Not listed	Not listed	126.61 ha
Coastal Escarpment Littoral Rainforest	S_RF07	910	Littoral Rainforest	Littoral Rainforest & Coastal Vine Thickets	4.05 ha
Coastal Flats Swamp Mahogany Forest	S_FoW02	923	Swamp Sclerophyll Forest on Coastal Floodplains	Not listed	36.82 ha
Coastal Flats Tall Moist Forest	S_WSF36	1915	Not listed	Not listed	3.88 ha
Coastal Freshwater Wetland	S_FrW03	781	Coastal Freshwater Wetlands on Coastal Floodplains	Not listed	20.02 ha
Coastal Freshwater Swamp Forest	S_FoW03				23.69 ha
Coastal Fore-dune Wattle Scrub	S_HL05	772	Not listed	Not listed	11.15 ha
Coastal Headland Clay Heath	S_HL01	815	Not listed	Not listed	10.37 ha

<b>Sydney Metro (OEH 2013)</b>	<b>SM Veg Code</b>	<b>NSW PCT</b>	<b>TSC Act</b>	<b>EPBC Act</b>	<b>Area within the locality (5 kilometres<sup>2</sup>)</b>
Coastal Headland Grassland	S_GL02	897	Themeda Grasslands on Seacliffs & Coastal Headlands	Not listed	0.34 ha
Coastal Sand Bangalay Forest	S_DSF21		Bangalay Sand Forest	Not listed	0.63 ha
Coastal Swamp Paperbark-Swamp Oak Scrub	S_FoW12	1236	Swamp Oak Floodplain Forest	Not listed	10.30 ha
Coastal Sand Tea-tree-Banksia Scrub	S_HL02	771	Not listed	Not listed	2.33 ha
Coastal Sandstone Foreshores Forest	S_DSF06	1778	Not listed	Not listed	5.50 ha
Coastal Sandstone Gallery Rainforest	S_RF02	1292	Not listed	Not listed	52.20 ha
Coastal Sandstone Gully Forest	S_DSF09	1250	Not listed	Not listed	1832.18
Coastal Sandstone Heath-Mallee	S_HL08	882	Not listed	Not listed	1158.14 ha
Coastal Sandstone Riparian Forest	S_DSF08	1292	Not listed	Not listed	119.16 ha
Coastal Sandstone Rock Plate Heath	S_HL09	881	Not listed	Not listed	72.35 ha
Coastal Shale-Sandstone Forest	S_WSF06	1085	Not listed	Not listed	32.02 ha
Coastal Upland Damp Heath Swamp	S_FrW01	1804	Coastal Upland Swamp	Not listed	49.54 ha
Coastal Upland Wet Heath Swamp	S_FrW02	1804	Coastal Upland Swamp	Not listed	10.37 ha
Coastal Warm Temperate Rainforest	S_RF03	1529	Part of Lowland Rainforest on North Coast & Sydney Basin	Not listed	23.94 ha
Estuarine Mangrove Forest	S_SW01	920	Can include Coastal Saltmarsh	Not listed	9.01 ha
Estuarine Reedland	S_FrW06	1808	Can be part of Swamp Oak Floodplain Forest	Not listed	1.83 ha
Estuarine Saltmarsh	S_SW02	1126	Coastal Saltmarsh	Not listed	4.64 ha
Estuarine Swamp Oak Forest	S_FoW08	1234	Swamp Oak Floodplain Forest	Not listed	46.88 ha

<b>Sydney Metro (OEH 2013)</b>	<b>SM Veg Code</b>	<b>NSW PCT</b>	<b>TSC Act</b>	<b>EPBC Act</b>	<b>Area within the locality (5 kilometres<sup>2</sup>)</b>
Hawkesbury River Escarpment Dry Forest	S_DSF69	1181	Not listed	Not listed	4.33 ha
Pittwater Spotted Gum Forest	S_WSF11	1214	Pittwater & Wagstaffe Spotted Gum Forest	Not listed	59.97 ha
River-flat Paperbark Swamp Forest	S_FoW05	923	Swamp Sclerophyll Forest on Coastal Floodplains	Not listed	2.80 ha
Sandstone Cliff-face Soak	S_FoW21	1127	Not listed	Not listed	0.09 ha
Sydney Ironstone Bloodwood-Silvertop Ash Forest	S_DSF14	1786	Duffys Forest	Not listed	295.93 ha
Sydney North Exposed Sandstone Woodland	S_DSF11	1783	Not listed	Not listed	2776.03 ha
Weed_Ex: Weeds and Exotics	Weed_Ex	-	Not listed	Not listed	118.84 ha
Urban_E/N: Urban Exotic/Native	Urban Exotic/Native	-	Not listed	Not listed	273.07 ha



### **2.5.2 The study area**

The study area is centred on a narrow ridgeline within a sandstone environment extending a short distance into steeper slopes and gully heads. The vegetation was originally mapped and described by Smith and Smith (2011) and subsequently mapped by OEH (2013) and then ground-truthed and revised by Ecosure (2015) specifically within the study area for this proposal. The vegetation mapping for the SIS references both the Ecosure (2015) and OEH (2013) mapping. The detailed ground-truthed mapping produced by Ecosure (2015) is used within the study area, with some additional areas mapped by SMEC (Figure 9). The study area contains around 37 hectares of vegetation, 34 hectares of which is native, and includes five native vegetation communities. A summary of the vegetation communities occurring within the study area is provided in Table 5.

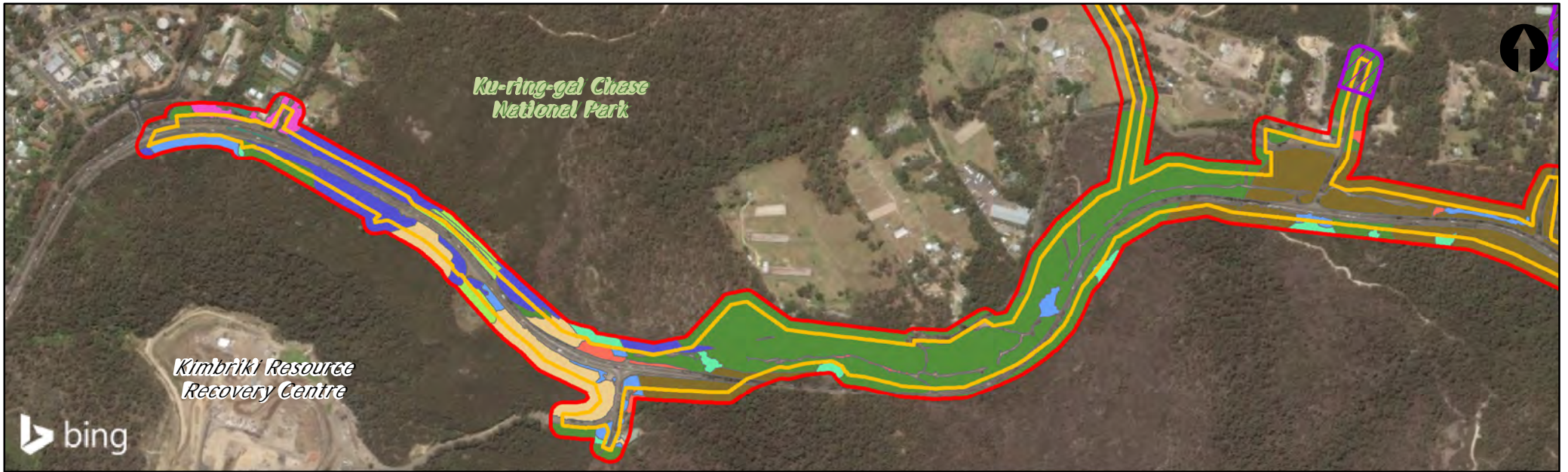
Sydney North Exposed Sandstone Woodland (Bloodwood-Scribbly Gum Woodland) and Coastal Sandstone Gully Forest (Peppermint-Angophora Forest) are the dominant communities. On higher ground at the western and eastern extent of the study area, smaller areas of the Duffys Forest endangered ecological community occur on flatter deeply weathered plateau surfaces associated with the Somersby Residual soil landscape. The unlisted but nationally rare Yellow-topped Ash Mallee community also occurs in the vicinity of the site. Highly disturbed vegetation, including weeds and plantings, comprise approximately 3 hectares or almost 9% of the study area (Table 4).

One endangered ecological community (EEC or more generally referred to as threatened ecological communities - TEC) listed under the TSC Act and/or EPBC Act occurs within the study area: Duffys Forest Ecological Community.

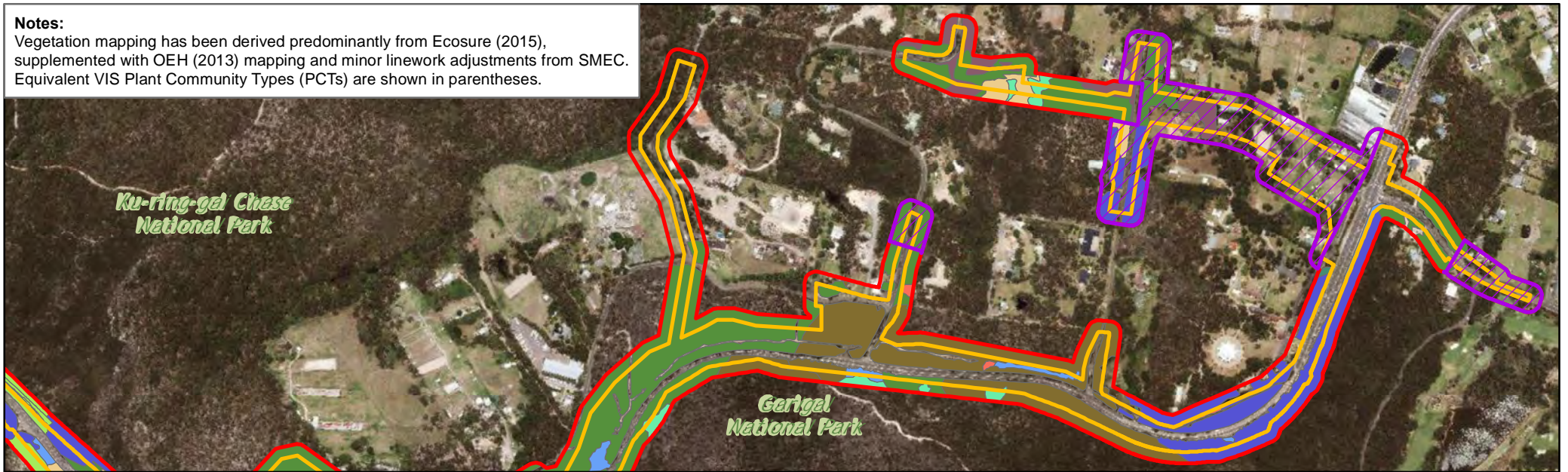
### **2.5.3 Subject site**

Not all vegetation types identified within the study area fall within the subject site. Vegetation within the subject site (Construction impact area) is shown in Figure 9. The areas of each vegetation type to be cleared are shown in Table 5. Around 17 hectares of vegetation occurs within the subject site including 3.4 hectares of DFEC. The dominant communities are Sydney North Exposed Sandstone Woodland (Bloodwood-Scribbly Gum Woodland) and Coastal Sandstone Gully Forest (Peppermint-Angophora Forest).





**Notes:**  
 Vegetation mapping has been derived predominantly from Ecosure (2015), supplemented with OEH (2013) mapping and minor linework adjustments from SMEC. Equivalent VIS Plant Community Types (PCTs) are shown in parentheses.



- Study Area | Revised Construction Boundary (Nov 2016)
- Construction Footprint | Revised Construction Boundary (Nov 2016)

- Community**
- Highly disturbed vegetation
  - PCT ME008 - Sandstone Rocky Heath (Good)

- PCT ME012 - Peppmnt/Angoph Forest (Good)
- PCT ME039 - DFEC (Good)
- PCT ME039 - DFEC (Mod - Good) - other

- PCT ME039 - DFEC (Mod - Good) - poor
- PCT ME100: Mallee - Banksia - Tea-tree - Hakea heath-woodland of the coastal sandstone plateaus of the Sydney basin (Good)

- PCT ME106: Red Bloodwood - Scribbly Gum / Old-man Banksia open forest on sandstone ridges of northern Sydney and the Central Coast (Good)
- Plantings

- Urban Exotic / Native
- Weeds
- Not Ground Truthed Veg (16/01/2017)

**Vegetation Types Mapped within the Study Area and Subject Site**  
 Vector base dataset RoadNet © MDS 2016

**Figure 9**



**Table 5: Vegetation types of the study area and subject site**

Vegetation type (revised by SMEC 2016)	Vegetation community (Ecosure)	Sydney Metro (OEH 2013)	NSW PCT	TSC Act	EPBC Act	Hectares within the Study Area	Hectares within the construction footprint	Hectares within a 5 kilometre radius
PCT ME106 - Red Bloodwood - Scribbly Gum / Old-man Banksia open forest on sandstone ridges of northern Sydney and the Central Coast (Good)	Bloodwood-Scribbly Gum Woodland	Sydney North Exposed Sandstone Woodland (S_DSF11)	Red Bloodwood - Scribbly Gum / Old-man Banksia open forest on sandstone ridges of northern Sydney and the Central Coast (ME106) NSW PCT1783	Not listed	Not listed	16.3	9.3 ha	2,776 ha
PCT ME98 - Duffys Forest Ecological Community (DFEC) (Good)	Duffys Forest Ecological Community (DFEC)	Sydney Ironstone Bloodwood-Silvertop Ash Forest (S_DSF14)	Red Bloodwood – Smooth-barked Apple shrubby forest on shale or ironstone of coastal plateaux, Sydney Basin Bioregion (ME98) NSW PCT1786	Endangered	Not listed	6.97	3.06 ha	296 ha
PCT ME98 - Duffys Forest Ecological Community (DFEC) (Moderate - Good) - other	Duffys Forest (DFEC) translocation sites	Sydney Ironstone Bloodwood-Silvertop Ash Forest (S_DSF14)	Red Bloodwood – Smooth-barked Apple shrubby forest on shale or ironstone of coastal plateaux, Sydney Basin Bioregion (ME98) NSW PCT1786	Endangered	Not listed	0.7	0.2 ha	-



Vegetation type (revised by SMEC 2016)	Vegetation community (Ecosure)	Sydney Metro (OEH 2013)	NSW PCT	TSC Act	EPBC Act	Hectares within the Study Area	Hectares within the construction footprint	Hectares within a 5 kilometre radius
PCT ME98 - Duffys Forest Ecological Community (DFEC) (Moderate - Good) - poor	DFEC with highly disturbed understorey	Sydney Ironstone Bloodwood-Silvertop Ash Forest (S_DSF14)	Red Bloodwood – Smooth-barked Apple shrubby forest on shale or ironstone of coastal plateaux, Sydney Basin Bioregion (ME98) NSW PCT1786	Endangered	Not listed	0.4	0.1 ha	-
PCT ME012 - Peppermint-Angophora Forest (Good)	Peppermint-Angophora Forest	Coastal Sandstone Gully Forest (S_DSF09)	Sydney Peppermint – Smooth-barked Apple – Red Bloodwood shrubby open forest on slopes of moist sandstone gullies, eastern Sydney Basin Bioregion (ME012) NSW PCT1250	Not listed	Not listed	6.6	3.6 ha	1,832 ha
PCT ME008 - Sandstone Rocky Heath	Sandstone Heath and Sandstone Rocky Heath	Coastal Sandstone Rock Plate Heath (S_HL09)	Hairpin Banksia – <i>Kunzea ambigua</i> – <i>Allocasuarina distyla</i> heath on coastal sandstone plateaux, Sydney Basin Bioregion (ME008) NSW PCT881	Not listed	Not listed	0.9	0.2 ha	72 ha

Vegetation type (revised by SMEC 2016)	Vegetation community (Ecosure)	Sydney Metro (OEH 2013)	NSW PCT	TSC Act	EPBC Act	Hectares within the Study Area	Hectares within the construction footprint	Hectares within a 5 kilometre radius
PCT ME100 Mallee - Banksia - Tea-tree - Hakea heath-woodland of the coastal sandstone plateaus of the Sydney basin	Yellow-top Ash Mallee	Coastal Sandstone Heath Mallee (S_HL08)	Mallee - Banksia - Tea-tree - Hakea heath-woodland of the coastal sandstone plateaus of the Sydney basin (ME100) NSW PCT1824 (Previously ME013)	Not listed	Not listed	2.5	1.3 ha	1,158 ha
Highly disturbed vegetation	Highly disturbed vegetation	Weeds and exotics	n/a	Not listed	Not listed	1.1	0.7 ha	-
Plantings	Plantings		n/a	Not listed	Not listed	0.1	0.04 ha	-
Urban /Exotic Native	-	- Urban /Exotic Native	n/a	Not listed	Not listed	1.4	0.5	
Weeds	Weeds	Weeds and exotics	n/a	Not listed	Not listed	0.4	0.3 ha	-
	<b>Total</b>					<b>37.37 ha</b>	<b>19.3 ha</b>	

## 2.6 PLANS AND MAPS

The location of the study area and subject site, land tenure and land use, significant areas for biodiversity (habitat maps; records) vegetation types, topography and water bodies, fire history, survey locations and survey findings are mapped in figures which are outlined in Table 6. These figures are located in the relevant sections of the document.

**Table 6: Plans and maps presented in sections of the SIS**

Figure no.	Title	Section
1	Proposed Mona Vale road west alignment	2.2, Appendix B
2	Location of study area and subject site	2.3
3	Location of study area and subject site on a topographic base data	2.3
4	Locality overlaid on the aerial photograph	2.3
5	Regional location	2.4
6	Land uses in the locality	2.4
7	Land uses in the study area	2.4
8	Vegetation communities in the locality	2.5
9	Vegetation types mapped within the study area and subject site	2.5
10	Threatened flora records within the locality	3.1.2
11	Threatened fauna records within the locality	3.1.3
12	Flora survey locations	4.2.1
13	Fauna survey locations	4.2.2
14	<i>Grevillea caleyi</i> records and habitat map	4.2.4
15	<i>Microtis angusii</i> records and habitat map	4.2.4
16	<i>Tetratheca glandulosa</i> records and habitat map	4.2.4
17	<i>Pimelea curviflora</i> var <i>curviflora</i> records and habitat map	4.2.4
18	Fauna survey results	4.2.4
19	Goanna termite mounds habitat map	4.2.4
20	Red crowned Toadlet and Giant Burrowing Frog records and habitat map	4.2.4
21	Eastern Pygmy Possum habitat map	4.2.4
22	Fire history map	5.3.1
23	Duffys Forest habitat map (study area)	6.2.1
24	Duffys Forest habitat mapped in locality	6.2.2
25	Proposed mitigation measures	7.1.1
26	Biobank landscape assessment mapping – percent native vegetation cover	7.1.2
27	Biobank landscape assessment mapping – connecting links	7.1.2
28	Biobank landscape assessment mapping – area/perimeter ratio	7.1.2

### 3 INITIAL ASSESSMENT

#### 3.1 IDENTIFYING SUBJECT THREATENED SPECIES, POPULATIONS AND ECOLOGICAL COMMUNITIES

The DGRs issued by OEH for the proposal list a number of species, populations and ecological communities that are to be considered as subject species in the preparation of the SIS. Table 7 outlines the subject species and ecological communities specified in the DGRs and their conservation status under the TSC Act. Some of these species are also listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

**Table 7: Subject species, populations and ecological communities listed in the DGRs issued by OEH**

Scientific Name	Common Name	TSC Act	EPBC Act
<b>AMPHIBIANS</b>			
<i>Heleioporus australiacus</i>	Giant Burrowing Frog	V	V
<i>Pseudophryne australis</i>	Red-crowned Toadlet	V	-
<b>BIRDS</b>			
<i>Callocephalon fimbriatum</i>	Gang-gang Cockatoo	V	-
<i>Calyptorhynchus lathami</i>	Glossy Black Cockatoo	V	-
<i>Glossopsitta pusilla</i>	Little Lorikeet	V	-
<i>Hieraaetus morphnoides</i>	Little Eagle	V	-
<i>Ixobrychus flavicollis</i>	Black Bittern	V	-
<i>Lathamus discolor</i>	Swift Parrot	E	CE
<i>Ninox connivens</i>	Barking Owl	V	-
<i>Ninox strenua</i>	Powerful Owl	V	-
<i>Pandion cristatus</i>	Eastern Osprey	V	-
<b>MAMMALS</b>			
<i>Cercartetus nanus</i>	Eastern Pygmy-possum	V	-
<i>Chalinolobus dwyeri</i>	Large-eared Pied Bat	V	V
<i>Dasyurus maculatus</i>	Spotted-tailed Quoll	V	E
<i>Isodon obesulus obesulus</i>	Southern Brown Bandicoot (eastern)	E	E
<i>Miniopterus australis</i>	Little Bentwing-bat	V	-

Scientific Name	Common Name	TSC Act	EPBC Act
<i>Miniopterus schreibersii oceanensis</i>	Eastern Bentwing-bat	V	-
<i>Myotis macropus</i>	Southern Myotis	V	-
<i>Phascolarctos cinereus</i>	Koala	V	V
<i>Pteropus poliocephalus</i>	Grey-headed Flying-fox	V	V
<i>Scoteanax rueppellii</i>	Greater Broad-nosed Bat		-
<i>Vespadelus troughtoni</i>	Eastern Cave Bat	V	-

#### REPTILES

<i>Varanus rosenbergi</i>	Rosenberg's Goanna	V	-
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#### FLORA

<i>Callistemon linearifolius</i>	Nettled Bottle Brush	V	-
<i>Diuris bracteata</i>		E	K
<i>Epacris purpurascens var. purpurascens</i>		V	-
<i>Eucalyptus camfieldii</i>	Camfield's Stringybark	V	V
<i>Genoplesium baueri</i>	Bauer's Midge Orchid	E	E
<i>Grevillea caleyi</i>	Caley's grevillea	CE	E
<i>Haloragodendron lucasii</i>	Hal	E	E
<i>Melaleuca deanei</i>	Deane's Paperbark	V	V
<i>Microtis angusii</i>	Angus's Onion Orchid	E	E
<i>Syzygium paniculatum</i>	Magenta Lilly Pilly	E	V
<i>Tetratheca glandulosa</i>		V	-

#### ENDANGERED POPULATIONS

<i>Phascolarctos cinereus</i>	Koala in the Pittwater Local Government Area	E	N/A
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#### ENDANGERED OR CRITICALLY ENDANGERED ECOLOGICAL COMMUNITIES

Duffys Forest Ecological Community in the Sydney Basin Bioregion	E	-
Coastal Upland Swamp in the Sydney Basin Bioregion	E	E

V = vulnerable, E = endangered, CE = critically endangered, K = extinct

### **3.1.1 Assessment of available information**

Background information and data on flora and fauna in the study area and within a 10 by 10 kilometre radius of the study site were obtained from the sources listed in Table 8. A number of these data sources were reviewed by Ecosure to inform the initial surveys and reporting undertaken for the Biodiversity Investigation Report (Ecosure 2015). Where it was deemed appropriate these data sources and others relevant to the proposal were updated with the most recent information to inform this SIS. All data sources are included in Table 8.



**Table 8: Literature and database review – sources consulted**

Databases/Literature	References
Atlas of Living Australia	Atlas of Living Australia (2013) Species by Location – Local Government (Pittwater (A)), Australian Government, Canberra ACT. Available at <a href="http://regions.ala.org.au/lgas/Pittwater%20(A)">http://regions.ala.org.au/lgas/Pittwater%20(A)</a> . Accessed by Ecosure on 20 September 2013
Australian Centre for Value Management (2013)	ACVM (2013) Mona Vale Road Upgrade: McCarrs Creek Road to Powder Works Road Project Option Assessment Value Management Workshop. The Australian Centre For Value Management, NSW
BioNet	BioNet (2015) The website for the Atlas of NSW Wildlife, Office of Environment and Heritage, NSW Government. Available at <a href="http://www.bionet.nsw.gov.au/">http://www.bionet.nsw.gov.au/</a> . Accessed on 23 January 2015, updated March 2016
Birdata	Birdlife Australia (2005-2007) Atlas Bird Lists – Quick Postcode search (2101), Birdlife Australia. Available at <a href="http://www.birdata.com.au/maps.vm">http://www.birdata.com.au/maps.vm</a> . Accessed on 23 January 2015
Briggs and Leigh (1995)	Rare or Threatened Australian Plants. CSIRO Publishing, Collingwood
Clouston Associates (2013)	Clouston Associates (2013) Mona Vale Road Ingleside Preliminary Urban Design Strategy. Clouston Associates for Roads and Maritime Services, NSW
Department of Primary Industries (DPI) Noxious Weeds – Pittwater Council	DPI (2015a) Noxious Weed Declarations for Pittwater Council, Department of Primary Industries, NSW Government. Available at <a href="http://weeds.dpi.nsw.gov.au/WeedDeclarations?RegionId=92">http://weeds.dpi.nsw.gov.au/WeedDeclarations?RegionId=92</a> . Accessed on 23 January 2015, updated September 2016
Department of Primary Industries (DPI) Noxious Weeds – Warringah Council	DPI (2015b) Noxious Weed Declarations for Warringah Council. Department of Primary Industries, NSW Government. Available at <a href="http://weeds.dpi.nsw.gov.au/WeedDeclarations?RegionId=116">http://weeds.dpi.nsw.gov.au/WeedDeclarations?RegionId=116</a> . Accessed on 23 January 2015, updated September 2016
Department of Environment and Climate Change (2009)	The native vegetation of the Sydney Metropolitan Catchment Management Authority Area - Draft. Volume 1: Technical Report. Department of Environment, Climate Change and Water, NSW
Department of Environment and Climate Change (2009)	The native vegetation of the Sydney Metropolitan Catchment Management Authority Area - Draft. Volume 2: Vegetation Community Profiles. Department of Environment, Climate Change and Water, NSW

Databases/Literature	References
Department of Environment and Climate Change (2010)	Recovery Plan for <i>Microtis angusii</i> , Department of Environment, Climate Change and Water, NSW
Department of Environment and Conservation (2004)	Threatened Species Survey and Assessment: Guidelines for developments and activities (working draft), New South Wales Department of Environment and Conservation, Hurstville, NSW.
Department of Primary Industries Records viewer	DPI (2013) Threatened and Protected Species – Records Viewer, Department of Primary Industries, NSW Government. Available at <a href="http://www.dpi.nsw.gov.au/fisheries/species-protection/records/viewer">http://www.dpi.nsw.gov.au/fisheries/species-protection/records/viewer</a> . Accessed on 16 October 2013 Updated September 2016 at <a href="http://www.dpi.nsw.gov.au/fishing/species-protection/threatened-species-distributions-in-nsw/freshwater-threatened-species-distribution-maps">http://www.dpi.nsw.gov.au/fishing/species-protection/threatened-species-distributions-in-nsw/freshwater-threatened-species-distribution-maps</a>
Director General’s Requirements	DGRs (data obtained 25 May 2015 and 21 July 2015)
Eco Logical Australia (2016)	Ingleside Precinct – <i>Microtis angusii</i> (Angus’s Onion Orchid) Report.
Eco Logical Australia (2013)	Eco Logical (2013) Preliminary Ecological Specialist Advice, Mona Vale Road upgrade – Terrey Hills to Ingleside. Eco Logical Australia, Sydney NSW.
Ecosure (January 2015)	Mona Vale Road West Upgrade: Biodiversity Investigation. Final Report (Ecosure Jan 2015)
Ecosure (May 2015)	Mona Vale Road East Detailed Biodiversity Investigation Report: Volume 1: Main Report (Ecosure May 2015)
GHD (2012)	GHD (2012) Mona Vale Road Upgrade – Terrey Hills to Ingleside. Preliminary Environmental Investigation. Prepared for Roads and Maritime Services, NSW
Law (2013)	A Survey for Eastern Pygmy Possums <i>Cercartetus nanus</i> on the Ingleside Escarpment, Pittwater (B. Law June 2013)
Law (2014)	A Survey for Eastern Pygmy Possums <i>Cercartetus nanus</i> in selected Reserves of Pittwater (B. Law August 2014)
NSW Threatened Species Profile Database	OEH (2016) NSW Threatened Species Profile Database, Office of Environment and Heritage, NSW Government. Available at <a href="http://www.environment.nsw.gov.au/threatenedspecies/">http://www.environment.nsw.gov.au/threatenedspecies/</a> Accessed on various dates between 2012 and 2016

Databases/Literature	References
Office of Environment and Heritage (OEH) (2013)	(OEH 2013a) The Native Vegetation of the Sydney Metropolitan Area.
Office of Environment and Heritage (OEH) (2013b)	OEH (2013b) Critical Habitat Register. Available at <a href="http://www.environment.nsw.gov.au/criticalhabitat/CriticalHabitatProtectionByDoctype.htm">http://www.environment.nsw.gov.au/criticalhabitat/CriticalHabitatProtectionByDoctype.htm</a> . Accessed on 14 December 2013. Office of Environment and Heritage, NSW Government
Office of Environment and Heritage (OEH) (2014a)	OEH (2014a) BioBanking. Office of Environment and Heritage, NSW Government. Available at <a href="http://www.environment.nsw.gov.au/biobanking/">http://www.environment.nsw.gov.au/biobanking/</a> last accessed on 24 January 2017
OEH Final Determinations index	<a href="http://www.environment.nsw.gov.au/committee/FinalDeterminations.htm">http://www.environment.nsw.gov.au/committee/FinalDeterminations.htm</a> (2014-2016).
Pittwater Council (1995)	Pittwater Council (1995) Habitat and Wildlife Corridors: A Conservation Strategy. Pittwater Council, NSW
Pittwater Council (2011a)	Bangalay (Ecological and Bushfire) and Eastcoast Flora Survey (2011) Pittwater Native Vegetation Classification, pre-1750 Vegetation Mapping and Vegetation Profiles. Report prepared for Pittwater Council, NSW
Pittwater Council (2011b)	Bangalay (Ecological and Bushfire) and Eastcoast Flora Survey (2011) Pittwater Native Vegetation Management Plan. Report prepared for Pittwater Council, NSW
Pittwater Council (2011c)	Bangalay (Ecological and Bushfire) and Eastcoast Flora Survey (2011) Pittwater pre-1750 Native Vegetation Mapping. GIS prepared for Pittwater Council, NSW
Pittwater Council (2011d)	Pittwater Council (2011d) Native Fauna Management Plan for the Pittwater local Government Area. Pittwater Council, NSW
Plantnet	The Royal Botanic Gardens Trust Sydney 'Plant Net' database (accessed across the study period)
Protected Matters Search Tool (PMST)	DoE (2015) Protected Matters Search Tool, Department of Environment, Canberra ACT. Available at <a href="http://www.environment.gov.au/epbc/pmst/">http://www.environment.gov.au/epbc/pmst/</a> . Accessed on 23 January 2015, updated September 2016
Vegetation Types Database	OEH (2015b) Vegetation Types Database, Office of Environment and Heritage, NSW Government. Available at <a href="http://www.environment.nsw.gov.au/biobanking/vegtypedatabase.htm">http://www.environment.nsw.gov.au/biobanking/vegtypedatabase.htm</a> . Accessed on 23 January 2017

Databases/Literature	References
Roads and Maritime Services (2012)	RMS (2012) Mona Vale Road Upgrade: Options Report. Roads and Maritime Services, NSW
Roads and Maritime Services (2013)	RMS (2013) Mona Vale Road Upgrade: Community Consultation Summary Report. Roads and Maritime Services, NSW
Roads and Maritime Services (2013)	RMS (2013) Mona Vale Road Upgrade: Road Options - Community Consultation Summary Report. Roads and Maritime Services, NSW
Robinson (2003)	Robinson (2003) Field Guide to Native Plants of Sydney. Revised 3rd Edition. Kangaroo Press, East Roseville NSW
Scotts (2003)	Scotts, D. (2003) Key Habitats and Corridors for Forest Fauna: A Landscape Framework for Conservation in north-east New South Wales. NSW National Parks and Wildlife Service, Huntersville NSW
SKM (2013)	SKM (2013) Mona Vale Road Upgrade: Preferred Options Report. Roads and Maritime Services, NSW
SMEC (2011)	SMEC (2011) Northern Beaches Roadkill – Advice on reduction options. Prepared for the Roads and Traffic Authority of New South Wales, North Sydney, NSW
Smith and Smith (2005)	Smith, P., Smith, J. (2005) Warringah Natural Area Survey: Vegetation communities and Plant Species. Report Prepared for Warringah Council, Sydney
Smith and Smith (2011)	Smith, P., Smith, J. (2011) Preliminary Ecological Assessment for Upgrading of Mona Vale Road between Terrey Hills and Ingleside. Prepared for NSW Roads and Traffic Authority, NSW
The Royal Botanic Gardens and Domain Trust (February 2014)	<i>Microtis angusii</i> research program- Progress Report 1 (The Royal Botanic Gardens and Domain Trust February 2014)
The Royal Botanic Gardens and Domain Trust (August 2014)	<i>Microtis angusii</i> research program- Progress Report 2 (The Royal Botanic Gardens and Domain Trust August 2014)
The Royal Botanic Gardens and Domain Trust (February 2015)	<i>Microtis angusii</i> research program- Progress Report 3 (The Royal Botanic Gardens and Domain Trust February 2015)

### 3.1.2 Flora

A list of threatened ecological communities, populations and flora species within a ten kilometre radius of the subject site was compiled (Table 9) from the data sources identified in Table 8 and any nominated species that were required to be considered according to the Director General's Requirements. Flora species records as shown in BioNet Atlas of NSW are mapped in Figure 10.

**Table 9: Threatened flora species, endangered populations and ecological communities recorded within 10 kilometres of the study area or included in the DGRs**

Name	Conservation Status		Habitat within study area	No. of database records	Likelihood of occurrence	Recorded Ecosure survey
	TSC Act	EPBC Act				
<b>ENDANGERED ECOLOGICAL COMMUNITIES</b>						
Bangalay Sand Forest of the Sydney Basin Bioregion	E		No		None	No
Blue Gum High Forest of the Sydney Basin Bioregion	CE	CE	No		None	No
Castlereagh Scribbly Gum and Agnes Banks Woodlands of the Sydney Basin Bioregion	V	E	No		None	No
Coastal Saltmarsh in the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	E	V	No		None	No
Coastal Upland Swamps in the Sydney Basin Bioregion	E	E	Yes		High- Known	Yes
Cooks River /Castlereagh Ironbark Forest of the Sydney Basin Bioregion	E	CE	No		None	No
Duffys Forest Ecological Community in the Sydney Basin Bioregion	E		Yes		High- Known	Yes
Eastern Suburbs Banksia Scrub in the Sydney Basin Bioregion	E	E	No		None	No
Freshwater Wetlands on Coastal Floodplains of the	E		No		None	No

Name	Conservation Status		Habitat within study area	No. of database records	Likelihood of occurrence	Recorded Ecosure survey
	TSC Act	EPBC Act				
North Coast, Sydney Basin and South East Corner Bioregions						
Littoral Rainforest and Coastal Vine Thickets of Eastern Australia	E	CE	No		None	No
Lowland Rainforest in the New South Wales North Coast, Sydney Basin & South East Corner Bioregions	E	?	No		None	No
Pittwater and Wagstaff Spotted Gum Forest in the Sydney Basin Bioregion	E		No		None	No
<i>Posidonia australis</i> seagrass meadows of the Manning-Hawkesbury ecoregion		E	No		None	No
River-flat Eucalypt Forest on Coastal Floodplains of the North Coast, Sydney Basin and South East Corner Bioregions	E		No		None	No
Shale Sandstone Transition Forest of the Sydney Basin Bioregion	CE	CE	No	No	None	No
Swamp Oak Floodplain Forest on Coastal Floodplains of the North Coast, Sydney Basin and South East Corner Bioregions	E		No	No	None	No
Swamp Sclerophyll Forest on Coastal Floodplains of the North Coast, Sydney Basin and South East Corner bioregions	E		No	No	None	No

Name	Conservation Status		Habitat within study area	No. of database records	Likelihood of occurrence	Recorded Ecosure survey
	TSC Act	EPBC Act				
Themeda Grasslands on Seacliffs and Coastal Headlands of the North Coast, Sydney Basin and South East Corner Bioregions	E		No		None	No
Sydney Turpentine-Ironbark Forest in the Sydney Basin Bioregion	E	CE	No	No	None	No
Western Sydney Dry Rainforest and Moist Woodland Western Sydney Dry Rainforest in the Sydney Basin	E	CE	No	Yes	None	No

#### THREATENED FLORA

<i>Acacia bynoeana</i>	E	V	Yes	5	Moderate	No
<i>Acacia terminalis</i> subsp. <i>terminalis</i>	E	E	Yes	10	Moderate	No
<i>Allocasuarina glareicola</i>	E	E	No	0	None	No
<i>Asterolasia elegans</i>	E	E	Marginal	1	Low	No
<i>Boronia umbellata</i>	V	V	No	1 (doubtful)	None	No
<i>Caladenia tessellata</i>	E	V	Yes	0	Low	No
<i>Callistemon linearifolius</i>	V		Yes	13	Moderate	No
<i>Chamaesyce psammogeton</i>	E		No	5	None	No
<i>Cryptostylis hunteriana</i>	V	V	Yes	2	Low	No
<i>Darwinia biflora</i>	V	V	Yes	81	Moderate	No
<i>Darwinia peduncularis</i>	V		Yes	2	Low	No
<i>Deyeuxia appressa</i>	E	E	Yes	2	Low	No
<i>Diuris bracteata</i>	E	X	Yes	1	Low	No

Name	Conservation Status		Habitat within study area	No. of database records	Likelihood of occurrence	Recorded Ecosure survey
	TSC Act	EPBC Act				
<i>Epacris purpurascens</i> var. <i>purpurascens</i>	V		Marginal	45	Low	No
<i>Eucalyptus camfieldii</i>	V	V	Yes	56	Low	No
<i>Eucalyptus nicholii</i>	V	V	No	9	None	No
<i>Eucalyptus scoparia</i>	E	V	No	1	None	No
<i>Genoplesium baueri</i>	E	E	Yes	40	Moderate	No
<i>Grammitis stenophylla</i>	E		No	5	None	No
<i>Grevillea caleyi</i>	CE	E	Yes	334	High	Yes
<i>Grevillea shiressii</i>	V	V	No	0	None	No
<i>Haloragis exalata</i> subsp. <i>exalata</i>	V	V	No	0	None	No
<i>Haloragodendron lucasii</i>	E	E	Marginal	30	Very low	No
<i>Hibbertia puberula</i>	E		Yes	1	Low	No
<i>Hibbertia superans</i>	E		Yes	1	Very low	No
<i>Kunzea rupestris</i>	V	V	Marginal	3	Low	No
<i>Lasiopetalum joyceae</i>	V	V	Yes	13	Low	No
<i>Leptospermum deanei</i>	V	V	No	5	None	No
<i>Melaleuca biconvexa</i>	V	V	No	0	None	No
<i>Melaleuca deanei</i>	V	V	Yes	21	Low-Moderate	No
<i>Microtis angusii</i>	E	E	Yes	82	High	Yes
<i>Pelargonium</i> sp. <i>Striatellum</i>	E	E	No	0	None	No
<i>Persoonia hirsuta</i>	E	E	Yes	32	Moderate	No but earlier record
<i>Persoonia laxa</i>	E		Yes	1	Very Low	No



Name	Conservation Status		Habitat within study area	No. of database records	Likelihood of occurrence	Recorded Ecosure survey
	TSC Act	EPBC Act				
<i>Persoonia mollis</i> subsp. <i>maxima</i>	E	E	Yes	79	Low	No
<i>Pimelea curviflora</i> var. <i>curviflora</i>	V	V	Yes	49	Moderate	No but earlier record
<i>Pimelea spicata</i>	E	E	No	0	None	No
<i>Prostanthera marifolia</i>	CE	CE	Yes	1	Low	No
<i>Senecio spathulatus</i>	E		No	1	None	No
<i>Syzygium paniculatum</i>	E	V	No	23	None	No
<i>Tetradlea glandulosa</i>	V		Yes	262	High	No but earlier record
<i>Thesium australe</i>	V	V	No	0	None	No
<i>Triplarina imbricata</i>	E	E	No	0	None	No

Based on habitat assessment and dominant canopy species only two of the threatened communities are considered likely to occur on the subject site:

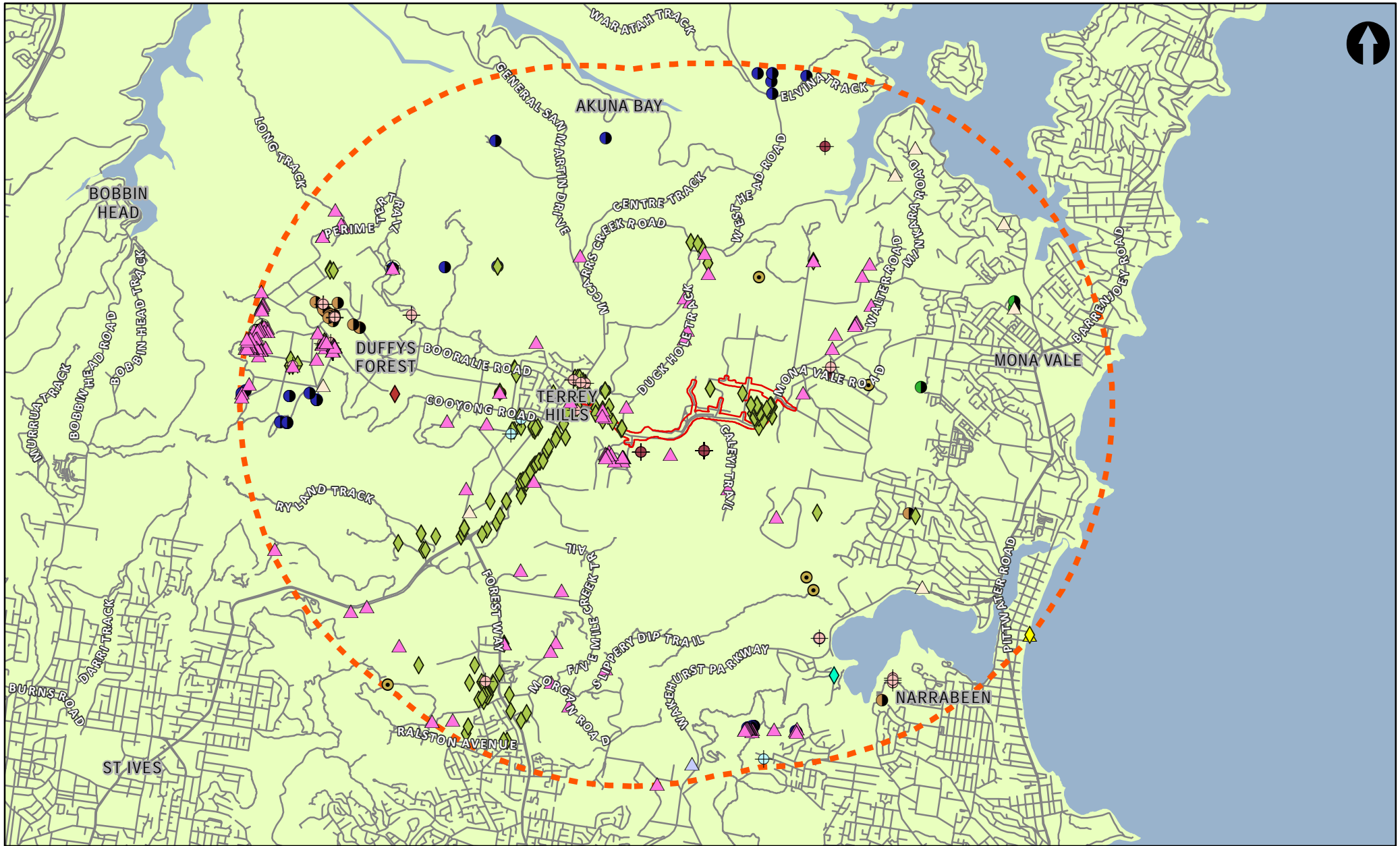
- Duffys Forest Ecological Community in the Sydney Basin Bioregion
- Coastal Upland Swamp in the Sydney Basin Bioregion.

These two communities are confirmed as present (Smith & Smith 2011; GHD 2012; Ecosure 2015; SMEC 2015). No listed flora populations are likely to or known to occur within the study area and are not considered further.

Forty-three threatened flora species were identified from the data searches or identified in the DGR's as species that must be considered for inclusion in the list of subject species. An assessment of likely occurrence was based on frequency of records, habitat availability, level of general and targeted survey and professional knowledge (Table 9). Ten species were determined to have a reasonable likelihood of occurrence (moderate and high or known probability) and warrant inclusion as subject species (Table 10).

**Table 10: Subject flora species**

Name	TSC Act	EPBC Act	Know or predicted vegetation preferences	Recorded from study area
<i>Acacia bynoeana</i>	E	V	Heath, woodland and dry forest on sandstone	No
<i>Acacia terminalis subsp. terminalis</i>	E	E	Heath, woodland and dry forest on sandstone	Unconfirmed records (Smith & Smith 2011)
<i>Callistemon linearifolius</i>	V	-	Heath, woodland and dry forest on sandstone	No, but record from 2014 on Mona Vale Road (BioNet)
<i>Darwinia biflora</i>	V	V	Heath, woodland and dry forest on sandstone	No
<i>Genoplesium baueri</i>	E	E	Woodland & sparse forest	No
<i>Grevillea caleyi</i>	CE	E	Woodland or forest on sandstone often with lateritic influence (Duffys Forest EEC & Bloodwood-Scribbly Gum Woodland)	Yes
<i>Microtis angusii</i>	E	E	Disturbed areas	Yes
<i>Persoonia hirsuta</i>	E	E	Heath, woodland and dry forest on sandstone	No
<i>Pimelea curviflora var. curviflora</i>	V	V	Heath, woodland and dry forest on sandstone. Recorded from Duffys Forest EEC within study area.	Yes
<i>Tetratheca glandulosa</i>	V		Heath, woodland and dry forest on sandstone. Recorded from Duffys Forest EEC and Bloodwood-Scribbly Gum Woodland within study area.	Yes - western end on southern side from 1996, 1998, 2011 (Smith & Smith 2011)



- |   |  |   |   |
|---|--|---|---|
| <ul style="list-style-type: none"> <li><span style="color: red;">▭</span> Study Area   Revised Construction Boundary (Nov 2016)</li> <li><span style="color: orange;">- - -</span> Locality (5km radius)</li> <li><span style="color: yellow;">●</span> <i>Callistemon linearifolius</i> (5)</li> <li><span style="color: green;">▲</span> <i>Chamaesyce psammogeton</i> (2)</li> </ul> | <ul style="list-style-type: none"> <li><span style="color: blue;">●</span> <i>Diuris bracteata</i> (1)</li> <li><span style="color: brown;">●</span> <i>Epacris purpurascens</i> var. <i>purpurascens</i> (35)</li> <li><span style="color: blue;">●</span> <i>Eucalyptus camfieldii</i> (38)</li> <li><span style="color: green;">●</span> <i>Eucalyptus nicholii</i> (4)</li> <li><span style="color: red;">●</span> <i>Eucalyptus scoparia</i> (1)</li> </ul> | <ul style="list-style-type: none"> <li><span style="color: cyan;">◆</span> <i>Genoplesium baueri</i> (1)</li> <li><span style="color: yellow;">◆</span> <i>Grammitis stenophylla</i> (1)</li> <li><span style="color: green;">◆</span> <i>Grevillea caleyi</i> (313)</li> <li><span style="color: red;">◆</span> <i>Haloragodendron lucasii</i> (1)</li> <li><span style="color: brown;">★</span> <i>Melaleuca deanei</i> (5)</li> <li><span style="color: red;">●</span> <i>Microtis angusii</i> (82)</li> </ul> | <ul style="list-style-type: none"> <li><span style="color: blue;">⊕</span> <i>Persoonia hirsuta</i> (3)</li> <li><span style="color: red;">⊕</span> <i>Pimelea curviflora</i> var. <i>curviflora</i> (34)</li> <li><span style="color: blue;">▲</span> <i>Prostanthera marifolia</i> (1)</li> <li><span style="color: brown;">▲</span> <i>Syzygium paniculatum</i> (7)</li> <li><span style="color: pink;">▲</span> <i>Tetratheca glandulosa</i> (149)</li> </ul> |
|---|--|---|---|

Threatened Flora Records within a 5km radius in the Locality **Figure 10**

Vector base dataset RoadNet © MDS 2016

### 3.1.3 Fauna

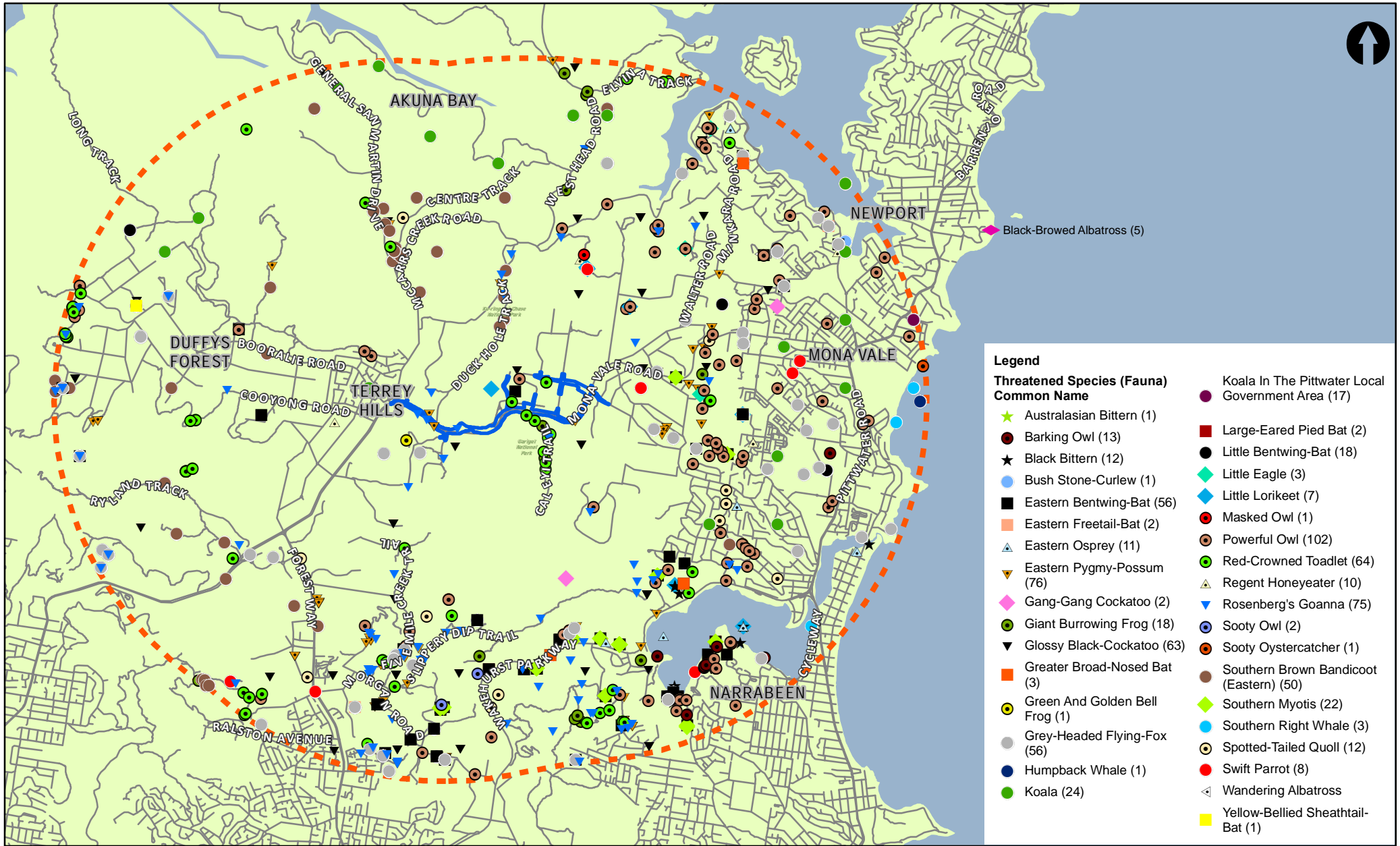
One hundred and two threatened or migratory fauna species have been recorded within 10 kilometres of the subject site, or identified in the DGR's as species that must be considered for inclusion in the list of subject species (Appendix C). The records mapped in BioNet Atlas of NSW are shown in Figure 11. An assessment of likely occurrence was made based on database and other records, habitat availability, targeted survey (Ecosure 2015 and SMEC 2015), preliminary field inspection and professional knowledge. The species in Table 11 were considered to have greater than a moderate likelihood of occurrence or have been identified within the study area. The Gang-gang Cockatoo (*Callocephalon fimbriatum*), Spotted-tailed Quoll (*Dasyurus maculatus*), Little Lorikeet (*Glossopsitta pusilla*) and Koala (*Phascolarctos cinereus*) were identified as having a low likelihood of occurrence based on recent records, survey results and the availability of suitable habitat within the study area (Appendix C).

The Koala in the Pittwater Local Government Area is listed as an Endangered Population under Part 2 of Schedule 1 of the TSC Act and identified by the DGRS. Targeted surveys (Spot Assessment Technique), and frequency of records revealed that although habitat is present for koalas in parts of the survey area, the likelihood of a resident population occurring is low. No other endangered fauna populations are known to occur within the study area and are not considered further.

The following fauna species will form the subject species for the remainder of this document:

- Giant Burrowing Frog (*Heleioporus australiacus*)
- Red-crowned Toadlet (*Pseudophryne australis*)
- Powerful Owl (*Ninox strenua*)
- Eastern Pygmy-possum (*Cercartetus nanus*)
- Southern Brown Bandicoot (eastern) (*Isodon obesulus obesulus*)
- Large-eared Pied Bat (*Chalinolobus dwyeri*)
- Little Bentwing-bat (*Miniopterus australis*)
- Eastern Bentwing-bat (*Miniopterus orianae oceanensis*)
- Eastern Freetail-bat (*Mormopterus norfolkensis*)
- Greater Broad-nosed Bat (*Scoteanax rueppellii*)
- Grey-headed Flying-fox (*Pteropus poliocephalus*)
- Rosenberg's Goanna (*Varanus rosenbergi*)

Relevant details for each of these fauna species are provided in Table 11.



Construction Footprint | Revised  
 Construction Boundary (Nov 2016)  
 Locality (5km radius)

**Threatened Fauna Records within a 5km radius in the Locality Figure 11**

Vector base dataset RoadNet © MDS 2016

0 1 2 km  
 Last updated by: DW13219 on 12/01/2017 at 16:08

**Table 11: Threatened fauna species with potential to occur in the study area**

Name	Conservation status		Database records from locality?	Habitat within study area	Likelihood of Occurrence (study area)	Likelihood of Occurrence (subject site)	Affected by proposal?
	TSC Act	EPBC Act					
<b>AMPHIBIANS</b>							
<i>Heleioporus australiacus</i> Giant Burrowing Frog	V	V	Yes	Yes	High – Known	High – Known	Yes – suitable habitat will be removed/modified
<i>Pseudophryne australis</i> Red-Crowned Toadlet	V	-	Yes	Yes	High – Known	High – Known	Yes – suitable habitat will be removed/modified
<b>BIRDS</b>							
<i>Apus pacificus</i> Fork-tailed Swift	-	M	Yes	Yes	High	Low	No – Aerial forager
<i>Calyptorhynchus lathami</i> Glossy Black-Cockatoo	V	-	Yes	Yes	High – Known	Low	No – Although the Glossy Black-cockatoo was recorded in the study area (Ecosure 2015), there is no evidence of the species foraging in small stands of casuarinas within the study area.
<i>Falco peregrinus</i> Peregrine falcon	-	M	-	Yes	Moderate	Low	No – Unlikely to use the study area, only likely to be observed flying overhead
<i>Haliaeetus leucogaster</i> White-bellied Sea-Eagle	V	-	Yes	No	Moderate	Low	No – Unlikely to use the study area, only likely to be observed flying overhead



Name	Conservation status		Database records from locality?	Habitat within study area	Likelihood of Occurrence (study area)	Likelihood of Occurrence (subject site)	Affected by proposal?
	TSC Act	EPBC Act					
<i>Hieraaetus morphnoides</i> Little Eagle	V	-	Yes	No	Moderate	Low	No – Only likely to be observed flying over the study area. No nesting sites present within the subject site
<i>Hirundapus caudacutus</i> White-throated Needletail	-	M	Yes	Yes	Known	Low	No – Aerial forager
<i>Ninox connivens</i> Barking Owl	V	-	Yes	Yes	Moderate	Low	No – No roosting or breeding habitat will be affected. Unlikely to hunt within study area.
<i>Ninox strenua</i> Powerful Owl	V	-	Yes	Yes	Known	High	Yes – Proposal may affect prey species of the owl

#### MAMMALS

<i>Cercartetus nanus</i> Eastern Pygmy-Possum	V	-	Yes	Yes	Known	Known	Yes – Numerous records for the study area and breeding known to occur within the study area
<i>Chalinolobus dwyeri</i> Large-eared Pied Bat	V	V	Yes	Yes	Very High – Probable detection	High	Yes – Suitable foraging habitat will be modified
<i>Isodon obesulus obesulus</i> Southern Brown Bandicoot (eastern)	E	E	Yes	Yes	Moderate	Moderate	Yes – Recorded in nearby National Parks

Name	Conservation status		Database records from locality?	Habitat within study area	Likelihood of Occurrence (study area)	Likelihood of Occurrence (subject site)	Affected by proposal?
	TSC Act	EPBC Act					
<i>Miniopterus australis</i> Little Bentwing-bat	V	-	Yes	Yes	High	High	Yes – Suitable roosting and foraging habitat available
<i>Miniopterus schreibersii oceanensis</i> Eastern Bentwing-bat	V	-	Yes	Yes	Known	Known	Yes – Recorded during recent surveys and may use habitat adjacent to the road for foraging
<i>Mormopterus norfolkensis</i> Eastern Freetail-bat	V	-	Yes	Yes	Moderate	Moderate	Yes – Suitable roosting and foraging habitat available
<i>Pteropus poliocephalus</i> Grey-headed Flying-fox	V	V	Yes	Yes	Known	High	Yes – May use the study area for foraging and was identified during recent surveys
<i>Scoteanax rueppellii</i> Greater Broad-Nosed Bat	V	-	Yes		Moderate	Moderate	Yes – Suitable roosting and foraging habitat available

#### REPTILES

<i>Varanus rosenbergi</i> Rosenberg's Goanna	V	-	Yes	Yes	Known	High	Yes – Proposal will require the removal of termite mounds which are necessary for breeding
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## 4 SURVEY

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### 4.1 REQUIREMENT TO SURVEY

Preliminary field surveys and reporting were undertaken for the proposal by Ecosure (2015). This included:

- Vegetation type and vegetation condition surveys - including floristic, BioMetric plots and rapid data points, carried out during September and October 2013 and September 2014
- Targeted threatened flora surveys - including identification of threatened, non-threatened, ROTAP and locally significant species, conducted periodically over 15 months between September 2013 and January 2015
- Fauna surveys and fauna habitat assessments - carried out between 31 October 2013 and January 2015.

SMEC undertook a number of additional targeted surveys to meet the requirements of the DGRs and supplement the previous surveys undertaken by Ecosure. Targeted flora species for these additional surveys were *Acacia bynoeana*, *Callistemon linearifolius* and *Darwinia biflora* (surveyed 11 January 2015). Targeted fauna species for the SMEC surveys were the Eastern Pygmy-possum, Southern Brown Bandicoot and Rosenberg's Goanna (October 2015 – January 2016).

### 4.2 DOCUMENTATION

The survey method and effort for each survey component was designed to include and then build on existing data collected for the ecological assessment undertaken for the study area (Ecosure 2015) and to meet the specific survey requirements listed in the Director General's Requirements (as per Section 4 of the DGR Attachment – dated 25/5/2015 and any subsequent correspondence).

#### **4.2.1 Description of survey techniques and survey locations: fauna**

Fauna surveys (including habitat assessments) were carried out by Ecosure between 31 October 2013 and January 2015. SMEC undertook additional targeted surveys between October 2015 and January 2016 targeting the Eastern Pygmy Possum, Southern Brown Bandicoot, microbat roost and maternal sites, threatened amphibians and Rosenberg's Goanna to comply with the DGRs and supplement gaps in information from previous surveys.

Surveys for fauna groups were conducted at the time of year considered optimal for the respective species or faunal group. A summary of climatic conditions during surveys undertaken by Ecosure (2015) for each faunal group is outlined in Table 17.

Fauna survey locations are shown in Figure 12.

#### **Fauna habitat assessment**

The vegetation types found in the study area (Ecosure 2015) were stratified by Ecosure into six fauna habitat stratification units: wetland, casuarina, swamp, sandstone heath, open woodland and disturbed areas (Table 12). Three of these habitats units were then sampled during fauna habitat

assessments in the field. The other three (casuarina, wetland and swamp) are not located within the subject site and occupy none or very small parts of the current study area. Fauna habitat detail was recorded at a total of 54 locations throughout the study area.

**Table 12: Vegetation types and stratified fauna habitat units**

<b>Vegetation type</b>	<b>Area within study area (ha)</b>	<b>Fauna habitat</b>
Artificial wetland	0	wetland
Black She-oak Forest	0	casuarina
Bloodwood-Scribbly Gum Woodland	16.3	open woodland
Coastal Upland Swamp	0	swamp
Duffys Forest Ecological Community	7.0	open woodland
Duffys Forest Translocation Site	0.7	disturbed
Duffys Forest tree layer with highly disturbed understorey	0.43	disturbed
Highly disturbed vegetation	1.2	disturbed
Peppermint-Angophora Forest	6.6	open woodland
Plantings	0.12	disturbed
Sandstone Heath	2.5	sandstone heath
Sandstone Rocky Heath	0.94	sandstone heath
Weeds	0.39	disturbed
Yellow-top Ash Mallee	2.5	open woodland
<b>Total</b>	<b>38.7</b>	

Within the fauna habitat stratification units, plots of 50 by 10 metres were randomly assigned. In each plot, the following components were documented:

- Rocks and boulders, rocky outcrops, exfoliating rocks and rocks with crevices.
- Trees and logs with hollows: presence of senescent (old) or dead trees (stags) and trees or logs with peeling bark or loose bark (abundance).
- Estimate of habitat condition including % of shrub layer, ground cover and leaf litter (estimated % cover).
- Habitat features/critical food resources e.g. termite mounds, mistletoe (abundance).
- Presence of standing water or ephemeral waterways including wetland, riverine and groundwater springs (presence/absence)

In addition to formal habitat assessments, any significant features encountered during surveys (e.g. hollow-bearing trees, termite mounds, seeps, nests etc.) were documented and marked with a hand-held GPS.

### **Hollow-bearing trees**

Not all hollow-bearing trees within the study area were recorded by Ecosure (2015) as part of the scope of their survey; however, at each fauna habitat assessment point the number of hollow-bearing trees was noted within each quadrat.

A hollow-bearing tree assessment was conducted by SMEC within the subject site between August 2015 and August 2016. The information recorded included GPS location of the tree, species name, approximate height of hollow and a georeferenced photograph of each tree. Hollows were classified into four size classes:

- Small – Less than 5 centimetre diameter
- Medium – Between 5 and 10 centimetre diameter
- Large – Between 10 and 15 centimetre diameter
- Extra-large – Greater than 15 centimetre diameter

### **Fauna surveys**

#### **Area searches - birds**

Ecosure (2015) assigned search areas to regions of potential habitat and an experienced observer searched an area of two hectares (a site) for 20 minutes in the early morning. Sites were searched at least three times over the survey period.

Searches were also undertaken for hollow-bearing trees that provide suitable habitat for breeding and concentrations of foraging resources (e.g. mapping of areas of *Allocasuarina* as foraging habitat for glossy black-cockatoo) as part of general habitat searches.

#### **Point surveys - birds**

Ecosure (2015) established sixteen point sites for timed bird surveys within the local area, including eight in the vicinity of the survey area.

These point sites were visited in May, June, August and October 2014 to provide additional information on occurrence of bird species within the local area, and determine if any threatened bird species that were utilising the study area. This was in addition to the timed area searches of representative two hectare sites across the study area (reported in the above section area searches – birds). These point sites represented areas with different microhabitat features and also provided sites with less disturbance than other sites that were adjacent to the current Mona Vale Road.

#### **Diurnal active searches**

Ecosure (2015) conducted a minimum of two diurnal active searches of at least 30 minutes each along a single transect in each of the three main stratified fauna habitat units. Additionally, areas of

potentially good habitat were also searched (i.e. gullies, waterways, sandstone escarpments). Habitats were searched for inconspicuous fauna (e.g. reptiles in crevices or under bark, roosting bats) as well as for signs of fauna (scats, tracks, fur, feathers, diggings, scratches, nests, owl wash and pellets).

### **Nocturnal spotlight searches**

Spotlight search transects were completed by Ecosure (2015) in fauna habitat units so that the survey effort for these searches matched that of the diurnal searches. These surveys consisted of spotlight searches on foot and road surveys (not on Mona Vale Road as it is too busy, but in Tumburra Street, Addison Road, Wirreanda Road and other surrounding roads).

### **Infrared cameras**

Cameras were set up by Ecosure (2015) at areas with likely high fauna activity based on results of an initial one day site inspection and the diurnal active searches. Baits were used for all camera stations to increase the chance of detecting species such as the spotted-tailed quoll, brush-tailed phascogale and southern brown bandicoot. The survey method used traditional bait (peanut butter, oats and honey) and pieces of raw chicken at each bait station, approximately two metres in front of the cameras. Truffle-infused oil was also used at the bait stations to improve the attractiveness of the bait. Cameras were set up for a minimum of four nights at each location throughout the study area (Figure 12).

To meet specific survey requirements in the amended DGRs issued by OEH additional cameras were set up by SMEC in 2015 to monitor the Southern Brown Bandicoot and Rosenberg's Goanna (see Section 4.3.3 for details).

### **Songmeter echolocation call recording and analysis**

Six echolocation call devices (Songmeter 2+ and Anabat 2) were placed in areas of potential high bat activity across the study area, sampling woodland, heath and disturbed habitats (Figure 18). Calls were downloaded and converted to Anabat call sequence files and preliminary sorting and identification was carried out by the field team. The files were then sent to bat specialist, Greg Ford for confirmation of call identification. All calls were analysed using AnaLookW (Corben 2013) with a generic filter applied to exclude poor quality calls unsuitable for identification and noise. Calls with fewer than four clearly defined non-fragmented pulses were also excluded from analysis. Identification of species was carried out by comparing recorded calls to regional reference calls and published descriptions (Pennay *et al.* 2004).

### **Harp traps**

Six harp traps were placed in suitable flyways to sample the length of the study area (clearings/tracks in open woodland habitats determined (excluding "disturbed" areas)). Traps were checked each morning between 05:00 and 07:00 and were then moved or dismantled to prevent bycatch during the day (e.g. birds), before being reset in the evening.

### **Spot Assessment Technique**

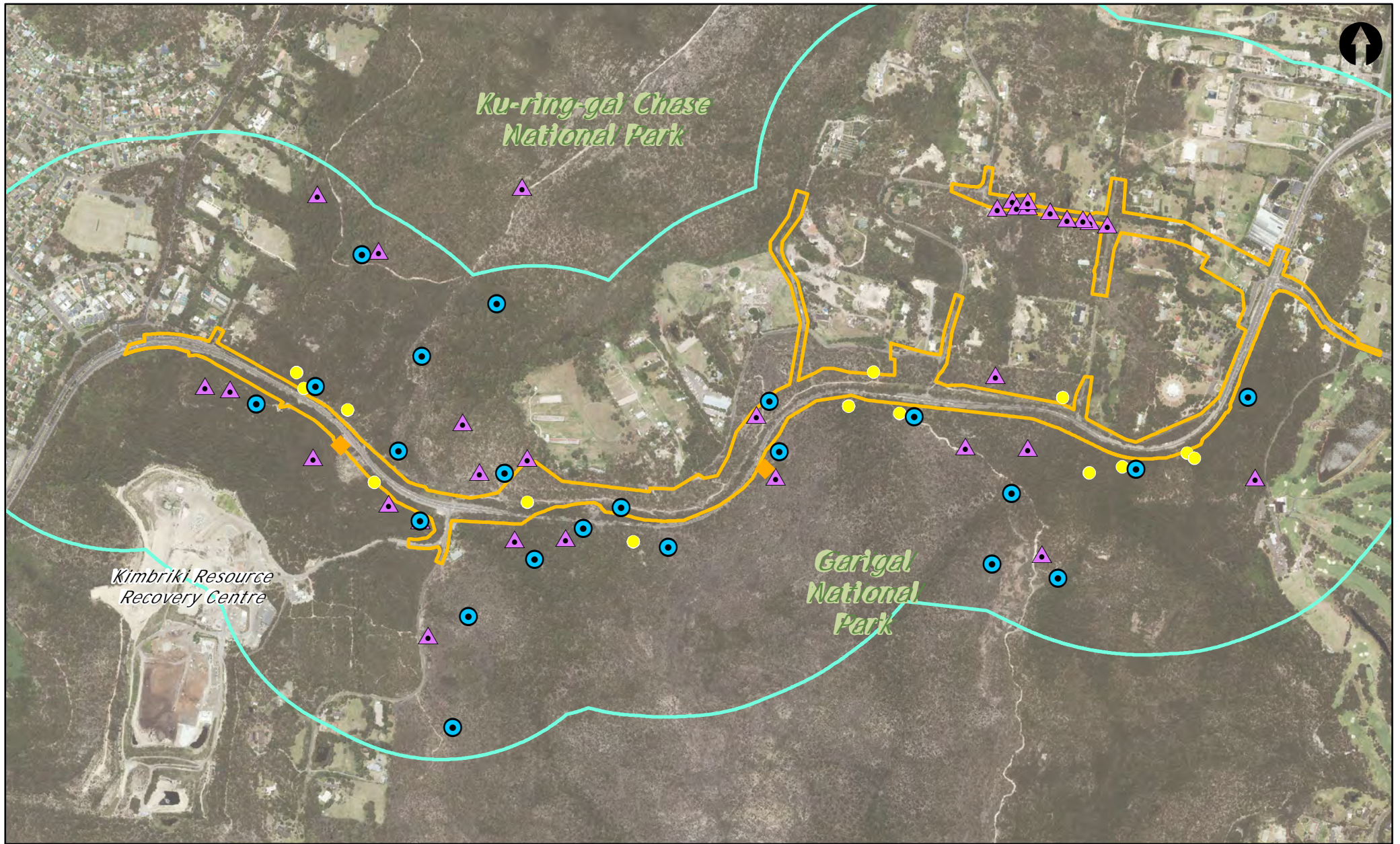
The Spot Assessment Technique (SAT) (Phillips & Callaghan 2011) was used to determine the presence or absence of koalas (*Phascolarctos cinereus*), and their activity throughout the study area. DoE

(2013b) recommend the use of SAT in their koala referral advice for proponents. Eleven survey site locations were selected approximately 350 metres apart using an alternating point transect along the survey area. This survey method was designed to provide even and unbiased sampling along adjacent sides of the road alignment. A central tree with a diameter at breast height (DBH) greater than 100 millimetres was selected; flagged and associated coordinates recorded using a handheld GPS device. The closest 29 trees with a DBH over 100 millimetres were then also sampled to complete the survey within each grid, with the species and DBH (millimetres) recorded for each tree. The base of each tree was searched for the presence or absence of scats using the one metre protocol of Phillips & Callaghan (2011) to determine the extent of tree use and associated activity by koalas.

Line transects are typically undertaken in areas that confirm koala presence during SAT surveys, and enable area-based koala density estimates to be derived. Thus equipped with compass and binoculars, three observers spaced 15 metres apart walked a fixed bearing searching for koalas along a 250-300 metre transect.

In order to support findings from the assessment, three targeted SAT surveys were undertaken in nearby Ku-ring-gai Chase National Park. These surveys assessed areas within the vicinity of the most recent known sightings for koalas recorded in the region; approximately 5.5 kilometres away in 2009 and 2010 (OEH 2013). To identify any potential koala presence, targeted surveys were conducted in areas containing known primary koala food trees (PKFTs), and SAT searches were conducted under each PKFT.





- ◆ Termite mound camera (SMEC)
- EPP Nestbox (Ecosure)
- Infrared baited camera (SMEC)
- ▲ EPP Nestbox (SMEC)
- Construction Footprint | Revised Construction Boundary (Nov 2016)
- Study Area - fauna | Revised Construction Boundary Rev 03 (Aug 2016)

**Fauna Survey Locations Figure 12**  
 Vector base dataset RoadNet © MDS 2016  
 Imagery supplied from RMS

0 250 500 m

Last updated by: DW13219 on 16/01/2017 at 17:24

Refer to Ecosure (2015) for additional fauna survey types and locations (e.g. Anabat, bird surveys, harp traps, spotlighting, trapping)



## 4.2.2 Description of survey techniques and survey locations: flora

### General Overview

The SIS has drawn for the most part upon two baseline flora datasets, these being baseline and targeted flora surveys of the study area by Smith and Smith (2011) and Ecosure (2015). Both these datasets were applicable to previous iterations of the proposal which comprised almost identical study areas relative to the current one that is the subject of this SIS.

Additional fieldwork has been undertaken by SMEC in 2016 consisting of:

- Flora survey in July 2016 to account for the addition of a link road section in the north east between Mona Vale Road and Bungendore Road
- The geo-referencing of a subset of regenerating *Grevillea caleyi* recorded by Ecosure by a registered surveyor accompanied by a SMEC ecologist following a hazard reduction burn in August 2016 maximising the potential for identifying regenerating *Grevillea caleyi*.

A summary of the flora survey methods associated with the datasets drawn upon for the SIS are provided below. A complete description of the flora survey methods undertaken by Smith and Smith (2011) and Ecosure (2015) is provided in the reports provided as Appendix G and Appendix H.

A third flora data subset, a Biocertification assessment of the Ingleside Planning Precinct, prepared by EcoLogical Australia (ELA 2016), was considered in the preparation of the SIS which comprised GIS vegetation mapping and *Microtis angusii* records. The ELA study area comprised the wider Ingleside locality and included the eastern half of the SIS study area (west to Kimbriki Rd). This dataset was drawn upon predominantly to obtain distribution and abundance data for the endangered orchid, *Microtis angusii*. Additional resources that were consulted for specific species are discussed in Section 4.2.4.

### Baseline surveys – Smith and Smith (2011)

Plant species and vegetation communities were surveyed over 10 days between 17 June 2011 and 3 August 2011. All native plant species encountered in the survey area, either naturally occurring or derived from translocation projects for conservation purposes, were identified, except for a few species for which there was insufficient material for identification. Native plantings in gardens or for other landscaping purposes were not listed as these do not have conservation significance in this area. Survey dates and weather conditions are provided below in Table 13.

**Table 13: Timing and weather conditions of the field survey**

Date	Time	Weather conditions
17/6/11	1310-1700	Clear to 1/4 cloud, moderate to strong wind, maximum temperature at Terrey Hills 16°C, following a week of rain
22/6/11	1030-1430	Clear sky, light wind, maximum temperature at Terrey Hills 14°C
22/6/11	1630-1830	Clear to 1/2 cloud, light to moderate wind, temperature 8-11°C, no moon

Date	Time	Weather conditions
23/6/11	0900-1630	Clear sky, light wind, maximum temperature at Terrey Hills 18°C
23/6/11	1630-1830	Clear sky, calm, temperature 9-15°C, no moon
24/6/11	0930-1720	Clear sky, light wind, maximum temperature at Terrey Hills 17°C
28/6/11	1050-1330, 1400-1650	Overcast, calm to light wind, intermittent rain, maximum temperature at Terrey Hills 14°C
29/6/11	0900-1640	3/4 cloud to overcast, calm to light wind, occasional light rain, maximum temperature at Terrey Hills 16°C
30/6/11	0900-1600	3/4 cloud to overcast, calm to moderate wind, maximum temperature at Terrey Hills 16°C
4/7/11	0930-1600	Clear to 1/4 cloud, moderate to strong wind, briefly overcast with a shower of rain, maximum temperature at Terrey Hills 19°C
2/8/11	1320-1720	1/4 cloud, calm, maximum temperature at Terrey Hills 23°C
3/8/11	1020-1500	Clear to 3/4 cloud, light to moderate wind, maximum temperature at Terrey Hills 23°C

### **Baseline surveys - Ecosure (2015)**

Ecosure carried out a total of 20 Biobank plots comprising a full floristic 20 by 20 metre quadrat nested within a larger 50 by 20 metre plot. Full floristic data was collected in the subplot along with Braun Blanquet cover values whilst vegetative structure and fauna habitat data was recorded within the wider plot area. The Biobank plots were undertaken in accordance with the Biobank Assessment Methodology (BBAM 2008). Ecosure (2015) also undertook a series of rapid data points (RDPs) to validate vegetation mapping and condition which typically comprises the collection of dominant floristic data for each stratum along with key physiographic attributes. The Ecosure (2015) study area was approximately 108 hectares.

Flora survey effort and timing for surveys undertaken by Ecosure (2015) is shown below in Table 14 and Table 15. Ecosure (2015) Biobank plot locations are shown in Figure 13. Completed Biobank plot proformas are provided as Appendix E.

**Table 14: Vegetation communities and Biometric plots completed for BioBank surveys (Ecosure 2015)**

Vegetation type	Area of vegetation type in study area (ha)	Plots required (DECC 2008)	Plots completed
Coastal Upland Swamp*	0.05	1	1
Sandstone Rocky Heath	0.09	1	2



Vegetation type	Area of vegetation type in study area (ha)	Plots required (DECC 2008)	Plots completed
Sandstone Heath	0.02	0	1
Bloodwood Scribbly Gum Woodland	7.51	3	5
Duffys Forest Ecological Community	2.13	2	3
Duffys Forest Translocation Site	0.1	0	1
Duffys Forest (Disturbed)	0.11	0	1
Peppermint-Angophora Forest	4.05	2	3
Yellow-top Ash Mallee	0.95	0	3
Total	14.98	9	20

\* Note: More detailed vegetation surveys have excluded Coastal Upland Swamp as it does not occur in the current study area.

**Table 15: Flora survey timing**

Vegetation Type (Ecosure 2015)	Biobank Plot Site number	Survey dates
Bloodwood Scribbly Gum Woodland	4, 5, 6, 7, 32	30/09/2013 (site 4,5); 1/10/2013 (site 6, 7); 26/09/2014 (site 32);
Duffys Forest Ecological Community - Endangered	8, 12, 13	1/10/2013 (site 8); 2/10/2013 (site 12,13);
Duffys Forest Translocation Site	9	2/10/2013
Duffys Forest Disturbed Site	19	18/10/2013
Peppermint-Angophora Forest	15, 16, 17	2/10/2013 (site 15,16); 3/10/2013 (site 17)
Sandstone Rocky heath	2, 3	30/9/2013 (site 2,3)
Sandstone Heath	14	2/10/2013
Upland Swamp – Endangered	18	18/10/2013
Yellow-top Ash Mallee Woodland	1, 10, 11	30/9/2013 (site 1,10); 2/10/2013 (site 11)

### Targeted threatened flora searches

Smith and Smith (2011), Ecosure (2015) and SMEC (2016) undertook targeted searches for a suite of threatened flora species that had been previously recorded in the Ingleside/Terrey Hills locality, including:

- *Acacia bynoeana* (Bynoe's Wattle)
- *Callistemon linearifolius* (Netted Bottle Brush)
- *Darwinia biflora*
- *Epacris purpurascens* var. *purpurascens* (Port Jackson heath)
- *Eucalyptus camfieldii* (Camfield's Stringybark)
- *Genoplesium baueri* (Bauer's Midge Orchid)
- *Grevillea caleyi* (Caley's Grevillea)
- *Haloragodendron lucasii*
- *Leptospermum deanei*
- *Melaleuca deanei* (Deane's Paperbark)
- *Microtis angusii* (Angus's Onion Orchid)
- *Persoonia hirsuta* (Hairy Geebung)
- *Pimelea curviflora* var. *curviflora*
- *Tetratheca glandulosa*.

Searches were undertaken using random meander transects through suitable vegetation types (Cropper 1993). Three reference sites for *Genoplesium baueri* (endangered) and *Pimelea curviflora* var. *curviflora* (vulnerable) were also visited in January 2015 by Ecosure (2015) to aid in threatened flora identification within the survey area.

All *G. caleyi* individuals recorded by SMEC during the 2016 targeted searches were geo-referenced by a SMEC registered surveyor to sub-metre accuracy.

Survey dates for threatened flora surveys undertaken are provided in Table 16. Threatened flora transect locations are shown in Figure 13.

**Table 16: Flora survey effort**

Flora species scientific name	Flora species common name	Flowering period	Dates surveyed
<i>Acacia terminalis</i> subsp. <i>terminalis</i>	Sunshine Wattle	Autumn (OEH 2012-2014).	30 September – 4 October 2013 and 3 December 2013 (does not require flowers for identification) Ecosure (2015)  17 June-3 Aug 2011 (Smith and Smith)

Flora species scientific name	Flora species common name	Flowering period	Dates surveyed
<i>Acacia bynoeana</i>	Bynoe's Wattle	Summer (Plantnet)	11 Jan 2016 (SMEC)
<i>Callistemon linearifolius</i>	Netted Bottle-brush	Spring and Summer (PlantNet)	11 Jan 2016 (SMEC)
<i>Darwinia biflora</i>		Winter and Spring (PlantNet)	11 Jan 2016 (SMEC)
<i>Epacris purpurascens</i> var. <i>purpurascens</i>	Port Jackson Heath	July to September (Harden 1992).	17 June – 3 August 2011 (Smith and Smith) 30 September – 4 October 2013 and 3 December 2013 Ecosure (2015) 29 February 2016 (SMEC) (Addison-Tumburra Road remnant)
<i>Eucalyptus camfieldii</i>	Camfield's Stringybark	Flowering period is irregular with flowers recorded throughout the year, especially from April to December (Benson and McDougall 1998, OEH 2012-2014).	30 September – 4 October 2013 and 3 December 2013 (does not require flowers for identification) Ecosure (2015)
<i>Genoplesium baueri</i>	Bauer's Midge Orchid	December to May (OEH 2012-2014, Robinson 2003).	3 December 2013, January 2015 Ecosure (2015)
<i>Grevillea caleyi</i>	Caley's Grevillea	The flowering period is sporadic throughout the year (particularly around July-November) however a definite flowering period occurs in spring (2012-2014, Robinson 2003).	17 June – 3 August 2011 (Smith and Smith) 30 September – 4 October 2013 (does not require flowers for identification) Ecosure (2015) 4, 18, 25 February 2016 (SMEC) via random meander transects through all stands of Duffys Forest in the proposed construction footprint and validation of Ecosure (2015) <i>G. caleyi</i> records.

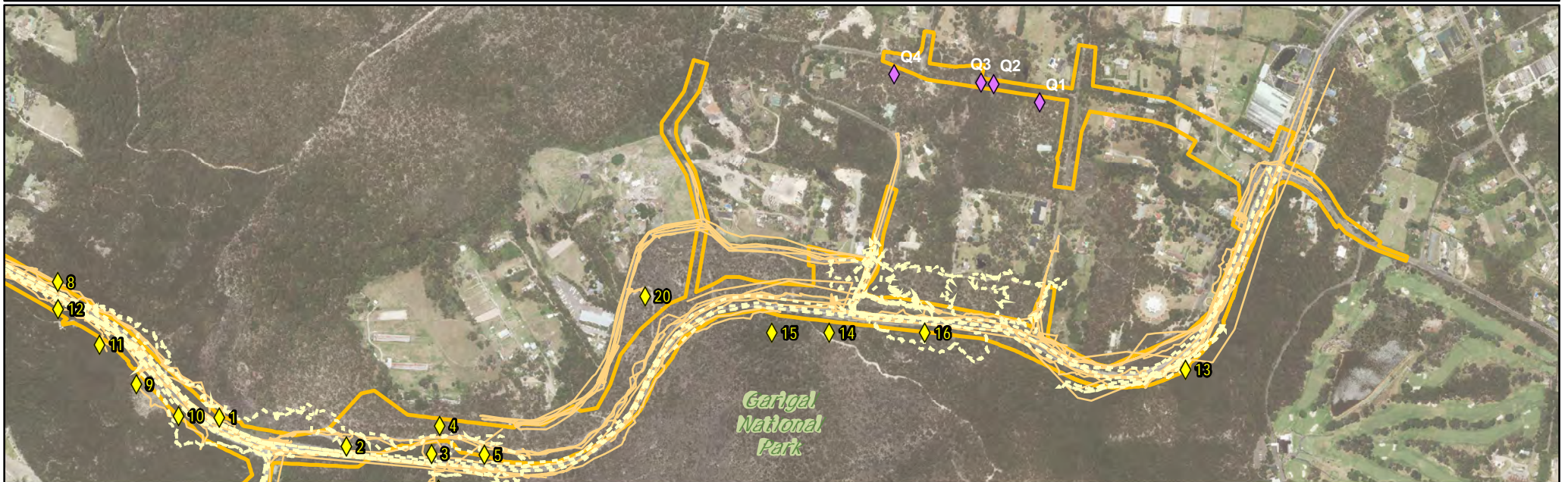
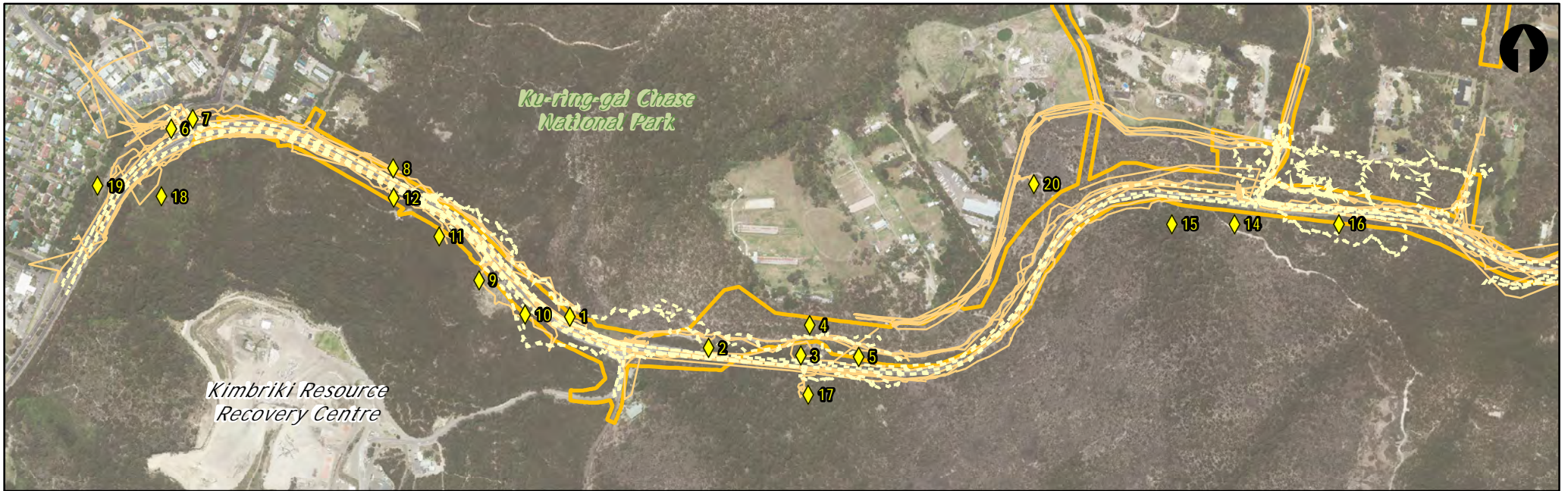
Flora species scientific name	Flora species common name	Flowering period	Dates surveyed
<i>Haloragodendron lucasii</i>		August to November (OEH 2012-2014).	30 September – 4 October 2013 Ecosure (2015)
<i>Leptospermum deanei</i>		October to November (OEH 2012-2014).	30 September – 4 October 2013 Ecosure (2015)
<i>Melaleuca deanei</i>	Deane's Melaleuca	Spring and summer months (OEH 2012-2014).	30 September – 4 October 2013 (does not require flowers for identification) Ecosure (2015)
<i>Microtis angusii</i>	Angus's Onion Orchid	May to October peaking in September and October (DECCW 2010, NSW Scientific Committee 1997).	17 June – 3 August 2011 (Smith and Smith) 30 September – 4 October 2013 and September 2014 Ecosure (2015) 21 September – 2 October 2015 Eco Logical (2015) RBG (2015)
<i>Persoonia hirsuta</i>	Hairy Geebung	Summer months especially November to January (DoE 2012-2014, Robinson 2003).	3 December 2013 (does not require flowers for identification) Ecosure (2015)
<i>Pimelea curviflora</i> var. <i>curviflora</i>	Curved Rice-flower	October to May (OEH 2012-2014, DoE 2012-2014).	17 June – 3 August 2011 (Smith and Smith) 30 September – 4 October 2013 and 3 December 2013 Ecosure (2015) 29 February 2016 (SMEC) (Addison Rd-Tumburra Road remnant)

Flora species scientific name	Flora species common name	Flowering period	Dates surveyed
<i>Tetratheca glandulosa</i>	Glandular Pink-bell	July to November with some flowers persistent until late December (OEH 2012-2014, RBG 2014)	17 June – 3 August 2011 (Smith and Smith) 30 September – 4 October 2013 and 3 December 2013, September 2014 and January 2015 Ecosure (2015) 29 February 2016 (SMEC) (Addison Rd-Tumbarra Road remnant)

### ***Survey methods: vegetation mapping***

Both Smith and Smith (2011) and Ecosure (2015) mapped the vegetation of the study area through a combination of desktop review of existing mapping datasets, aerial photo interpretation and field surveys. Small ‘gaps’ in between vegetation polygons that arose when incorporating these datasets into the current study area were filled in using regional vegetation mapping (OEH 2013) supplemented by minor boundary adjustments made by SMEC based on API. The extent of these vegetation communities are shown in Figure 9.





- ◆ SMEC Biobank Plots
- ◆ Ecosure Biobank Plots
- SMEC Threatened Flora Survey Tracks (2016)
- Ecosure Threatened Flora Survey Tracks (2013-2015)
- Subject Site | Revised Construction Boundary (Nov 2016)

**Flora Survey Locations Figure 13**  
 Vector base dataset RoadNet © MDS 2016  
 Imagery supplied from RMS



### 4.2.3 Documenting survey effort and results

#### Survey effort and conditions: fauna

Surveys for fauna groups were undertaken at the time of year considered optimal for the respective species or fauna group. A summary of climatic conditions during surveys undertaken by Ecosure (2015) for each fauna group is outlined in Table 17. Additional surveys undertaken by SMEC are outlined in Section 4.3 for specific species. Fauna survey locations are shown in Figure 12.

**Table 17: Survey effort and conditions during survey periods**

Survey Type	Effort (Ecosure 2015)	Date	Rainfall (mm)	Temperature (°C)	Personnel
Threatened bird surveys	56 hours	20 November 2013	0.2	14.5 – 24.8	WJ, BB
		21 November 2013	0.2	17.5 - 23.9	
		22 November 2013	2.4	18.0 – 23.1	
Nocturnal surveys	18 hours over 4 nights	31 October 2013	0	12.2 – 22.5	EL, FL, CF, MS
		2 December 2013	0	13.1 – 23.3	
		4 December 2013	0	15.4 - 29.4	
		19 February 2014	0.2	18.5 – 27.2	
		15 May 2014	0	10.5 – 21.3	
		16 May 2014	0	10.3 – 22.9	
		17 May 2014	0	12.2 – 13.8	
		18 May 2014	0	13.6 – 23.0	
		19 May 2014	0	12.6 – 23.6	
		20 May 2014	0	12.9 – 22.0	
Remote camera trapping (especially for southern brown bandicoots and spotted-tailed quolls)	14 camera trap nights over 4 nights and then 20 trap nights over 5 nights	2 December 2013	0	13.1 – 23.3	EL, CF
		3 December 2013	0	13.4 – 23.9	
		4 December 2013	0	15.4 - 29.4	
		5 December 2013	5.0	17.7 – 25.0	
		6 December 2013	0	9.3 – 20.4	
		15 May 2014	0	10.5 – 21.3	
		16 May 2014	0	10.3 – 22.9	
		17 May 2014	0	12.2 – 13.8	
		18 May 2014	0	13.6 – 23.0	
		19 May 2014	0	12.6 – 23.6	
	32 hours	31 October 2013	0.2	12.2 – 22.5	FL, EL
		1 November 2013	0.4	14.5 – 21.6	

Survey Type	Effort (Ecosure 2015)	Date	Rainfall (mm)	Temperature (°C)	Personnel
Fauna habitat surveys and active searches		3 December 2013	0	13.4 – 23.9	
		4 December 2013	0	15.4 - 29.4	
Koala SAT surveys	52 hours	3 December 2013	0	13.4 – 23.9	SP,GB, EH
		4 December 2013	0	15.4 - 29.4	
Harp traps	4 nights with 6 traps = 24 trap nights	2 December 2013	0	13.1 – 23.3	MS, CF
		3 December 2013	0	13.4 – 23.9	
		4 December 2013	0	15.4 - 29.4	
		5 December 2013	5.0	17.7 – 25.0	
		6 December 2013	0	9.3 – 20.4	
Nest boxes - installation	14 nest boxes over 400 nights	3 December 2013- 7 December 2014			MS, CF, EL, DJ, NH
Nest boxes - monitoring		23 January 2014,	3.8	17.5 – 23.5	
		18 June 2014,	0	10.5 – 18.0	
		6 August 2014,	0	5.5 – 18.8	
		18 October 2014,	0	9.8 – 18.7	
		13 January 2015	1.6	17.6 – 27.4	
Bat echolocation call detectors	3 x songmeters over 4 nights = 12 trap nights	2 December 2013	0	13.1 – 23.3	MS, CF, NH (analysis by GF)
		3 December 2013	0	13.4 – 23.9	
		4 December 2013	0	15.4 - 29.4	
		5 December 2013	5.0	17.7 – 25.0	
		6 December 2013	0	9.3 – 20.4	
		12 January 2015	14.8	18.7 – 21.6	
		13 January 2015	1.6	17.6 – 27.4	
		14 January 2015	0.6	19.5 – 31.5	
15 January 2015	0	19.5 – 26.7			
Targeted auditory searches for giant burrowing frog ( <i>Heleioporus australiacus</i> ).	4 hours	19 February 2014	0.2	18.5 – 27.2	FL
Giant burrowing frogs - tadpole searches	4 hours	18 September 2014	0	9.7 – 17.1	FL, EL
Threatened owl surveys	40 hours	15 May 2014	0	10.5 – 21.3	EL, CF, NH, DJ
		16 May 2014	0	10.3 – 22.9	

Survey Type	Effort (Ecosure 2015)	Date	Rainfall (mm)	Temperature (°C)	Personnel
		17 May 2014	0	12.2 – 13.8	
		18 May 2014	0	13.6 – 23.0	
		19 May 2014	0	12.6 – 23.6	
		20 May 2014	0	12.9 – 22.0	
Trapping for eastern pygmy possums ( <i>Cercartetus nanus</i> ).	40 hours	15 May 2014	0	10.5 – 21.3	EL, CF, DJ, NH
		16 May 2014	0	10.3 – 22.9	
		17 May 2014	0	12.2 – 13.8	
		18 May 2014	0	13.6 – 23.0	
		19 May 2014	0	12.6 – 23.6	
		20 May 2014	0	12.9 – 22.0	

Personnel: DJ - David James, EL - Dr Elvira Lanham, CF - Dr Carissa Free, FL - Dr Frank Lemckert, SP - Dr Steve Phillips, MS - Matthew Stanton, GB - Dr Grant Brearley, GF - Greg Ford, EH - Emily Hatfield, NH - Nicola Head, NS - Nathan Smith, WJ - Will Jamieson, BB - Ben Blewitt

#### 4.2.4 Description and mapping of results of vegetation, flora and fauna surveys

##### Survey results: vegetation communities

Both Smith and Smith (2011) and Ecosure (2015) mapped the vegetation of the study area through a combination of desktop review of existing mapping datasets, aerial photo interpretation and field surveys. Small ‘gaps’ in between vegetation polygons that arose when incorporating these datasets into the current study area were filled in using regional vegetation mapping (OEH 2013) supplemented by minor boundary adjustments from SMEC based on API and ground-truthed by SMEC on 7 September 2016. The extent of these vegetation communities are shown in Figure 9.

A full description of the vegetation communities recorded by Smith and Smith (2011) and Ecosure (2015) within the survey area is provided in these two reports which are reproduced in this SIS as Appendix H and Appendix G, respectively.

One EEC occurs within the current study area: Duffys Forest Ecological Community.

##### Duffys Forest EEC

The Duffys Forest Ecological Community is associated with shale lenses in Hawkesbury Sandstone, usually where these form ridgetop caps over the sandstone (Smith and Smith 2011). Soils are slightly more fertile and have a higher clay content than typical Hawkesbury Sandstone soils, and are usually lateritic, characterised by the presence of ironstone gravel. The community is associated in the study area with the Somersby residual soil landscape Sandstone outcrops are generally absent, except on the fringes of the community. The community occurs on the higher ground at the western (Tumbledown Dick Hill) and eastern (Baha’i Temple) ends of the study area with a total extent of approximately 8 hectares and represents intact good condition vegetation.

## Duffys Forest Translocation Sites

Two sites within and adjoining the study area at Tumbledown Dick Hill (west of Kimbriki Road) have been receptor sites for Duffys Forest Ecological Community soil seedbank translocation projects (Smith and Smith 2011). Soil material from development sites at Belrose where Duffys Forest was being cleared have been translocated to highly degraded sites at Tumbledown Dick Hill that formerly supported the Duffys Forest EEC. The objective of the translocation project was to restore the Duffys Forest EEC at these two sites to a near natural structure. One site on the northern side of Mona Vale Road received translocated soil in 1999, with the vegetation at this site presently supporting a closed-heath to closed-scrub dominated by *Dodonaea triquetra* (Common Hop Bush), *Grevillea linearifolia* (White Spider-flower) and *Hakea teretifolia* (Dagger Hakea) (Smith and Smith 2011).

The second translocation site is located on the southern side of Mona Vale Road, essentially opposite the northern site. This second site received translocated soil in August-September 2009 with the vegetation currently considered to be at an early stage of regeneration. Site vegetation comprises a sparse regenerating shrubland dominated by shrubs *Epacris pulchella*, *Grevillea linearifolia* and *Platysace linearifolia*, as well as groundcover taxa such as *Austrostipa pubescens*, *Cyathochaeta diandra*, *Entolasia stricta*, *Gonocarpus teucroides*, *Micrantheum ericoides*, *Microlaena stipoides* and *Xanthosia tridentata* (Smith and Smith 2011).

The total areal extent of this translocated community within the study area is approximately 0.5 ha.

A summary of the floristics, structure, condition and areal extent of each native vegetation community recorded by Ecosure (2015) is provided below in Table 18. A full description of the vegetation communities recorded by Smith and Smith (2011) and Ecosure (2015) within the survey area is provided in these two consultancy reports which are reproduced in this SIS as Appendix G and Appendix H.

A detailed description of the habitat, distribution, abundance and conservation status of Duffys Forest EEC is provided in Chapter 6 of this SIS.

**Table 18: Targeted vegetation types found within the subject site**

Vegetation Community	Sites	Dominant overstorey species	Dominant midstorey species	Dominant groundcover species	Average % coverage	Vegetation condition	Hectares within subject site	Significant features
Bloodwood Scribbly Gum Woodland	4, 5, 6, 7, 32	<i>Corymbia gummifera</i> , <i>Eucalyptus haemastoma</i> , <i>Eucalyptus oblonga</i>	<i>Banksia serrata</i> , <i>Leptospermum trinervium</i> , <i>Dampiera stricta</i>	<i>Entolasia stricta</i> , <i>Cyathochaeta diandra</i> , <i>Micrantheum ericoides</i> , <i>Anisopogon avenaceus</i>	Overstorey – 14% Midstorey - 8.3% Groundstorey* – 31.7%	Good	9.34	Rocky outcrop, some overhangs present in the central-northern part of the site, Low amount of fallen logs (20 m)
Duffys Forest Ecological Community - <i>Endangered</i>	8, 12, 13	<i>Corymbia gummifera</i> , <i>Eucalyptus sieberi</i>	<i>Leptospermum trinervium</i> , <i>Hakea sericea</i> and <i>Banksia ericifolia</i>	<i>Cyathochaeta diandra</i> , <i>Patersonia glabrata</i> and <i>Anisopogon avenaceus</i>	Overstorey – 22.8% Midstorey - 16.9% Groundstorey* – 29.3%	Good	3.06	Minimal surface rock, Moderate amount of fallen logs (45 m)
Duffys Forest Translocation Site	9	N/A	<i>Lepidosperma laterale</i>	<i>Gahnia sieberiana</i> , <i>Xanthosia tridentate</i> and <i>Cyathochaeta diandra</i>	Overstorey – 0% Midstorey - 6% Groundstorey* – 32%	Moderate	0.19	Very high amount of fallen logs (140 m)
Duffys Forest Disturbed	19	<i>Eucalyptus sieberi</i> , <i>Corymbia gummifera</i> and <i>Pittosporum undulatum</i>	<i>Ceratopetalum gummiferum</i> , <i>Acacia elata</i> and <i>Cyathea cooperi</i>	<i>Lomandra longifolia</i> , <i>Pteridium esculentum</i> and <i>Chlorophytum comosum</i>	Overstorey – 22.5% Midstorey - 10% Groundstorey* – 2.7%	Moderate	0.12	Moderate to high amount of fallen logs (60 m), evidence of fire in the past



Vegetation Community	Sites	Dominant overstorey species	Dominant midstorey species	Dominant groundcover species	Average % coverage	Vegetation condition	Hectares within subject site	Significant features
Peppermint-Angophora Forest	15, 16, 17	<i>Angophora costata</i> , <i>Eucalyptus piperita</i> and <i>Corymbia gummifera</i>	<i>Leptospermum trinervium</i> , <i>Ceratopetalum gummiferum</i> and <i>Banksia serrata</i>	<i>Lomandra longifolia</i> , <i>Lomandra filiformis</i> subsp. <i>filiformis</i> and <i>Xanthorrhoea arborea</i>	Overstorey – 26.2% Midstorey - 8.2% Groundstorey* – 18.2%	Good	3.64	Very steep aspect in the central-southern part of the site, rocky outcrop, overhangs and cliffs, high amount of fallen logs (94 m)
Sandstone Rocky heath	2, 3	<i>Angophora costata</i> , <i>Allocasuarina distyla</i> and <i>Allocasuarina littoralis</i>	<i>Kunzea ambigua</i> , <i>Banksia ericifolia</i> and <i>Crocea saligna</i>	<i>Lepidosperma laterale</i> , <i>Lepyrodia scariosa</i> and <i>Schoenus apogon</i>	Overstorey – 6% Midstorey - 6.1% Groundstorey* – 6%	Good	0.20	Rocky outcrop, Very low amount of fallen logs (1 m), low-moderate mosses and lichen
Sandstone heath	14	<i>Allocasuarina distyla</i>	<i>Kunzea ambigua</i> , <i>Banksia ericifolia</i> and <i>Hakea teretifolia</i>	<i>Ptilothrix deusta</i> , <i>Baeckea virgata</i> and <i>Lepidosperma laterale</i>	Overstorey – 20% Midstorey - 5% Groundstorey* – 30%	Good	0	Surface rock present
Yellow-top ash mallee	1, 10, 11	<i>Eucalyptus luehmanniana</i> , <i>Corymbia gummifera</i>	<i>Leptospermum trinervium</i> , <i>Banksia ericifolia</i>	<i>Cyathochaeta diandra</i> , <i>Anisopogon avenaceus</i> , <i>Lepidosperma laterale</i> , <i>Lepyrodia scariosa</i>	Overstorey – 13.7% Midstorey - 22.6% Groundstorey* – 33.3%	Good	1.30	Prominent rocky outcrop in the central-western part of the site, Minimal fallen logs

Source: Ecosure (2015)

## Survey results: threatened flora

### *Grevillea caleyi* (Caley's Grevillea)

The approved recovery plan for *Grevillea caleyi* (DEC 2004) provides results from a 1994 targeted survey of the species within and adjoining the current study area following a wildfire. The survey estimated population sizes and plant densities and mapped the areal extent of the following three populations of the species that occur within the study area:

- Baha'i Temple population (DEC Recovery Plan Site 5; northern and southern side of Mona Vale Road)
- Tumbledown Dick Hill population (DEC Recovery Plan Site 2; northern and southern side of Mona Vale Road)
- Terrey Hills Interchange population (DEC Recovery Plan Site 14; northern and southern side of Mona Vale Road)

A summary of the 1994 survey dataset detailed in DEC (2004) for the three populations that occur within the study area is shown in Table 19. The mapped populations of *G. caleyi* (DEC 2004) within and adjoining the study area are shown in Figure 14. The total areal extent of the three mapped *G. caleyi* populations that occur within and adjoin the study area is 12 ha. The total areal extent of the three mapped *G. caleyi* populations within the subject site is approximately 1.7 ha.

**Table 19: *G. caleyi* DEC (2004) dataset summary**

Site ID in Recovery Plan	Population estimate after fire	Density of plants	Habitat in proposal area (ha)	No. of plants potentially affected (rough estimate)
2: Tumbledown Dick Hill – north side of Mona Vale Rd	1994 – 2,878±496 35 in 100 m <sup>2</sup>	0.35/m <sup>2</sup>	Approx. 0.11	385
2: Tumbledown Dick Hill – south side of Mona Vale Rd	1994 – 1,847±301	0.29/m <sup>2</sup>	Approx. 0.67	1,943
5: Baha'i Temple – north side of Mona Vale Road	281 adults, 544 dead adults and 428 seedlings	0.07/m <sup>2</sup>	Approx. 0.6	420
5: Baha'i Temple – south side of Mona Vale Rd	1,392±193	0.12/m <sup>2</sup>	Approx. 0.32	384

Smith and Smith (2011) recorded a total of 77 live, and three dead, *Grevillea caleyi* plants within Duffys Forest EEC at the three known populations of the species (DEC 2004) within their study area. A total of 7 and 21 *G. caleyi* plants recorded by Smith and Smith (2011) occur within the current subject site and study area, respectively.

Ecosure (2015) recorded a total of 92 plants of *G. caleyi* in Duffys Forest EEC within their study at the Baha'i Temple and Terrey Hill Interchange populations. A total of 7 and 20 *G. caleyi* plants recorded

by Ecosure (2015) occur within the current subject site and study area, respectively.

A summary of SMEC's 2016 targeted *G. caleyi* surveys are shown in Table 20.

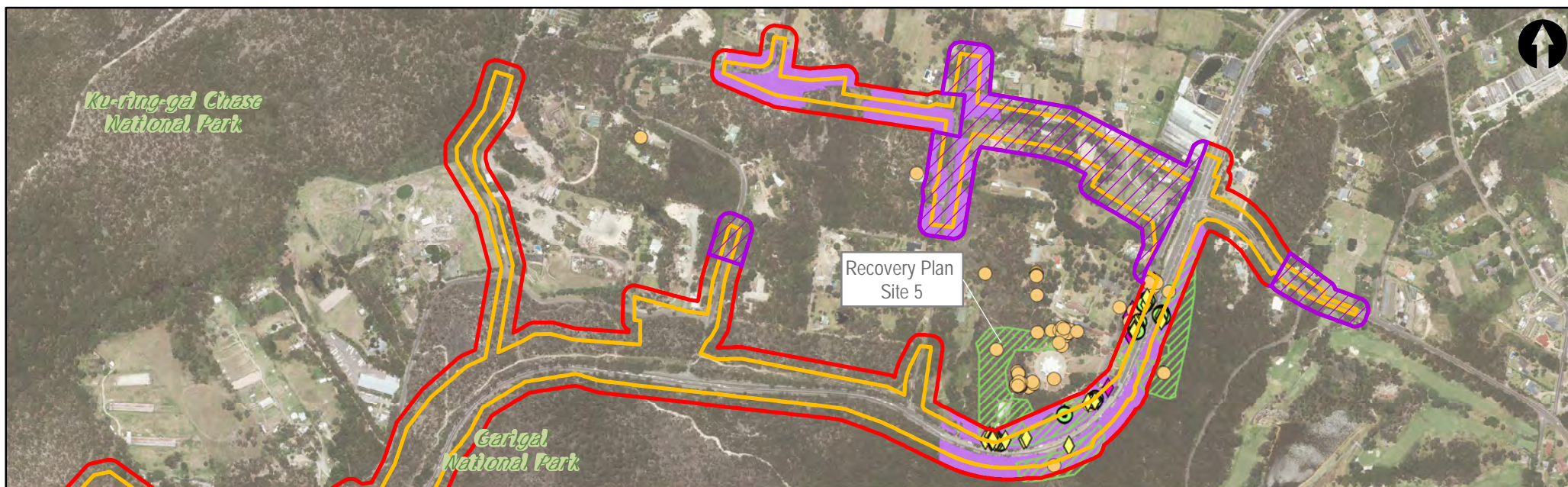
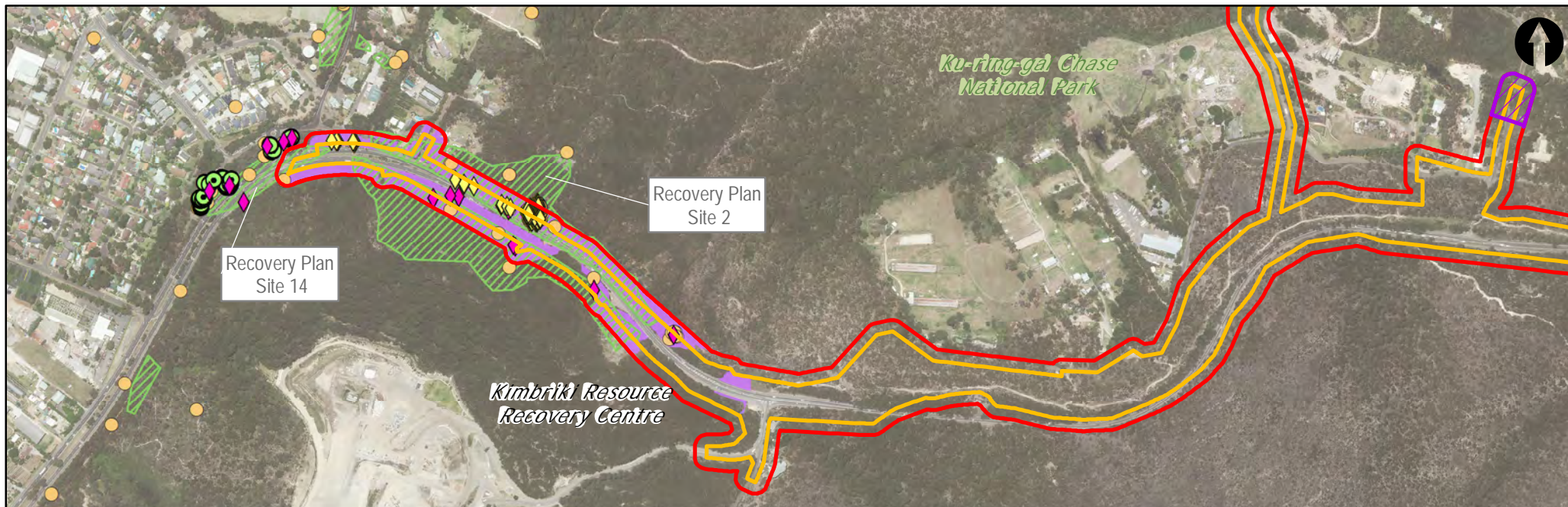
**Table 20: SMEC 2016 *G. caleyi* survey results**

Population Name	No. of above ground individuals recorded
Tumbledown Dick Hill (Recovery Plan Site 2)	218 seedlings (including 208 seedlings within a 903 m <sup>2</sup> burnt patch on the northern side of Mona Vale Road)
Baha'i Temple (Recovery Plan Site 5)	36 adults (2 dead) + 2 seedlings
Terrey Hills Interchange (Recovery Plan Site 14)	11 adults

SMEC (2016) recorded a total of 208 *G. caleyi* seedlings within a 900 m<sup>2</sup> portion of a larger 13.8 hectare patch of vegetation that was subject to a prescribed burn in August 2015 (shown on NSW RFS Fire map, Figure 22). The burn patch is situated within and adjoining the Tumbledown Dick Hill *G. caleyi* population west of Kimbriki Road on the northern side of Mona Vale Road. Using the results from the SMEC (2016) site inspection, a *G. caleyi* plant density of 0.23 plants/m<sup>2</sup> was derived based on an areal extent of the seedlings within the patch (900m<sup>2</sup>). This plant density is generally consistent with that found by DEC (2004) for the Tumbledown Dick Hill population.

SMEC (2016) recorded a total of 36 adult *G. caleyi* plants at the Baha'i Temple population, all occurring within the study area. These SMEC (2016) Baha'i temple records essentially validated the Ecosure (2015) records of the species at this population.

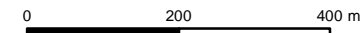




- Study Area | Revised Construction Boundary (Nov 2016)
- Construction Footprint | Revised Construction Boundary (Nov 2016)
- ◆ *Grevillea caleyi* (SMEC 2016)
- ◆ *Grevillea caleyi* (Smith and Smith 2011)
- *Grevillea caleyi* (Ecosure 2015)
- *Grevillea caleyi* (BioNet)
- Grevillea caleyi* Recovery Plan Sites
- Potential Habitat
- Not Ground Truthed Veg (16/01/2017)

***Grevillea caleyi* Records and Habitat Figure 14**

Vector base dataset RoadNet © MDS 2016





### ***Microtis angusii* (Angus's Onion Orchid)**

Four sub-populations of *Microtis angusii* were identified and mapped by the Royal Botanic Gardens (RBG) (RBG 2015) as part of detailed investigations into the ecology and genetics of the species. All four sub-populations occur within the study area at the western end (Terrey Hills), the Kimbriki Site (main or type population) and eastern sections (Tumburra Road to the Baha'i Temple), all on the northern side of Mona Vale Road. The locations of the four *M. angusii* sub-populations recorded by RBG (2015) are shown in Figure 15. All four sub-populations were recorded in exotic grassland roadside verge habitat, with the type population occurring on imported fill material.

The type location (Kimbriki Site) is located in a disturbed, open area on the northern side of Mona Vale Road opposite the Kimbriki Resource Recovery Centre. This sub-population has been undergoing monitoring since 1998 including more recently by the RBG in accordance with the National Recovery Plan for the species (DECCW 2010). Numbers are known to fluctuate considerably from year to year with a peak of 1,240 individuals recorded in 2014 (RBG 2015). Fluctuations appear to be strongly related to rainfall and soil moisture (RBG 2015). The peripheral sub-populations vary in size from one observed individual to 300 and are genetically more similar to each other than to the type sub-population (RBG 2015). RBG (2015) estimate a total *M. angusii* population size from the four sub-populations as between 1,300-1,500 individuals, with the type population accounting for approximately 90 percent of the total plant numbers.

Ecosure (2015) recorded a total of 77 *M. angusii* plants within three of the four 'peripheral' sub-populations in their study area as defined in their report. The location of *M. angusii* recorded by Ecosure (2015) within the study area is shown in Figure 15. The type population at Kimbriki Road was not included as part of the Ecosure surveys.

As part of the Ingleside Precinct Biocertification, EcoLogical Australia (2016) were commissioned to undertake targeted survey and habitat mapping of *Microtis angusii* in September and October 2015. The study area for the ELA *Microtis* survey overlaps that of the eastern half of the Mona Vale Road West study area and thus can be drawn upon for the purposes of this assessment. A total of 8,500 *Microtis* individuals were counted and classified into species based on morphology during the survey. As part of the project, leaf samples of *Microtis* individuals were obtained and submitted to the plant pathology unit of the Royal Botanic Gardens, Sydney, for genetic analysis. Key results from the ELA (2016) study are as follows:

- Four *Microtis* species were genetically confirmed from a subset of the 8,500 individuals counted, these being *M. angusii*, *M. rara*, *M. parviflora* and *M. affiliate angusii*;
- None of the samples submitted were genetically confirmed as *M. unifolia*, even though the samples submitted were initially classified as *M. unifolia* based on morphological characteristics. All these samples that were initially classified as *M. unifolia* were genetically confirmed to be *M. angusii*.

ELA (2015) also developed a habitat model for the species based on the following attributes:

#### **Habitat types having a high chance of species occurrence:**

- Sydney North Exposed Sandstone Woodland (HN566) (disturbed condition types)
- Sydney Ironstone Bloodwood Silvertop Ash Forest (HN567) (disturbed condition types)



- Coastal Sandstone Gully Forest (ME012/HN651) (disturbed condition types) vegetation communities
- 10 m buffer from the edge of the mapped polygons for vegetation communities:
  - Sydney North Exposed Sandstone Woodland (HN566) (all condition types), -Sydney - Ironstone Bloodwood Silvertop Ash Forest (HN567) (all condition types) and
  - Coastal Sandstone Gully Forest (ME012/HN651) (all condition types).

**Habitat types having a moderate chance of species occurrence:**

- Sydney North Exposed Sandstone Woodland (HN566) (non-disturbed condition)
- Sydney Ironstone Bloodwood Silvertop Ash Forest (HN567) (non-disturbed condition)
- Coastal Sandstone Gully Forest (ME012/HN651) (non-disturbed condition)

These vegetation communities are likely to represent the original vegetation that would have been present at the known orchid locations. Given the apparent preference for disturbed areas, these vegetation communities were ranked lower than the disturbed types (listed above).

**Areas with a low chance of species occurrence:** All other mapped vegetation, including areas mapped as exotic.

The vegetation communities in the low ranking have not been associated with, or do not occur adjacent to known orchid locations. However, they occur within the locality and are likely to have similar soil characteristics to the vegetation within the high and moderate potential habitats.

**Areas with very a low chance of species occurrence:** Cleared lands.

The ELA (2015) *Microtis* GIS dataset, provided to SMEC by Roads and Maritime, revealed a total of 625 *M. angusii* records within their planning precinct study area. Of these, a total of 229 *M. angusii* records were recorded in the subject site. The location of ELA's (2015) *M. angusii* records that occur in both the wider Ingleside planning precinct and the study area and subject site are shown in Figure 15.

It is also understood that additional samples of *Microtis* '*unifolia*' from other areas of NSW and Australia (including two samples from the study area collected by Ecosure) were sent to the RBG in 2015 and subject to similar genetic analysis. Most of these additional samples were also understood to be genetically confirmed as *M. angusii* (pers. comm. Greg Steenbeeke, ELA 2016).

The results associated with the Ingleside and state-wide genetic investigations would suggest that:

- *M. angusii* is much more widespread than previously thought; and
- There may not be a presence of *M. unifolia* in NSW or Australia (the type '*unifolia*' specimen was collected from the Bay of Plenty in New Zealand).

RBG (2015) note that further genetic investigations would be required to resolve the taxonomic uncertainty in relation to *M. angusii/unifolia* group. Nevertheless, the latest information known to date on the species was sufficient for the former Senior Threatened Species Officer, Greg Steenbeeke, a recognised orchid expert, to modify the Threatened Species Profile Database, to allow for the removal of a total of 150 individuals of the species per LGA as an 'able to withstand loss' attribute, based on the increased size of the known population at Ingleside.

As part of the Ingleside Planning Precinct study referred to above (ELA 2015), a total of 220 *Microtis* specimens were sent to scientific officers at the Royal Botanic Gardens (RBG), Sydney, to undergo genetic analysis. The 220 specimens that were submitted to the RBG appeared to be morphologically similar to what has been described in NSW as *Microtis unifolia*. The 220 specimens were subsequently genetically confirmed by the RBG to be *Microtis angusii*.

It is also understood that additional samples of *Microtis 'unifolia'* from other areas of NSW and Australia (including two samples from the study area collected by Ecosure) were sent to the RBG in 2015 and subject to similar genetic analysis. Most of these additional samples were also understood to be genetically confirmed as *M. angusii* (pers. comm. Greg Steenbeeke, ELA 2016).

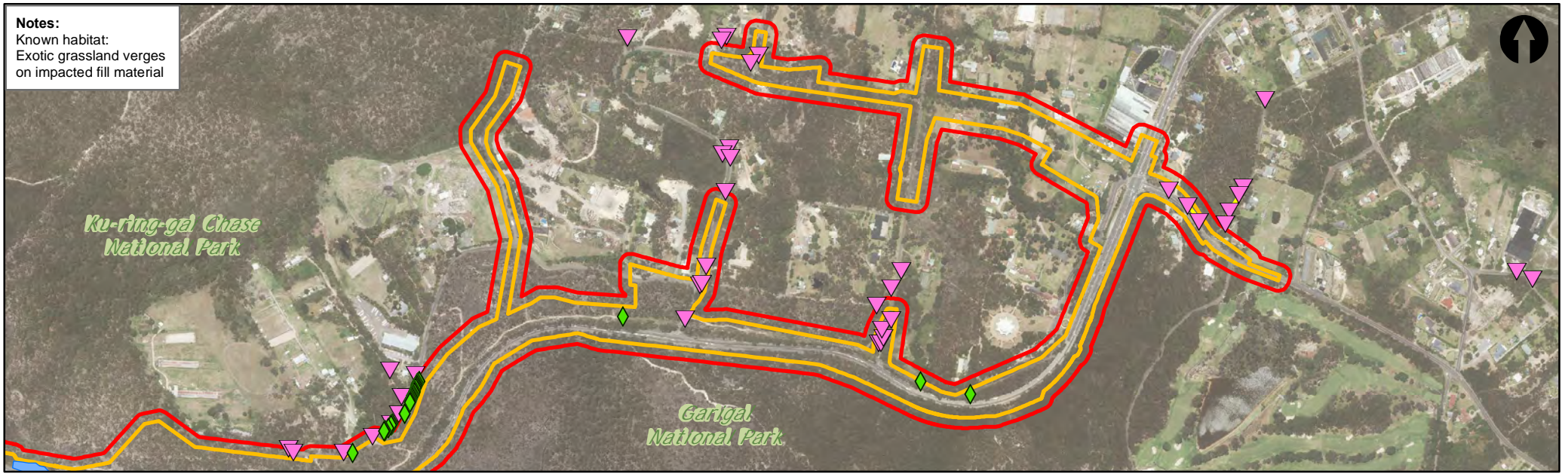
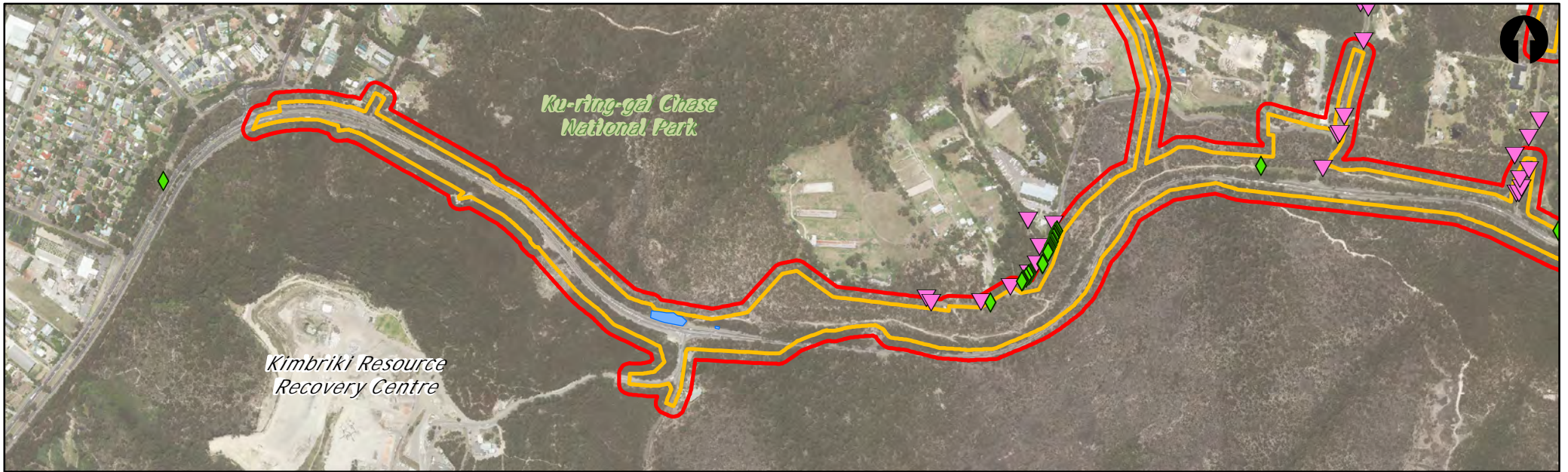
The results associated with the Ingleside and state-wide genetic investigations would suggest that:

- *M. angusii* is much more widespread than previously thought
- There may not be a presence of *M. unifolia* in NSW or Australia (the type 'unifolia' specimen was collected from the Bay of Plenty in New Zealand).

Further survey by EcoLogical indicate that the *Microtis angusii* present within and close to the study area may be a genetic variant of the more geographically widespread *Microtis uniflora*. A formal application to the Scientific Committee for delisting the threatened status of this species has been made based on the findings of genetic studies of this population. EcoLogical is currently collecting specimens for genetic analysis across New South Wales and New Zealand to assist with the application for delisting of the threatened species status.

*M. angusii* records in the study area from the relevant survey datasets are shown in Figure 15.





**Notes:**  
 Known habitat:  
 Exotic grassland verges  
 on impacted fill material

- ▭ Study Area | Revised Construction Boundary (Nov 2016)
- ▭ Construction Footprint | Revised Construction Boundary (Nov 2016)
- ◆ *Microtis angusii* Spread
- ◆ *Microtis angusii* (Ecosure 2015)
- ▼ *Microtis angusii* (Eco Logical 2015)
- ▭ *Microtis angusii* main (type) population (Smith and Smith 2011)

***Microtis angusii* Records and Habitat** Figure 15  
 Vector base dataset RoadNet © MDS 2016





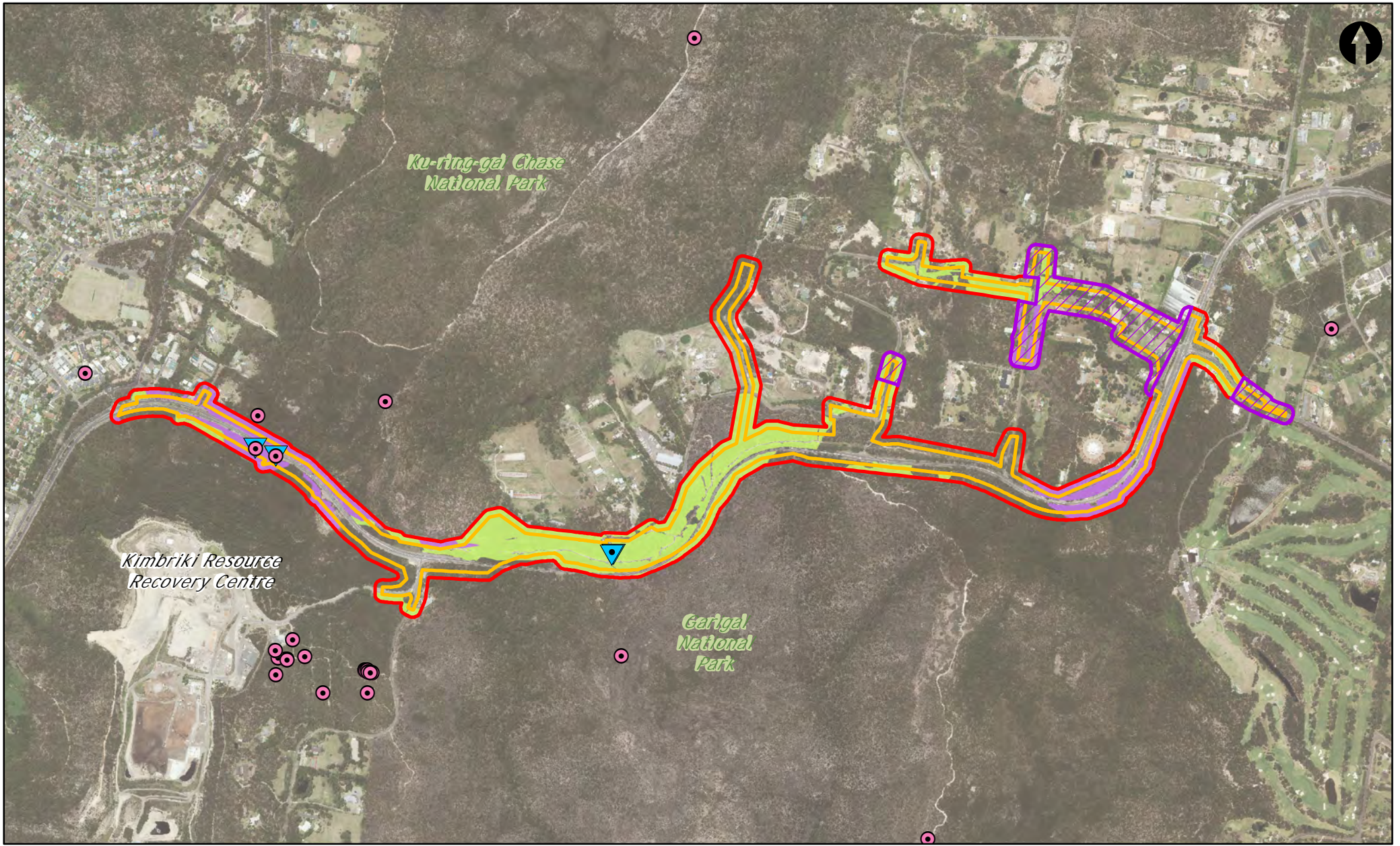
### ***Tetratheca glandulosa***

Smith and Smith (2011) recorded two plants of the threatened shrub, *Tetratheca glandulosa*, within the Bloodwood-Scribbly Gum Woodland on the northern side of Mona Vale Road within the study area. Smith and Smith (2011) noted that their flora survey was mainly carried out at a time of year when the species was not in flower (i.e. winter) and thus was a limitation to its detection. As a result of survey timing, Smith and Smith (2011) stated that it is likely that *T. glandulosa* occurs more widely in the study area than the survey results suggest. The natural year to year variability in flowering typically exhibited by this species (as well as likely fire cues needed for resprouting and germination of the soil seedbank) can also significantly affect the detectability of this species and its presence in the study area should not be discounted.

Smith and Smith (2011) also noted that the species has been recorded previously within the study area in Duffys Forest EEC on Tumbledown Dick Hill in 1996 and 1998, with the latter record comprising a population of 120 plants. The location of the Smith and Smith (2011) survey records for the species is shown in Figure 16.

*Tetratheca glandulosa* was not subsequently recorded by Ecosure (2015) within the study area, although as stated above, cannot be discounted from occurring (in the study area) due to its particular life cycle characteristics.

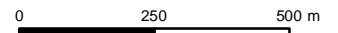




- Study Area | Revised Construction Boundary (Nov 2016)
- Construction Footprint | Revised Construction Boundary (Nov 2016)
- Tetratheca glandulosa* (BioNet)
- ▲ *Tetratheca glandulosa* (Smith and Smith 2011)
- Marginal Habitat (Bloodwood-Scribby Gum Woodland, Sandstone Rocky Heath)
- Preferred Habitat (Duffys Forest)
- Not Ground Truthed Veg (16/01/2017)

***Tetratheca glandulosa* Records and Habitat Figure 16**

Vector base dataset RoadNet © MDS 2016



Last updated by: DW13219 on 16/01/2017 at 10:21



### ***Acacia terminalis* subsp. *terminalis***

Smith and Smith (2011) tentatively recorded four plants at three locations within the study area as *Acacia terminalis* (subsp. *terminalis* or subsp. *longiaxialis*) and noted that flowers were needed to distinguish between the two subspecies. One of the plants was a seedling in the southern Duffys Forest translocation site and may have been derived from the Duffys Forest soil seedbank translocated to the site from Belrose in August/September 2009 (Smith and Smith 2011). The other three plants appear to be native to the survey area. There have been no previous records of subspecies *terminalis* within 5 kilometres of the study area (usually found very close to the sea).

Ecosure (2015) note that based on a review of the photo of the seedling contained in the Smith and Smith (2011) and based on their botanist's knowledge of the morphology of the species on the Northern Beaches, the photo specimen was confirmed as subsp. *angustifolia*. Ecosure (2015) did not record the threatened subspecies in their study.

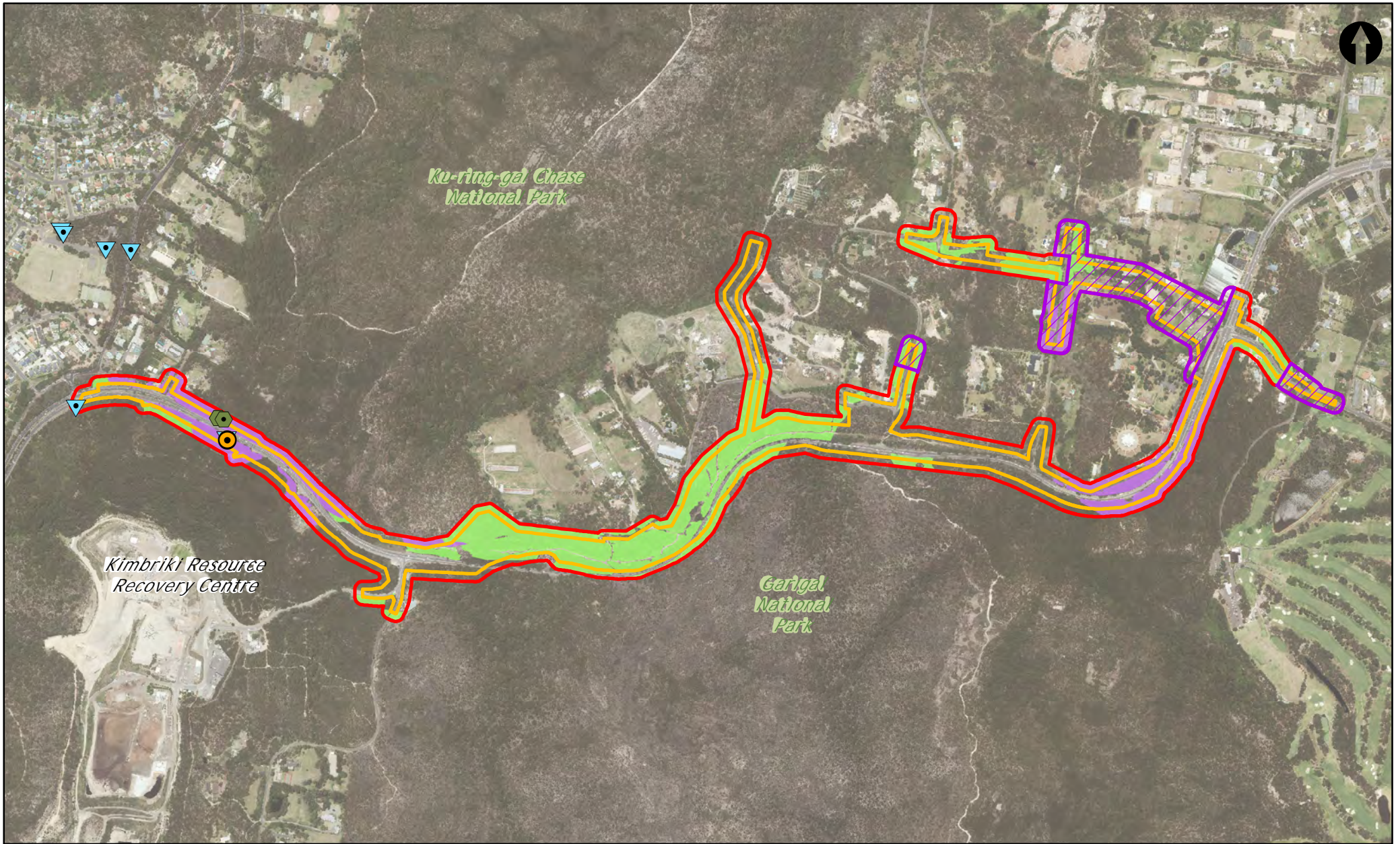
### ***Pimelea curviflora* var. *curviflora***

*Pimelea curviflora* var. *curviflora* is a threatened shrub that was not recorded by Smith and Smith (2011) in the study area. Smith and Smith (2011) note that the survey was undertaken at a time of year when the species was not in flower and thus was difficult to detect. Smith and Smith (2011) also noted that the species has been recorded previously within Duffys Forest EEC on Tumbledown Dick Hill in 1996, in the western section of the study area on the southern side of Mona Vale Road. The 1996 record did not provide any abundance data.

Ecosure (2015) did not record the species in subsequent targeted surveys and concluded the likely presence in the study area was low given that the surveys were undertaken during its known flowering period.

Opportunistic observations by SMEC identified *Pimelea curviflora* var. *curviflora* in the subject site in December 2016 (Figure 17).





Construction Footprint | Revised Construction Boundary (Nov 2016)

Study Area | Revised Construction Boundary (Nov 2016)

*Pimelea curviflora* (SMEC 2016)

*Pimelea curviflora curviflora* (Smith and Smith 2011)

*Pimelea curviflora* var. *curviflora* (BioNet)

Marginal Habitat (Bloodwood-Scribbly Gum Woodland)

Preferred Habitat (Duffys Forest Ecological Community)

Not Ground Truthed Veg (16/01/2017)

***Pimelea curviflora* var. *curviflora* Records and Habitat Figure 17**

Vector base dataset RoadNet © MDS 2016

0 200 400 m

Last updated by: DW13219 on 16/01/2017 at 10:21



## **Survey results: fauna**

### **Fauna habitat**

The study area includes a large number of rock outcrops, providing habitat for invertebrates, reptiles and mammals, among others. Ecosure identified six fauna habitat stratification units: wetland, casuarina, swamp, sandstone heath, open woodland and disturbed areas (Table 21). Within the fauna habitat stratification units, the following attributes were documented in a 10m by 50m plot:

- Rocks and boulders, rocky outcrops, exfoliating rocks and rocks with crevices
- Trees and logs with hollows: presence of senescent (old) or dead trees (stags) and trees or logs with peeling bark or loose bark (abundance)
- Estimate of habitat condition including % of shrub layer, ground cover and leaf litter (estimated % cover)
- Habitat features/critical food resources e.g. termite mounds, mistletoe (abundance)
- Presence of standing water or ephemeral waterways including wetland, riverine and groundwater springs (presence/absence)
- Significant features (e.g. hollow-bearing trees, termite mounds, seeps, nests etc.)

A total of 22 termite mounds were identified. Five of these were terrestrial termite mounds suitable for use by female Rosenberg's Goannas. Three of these had evidence of recent excavation by lizards, suggesting breeding activity. Twelve terrestrial termite mounds had been previously recorded (Smith and Smith 2011). Fauna habitats present within the study area are listed and described in Table 21.

Ecosure (2015) observed an overall low density of hollow-bearing trees and concluded this was due primarily to the shallow sandy soils, with large hollow bearing trees only occasionally found. Not all hollow-bearing trees within the study area were recorded as part of the scope of this survey, though at each fauna habitat assessment point the number of hollow-bearing trees was noted within each quadrat. The majority of sites (42 of 54) had no hollow bearing trees or only one. The highest value was seven hollow bearing trees, which occurred opposite the Baha'i Temple in an area of large, old trees. This analysis excludes the Duffys Forest Translocation Site where artificial hollows, in the form of nest boxes, are installed and therefore numbers of individual hollows are higher.

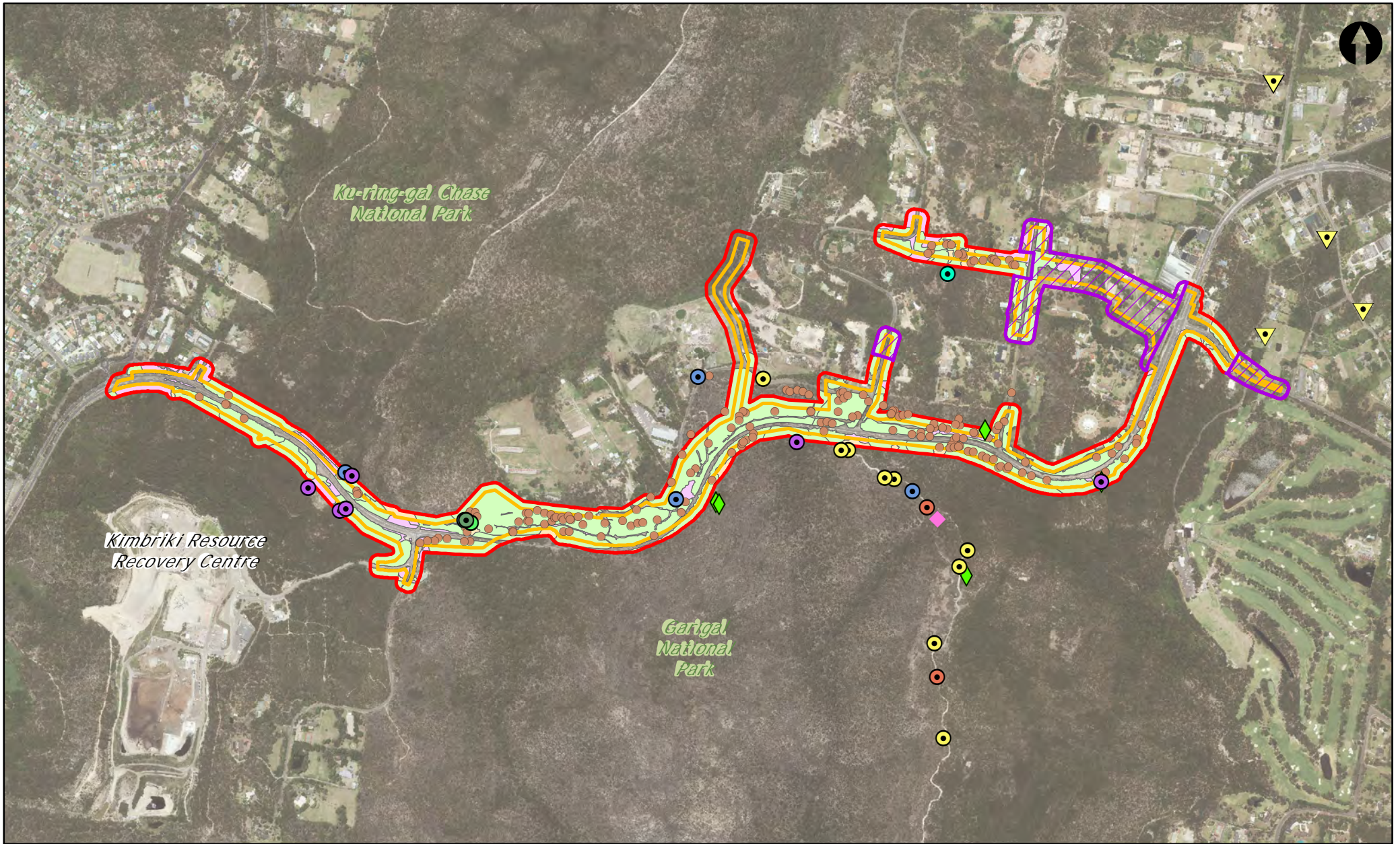
SMEC identified 135 hollow-bearing trees within the subject site including 217 hollows of varying sizes (78 small, 70 medium, 59 large and 12 extra-large). A number of trees also had fissures that may be suitable for reptiles and small mammals, including microbats.

Microbat habitat within the study area consists of Sandstone Heath, Wet Sclerophyll Forest, Open Woodland and disturbed and cleared areas. The Sandstone Heath and Open Woodland provides foraging and roosting opportunities for microbats. Hollow bearing trees were present and are likely to provide good roosting opportunities for species such as white-striped free-tail bat and large forest bat. Caves, rock overhangs and rock crevices are common in the sandstone heath habitats and may provide roosting opportunities for large-eared pied bat, although the types of caves they use are very specific and are unlikely to be present in the study area (Ecosure 2015). Other roosting opportunities are also available in buildings in the nearby residential and commercial areas for the adaptable *Nyctophilus* species. The surrounding woodland and heath provide habitat for insect prey although sandstone

heath generally has low insect biomass (Threlfall *et al.* 2013). The nearby Garigal and Ku-ring-gai Chase National Parks provide large areas for foraging. Unfortunately, large parts of the area around the proposed road upgrade site are occupied by low density housing, roads and commercial buildings. This has meant that much of the remaining habitat is disturbed through noise, lighting, people and traffic. Although some bat species will forage and roost in urban areas (e.g. White-striped Free-tail Bat (*Austronomus australis*)) others are more sensitive to increased light and noise and may be impacted by expanding human infrastructure (Threlfall *et al.* 2013).

The locations of hollow bearing trees and termite mounds recorded in the study area are shown in Figure 18.



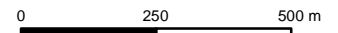


- ▼ Bats (Pittwater Council)
- ◆ Rosenberg's goanna (SMEC 2015)
- ◆ EPP captures (SMEC 2016)
- Hollow Bearing Trees (SMEC 2016)
- Study Area | Revised Construction Boundary (Nov 2016)
- Construction Footprint | Revised Construction Boundary (Nov 2016)

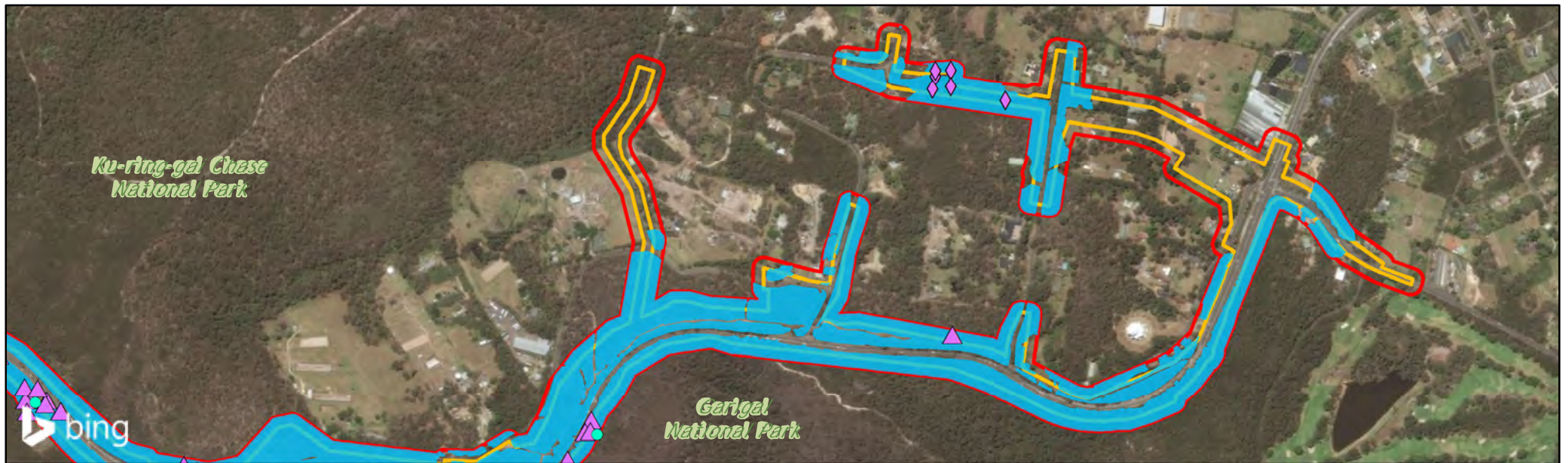
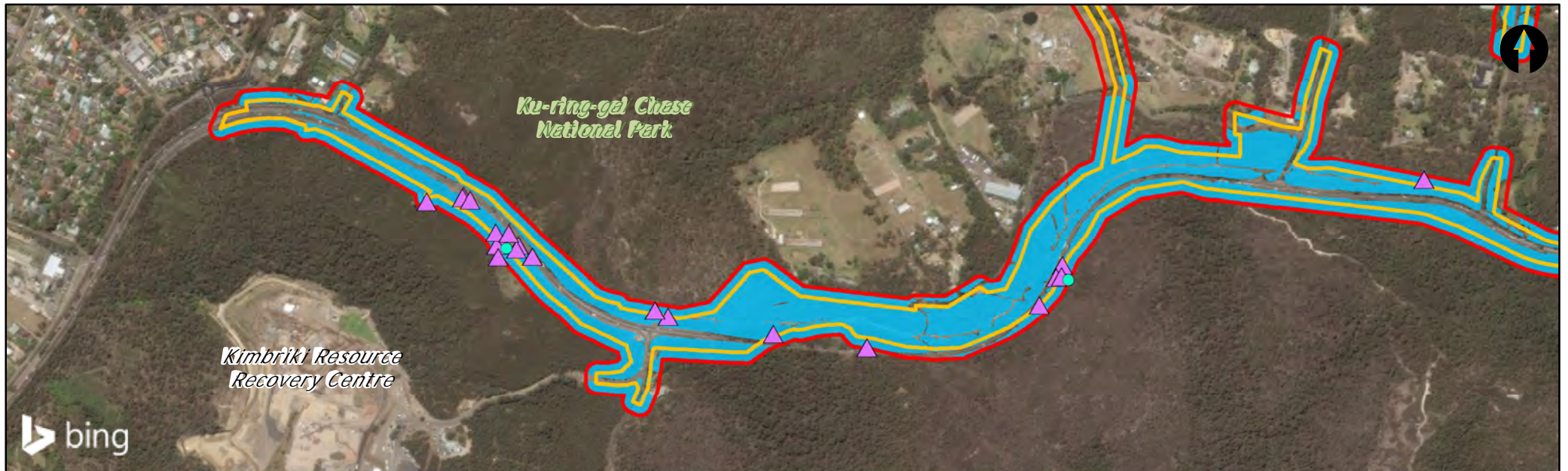
- Threatened fauna (Ecosure 2015)**
- Eastern bentwing-bat
  - Eastern pygmy possum
  - Giant burrowing frog
  - Grey-headed flying-fox
  - Heath monitor
  - Red-crowned toadlet

- Threatened fauna (SMEC 2016)**
- Red-crowned toadlet
- Habitat Type**
- Disturbed
  - Sandstone Heath
  - Open Woodland
  - Not Ground Truthed Veg (16/01/2017)

**Fauna Survey Results Figure 18**  
 Vector base dataset RoadNet © MDS 2016  
 Imagery supplied from RMS







- Study Area | Revised Construction Boundary (Nov 2016)
- Construction Footprint | Revised Construction Boundary (Nov 2016)
- Termite mound camera (SMEC)
- ◆ Terrestrial termite mound (SMEC)
- ▲ Terrestrial termite mound (Ecosure)
- Potential Goanna Habitat

**Goanna Habitat Mapping and Existing Termite Mounds Figure 19**

Vector base dataset RoadNet © MDS 2016

0 200 400 m

Last updated by: DW13219 on 13/01/2017 at 16:40

**Table 21: Summary of fauna habitats present within the study area**

Fauna habitat type	Description (Ecosure 2015)	Main areas within study area	Area within subject site (ha)	Significant fauna species detected during current surveys (Ecosure)
Wetland	Dam on private property	On private land unlikely to be impacted	-	Not investigated further
Casuarina	Grove of casuarina trees within open woodland areas		-	May be occasionally utilised by glossy black cockatoos (located within the local area, but not within the current study area)
Open Woodland	Mixed species of eucalypt, including silvertop ash, red bloodwood and broad-leaved scribbly gum and small sections of smooth-barked apple. Mid storey and ground cover often containing heath species, especially heath-leaved banksia and tea tree. Trees with hollows are not common, due to the lack of soil nutrition and subsequent slow growth of the trees within this area. Mistletoe rarely encountered. Sections of <i>Allocasuarina distyla</i> .	Throughout	17.6	Giant Burrowing Frog, Rosenberg's Goanna and Red-crowned Toadlet, Powerful Owl, Glossy Black-cockatoo, Eastern Pygmy-possum.
Sandstone Heath	Occasional eucalypt species as emergents, especially red bloodwood, broad-leaved scribbly gum and stringybark. Sub-canopy and mid-storey dominated by heath-leaved banksia, slender tea-tree, hakeas and conesticks. Dense shrub in some areas. Subject to burning, surrounding rock plateaux in a small number of areas. Rock outcrops common. Hollow-bearing trees absent or uncommon.	Limited in this section of the road. Patches throughout extent of study area.	0.20	None, but likely to be foraging habitat for Eastern Pygmy-possum and Rosenberg's Goanna.

Fauna habitat type	Description (Ecosure 2015)	Main areas within study area	Area within subject site (ha)	Significant fauna species detected during current surveys (Ecosure)
Disturbed	Cleared areas with little or no remnant vegetation. Occasional paddock trees may have been kept after clearing. Planted native, but not indigenous trees also present. Non-native pasture, weeds and/or cement constitutes the ground layer of this community.	Patches throughout, especially either end of concept design footprint	1.54	None

Note: Table modified from Ecosure 2015. Swamp habitat no longer considered as part of the study area



A total of 104 vertebrate fauna species were confirmed during surveys (Table 22; full list in Appendix G). These were within the three main fauna habitats (open woodland, sandstone heath and disturbed) found to be present within or immediately surrounding the study area. Four additional microbat species possibly occur, based on echolocation call analysis, but were not confirmed (see below for further details on these species).

**Table 22: Summary of fauna species detected during surveys**

Taxa	Number of species detected during surveys
Amphibians	8**
Birds	73
Bats	8*
Non-flying mammals	5
Reptiles	7+
Total	108 (104 confirmed)

\*1 definite threatened species, 3 definite common species, 4 possible species and one species group (See 4.2 for more information)

\*\*two threatened species, +one threatened species.

### Rosenberg's Goanna

The Rosenberg's goanna (*Varanus rosenbergi*) was recorded during surveys by SMEC (2016) and Ecosure (2015) in woodland to the north of Mona Vale Road and heath to the south (Figure 18). Numerous termite mounds exhibiting signs of nesting by a varanid lizard were also found in woodland habitat close proximity to the existing road (Figure 19).

### Giant Burrowing Frog

Two individuals of the Giant Burrowing Frog were located in Garigal National Park on 19 February 2014 along the Caley Track, which passes through heath and woodland habitat (Figure 20) (Ecosure 2015). One was recorded approximately 150 metres south of the study area and the other approximately 575 metres south of the study area within Garigal National Park.

### Red crowned Toadlet

Along the same Caley track as noted above, the Red-crowned Toadlet was heard to the south of the study area, in a sandstone seep along the Caley track in Garigal National Park (Figure 20). The Red-crowned Toadlet was also heard calling near Wirreanda Road (Ecosure 2015). In July 2016 the Red-crowned Toadlet was heard calling between Harvey Road and Addison Road within cracks of a sandstone rock platform adjacent to the proposal.

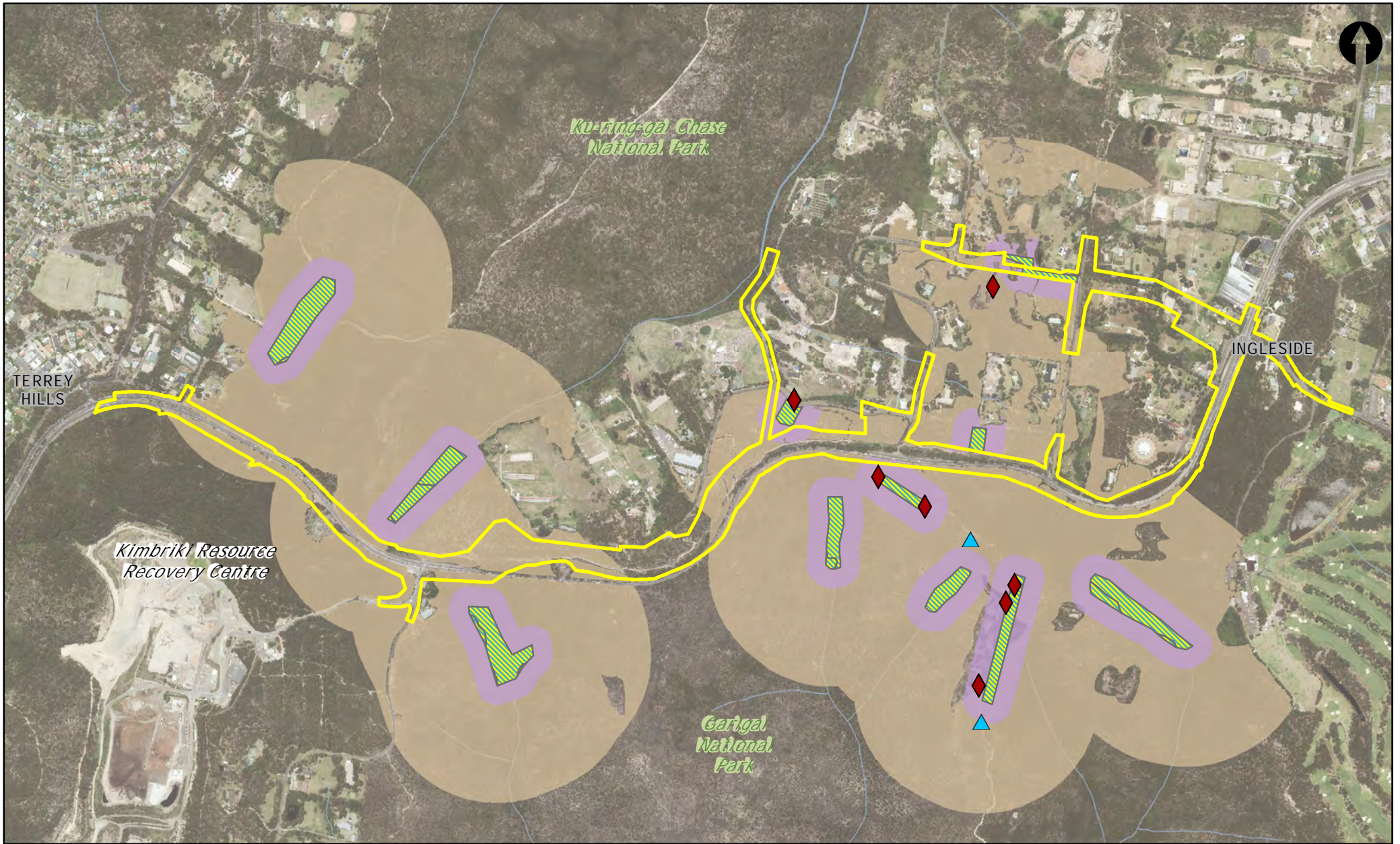
## Threatened Microbats

A number of possible calls from the EPBC Act-listed Large-eared Pied Bat (*Chalinolobus dwyeri*) were recorded within the road corridor, but the duration and quality were not sufficient to positively confirm its presence. Eastern Bentwing-bat (*Miniopterus oriana oceanensis*), listed as Vulnerable under the TSC Act, was one of the four species positively identified from call analysis (Figure 18).

**Table 23: Microbat species recorded by ultrasonic detection (Ecosure 2015)**

Species name	Common name	Status under TSC Act	Status under EPBC Act	Accuracy of identification based on call
<i>Austronomus australis</i> (previously <i>Tadarida australis</i> )	White-striped free-tail bat	-	-	Definite
<i>Chalinolobus dwyeri</i>	Large-eared pied bat	V	V	Possible
<i>Chalinolobus gouldii</i>	Gould's wattled bat	-	-	Definite
<i>Chalinolobus morio</i>	Chocolate wattled bat	-	-	Definite
<i>Miniopterus oriana oceanensis</i>	Eastern bent-wing bat	V	-	Definite
<i>Mormopterus ridei</i>		-	-	Possible
<i>Nyctophilus</i> sp. or <i>Myotis</i>		Unknown	Unknown	Possible (species in these genera cannot be distinguished by calls)
<i>Vespadelus darlingtoni</i>	Large forest bat	-	-	Definite (captured by harp trap)
<i>Vespadelus pumilus</i>	Eastern forest bat	-	-	Possible
<i>Vespadelus regulus</i>	Southern forest bat	-	-	Possible
<i>Vespadelusroughtoni</i>	Eastern cave bat	V	-	Possible
<i>Vespadelus vulturnus</i>	Little forest bat	-	-	Possible





- ▲ Giant burrowing frog
- ◆ Red-crowned toadlet
- Construction Footprint | Revised Construction Boundary (Nov 2016)
- Breeding habitat (RCT & GBF)
- Non-breeding habitat (Red-crowned toadlet)
- Non-breeding habitat (Giant burrowing frog)

**Red Crowned Toadlet and Giant Burrowing Frog Habitat and Records Map Figure 20**

Vector base dataset RoadNet © MDS 2016

0 250 500 m

Last updated by: DW13219 on 12/01/2017 at 16:39

## Eastern Pygmy-possum

Seventeen Eastern Pygmy-possums were recorded from May 2014 to January 2015 within the study area. One animal was trapped during targeted trapping surveys in May 2014, two individuals were spotlighted during that period, and the remainder were found in nest boxes in May 2014, June 2014 and January 2015 (Figure 21).

During May surveys, one box in open woodland was found to be used by an adult female and her six dependent young. The young were fully furred but based on the condition of the female's mammary glands, were still not weaned. The female had installed a significant amount of nesting material in the nest box. The nest box was very close to the existing road (less than 10 metres away) in the Duffys Forest Translocation Site (open woodland). This community had few large trees with hollows.

Several of the other boxes showed signs of previous occupation. One box had a significant amount of small, green non-eucalyptus leaves (which are consistent with occupation by Eastern Pygmy-possum (Law 2014)). Scats at some of the other nest boxes suggest that Brown Antechinus (*Antechinus stuartii*) may have been using the boxes as well. Although nesting material for this species (dead eucalypt leaves), was not found.

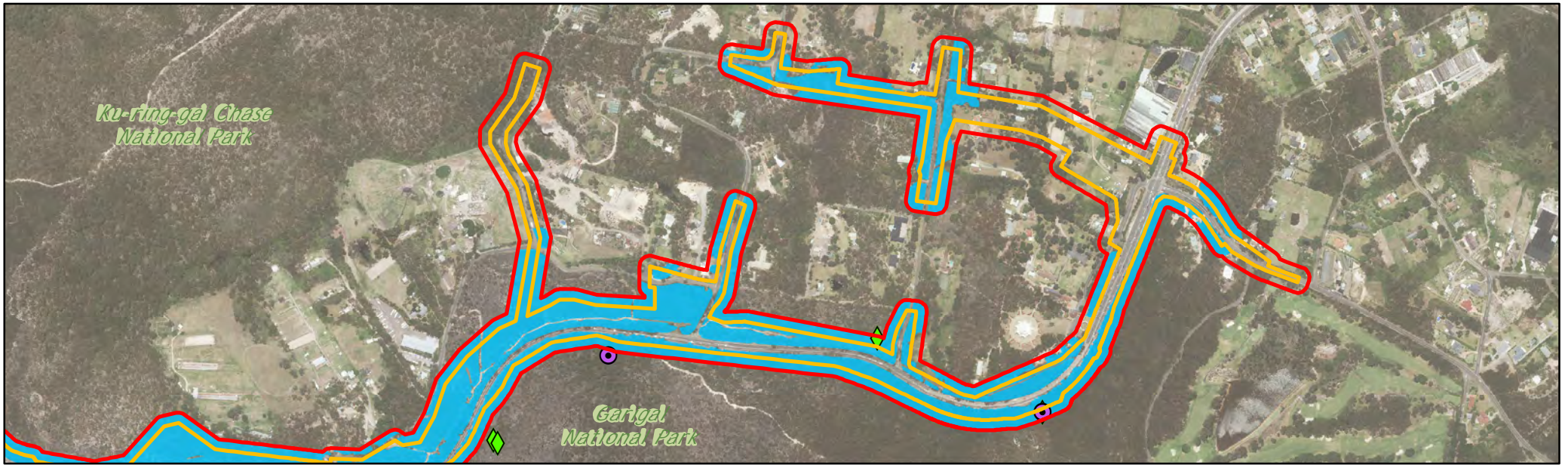
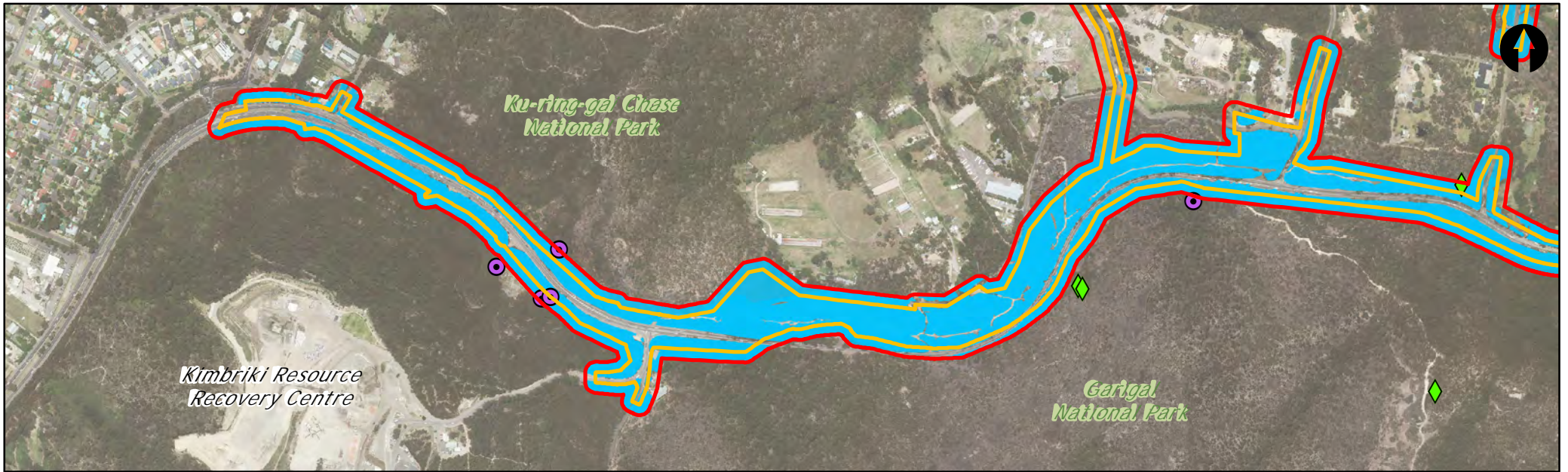
Nest box surveys and trapping undertaken by SMEC between October 2015 and January 2016 identified a total of 22 individuals.

## Southern Brown Bandicoot

No individuals of the Southern Brown Bandicoot were recorded during the Ecosure or SMEC supplementary surveys.

Although the Southern Brown Bandicoot was not identified during recent surveys, there are recent records of the species at Bobbin Head and West Head in Ku-ring-gai Chase National Park. Intensive trapping to the south of the subject site in Garigal National Park has not detected the species since 2000 (Ecosure 2015). Suitable habitat for this species occurs in the locality within both National Parks and some private property. The species is naturally rare and a lack of knowledge regarding population size, dynamics and importance of difference habitat types has been acknowledged (DEC 2006).





Study Area | Revised Construction Boundary (Nov 2016)

Construction Footprint | Revised Construction Boundary (Nov 2016)

Eastern Pygmy Possum (Eclosure)

Eastern Pygmy Possum Capture Location (SMEC)

Potential/Known Habitat

**Eastern Pygmy-Possum Records and Habitat Map Figure 21**

Vector base dataset RoadNet © MDS 2016  
Imagery Supplied from RMS

0 150 300 m

Last updated by: DW113219 on 13/01/2017 at 17:12



## 4.3 SPECIFIC SURVEY REQUIREMENTS

In addition to the survey results reported above, the Director General's Requirements (DGRs) outline specific survey requirements (Section 4.3 of the Director General's Requirements). These specific requirements are reported in this Section (Section 4.3).

### 4.3.1 *Endangered Ecological Communities*

The DGRs state that Duffys Forest Ecological Community must be surveyed documented and mapped in accordance with sections 2, 4 and 6.2 of the requirements. Ecosure (2015) carried out detailed surveys of the vegetation within the survey area of approximately 108 hectares, primarily on either side of the current Mona Vale Road alignment. These surveys included plot and transect and full floristic surveys (survey design detailed in Section 4.2.2, plot data is provided in Appendix E and flora species recorded are listed in Appendix H and results summarised in Section 4.2.5.1) and produced updated ground-truthed vegetation mapping (see Figure 9). Three plot and transect and full floristic plots were completed in the mapped Duffys Forest EEC, one in the Duffys Forest Translocation Site and one in the Duffys Forest disturbed vegetation (which exceeds the survey requirements specified by BBAM 2014). The results of these surveys are summarised in Table 18 (in Section 4.2.5.1).

### 4.3.2 *Flora Species*

Specific survey requirements were identified in the DGRs for four threatened flora species: *Grevillea caleyi*, *Microtis angusii*, *Pimelea curviflora* var. *curviflora* and *Tetratheca glandulosa*.

Caley's *Grevillea* and Angus's Onion Orchid were detected during field surveys for this proposal in October 2013 and September 2014. *Pimelea curviflora* var. *curviflora* was identified in the study area in December 2016. The remaining species has a low likelihood of occurrence based on the results of extensive field surveys (Appendix C).

#### ***Grevillea caleyi* (Caley's *Grevillea*)**

Caley's *Grevillea* is known to occur within the study area along Mona Vale Road, adjacent to the Baha'i Temple (Figure 14). Twenty-nine plants were found on ironstone laterite in multiple patches of Duffys Forest Endangered Ecological Community (EEC) in the far eastern and far western part of the study area as well as in the Bloodwood Scribbly Gum Woodland in the far eastern part of the study area. In addition to these findings, Smith and Smith (2011) recorded Caley's *Grevillea* in multiple locations throughout the Duffys Forest EEC in the central-eastern part of the study area (Table 19 and Table 20).

Targeted searches were undertaken by SMEC in 2016 and all *G. caleyi* individuals recorded were geo-referenced by a SMEC registered surveyor to sub-metre accuracy.

#### ***Microtis angusii* (Angus's Onion Orchid)**

Angus's Onion Orchid (listed as endangered under EPBC and TSC Acts) was, until three years ago, only known to occur in imported fill on the northern side of Mona Vale Road, opposite Kimbriki Road, Ingleside. During random meander surveys during October 2013 and September 2014, many more *Microtis* species including the threatened *Microtis angusii* were found along Mona Vale Road (Figure 15) (Ecosure 2015). Locations of *Microtis angusii* are mapped on Figure 15.

GIS vegetation mapping and *Microtis* records provided with the Biocertification assessment of the Ingleside Planning Precinct, prepared by EcoLogical Australia (ELA 2015), was also considered in the preparation of the SIS. The ELA study area comprised the wider Ingleside locality and included the eastern half of the SIS study area (west to Kimbriki Rd).

This dataset was drawn upon predominantly to obtain distribution and abundance data for the endangered orchid, *Microtis angusii*.

### ***Pimelea curviflora var. curviflora***

Targeted random meander surveys for *Pimelea curviflora var. curviflora* were undertaken through suitable vegetation types in September, October and December 2013. No individuals of this species were recorded during these surveys. In December, two individuals were identified in the west of the study area that had been subject to a hazard reduction burn in August 2015. Previous records and habitat mapping are shown on Figure 17.

### ***Tetratheca glandulosa***

Targeted random meander surveys for *Tetratheca glandulosa* were undertaken through suitable vegetation types in September, October and December 2013, September 2014 and January 2015. No individuals of this species were recorded. Previous records and habitat mapping are shown in Figure 16.

## **4.3.3 Fauna Species**

In addition to any surveys carried out to assess the subject species, the following targeted surveys were undertaken in accordance with the DGRs:

### ***Microchiropteran bats***

Six echolocation call devices (Songmeter 2+ and Anabat 2) were placed in areas of potentially high bat activity across the study area, sampling woodland, heath and disturbed habitats (Figure 18). Calls were downloaded and converted to Anabat call sequence files and preliminary sorting and identification was carried out by the field team. The files were then sent to bat specialist, Greg Ford for confirmation of call identification. All calls were analysed using AnaLookW (Corben 2013) with a generic filter applied to exclude poor quality calls unsuitable for identification and noise. Calls with fewer than four clearly defined non-fragmented pulses were also excluded from analysis. Identification of species was carried out by comparing to regional reference calls and published descriptions (Pennay *et al.* 2004).

Six harp traps were placed in suitable flyways to sample the length of the study area (clearings/tracks in open woodland habitats determined (excluding “disturbed” areas)). Traps were checked each morning between 05:00 and 07:00 and were then moved or dismantled to prevent bycatch during the day (e.g. birds), before being reset in the evening.

Diurnal active searches were undertaken by Ecosure (2015) and included crevices and under bark to detect roosting bats. In addition, opportunistic searches of rock overhangs for roost and maternal sites of cave-dwelling bats were undertaken by SMEC during spring and summer surveys. As these surveys were undertaken during appropriate survey periods, they are considered to have adequately met the

survey requirements for microbats outlined in the DGRS.

### ***Eastern Pygmy-possum***

Eastern Pygmy-possum surveys were undertaken to determine the importance of individuals within the proposal area to the ongoing/long-term survival of the population that occupies the study area. This included collecting data to gain a better understanding of the movements of individuals across the existing road. The surveys were also undertaken to determine the importance of the habitat present in the study area and the availability of similar habitat in the wider locality to determine the impact on the species and population if this habitat is to be removed.

SMEC's investigations included a mark recapture survey undertaken over spring/summer 2015 (October 2015 to January 2016). This was undertaken via inspection of 14 nest boxes previously installed in the Mona Vale Road West study area, 14 nest boxes previously installed within the Mona Vale Road East study area and an additional 28 nest boxes installed by SMEC in September 2016 for this survey. Boxes installed in nearby bushland by Pittwater Council were also checked where possible. In July 2016 a further ten nest boxes were installed by SMEC in suitable Eastern Pygmy-possum habitat between Harvey Road and Addison Road.

In addition to the nest box inspections, an initial two week intensive survey was undertaken between 19 October and 30 October 2015 to increase the trapping probability of individuals at the beginning of the survey. This included five days and four nights of Elliot A traps attached to *Banksia* species around the nest box locations (total 480 trap nights). Traps were baited with peanut butter, rolled oats and honey. A diluted honey mixture was sprayed around the traps.

All individuals captured were fitted with a Trovan ID100 microchip with a unique identification number. The following details were recorded for all individuals captured:

- Microchip number and date inserted (if new individual)
- Location of capture
- Weight to nearest 0.5g
- Caudal fat index (as described by Bladon *et al.* 2002)
- Sex
- Presence and type of parasites
- Breeding condition
  - Females – examining pouches for young, enlarged nipples etc, record the number and size of young
  - Males – length and width of testes (use testis index of Ward 1990)
- Age class (using weight and reproductive criteria, following Ward 1990)

DNA was collected during the surveys by taking a small ear notch with a hole punch followed by the application of antiseptic liquid on the ear margin. Collected samples were stored in ethanol in plastic vials. Samples were sent to the Australian Museum for analysis.



### ***Southern Brown Bandicoot***

The Southern Brown Bandicoot surveys were undertaken to identify habitat use on both sides of the road and determine if the species is crossing the road.

Remote infrared camera trapping was completed over a nine week period during spring and summer in 2015 (13/14 October to 21 December 2015). Trap locations extended to a 500 metre buffer perpendicular to both sides of the existing Mona Vale Road, in suitable habitat. Consistent with the amended DGRs, the Commonwealth Draft Referral Guidelines for the Southern Brown Bandicoot were used to determine survey effort within the study area. This consisted of 22 cameras, spaced 200-300 metres apart, within the 220 hectares of habitat up to the 500 metre buffer (Figure 12). Cameras (PC900 HyperFire, Reconyx) were set to take five images with no delay.

Bait consisted of a basic bait mix (rolled oats and peanut butter) and sesame oil. Additional oil was sprinkled around the camera traps as an attractant. Each camera was rebaited twice during the survey period (November and December).

Data collected by Ecosure from five infrared cameras deployed during 2014 surveys was also considered.

### ***Rosenberg's Goanna***

Mapping of termite mounds within the study area was previously undertaken by Ecosure. SMEC inspected these termite mounds and where appropriate and deemed to be in use, infrared cameras (PC900 HyperFire, Reconyx) were set up to detect use during the egg laying season (spring/summer). One camera was left in place for 68 days (October to December 2015). Another camera was set up for a period of 30 days (October to November). It was removed earlier as a result of security risks due to close proximity to the road.

### ***Red-crowned Toadlet***

SMEC undertook habitat mapping within the study area (in drainage lines, upland swamps and soaks) and downstream areas. Habitat mapping also included any areas that would receive runoff from the study area and that could be indirectly affected, as well as areas considered to be non-breeding habitat. Previous data collected by Ecosure (2015) on habitat features suitable for the Red-crowned Toadlet was incorporated into the assessment. No formal census was conducted in line with the approved alternative survey guidelines received from OEH on 21 July 2015, however opportunistic recordings have been included in the assessment of this species.

### ***Giant Burrowing Frog***

SMEC undertook habitat mapping within the study area (in drainage lines, upland swamps and soaks) and downstream areas that may provide suitable habitat. Habitat mapping also included any areas that would receive runoff from the proposal area and that could be indirectly affected as well as areas considered non-breeding habitat. Previous data collected by Ecosure (2015) on habitat features suitable for the Giant Burrowing Frog was incorporated into the assessment. No formal census was conducted in line with the approved alternative survey guidelines received from OEH on 21 July 2015.

## 5 ASSESSMENT OF LIKELY IMPACTS ON THREATENED SPECIES AND POPULATIONS

### 5.1 ASSESSMENT OF SPECIES LIKELY TO BE AFFECTED

The DGR's specified 23 fauna species, 11 flora species, one endangered population and two endangered ecological communities were to be considered for inclusion in the list of subject species for assessment by this SIS. Details of how these species, populations and communities were considered (and how other species, population and communities were also selected for consideration) in relation to potential impacts are outlined below.

#### 5.1.1 Flora Species

Database searches and relevant reports and studies identified 43 threatened flora species with known populations within a 10 kilometre radius of the site (Section 3.2.2). An assessment of the likely occurrence of these within the study area identified 10 species with a moderate or high likelihood of occurrence (Table 24). Two species, *Grevillea caleyi* and *Microtis angusii*, have known extant populations and three species (*Pimelea curviflora* var. *curviflora*, *Tetratheca glandulosa* and *Persoonia hirsuta*) have been recorded from the study area previously. The location of threatened species records within the study area is shown in Figure 17. Records and habitat of those subject species recorded within the study area are shown in (Figure 14, 15, 16 and 17). Three species, *Acacia bynoeana*, *Callistemon linearifolius* and *Darwinia biflora* have a moderate probability of occurrence based on a consideration of local records and/or suitable habitat being present. Thus subject flora species for the purpose of this SIS (based on the species specified in the Director General's Requirements and a consideration of previous records and habitat, vegetation and habitat mapping and surveys undertaken) are identified and summarised in Table 24.

**Table 24: Flora subject species summary**

Name	Presence within study area	Targeted survey	Known or predicted location in study area	Notes
<i>Acacia bynoeana</i>	None	No	Potentially in any of the drier heath & woodland mapped communities	Tiny wattle that is easily missed even when flowering
<i>Acacia terminalis</i> subsp. <i>terminalis</i>	Tentative id (2011) some plants since identified as ssp. <i>angustifolia</i>	Yes	Potentially in any of the mapped heath and woodland communities	Can be confused with non-listed subspecies
<i>Callistemon linearifolius</i>	None but record from Mona Vale Road East (2014), about 1.5km from study area	No	Potentially in the mapped open-forest communities	Larger plant but flowers Oct-Nov outside of main survey periods

Name	Presence within study area	Targeted survey	Known or predicted location in study area	Notes
<i>Darwinia biflora</i>	None	No	Potentially in any of the mapped communities except Upland Swamp	Small plant with numbers declining as taller vegetation regenerates
<i>Genoplesium baueri</i>	None	Yes	Woodland & sparse forest	Cryptic species
<i>Grevillea caleyi</i>	77 plants – 2011 and 29 plants – 2014 (recorded in subject site)	Yes	Duffys Forest EEC & Bloodwood-Scribbly Gum Woodland	Easily identified without flowers
<i>Microtis angusii</i>	Yes, 1240 counted in 2014 but varies from year to year (RBG 2015)	Yes	Disturbed areas	Well surveyed
<i>Persoonia hirsuta</i>	1994 record from Tumbledown Dick Hill but since destroyed, 1 record from Baha'i Temple (Scott et al 1995, Smith & Smith 2000).	Yes	Potentially in the heath and woodland	Although a larger species it often occurs as 1 or few plants and is difficult to see particularly in denser vegetation
<i>Pimelea curviflora</i> var. <i>curviflora</i>	Yes, 1996 (unknown number) Also record in 2007 close to study area at Ingleside Two individuals recorded Dec 2016.	Yes	Duffys Forest EEC, Western end on southern side (1996) and northern side (2016)	Cryptic species even when flowering as often hidden among taller grasses and herbs; often not visible above ground
<i>Tetradlea glandulosa</i>	Found western end on south side (1996-1998) & just south of Wirreanda Road (2011)	Yes	Duffys Forest, Bloodwood-Scribbly Gum Woodland, Heath	Visibility and flowering reduced among denser vegetation, needs open conditions

### **Threatened flora subject species recorded from the study area**

*Grevillea caleyi* and *Microtis angusii* have known extant populations within the study area and both species have a high potential of being impacted by the proposal. *Pimelea curviflora* var. *curviflora* was also identified in the study area in December 2016. *Tetradlea glandulosa* and *Persoonia hirsuta* have previously been recorded from the study area and although not encountered in the 2014-15 survey

may still persist as plants, rootstock or seed in the soil seed bank. These three species can be cryptic even when in flower and visibility or numbers affected by habitat conditions, particularly denser vegetation in the absence of fire.

### ***Threatened flora subject species not previously recorded from the study area***

The following are subject species not recorded from the site but with moderate probability of occurring are discussed further below.

#### ***Acacia bynoeana* (Tiny Wattle)**

Although there are few local records *Acacia bynoeana* it is included as a subject species on the basis that potential habitat occurs though the study area, it is a very small and cryptic plant, occurs in small populations and is easily missed particularly in the absence of targeted survey.

#### ***Acacia terminalis* subsp. *terminalis* (a Sunshine Wattle)**

Smith and Smith (2011) noted that a few plants within the study area were different to the others (subsp. *angustifolia*) and keyed out to subsp. *terminalis* or subsp. *longiaxialis* (presumably due to the presence of hairy branches). It is noted that the latter subspecies has not previously been recorded from this far south with its southern limit on the Central Coast. The conclusion made in the Ecosure report (2015) that these specimens are just subsp. *angustifolia* is questionable as the presence or absence of hairs on the branches is an easy character to observe. The SIS adopts the precautionary principle and assumes that the hairy plants observed by Smith & Smith (2011) were most likely to have been *Acacia terminalis* subsp. *terminalis*. In the absence of further targeted survey, the report assumes that these plants persist in the study area either as plants or seed.

#### ***Callistemon linearifolius* (Netted Bottlebrush)**

A larger shrub (3-4 m tall) *Callistemon linearifolius* is most easily reliably recognised when flowering in October-November. No surveys undertaken by Smith & Smith (2011) and Ecosure (2015) targeted this species during the flowering period. Due to the lack of previous targeted survey, presence of habitat within the study area and a recent sighting (2014) from along Mona Vale Road within a few kilometres of the study area, this species is included as a subject species.

#### ***Darwinia biflora***

A small shrub to c. 80 cm high that can be difficult to see in areas of taller vegetation with populations also known to decline in such conditions. The presence of suitable habitat throughout most of the study area and a relatively high frequency of records (81) within 10 kilometres indicates a reasonable likelihood of occurrence. *Darwinia biflora* was not identified as a potential species in Ecosure (2015) or Smith & Smith (2011) and consequently targeted survey was only undertaken in January 2016 (SMEC).

#### ***Genoplesium baueri***

A small orchid species found in woodland and sparse forest. Although there has been targeted survey (not found) it is included due to its cryptic, short-lived nature and the occurrence of 41 records within 10 kilometres of the study area.



### 5.1.2 Fauna Species

Database searches and relevant reports and studies identified 102 threatened fauna species with potential to occur within a 10 kilometres radius of the site. An assessment of the likely occurrence of these within the study area identified 12 species with a moderate or high likelihood of occurrence (Appendix C).

**Table 25: Fauna subject species summary**

Name	Presence within study area	Targeted survey	Know or predicted location in study area	Notes
Giant Burrowing Frog	Recorded by Ecosure (2015) on Caley Trail	Yes	Breeding habitat in ephemeral drainage lines. Non-breeding habitat within 500 m of breeding habitat.	Cryptic species
Red-crowned Toadlet	Recorded by Ecosure (2015) and by SMEC in 2016 on Caley Trail, Wirreanda Road and near Harvey Road	Yes	Breeding habitat in ephemeral drainage lines. Non-breeding habitat within 50 m of breeding habitat.	
Powerful Owl	No, but recorded in gullies on either side of the alignment (Ecosure 2015)	Yes	Suitable habitat for prey species of the Powerful Owl.	
Eastern Pygmy-possum	Recorded within the study area	Yes	Potential and known habitat throughout the study area	
Southern Brown Bandicoot	None	Yes	Unlikely to occur but known from Ku-ring-gai Chase National Park.	
Large-eared Pied Bat	Probably call from study area (Ecosure 2015)	Yes	Only foraging habitat in the study area	Requires specific cave structures for breeding
Little Bentwing-bat	None. Nearby records	Yes	Only foraging habitat in the study area	
Eastern Bentwing Bat	Recorded by Ecosure (2015)	Yes	Roosting and foraging habitat in woodland	
Eastern Freetail-bat	None	Yes	Roosting and foraging habitat in woodland	

Name	Presence within study area	Targeted survey	Know or predicted location in study area	Notes
Greater Broad-nosed Bat	None	Yes	Roosting and foraging habitat in woodland	
Grey-headed Flying-fox	Observed foraging in study area (Ecosure 2015).	Yes	Foraging habitat throughout the study area	
Rosenberg's Goanna	Records from Ecosure (2015) and SMEC (2015).	Yes	Foraging habitat throughout habitat. Nests in termite mounds.	

### ***Giant Burrowing Frog***

During surveys by Ecosure in February 2014, the Giant Burrowing Frog was identified along the Caley Trail in Garigal National Park approximately 500 metres to the south of the subject site (Figure 20). Suitable non-breeding habitat for the Giant Burrowing Frog occurs in the subject site (Ecosure 2015). The proposal will require the removal of potential habitat for the Giant Burrowing Frog and there may be some indirect impacts to breeding habitat outside the subject site.

### ***Red-crowned Toadlet***

Numerous Red-crowned Toadlet individuals were recorded close to the subject site at several locations during surveys by Ecosure in December 2013 and February 2014, and SMEC in 2016 (Figure 20). Suitable breeding and foraging habitat for this species occurs with the study area and some of this habitat will be removed by the proposal. Suitable breeding habitat within the study area is likely to also be subject to indirect impacts such as alterations to hydrology.

### ***Powerful Owl***

The Powerful Owl was not recorded within the study area, but was found in the gullies on either side of the current alignment and they are highly likely to utilise the study area for foraging on occasion (Ecosure 2015). The subject area provides habitat for prey species of the Powerful Owl.

### ***Eastern Pygmy-possum***

The Eastern Pygmy-possum is known to the locality (NSW Atlas of Wildlife; Law 2013) and was recorded within the study area. A total of 17 records were obtained in the study area by Ecosure (2014) between May 2014 and January 2015. Detection methods were Elliott traps (one individual), nest boxes (14 records) and spotlighting (two records). Seven of the nest box records came from one box, which contained an adult female and six offspring. Thus, records were obtained from eight nest boxes. These records were distributed along the existing road, but were concentrated in the west, around Kimbriki Road. Records were obtained on both sides of the existing road, suggesting it is likely to be a movement barrier for Eastern Pygmy-possum. Eastern Pygmy-possums were not marked, so the number of individuals detected is not known.

One nest box within ten metres of the existing road produced an adult female with six offspring

(Ecosure 2014). Ecosure (2014) also found several Eastern Pygmy-possum nests within nest boxes, which were still present during recent surveys. Well-constructed nests are only made by breeding females (Ward 1990). Clearly, the Eastern Pygmy-possum breeds within the study area.

Recent surveys (October 2015 – January 2016) by SMEC produced a further five Eastern Pygmy-possum records (one by Elliott trapping, four in nest boxes). Individual marks (PIT tags) indicated three adult males, a non-parous female and a nulliparous female were present. Fresh leaves were present in ten boxes and nests observed by Ecosure (2015) were also recorded.

The proposal would affect living and breeding habitat occupied by the Eastern Pygmy-possum. Direct impacts include 16 hectares of habitat loss, increased habitat fragmentation associated with the existing road (wider corridor proposed) and direct mortality due to vehicle strike.

### ***Southern Brown Bandicoot***

Although the Southern Brown Bandicoot was not identified during recent surveys, there are records of the species between 2010 and 2015 at Bobbin Head and West Head in Ku-ring-gai Chase National Park. Intensive trapping to the south of the subject site in Garigal National Park has not detected the species since 2000 (Ecosure 2015). Suitable habitat for this species occurs in the locality within both National Parks and some private property. The species is naturally rare and a lack of knowledge regarding population size, dynamics and importance of difference habitat types has been acknowledged (DEC 2006).

### ***Large-eared Pied Bat***

A call from this species was probably detected in the road corridor during recent surveys (Ecosure 2015). They are also known to occur in the locality although no roosting sites have been identified (Benson 2012). Potential roosting habitat along sandstone clifflines is unlikely to be affected. The Large-eared Pied Bat is likely to only utilise the study area for foraging. Some potential foraging habitat will be removed by the proposal.

### ***Little Bentwing-bat***

Numerous records of the Little Bentwing-bat occur to the south-west of the study area in Garigal National Park (NSW BioNet). This species was possibly detected during recent surveys to the east of the study area (Ecosure 2015). Some potential foraging habitat will be removed by the proposal.

### ***Eastern Bentwing-bat***

The Eastern Bentwing-bat was recorded in the road corridor by Ecosure in 2015. Additional numerous records occur in the adjacent Ku-ring-gai Chase and Garigal National Parks. Suitable foraging habitat and roosting habitat in hollow-bearing trees occurs within the study area. Potential roosting habitat along sandstone clifflines is unlikely to be affected.

### ***Eastern Freetail-bat***

Although this species was not identified during recent surveys, suitable foraging and roosting habitat occurs in the study area (Ecosure 2015). The Eastern Freetail-bat occurs in a variety of habitats and is known to roost in hollows, under bark and in man-made structures.

### **Greater Broad-nosed Bat**

Although the Greater Broad-nosed Bat was not identified during recent surveys, suitable foraging and potential roosting habitat occurs in the study area and it is considered that this species could utilise the study area on occasion (Ecosure 2015). They primarily roosting in tree-hollows but are also known to roost in buildings (OEH 2016).

### **Grey-headed Flying-fox**

The Grey-headed Flying-fox was observed foraging in the study area as well as flying overhead during recent surveys. The closest camp occurs at Warriewood, approximately five kilometres from the subject site (Ecosure 2015). Other camps within travelling distance are known to occur. Some suitable foraging habitat for the Grey-headed Flying-fox will be removed by the proposal.

### **Rosenberg's Goanna**

The Rosenberg's Goanna was recorded with the study area during studies by Ecosure in December 2013 and SMEC in 2015 (Figure 19). They rely on termite mounds for breeding and numerous termite mounds have been identified within the study area, some quite close to the existing road. The proposal will result in the removal of 22 termite mounds that may be used for nesting by varanid lizards as well as some potential foraging and sheltering habitat. Widening of the road will also increase the barrier between suitable areas of habitat.

## **5.2 DISCUSSION OF LOCAL AND REGIONAL ABUNDANCE AND DISTRIBUTION**

### **5.2.1 Discussion of other known local populations**

#### **Flora**

##### ***Acacia bynoeana***

*Acacia bynoeana* if present within the study area would be considered of moderate to high significance with no known local populations and only three records (1998 and 2001) from the local area all within Ku-ring-gai Chase National Park. There is no record of population numbers, however, this species typically occurs in relatively small populations of less than five (OEH Threatened Species Profile). The species is widespread within the Sydney region from Morisset in the north to Berrima and the Illawarra in the south, and to the Blue Mountains in the west.

Given the absence of records of this species in the study area from the relevant flora survey datasets (i.e. potential species only), no record / habitat map has been produced for the SIS.

##### ***Acacia terminalis* subsp. *terminalis***

Any population of *Acacia terminalis* subsp. *terminalis* present within the study area would be considered of high significance with no known local populations and ten records (2009) between 5 and 10 kilometres, closer to the coast. This subspecies is highly restricted to near-coastal sites on the Sydney North Shore and south to Botany Bay.

Given the absence of records of this species in the study area from the relevant flora survey datasets



(i.e. potential species only), no record / habitat map has been produced for the SIS.

### ***Callistemon linearifolius***

*Callistemon linearifolius* if present within the study area would be considered important with only two known local populations of unknown size, around eight records from the Sydney region and documented loss of historic populations. One local record from Mona Vale Road near Ingleside is very recent (2014). The species is restricted to the Central Coast, Hornsby Plateau and Illawarra. Only about a quarter (5-6) of the historic populations persist today with several occurring within national parks (e.g. Ku-ring-gai Chase). Given the absence of records of this species in the study area from the relevant flora survey datasets (i.e. potential species only), no record / habitat map has been produced for the SIS.

### ***Darwinia biflora***

There are 81 known occurrences of *Darwinia biflora* within 10 kilometres of the study area. Some of these populations were recorded as being small but the majority had no population size details. This species commonly occurs in larger populations although above ground density is closely related to time since fire. Plants are killed by fire with regeneration from seed. Many local occurrences are within Ku-ring-gai Chase National Park. Any presence within the study area is likely to be small (not detected in general surveys) and of low to moderate significance. Given the absence of records of this species in the study area from the relevant flora survey datasets (i.e. potential species only), no record / habitat map has been produced for the SIS.

### ***Genoplesium baueri***

Any population of *Genoplesium baueri* present within the study area would be considered highly significant with many of the earlier records for this species (prior to 1960) not seen in recent years. It is currently known from only 200 plants across 13 sites (OEH Threatened Species Profile). Given the absence of records of this species in the study area from the relevant flora survey datasets (i.e. potential species only), no record / habitat map has been produced for the SIS.

### ***Grevillea caleyi***

*Grevillea caleyi* within the study area comprises two of the largest known remnants with a potential mature population estimated to comprise >50% of the total population of the species (Auld and Scott 2013). The species is highly restricted to three ridge-lines at Belrose, Duffys Forest/Terrey Hills and Ingleside and is associated predominantly with the Duffys Forest endangered community. There are 26 known sites ranging from a few metres squared to 1.2 hectares in area that are representative fragments of its former distribution (Auld and Scott 2013). Population numbers vary considerably depending on time since fire. Most sites are subject to high development pressure, disturbance and inappropriate fire regimes. Population decline within the study area is likely due to the absence of fire for >20 years in most areas. Only a few other populations include habitat within Ku-ring-gai Chase and Garigal National Parks and these are also suffering population decline (Auld and Scott 2013). Other local populations are typically small (<3 ha) and in poor condition with high edge to core ratios.

### ***Microtis angusii***

*Microtis angusii* has a highly restricted distribution and was originally reported as occurring in one

population at one location along Mona Vale Road, at Ingleside. Individual plants or populations have since been reported at other locations around Ingleside, in other suburbs of Sydney, and in one location west of the Blue Mountains (Flanagan *et al.* 2006; DECCW 2010). The presence of *M. angusii* in these additional locations has been difficult to confirm due to strong morphological similarities with other *Microtis* species (*M. parviflora*, *M. unifolia*) and awaits the findings of further phylogenetic analysis.

As part of the Ingleside Precinct Biocertification, EcoLogical Australia were commissioned to undertake a targeted survey and habitat mapping of *Microtis angusii* in September and October 2015. Eight thousand five hundred *Microtis* individuals were counted and classified into species based on morphology during the survey. As part of the project, leaf samples of *Microtis* individuals were obtained and submitted to the plant pathology unit of the Royal Botanic Gardens, Sydney, for genetic analysis. The study area for the *Microtis* survey overlaps that of the Mona Vale Road West proposal and is thus relevant to the SIS. Key results from the ELA study are as follows:

- Four *Microtis* species were genetically confirmed from a subset of the 8,500 individuals, these being *M. angusii*, *M. rara*, *M. parviflora* and *M. angusii*
- None of the samples submitted were genetically confirmed as *M. unifolia*, even though the samples submitted were initially classified as *M. unifolia* based on morphological characteristics. All these samples that were initially classified as *M. unifolia* were genetically confirmed to be *M. angusii*.

The mapped distribution and habitat extent of *M. angusii* in the study area is shown in Figure 15.

### ***Persoonia hirsuta***

Any population of *Persoonia hirsuta* present within the study area would be considered significant. Many of the local records can be attributed to relatively few sites at Cromer and Oxford Falls. Populations of this species are typically very small with one or few plants. Regionally the species is widespread from Singleton in the north to Bargo in the south and the Blue Mountains in the west. Given the absence of records of this species in the study area from the relevant flora survey datasets (i.e. potential species only), no record / habitat map has been produced for the SIS.

### ***Pimelea curviflora* var. *curviflora***

*Pimelea curviflora* var. *curviflora* was recorded in the study area in December 2016. There are also historical records of the species in the study area and a few sites within 5 kilometres including Ingleside, Duffys Forest and Terrey Hills. Population size is unknown for most records. Its presence within the study area is considered significant in view of the relatively few sites, marked fluctuations in populations related to disturbance and soil moisture levels (may survive as rootstock for periods) and generally poor knowledge of the species. Regionally the species occurs predominantly in coastal areas of Sydney extending west to Maroota with records also in the Illawarra.

The mapped distribution and habitat extent of *Pimelea curviflora* var. *curviflora* in the study area is shown in Figure 17.

### ***Tetratheca glandulosa***

Over 260 records of this species occur within 10 kilometres of the study area including populations at Ingleside, Duffys Forest, Terrey Hills and within Ku-ring-gai Chase National Park. Population extent/size is generally high. In the Sydney region approximately 150 populations are known predominantly on sandstone in northern Sydney. Any presence within the study area is considered to be of low to moderate significance.

The mapped distribution and habitat extent of *Tetratheca glandulosa* in the study area is shown in Figure 16.

## **Fauna**

### **Giant Burrowing Frog**

There are 18 records of the Giant Burrowing Frog within a five kilometre radius of the subject site, including two records south of the study area along the Caley trail in Ku-ring-gai Chase National Park (NSW Atlas of Wildlife; Ecosure 2015). The majority of these observations have been along tracks or trails as the species is particularly difficult to detect when not calling (Penman *et al.* 2005). Given the availability of suitable habitat, it is likely that there are local populations of Giant Burrowing Frogs associated with suitable breeding habitat in the study area, but no breeding sites occur in the subject site. The size and extent of these populations cannot be estimated due to insufficient data, however, it is considered that the Giant Burrowing Frog is naturally rare and they occupy non-overlapping home ranges of about 0.04 hectares (Penman *et al.* 2008; OEH 2012). The mapped distribution and habitat extent in the study area is shown in Figure 20.

### **Red-crowned Toadlet**

The Red-crowned Toadlet is restricted to sandstone habitat of the Sydney Basin and are believed to only disperse up to 50m from suitable breeding habitat. Thumm and Mahony (1999) identified 141 localities where Red-crowned Toadlets were recorded. The majority of these were associated with Hawkesbury Sandstone. Records from the Atlas of NSW Wildlife show records scattered across northern Sydney including on the fringes of Ku-ring-gai Chase and Garigal National Parks. There are 63 records of the Red-crowned Toadlet within five kilometres of the subject site (NSW Atlas of Wildlife, 2015). The locations are likely to represent the tendency for the toadlets to occur on the talus slope below the ridgeline (Thumm and Mahony 1999), where houses have been constructed at the national park boundaries. The mapped distribution and habitat extent in the study area is shown in Figure 20.

### **Powerful Owl**

The Powerful Owl was not detected within the study area, but was identified in a number of gully areas within close proximity (Figure 18). There are 103 records of the Powerful Owl within five kilometres of the subject site (NSW Atlas of Wildlife, 2015). Records of the Powerful Owl in Pittwater Council have generally come from the west of the council area, close to the study area (Smith and Smith 2000). Powerful Owls occupy a large home range of 300-1,500 hectares depending on the availability of food resources (DEC 2006). Given the availability of suitable habitat for the Powerful Owl and its prey in the locality, it is likely that multiple breeding pairs occur. At least ten known Powerful Owl nesting sites have been identified within ten kilometres of the study area including Frenchs Forest (approximately seven kilometres south), Narrabeen (4.5 kilometres to the south west in Jamieson Park) and Bayview (3.7 kilometres to the north east) (OEH 2016; SMEC 2015).

## Eastern Pygmy-possum

It is difficult to determine the abundance of the Eastern Pygmy-possum in the study area. Records by Ecosure (2014) suggest they are distributed along the existing road (Figure 21). They made 17 detections of the Eastern Pygmy-possum using several methods: targeted Elliott trapping in flowering *Banksias* (one individual), nest boxes (14 records) and spotlighting (two records). Seven of the nest box records came from one box, which contained an adult female and six offspring. Thus, records were obtained from eight nest boxes. It is not possible to determine how many individuals were captured as Ecosure did not mark any individuals. However, the Eastern Pygmy-possum is generally characterised by low capture rates (e.g. Harris and Goldingay 2005; Tulloch and Dickman 2006; Harris *et al.* 2007), implying a low probability of individual recapture, which Blandon *et al.* (2002) estimated to be 53% over a long-term study (about 2.5 years) using nest boxes. It is likely that 7-14 individual Eastern Pygmy-possums were recorded by Ecosure (2014), though six appear to have been juveniles, which are likely to have a lower survival rate than established adults (Blandon *et al.* 2002).

Recent surveys (October 2015 – January 2016) by SMEC produced a further five Eastern Pygmy-possum records (one by Elliott trapping, four in nest boxes). Individual marks (PIT tags) indicated three adult males, a non-parous female and a nulliparous female were present. Fresh leaves were present in ten boxes and nests observed by Ecosure (2015) were also recorded.

There is tenuous connectivity between the proposal area and the Ingleside Escarpment. Ecosure (2014) and SMEC (2016) recorded an Eastern Pygmy-possum on the south side of the proposal area, opposite the Baha'i Temple and above the Monash Country Club (Ecosure 2014; Figure 4). The Eastern Pygmy-possum was recorded just west of the northern extent of Ingleside Road adjacent to the Mona Vale Road East project area by SMEC in October 2015 in a recently installed nest box (Figure 21). The required movement distance between these records is about 1.5 kilometres (there is only one other nest box between them). There are some small patches of vegetation along Waratah Road (opposite the Country Club at the eastern end of the project area) and some disturbed areas of habitat around properties east of Manor Road (Figure 21) that provide connectivity between these two records. Approximately 600 metres further east of the Ingleside Road record are sites first surveyed by Law (2013) and where Eastern Pygmy-possum remain extant (SMEC 2016). Small patches of potential habitat are continuous between these records. The analysis of genetic samples collected by SMEC (2016) would enable this hypothesis to be tested.

The Atlas of NSW Wildlife also show records from Ku-ring-gai Chase NP and to the south of Garigal NP. Given the widespread availability of suitable habitat in these conservation reserves (upper slope sandstone heath and heathy woodland), it is likely that the Eastern Pygmy-possum is extensively distributed in the locality and a relatively large and an important population(s) is (are) present.

However, the use of nest boxes makes it difficult to compare the population size in the study area to other populations in the locality. While most authors do not report the interval between nest box installation and the first record of Eastern Pygmy-possum occupation, Harris and Goldingay (2005) found the first record occurred seven months after installation. Similarly, Law (2013) commenced nest box checks after one month and found that the number of detections per survey increased steadily over the study, particularly after about seven months (from April 2013 after installation in October 2012).



### **Southern Brown Bandicoot**

Within NSW there are considered to be two primary areas where Southern Brown Bandicoot occurs: just north of Sydney (Ku-ring-gai Chase and Garigal National Parks) and in the far south-east of the state (including national parks, reserves and forests around Yambulla, Nadgee and Green Cape). There are a few other scattered records from national parks, state forests and private properties (DEC 2006). The subject site lies within the known extent of the northern Sydney population. The estimated home range of the Southern Brown Bandicoot is 0.5 to 0.9 ha, with some variance depending on site productivity, habitat structure, gender and habitat use (DEC 2006). There are 50 records of the Southern Brown Bandicoot within five kilometres of the subject site (NSW Atlas of Wildlife, 2015).

The Southern Brown Bandicoot has been recorded at Bobbin Head and West Head in Ku-ring-gai Chase NP to the north of the subject site between 2010-2015. Intensive trapping by NPWS to the south of the subject site in Garigal NP has not detected the species since 2000 (Ecosure 2015). Suitable habitat for this species occurs in the locality within both national parks and some private property.

### **Large-eared Pied Bat**

The Large-eared Pied Bat has a continuous distribution from Shoalwater Bay in Queensland to Ulladulla in New South Wales. Distribution in the sandstone areas of the Sydney Basin is uncommon and patchy and neither Ku-ring-gai Chase nor Garigal National Parks are listed as conservation reserves from which the Large-eared Pied Bat is known to occur (DERM 2011). The NSW Atlas of Wildlife contains only two records of the species within a five kilometre radius, however, other records are known to occur and a possible detection was made during recent surveys (Ecosure 2015). This limited number of records may reflect the patchy distribution of the species. There is insufficient information to determine the size of any population that may utilise the study area.

There are a limited number of breeding sites known to occur in NSW; all of which are located west of the Great Dividing Range (DERM 2011).

### **Little Bentwing-bat**

The Little Bentwing-bat occurs along the east coast of Australia from Cape York in Queensland to Wollongong in New South Wales. There are only five maternity colonies of Little Bentwing Bats known in Australia (OEH 2012). There are 18 records of the species within five kilometres of the study area. This species was possibly detected to the east of the study area during recent surveys by Ecosure (2015) and has also been recorded around Ingleside in 2012 (Bonsen 2012).

### **Eastern Bentwing-bat**

The Eastern Bentwing-bat occurs along the east and north-west Australian coast. They are known to disperse about 300 kilometres from maternity caves (OEH 2016). There are 56 records of this species within five kilometres of the subject site and it was confidently identified during recent surveys by Ecosure (2015). It has also been recorded around Ingleside in 2012 (Bonsen 2012). It is expected that Eastern Bentwing-bats that utilise the study area are part of a single population distributed around a maternity cave, which is much larger than the study area.

### **Eastern Freetail-bat**

The Eastern Freetail-bat occurs in forest, woodland and swamp forests along the east coast from southern Queensland to southern New South Wales. Although this species has not been identified with the study area during recent surveys, it has been recorded in the locality and suitable habitat occurs. There are only two records in the locality, although it has been identified that this species is rarely recorded in peri-urban environments (Bonsen 2012).

Lack of records means it is impossible to determine the size of the population in the locality and how many of these individuals are utilising the study area.

### **Greater Broad-nosed Bat**

The Greater Broad-nosed Bat occurs below 500 metres in gullies and river systems from north-east Victoria to the Atherton Tableland. There are only three records of this species within five kilometres of the study area.

### **Grey-headed Flying-fox**

The Grey-headed Flying-fox occurs from Bundaberg to Geelong in forests and woodlands of the coastal lowlands, tablelands and slopes (DECCW 2009). They are a panmictic species that moves seasonally in response to availability of food. There are 56 records of the Grey-headed Flying-fox within five kilometres of the subject site (NSW Atlas of Wildlife 2015). A population is difficult to define with seasonal movements and climatic conditions; although fidelity to particular camps has been observed (DECCW 2009). The study area is likely to be utilised on occasion by various individuals depending on the seasonal availability of food resources. Three known camps have been identified in the locality; Warriewood (5 kilometres east), Gordon (10 kilometres south-west) and Balgowlah (12 kilometres south).

### **Rosenberg's Goanna**

There are 75 records of the Rosenberg's Goannas within five kilometres of the subject site between 1987 and 2014 (NSW Atlas of Wildlife 2015). Given the large and variable home ranges (2- 40 ha) of the Rosenberg's Goanna (King and Green 1999), it is difficult to define a local population. It is likely that individuals throughout Garigal and Ku-ring-gai Chase National Parks are capable of interacting with juveniles dispersing a great distance. As such these are all considered to be part of a single population.

The population of Rosenberg's Goannas that occurs in northern Sydney is isolated from other populations. The main stronghold for the Rosenberg's Goanna is on Kangaroo Island in South Australia. Other populations are known to occur south of Sydney and there are some records north of the Hawkesbury River and in the Blue Mountains. Genetic studies indicate the threatened NSW and ACT population of Rosenberg's Goanna has evolved separately from the rest of the species but not enough to warrant new taxa (Smith *et al.* 2007). The northern Sydney population of Rosenberg's Goannas is considered important within the locality.

## 5.3 ASSESSMENT OF HABITAT

### 5.3.1 Description of habitat values

The condition of vegetation within the study area is based on information provided in Smith & Smith (2011), GHD (2012), Ecosure (2015) and recent field verification for this proposal. The condition rating (good, moderate, poor, disturbed) is based on resilience or the capacity of a site to regenerate (modified version of Jones and Brodie (1999) as described in Section 3.5.2 of the Ecosure report (2015)). The methodology uses biological factors together with the health of the soil profile as well as the level of weed invasion. The condition classes are summarised in Table 26. Vegetation condition is mapped in Figure 9.

#### **Good to Moderate**

Native vegetation through much of the study area away from road/pathway/track edges is in good to moderate condition with moderate to high levels of resilience largely reflecting the infertile sandstone geology. A summary of vegetation condition within the native vegetation communities based on plot data compiled in Ecosure (2015) is provided in Table 27.

Fire history is important in relation to habitat condition and health of threatened flora. The fire history is shown in Figure 22 and details discussed below relevant to each species.

#### **Disturbed vegetation– degraded bushland or unmanaged space**

Native vegetation adjacent to Mona Vale Road, side roads and pathways is edge-effected with evidence of physical disturbance, weed invasion, altered micro-climate and batter fill areas. Edge effects are largely restricted to a zone approximately 1-3 m wide. Frequent exotic species within this zone include perennial exotic grasses such as Coolatai Grass (*Hyparrhenia hirta*), Whiskey Grass (*Andropogon virginicus*), Paspalum (*Paspalum dilatatum*) and African Lovegrass (*Eragrostis curvula*) with occasional woody weeds including Lantana (*Lantana camara*), Senna (*Senna pendula* var. *glabrata*) and the western Australian species, *Acacia saligna*. Common exotic herbs include *Coreopsis lanceolata* and Purple-top (*Verbena species*). Although in very low condition some of these areas represent known habitat for the threatened Angus's Onion Orchid (*Microtis angusii*).

Edge effects also occur along power lines, service tracks and close to non-bushland land-uses. Most remnants within the study area are fragmented by power lines and associated tracks. Larger areas affected by disturbance have been mapped as highly disturbed vegetation in Figure 9 and comprise an area of 1.15 ha. These are areas assessed as non-resilient with a permanently altered soil profile and minimal potential for natural regeneration. Typically, native vegetation has been largely replaced by weed species and at best a single structural layer remains intact. An area of 0.39 hectares is mapped separately as weeds where native vegetation has been more completely replaced by weeds species.

**Table 26: Summary of vegetation condition within the study area**

Resilience/Condition Class	Description
Good	<ul style="list-style-type: none"> <li>• Weed infestation absent or minor</li> <li>• All structural layers ± intact</li> <li>• In benchmark condition</li> <li>• High species richness</li> <li>• Low perimeter to core ratio and good connectivity</li> </ul>
Moderate	<ul style="list-style-type: none"> <li>• Weed infestation minor</li> <li>• One structural layer either absent or in poor condition</li> <li>• Close benchmark condition</li> <li>• Moderate species richness</li> <li>• Moderate perimeter to core ratio and good connectivity</li> </ul>
Poor	<ul style="list-style-type: none"> <li>• Weed infestation moderate to severe</li> <li>• Poor structure</li> <li>• Well outside benchmark condition</li> <li>• Low species richness</li> <li>• High perimeter to core ratio and poor connectivity</li> </ul>
Disturbed - degraded bushland or unmanaged space (Non-resilient)	<ul style="list-style-type: none"> <li>• Weed infestation severe</li> <li>• At best single structural layer present</li> <li>• Soil profile permanently altered with loss of soil seed bank</li> <li>• No regeneration potential</li> </ul>
Disturbed – rehabilitation or revegetation areas (Non-resilient)	<ul style="list-style-type: none"> <li>• Weed infestation moderate</li> <li>• Soil profile permanently altered, structure and composition unlikely to reach benchmark after treatment</li> <li>• Limited natural regeneration capacity after treatment &amp; high inputs</li> </ul>

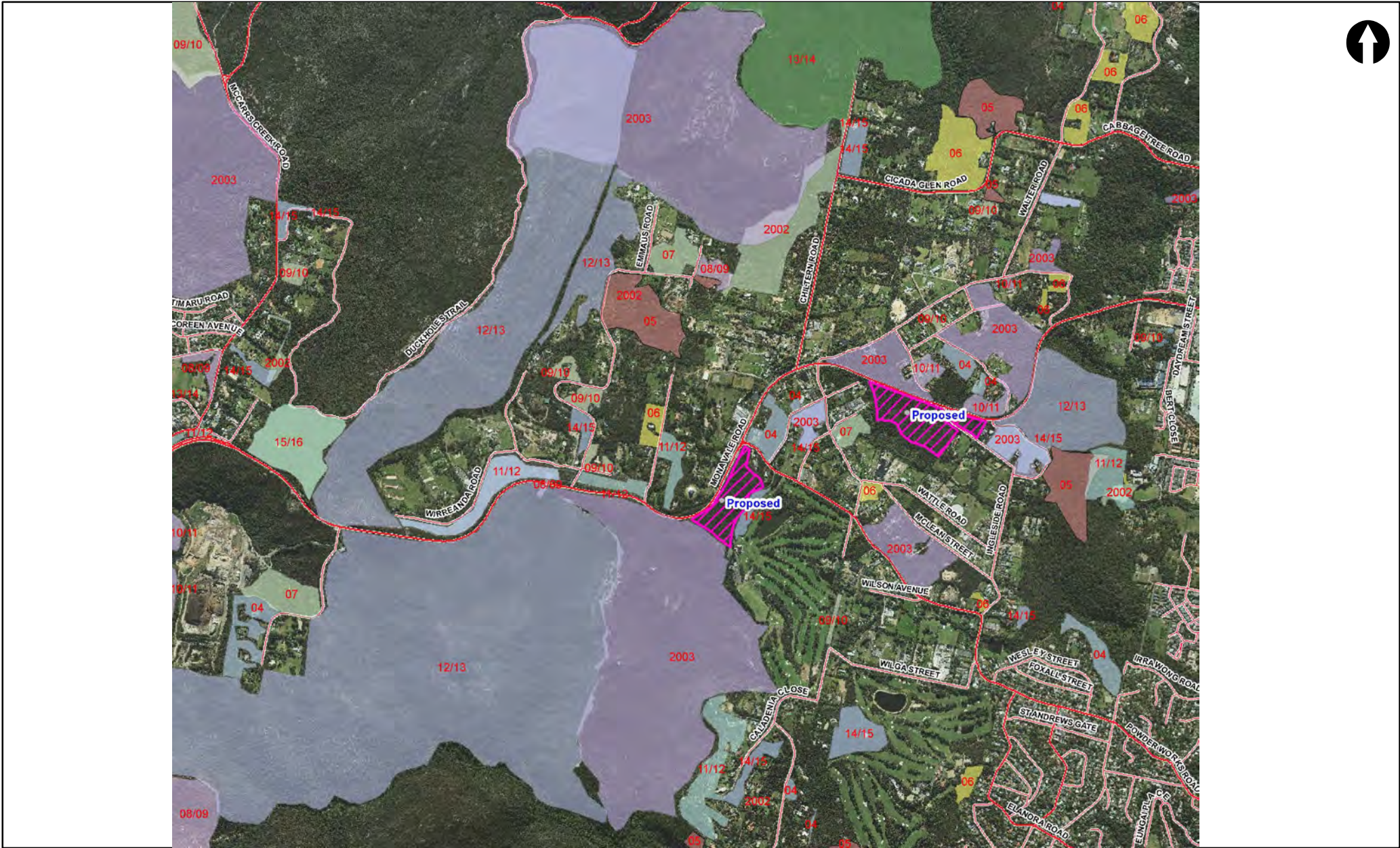
\*Based on modified version of Jones and Brodie (1999) as used in Ecosure (2015)

Twenty-three weed species were recorded in floristic plots (Ecosure 2015). A total of ten noxious weeds have been recorded in surveys within the study area. No targeted weed surveys have been undertaken and the number of exotic species present is likely to be much higher.



**Table 27: Summary of native vegetation condition within SIS study area (after Ecosure 2015)**

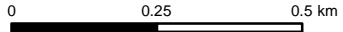
Vegetation Community	Sites	Average % cover	Vegetation condition	Last fire event (Warringah mapping)
Bloodwood Scribbly Gum Woodland	4, 5, 6, 7, 32	Overstorey – 14% Midstorey – 8.3% Groundstorey – 31.7%	Good	Mostly 2011/12
Coastal Upland Swamp	18	Overstorey – 10% Midstorey – 5% Groundstorey – 30%	Good	Not known
Duffys Forest EEC	8, 12, 13	Overstorey – 22% Midstorey – 16.9% Groundstorey – 29.3%	Good	Limited areas burnt in Aug 2015 & 2011/12 otherwise in 1994
Duffys Forest Translocation Site	9	Overstorey – 0% Midstorey – 6% Groundstorey – 32%	Good	Not known
Duffys Forest Disturbed	19	Overstorey – 22.5% Midstorey – 10% Groundstorey – 2.7%	Moderate	Not known
Peppermint-Angophora Forest	15,16,17	Overstorey – 26.2% Midstorey – 8.2% Groundstorey – 18.2%	Good	Not known 2012/13
Sandstone Rocky Heath	2, 3	Overstorey – 6% Midstorey – 6.1% Groundstorey – 6%	Good	2011/12
Sandstone Heath	14	Overstorey – 20% Midstorey – 5% Groundstorey – 30%	Good	2012/13
Yellow-top Ash	1, 10, 11	Overstorey – 13.7% Midstorey – 22.6% Groundstorey – 33.3%	Good	Not known



2014 Date and extent of latest fire

Fire History Map - as prepared by NSW Rural Fire Service Figure 22

Vector base dataset RoadNet © MDS 2016



Last updated by: DW13219 on 13/12/2016 at 14:58



## Flora

### *Grevillea caleyi*

*Habitat values:* *Grevillea caleyi* is restricted to an 8km<sup>2</sup> area around Terrey Hills, generally occurring on ridgetops with laterite soils from 170m-240m in elevation. The species is strongly associated with Duffys Forest EEC, however it can also occur within other vegetation types namely Bloodwood–Scribbly Gum Woodland along ridge-tops associated with ironstone laterite. The NSW Threatened Species Profile Database list 4 PCTs associated with *Grevillea caleyi*. Within the study area, plants are largely restricted to a zone within 10-20 m of the road reflecting the extent of laterite soils (Auld and Scott 2013). The extent of Duffys Forest within the locality is around 296 hectares, however there are few sites undisturbed and protected long term in a national park (small areas within or at edge of Ku-ring-gai Chase and Garigal National Parks) with remaining patches unprotected on private and public lands. It should also be noted that only a small proportion of the 296 hectares of Duffys Forest EEC within the locality would be considered suitable habitat for *G. caleyi*, as elevation and presence of laterite soils are also important habitat requirements for this species. The extent of Bloodwood-Scribbly Gum Woodland locally is significantly larger (2,776 hectares) although this provides very limited and marginal habitat.

For the purposes of this SIS, *Grevillea caleyi* habitat has been defined as the following:

- Areas within which *G. caleyi* has been recorded (SMEC, and records contained within Wildlife Atlas)
- Areas which are of the same soil landscape as that where the majority of *G. caleyi* have been recorded that occur between 170m-240m in elevation. In most cases, this soil landscape is contiguous with known occurrences of the species
- Within the study area, areas of vegetation which are not DFEC but are dominated by *Eucalyptus haemastoma* and *Corymbia gummifera*
- Within the study area, areas of mapped urban exotic/native vegetation within close proximity to *G. caleyi* records, DFEC, or *Eucalyptus haemastoma* and *Corymbia gummifera* dominated PCTs.

About 12.1 hectares of *Grevillea caleyi* habitat occurs within the study area. Of this, about 5.12 hectares will be removed as part of the proposal.

*Condition of habitat:* Duffys Forest and Bloodwood-Scribbly Gum Woodland within the study area is in relatively good condition with minimal weed infestation away from the road edges. It is structurally intact with good cover in all layers and dense in some places due to lack of recent fire. Most remnants of Duffys Forest within the locality are affected by clearing, fragmentation and edge-related disturbances (DEC 2004; OEH 2013).

*Fire history within study area:* Recent fires within the Duffys Forest EEC are restricted to a small area north of Mona Vale Road near the Booralie Road intersection subject to an ecological burn in 2012 and one in August 2015 on the northern side within Ku-ring-gai Chase National Park at the western end of the study area (see Figure 22). Other areas of Duffys Forest EEC are unburnt since a wildfire in 1994. Recent fires occurred during 2011/12 in Bloodwood-Scribbly Gum Woodland. Population numbers are known to decline significantly in the absence of fire with a recommended fire interval of 8-12 years (DEC 2004). Seedlings were identified in December 2015 just four months after the August

fire.

### ***Microtis angusii***

*Habitat values:* Known or potential habitat occurs at several locations within and close to the study area in highly disturbed low, grassy vegetation adjacent to roads and tracks. More natural habitat is likely to be grassy woodland on laterite (Jones 1996) including in the Duffys Forest Ecological Community. Some level of disturbance may be required within this habitat. Soils within *Microtis* habitat must contain specific mycorrhizal fungi (*Tulasnella calospora* or similar) for growth of plants and soil moisture levels are required to be >23% for best germination and development of seedlings (Newby *et al.* 2015).

*Condition of habitat:* This habitat of this species is in poor condition with high weed infestation. Exotic perennial grasses dominate including Coolatai Grass (*Hyparrhenia hirta*), African Lovegrass (*Eragrostis curvula*), Whiskey Grass (*Andropogon virginicus*) and Paspalum (*Paspalum dilatatum*). The exotic herbs Coreopsis (*Coreopsis lanceolata*) and Lily (*Lilium formosanum*) also occur extensively within the disturbed areas. Some regrowth of the wattles *Acacia saligna* and *A. longifolia* is also evident.

*Fire history within study area:* Approximately 50 per cent of the type population affected by a small fire started by lightning in 2016.

### ***Pimelea curviflora var. curviflora***

*Habitat values:* Found in woodland or open forest on sandstone ridges and upper slopes with clay or laterite influence. Associated with Duffys Forest EEC within the study area but could also occur in Bloodwood - Scribbly Gum Woodland or Peppermint-Angophora Forest (Figure 17). The extent of Duffys Forest within the locality totals 296 hectares but there are few sites undisturbed and protected long term in a national park (small areas known within or at edge of Ku-ring-gai and Garigal National Parks) with remaining patches unprotected on private and public lands. The extent of Bloodwood-Scribbly Gum Woodland and Peppermint-Angophora Forest locally is significantly larger (2776 hectares and 1832 hectares respectively).

*Condition of habitat:* Known and potential habitat is in good condition within the study area with minimal weed infestation away from the road edges although some areas are overgrown. Most remnants of Duffys Forest within the local area are impacted by clearing, fragmentation and edge-related disturbances (DEC 2004; OEH 2013). In contrast, Bloodwood - Scribbly Gum Woodland and Peppermint-Angophora Forest is likely to be generally in moderate to good condition in the locality.

*Fire history within study area:* Recent fires within the Duffys Forest EEC include a small area north of Mona Vale Road near the Booralie Road intersection subject to an ecological burn in 2012 and one in August 2015 on the northern side within Ku-ring-gai National Park at the western end of the study area. Since the August 2015 fire, at least two individuals have emerged. Other areas of Duffys Forest EEC are unburnt since a wildfire in 1994. Fires have occurred within the last four years in some areas of Bloodwood - Scribbly Gum Woodland and Peppermint-Angophora Forest. A fire regime of around 8-15 years is required to maintain relatively open, grassy habitat suited to this taxon.



### ***Persoonia hirsuta***

*Habitat values:* Occurs on ridge-lines in woodland and heath on sandstone. The 1994 records within the study area were in the Duffys Forest EEC (less common association). More typical potential habitat is found in Bloodwood - Scribbly Gum Woodland, Sandstone Heath and Rocky Sandstone Heath. The species can be associated with laterite and a slight clay influence. The extent of Duffys Forest within the locality totals 296 hectares but there are few sites undisturbed and protected long term in a national park (small areas known within or at edge of Ku-ring-gai and Garigal National Parks) with remaining patches unprotected on private and public lands. The extent of Bloodwood - Scribbly Gum Woodland (2776 ha) and Sandstone Heath/Rocky Sandstone Heath (c. 1200 ha) within the local area is relatively large.

*Condition of habitat:* The woodland and drier heath communities within the study area are in good condition away from disturbed edges and are likely to be in good condition generally within the local area. Vegetation in the vicinity of the 1994 record at Tumbledown Dick Hill is currently mostly overgrown and dense in the absence of fire.

*Fire history within study area:* Recent fires within the Duffys Forest EEC include a small area north of Mona Vale Road near the Booralie Road intersection subject to an ecological burn in 2012 and one in August 2015 on the north side within Ku-ring-gai National Park at the western end of the study area. Other areas of Duffys Forest EEC are unburnt since a wildfire in 1994. Fires occurred in 2011/12 and 2012/13 in Bloodwood-Scribbly Gum Woodland and the Sandstone Heath communities. Plants are killed by high intensity fire with subsequent regeneration from seed although due to small population size local extinctions are not uncommon.

### ***Tetratheca glandulosa***

*Habitat values:* Occurs in Duffys Forest EEC, Bloodwood - Scribbly Gum Woodland and heathland on sandstone ridge-tops associated with ironstone laterite and clay (Figure 16). The extent of Duffys Forest within the locality totals 296 hectares with few sites undisturbed and protected long term in a national park (small areas within or at edge of Ku-ring-gai and Garigal National Parks) with remaining patches unprotected on private and public lands. The extent of Bloodwood - Scribbly Gum Woodland (2776 hectares) and Sandstone Heath/Rocky Sandstone Heath (c. 1200 hectares) locally is significantly larger.

*Condition of habitat:* Duffys Forest, Bloodwood - Scribbly Gum Woodland and Sandstone Heath communities within the study area are in relatively good condition with minimal weed infestation away from the road edges. Most remnants of Duffys Forest within the local area are impacted by clearing, fragmentation and edge-related disturbances (Recovery Plan, DEC 2004, OEH 2013). In contrast, Bloodwood - Scribbly Gum Woodland and the Sandstone Heath communities are generally in moderate to good condition locally.

*Fire history within study area:* Recent fires within the Duffys Forest EEC include a small area north of Mona Vale Road near the Booralie Road intersection subject to an ecological burn in 2012 and one in August 2015 on the southern side within Ku-ring-gai National Park at the western end of the study area. Other areas of Duffys Forest EEC are unburnt since a wildfire in 1994. Fires occurred in 2011/12 and 2012/13 in Bloodwood - Scribbly Gum Woodland and the Sandstone Heath communities (mapping dated 09/09/2015). A relatively frequent fire regime (8-15 years) is required to maintain relatively

open, habitat suited to this small shrub species.

### ***Acacia bynoeana***

*Habitat values:* Occurs on ridge-lines in woodland and heath on sandstone. Potential habitat is found in Bloodwood-Scribbly Gum Woodland, Sandstone Heath and Rocky Sandstone Heath within the study area. The species can be associated with laterite and a slight clay influence. Open conditions are preferred due to its small size with overshadowing by larger shrubs likely to reduce flowering and seed production. The mid-storey figures provided in Table 27 indicate that the openness of habitat in these communities is mostly <20% and suitable for the species. The extent of Bloodwood-Scribbly Gum Woodland (2,776 ha) and Sandstone Heath/Rocky Sandstone Heath (c. 1,200 ha) within the local area is relatively large, however, *Acacia bynoeana* is restricted to ridgetops/upper slopes within this habitat. This species is often seen in woodland or heath that is subject to periodic slashing (e.g. powerline easements) or on track edges in an environment with reduced plant competition and increased sunlight penetration to the ground stratum (pers. obs. I Mamott). Such habitat is present in the study area.

*Condition of habitat:* The woodland and drier heath communities within the study area are in good condition away from disturbed edges and are likely to be in good condition generally within the local area.

*Fire history within study area:* Fires occurred in 2011/12 and 2012/13 in Bloodwood-Scribbly Gum Woodland and the Sandstone Heath communities (mapping dated 09/09/2015). A fire regime of 8-15 years is considered appropriate to maintain relatively open habitat and ensure seed soil storage.

### ***Acacia terminalis* subsp. *terminalis***

*Habitat values:* Occurs on ridge-lines in woodland and heath on sandstone. It is often associated with rocky outcrops. Potential habitat is found in Bloodwood-Scribbly Gum Woodland, Sandstone Heath and Rocky Sandstone Heath. The potential sighting by Smith and Smith (2011) was located within the southern Duffys Forest translocation area adjacent to remnant Yellow-top Ash Mallee. The extent of Bloodwood-Scribbly Gum Woodland (2,776 ha) and Sandstone Heath/Rocky Sandstone Heath (c. 1,200 ha) is relatively large within the local area.

Smith and Smith (2011) note that the suspected threatened subspecies contained densely hairy branchlets and leaf rachises which would key out the suspected individuals as either the threatened *Acacia terminalis* subsp. *terminalis* or non-threatened *Acacia terminalis* subsp. *longiaxialis*. The SIS author has not recorded the latter subspecies from the Sydney locality to date, with the southernmost record being from the western Lake Macquarie area (I Mamott, pers. obs.). The author has, however, only seen the threatened sub species on the Sydney harbour foreshores at Neilson Park, Clifton Gardens and on a clifftop at Dover Heights and thus views its possible presence in the study area (ridgeline some 3 kilometres from the sea) as unusual. One possible explanation for this unusual occurrence would be that since the suspected individuals were recorded in the Duffys Forest translocation area, the species may have been transferred from the original site's soil seedbank. Ecosure (2015) did not subsequently record the threatened subspecies as part of its field surveys in the study area.

*Condition of habitat:* The woodland and drier heath communities within the study area are in good

condition away from disturbed edges and are likely to be in good condition generally within the local area.

*Fire history within study area:* Fires occurred in 2011/12 and 2012/13 in Bloodwood-Scribbly Gum Woodland and the Sandstone Heath communities (mapping dated 09/09/2015). A maximum fire-free period of twenty years has been proposed in the national and state recovery plan for the species (DECCW 2010) although further research is needed to confirm.

### ***Callistemon linearifolius***

*Habitat values:* Found predominantly in open-forest on sandstone with potential habitat in the Duffys Forest EEC and Peppermint-Angophora Forest communities. Extent of Duffys Forest within the locality totals 296 hectares but there are few sites undisturbed and protected long-term in a national park (small areas known within or at edge of Ku-ring-gai Chase and Garigal National Parks) with remaining patches unprotected on private and public lands. The extent of Peppermint-Angophora Forest locally is significantly larger at 1,832 ha.

*Condition of habitat:* Potential habitat is in good condition within the study area with minimal weed infestation away from the road edges. Most remnants of Duffys Forest within the local area, however, are affected by clearing, fragmentation and edge-related disturbances (DEC 2004; OEH 2013). In contrast, Peppermint-Angophora Forest is likely to be generally in moderate to good condition locally.

*Fire history within study area:* Recent fires within the Duffys Forest EEC include a small area north of Mona Vale Road near the Booralie Road intersection subject to an ecological burn in 2012 and one in August 2015 on the northern side within Ku-ring-gai Chase National Park at the western end of the study area. Other areas of Duffys Forest EEC are unburnt since a wildfire in 1994. Fires have occurred within the last four years in some areas of Peppermint-Angophora Forest. As a larger shrub it is likely to be able to survive in the absence of fire for some time although regeneration (probably re-sprouting and from seed) is likely to be dependent on fire. Little information is available on the ecology and fire response of this species (Benson and McDougall 1998; OEH 2016).

### ***Darwinia biflora***

*Habitat values:* Occurs on ridge-lines in woodland and heath on sandstone with some clay influence. Potential habitat is found in Bloodwood-Scribbly Gum Woodland, Sandstone Heath and Rocky Sandstone Heath. The species can be associated with laterite and a slight clay influence. Open conditions are preferred due to its small size with overshadowing by larger shrubs likely to reduce flowering and seed production. The mid-storey figures provided in Table 27 indicate that the openness of habitat in these communities is mostly <20% and suitable for the species at least in some areas. The extent of Bloodwood-Scribbly Gum Woodland (2,776 ha) and Sandstone Heath/Rocky Sandstone Heath (c. 1,200 ha) within the local area is relatively large, however, *Darwinia biflora* is generally restricted to ridgetops/upper slopes within this habitat. The species is strongly associated with shale top ridgelines that follow the Pacific Highway from Lindfield to north of Wahroonga (pers. obs. I Mamott).

*Condition of habitat:* The woodland and drier heath communities within the study area are in good condition away from disturbed edges and are likely to be in good condition generally within the local area.

*Fire history within study area:* Fires occurred in 2011/12 and 2012/13 in Bloodwood-Scribbly Gum Woodland and the Sandstone Heath communities (mapping dated 9 September 2015). A fire regime of 8-15 years is considered appropriate to maintain relatively open habitat and ensure seed soil storage.

### ***Genoplesium baueri***

*Habitat values:* Occurs in open-forest, woodland and heath on sandstone often with some clay influence or where mossy. Potential habitat is found in the Duffys Forest EEC, Peppermint-Angophora Forest communities, Bloodwood-Scribbly Gum Woodland, Sandstone Heath and Rocky Sandstone Heath. Open conditions are preferred due to its small size with overshadowing by larger shrubs likely to reduce flowering and seed production. The mid-storey figures provided in Table 27 indicate that the openness of habitat in these communities is mostly <20% and suitable for the species at least in some parts. The extent of these communities (except Duffys Forest EEC) within the locality is relatively large (see Table 5).

*Condition of habitat:* The open-forest, woodland and drier heath communities within the study area are in good condition away from disturbed edges and are likely to be in good condition generally within the local area. Most remnants of Duffys Forest within the local area, however, are affected by clearing, fragmentation and edge-related disturbances (Recovery Plan, DEC 2004, OEH 2013).

*Fire history within study area:* Fires occurred in 2011/12 and 2012/13 in Bloodwood-Scribbly Gum Woodland and the Sandstone Heath communities (mapping dated 09/09/2015). A fire regime of around 8-15 years is considered appropriate to maintain relatively open habitat and ensure seed soil storage. Recent fires within the Duffys Forest EEC include a small area north of Mona Vale Road near the Booralie Road intersection subject to an ecological burn in 2012 and one in August 2015 on the northern side within Ku-ring-gai Chase National Park at the western end of the study area. Other areas of Duffys Forest EEC are unburnt since a wildfire in 1994.

### ***Fauna***

Condition of the vegetation within the study area is described above in Section 5.3.1.1. The quality of fauna habitat is generally related to the condition of the vegetation.

#### **Red-crowned Toadlet**

*Habitat values:* Red-crowned Toadlets breed in ephemeral drainage lines and occupy nearby habitat during non-breeding periods (Stauber 2006). Numerous ephemeral drainage lines flow away from Mona Vale Road towards Wirreanda and McCarrs Creeks in the north and Deep Creek in the south. The species lays its eggs in ephemeral drainage lines amongst leaf litter within such drainage lines. Bushrock is abundant in these areas, comprising an important aspect of breeding habitat and also providing sheltering sites both in crevices and in the leaf litter that accumulates amongst the rocks. In non-breeding periods the Red-crowned Toadlet shelters under rocks, amongst vegetation or under leaf litter close to breeding habitat.

*Condition of habitat:* Potential breeding habitat for the Red-crowned Toadlet within the study area is generally in good condition. Where these drainage lines originate close to the road there are occasional weed infestations. Such infestations often indicate higher nutrient levels and these



drainage lines are unlikely to be suitable for successful breeding. There are large areas of good quality non-breeding habitat surrounding other known potential breeding sites in Ku-ring-gai Chase and Garigal National Parks.

*Fire history within study area:* Fires occurred in Garigal National Park, where the Red-crowned toadlet was identified, in 2003 and 2012/13. Fires occurred in suitable habitat in Ku-ring-gai Chase National Park in 2012/13 and 2015. Areas near Wirreanda Road where the Red-crowned Toadlet was identified were burnt in 2011/12 (Figure 22).

### **Giant Burrowing Frog**

*Habitat values:* Giant Burrowing Frogs breed in ephemeral drainage lines and occupy nearby habitat during non-breeding periods (Stauber 2006). Numerous ephemeral drainage lines flow away from Mona Vale Road towards Wirreanda and McCarrs Creeks in the north and Deep Creek in the south.

This species lays its eggs in ephemeral drainage lines amongst leaf litter. The Giant Burrowing Frog may also use burrows that become inundated with water during rainfall events for egg-laying. Bushrock is abundant in these areas, contributing breeding habitat and also providing sheltering sites both in crevices and in the leaf litter that accumulates amongst the rocks. Giant Burrowing Frogs can be located further from breeding sites and shelter in burrows. They display high fidelity to particular burrows and the area surrounding these burrows (Penman *et al.* 2008).

*Condition of habitat:* Potential breeding habitat for the Giant Burrowing Frog within the study area is generally in good condition. Where drainage line habitat originates close to the road there are sometimes weed infestations. Such infestations often indicate higher nutrient levels and these drainage lines are unlikely to be suitable for breeding. There are large areas of good quality non-breeding habitat surrounding the potential breeding sites in Ku-ring-gai Chase and Garigal National Parks.

*Fire history within study area:* Fires occurred in Garigal National Park, where both the Red-crowned toadlet and Giant Burrowing Frog were identified, in 2003 and 2012/13. Fires occurred in suitable habitat in Ku-ring-gai Chase National Park in 2012/13 and 2015 (Figure 22).

### **Eastern Pygmy-possum**

*Habitat values:* The Eastern Pygmy-possum occupies habitats that are rich in flowering Myrtaceous and Proteaceous trees and shrubs. Flowering *Banksia* species appear to be a particularly important foraging resource. Given the variety of foraging resources available (Appendix G) it is clear that the Eastern Pygmy-possum would forage extensively within the study area.

Seventy-eight small hollows that may be suitable for the Eastern Pygmy-possum were identified within the subject site (Figure 21). Numerous other sheltering sites were observed throughout the study area. Apart from breeding females, there appears to be adequate shelter and breeding sites available for Eastern Pygmy-possums.

Eastern Pygmy-possums have been widely detected within the study area over numerous survey periods in the last two years. There is a diversity of foraging resources present for this species including dense *Banksia* patches (particularly *B. ericifolia*). The survey capture records include a breeding

female, adult males and nests (which are only constructed by breeding females) (Ecosure 2014; SMEC 2016). Moreover, the detection of a nulliparous sub-adult female in November 2015 indicates recruitment into the population. Eastern Pygmy-possum have small, relatively stable home-ranges (Harris *et al.* 2007; Law *et al.* 2013), so adult possums within the study area are likely to be resident there. Thus, a stable and likely important, population appears to be present in the study area.

Given the widespread availability of suitable, *Banksia*-rich habitat in Ku-ring-gai Chase NP and Garigal NP to the immediate north and south of the study area, respectively, the study area appears to be part of a large, viable population in the locality. Unfortunately, there have been no demonstrated recaptures from opposite sides of Mona Vale Road, so it is not possible to assess whether Eastern Pygmy-possums currently cross the existing road. Therefore, it cannot be determined whether the population in the locality is currently subdivided by this potential movement barrier.

The absolute abundance of the Eastern Pygmy-possum within the locality is not known. However, there appears to be a substantial area of suitable habitat based on its known habitat requirements. This is not surprising as much of the locality is within conservation reserves containing extensive areas of woodland, heathy woodland and heath. However, the existing Mona Vale Road is likely to be a major movement barrier subdividing populations to the north and south.

*Condition of habitat:* The open-forest, woodland and drier heath communities within the study area are most likely to be occupied by the Eastern Pygmy-possum. These communities are generally in good condition, located away from disturbed edges and are likely to be in good condition generally within the local area.

*Fire history within study area:* The majority of the areas where the Eastern Pygmy-possum has been detected (Garigal National Park west of the Caley Trail and north of Mona Vale Road) were burnt between 2011 and 2013. A section of Garigal National Park east of the Caley Trail was burnt in 2003 (Figure 22). A small area of habitat near Terrey Hills in Ku-ring-gai Chase National Park was burnt in 2015.

## **Powerful Owl**

*Habitat values:* Powerful Owls nest in large tree hollows. Twelve large hollows that may be suitable for the Powerful Owl were identified within the subject site. Other suitable sized hollows were observed in the study area and neighbouring habitat. No roosting habitat is likely to occur in the study area as the Powerful Owl prefers dense canopies for roosting, which occurs in nearby gullies outside the study area.

Powerful Owls are known to have very large home ranges, often in fragmented habitat. It is possible that some individuals may utilise the subject site for hunting on occasion as there are likely to be suitable prey of Ring-tailed possums, Sugar Gliders and roosting birds present. However, the subject site is not likely to be important habitat given size of Powerful Owl home ranges and the extent of suitable foraging habitat within the vicinity of suitable breeding sites.

*Condition of habitat:* Habitat suitable for the Powerful Owl within the study area is generally in good condition. Some clearing of canopy trees has occurred for roads, tracks and powerline easements. The native vegetation communities that are present within the study area generally have a relatively low level of canopy cover.

*Fire history within study area:* Most of the study area has been burnt between 2003 and 2013. A small area of habitat near Terrey Hills in Ku-ring-gai Chase National Park was burnt in 2015 (Figure 22).

### **Southern Brown Bandicoot**

*Habitat values:* In south-eastern Australian the Southern Brown Bandicoot occupies a variety of habitats including heathland, shrubland, dry sclerophyll forest, sedgeland and woodland (DEC 2006). Many of these habitats are prone to fire and it has been demonstrated that bandicoots are capable of surviving low-intensity burns (Hope 2012) and in some cases prefer regenerating habitats (DEC 2006).

The subject site is likely to be only utilised by Southern Brown Bandicoot for dispersal as suitable foraging, sheltering and breeding habitat does not occur in proximity to Mona Vale Road. Suitable habitat tends to occur further from the road in lower lying areas with a denser ground-cover layer. Some areas of the study area are quite rocky, which does not suit the foraging habits of this species.

Suitable foraging, breeding and sheltering habitat is available for the Southern Brown Bandicoot throughout the locality in Ku-ring-gai Chase and Garigal National Parks. The subject site is unlikely to provide important habitat for the Southern Brown Bandicoot (Ecosure 2015).

*Condition of habitat:* The majority of vegetation within the study area is in good condition, however, some areas are occupied by vegetation communities that have a lower density of groundcovers which does not suit the habitat requirements of the Southern Brown Bandicoot. Suitable habitat within the locality occurs in national parks and is generally in good condition.

*Fire history within study area:* Many of the habitats in which Southern Brown Bandicoots occur are prone to fire and it has been demonstrated that bandicoots are capable of surviving low-intensity burns. The areas where the Southern Brown Bandicoot is most likely to occur were burnt between 2011 and 2013. A section of Garigal NP east of the Caley Trail was burnt in 2003 (Figure 22).

### **Microbats**

*Habitat values:* Rock shelters, rock outcrops, caves and crevices suitable for cave-dwelling bat species are abundant in the study area as Mona Vale Road runs along a sandstone ridgeline. In addition to these features, 135 hollow bearing trees were identified in the subject site, some of which contain suitable roosting habitat for microbats that prefer to roost in tree hollows. Foraging habitat for microbats occurs throughout the study area. Foraging habitat along Mona Vale Road is subject to noise and lighting disturbance.

*Condition of habitat:* Forest and woodland communities within the study area, where microbats are likely to occur, are in relatively good condition with minimal weed infestation away from the road edges.

*Fire history within study area:* Most of the study area has been burnt between 2003 and 2013. A small area of habitat near Terrey Hills in Ku-ring-gai Chase National Park was burnt in 2015 (Figure 22).

### **Grey-headed Flying-fox**

*Habitat values:* Flowering trees that provide seasonal foraging resources for the Grey-headed Flying-fox occur throughout the subject site. No Grey-headed Flying-fox camps were identified and there are

no suitable camp sites in the study area. Grey-headed Flying-foxes roost in camps with large numbers of individuals, usually near water. No Grey-headed Flying-fox camps have been identified in the study area but three are known to occur close to the subject area: Warriewood (5 kilometres east), Balgowlah (12 kilometres south) and Gordon (10 kilometres south-east). Other camps are known to occur in the Sydney region (OEH 2016).

*Condition of habitat:* Duffys Forest, Bloodwood-Scribbly Gum Woodland and Sandstone Heath communities within the study area are in relatively good condition with minimal weed infestation away from the road edges.

*Fire history within study area:* Most of the study area has been burnt between 2003 and 2013. A small area of habitat near Terrey Hills in Ku-ring-gai Chase National Park was burnt in 2015 (Figure 22).

### **Rosenberg's Goanna**

*Habitat values:* The Rosenberg's Goanna is found in heath, open forest and woodland habitats on sandy soil. Their diet includes invertebrates, small mammals, birds, eggs and also carrion. They require large areas of habitat for foraging with home ranges of up to 40 hectares have been measured for individuals on Kangaroo Island (King and Green 1999). Larger home ranges may be required within the study area due to competition with the Lace Monitor (*Varanus varius*). Rosenberg's Goannas shelter in burrows constructed under hollow logs, flat rocks or shrubs. They also frequently use rabbit warrens instead of digging their own burrow (King and Green 1999). The study area contains foraging and sheltering habitat for the Rosenberg's Goanna. Large areas of suitable habitat also occur in the neighbouring Garigal and Ku-ring-gai Chase National Parks. Fallen logs and rocks are abundant and the European rabbit (*Oryctolagus cuniculus*) is known to occur in the study area, although no warrens were observed in the subject site.

Termite mounds are a critical habitat component as they are used for nesting (Wilson and Swan 2010; OEH 2012). Most large varanids use termite mounds for breeding (King and Green 1999) and Lace Monitors are regularly observed in the study area.

Sixteen termite mounds were identified during surveys by Ecosure (2015). Five of these were terrestrial termite mounds suitable for use by female Rosenberg's Goannas. Three of these had evidence of recent excavation by lizards, suggesting breeding activity. Twelve terrestrial termite mounds had been previously recorded (Smith and Smith 2011). Existing termite mound locations are shown in Figure 19. More recent observations by SMEC confirmed the presence of these termite mounds. One termite mound was observed to be utilised by Lace Monitors, which also uses termite mounds for breeding (King and Green 1999). Rock shelters, rock outcrops and crevices that could provide suitable burrowing sites for the Rosenberg's Goanna are abundant in study area.

*Condition of habitat:* Foraging habitat for the Rosenberg's Goanna is generally in good condition greater than 10 metres from the road as some weed infestations occur along the roadside. Some termite mounds are prone to disturbance due to their proximity to the road (less than 10 metres) (SMEC observations 2016).

*Fire history within study area:* Most of the study area, which provides foraging habitat for the Rosenberg's Goanna, has been burnt between 2003 and 2013. A small area of habitat near Terrey Hills in Ku-ring-gai Chase National Park was burnt in 2015 (Figure 22).



### 5.3.2 Discussion of habitat utilisation

#### Flora

##### *Grevillea caleyi*

*Population details:* The number of mature plants of *Grevillea caleyi* within the study area are declining with only 38% of the 2011 number recorded just a few years later. Lack of fire is likely to be the main factor causing this decline with most areas unburnt since a wildfire in 1994. In these areas plants were noted as mature to senescent (pers. comm. N. Smith 2015). This is likely to be a temporary state however as extensive seedling recruitment would be expected from the soil seed bank following future fires. This potential is confirmed following more recent ecological burns in the vicinity of the Booralie Road intersection (2012) and more recently (around August 2015) on the northern side of Mona Vale Road adjacent to Ku-ring-gai Chase National Park in the western part of the study area (site 2 of the Recovery Plan). Immature saplings to 1 m high, some flowering, were observed around the Terrey Hills traffic lights during the Ecosure surveys following the 2012 burn. Small seedlings were observed just four months after the August 2015 burn. A rapid count of seedlings at the latter site within an area of approx. 10 m x 10 m totalled 35 giving a density of around 0.35/m<sup>2</sup>. More detailed survey of this location and its surrounds in February 2016 revised this estimate down to 0.23 plants/m<sup>2</sup>.

Auld and Scott (2013) noted that estimates of abundance before and after fire showed very large changes in numbers of plants above ground. It is likely that potential population size within the study area is in the several thousands.

Table 28 summarises population details for *Grevillea caleyi* within the study area.

**Table 28: Population details for *G. caleyi* in study area**

Location	Sub-population (size and age)	Fire details	Reference
Tumbledown Dick Hill;	218 seedlings (including 208 seedlings within a 903 m <sup>2</sup> burnt patch on the northern side of Mona Vale Road);	August 2015 at Tumbledown Dick Hill;	SMEC targeted surveys (Feb 2016)
Baha'i Temple population	36 adults (2 dead) + 2 seedlings	Wildfire 1994	
Study area (west end, north side)	35 seedlings in 10 m x 10 m plot	August 2015 including adjacent national park	SMEC site inspection Dec 2015
Study area	77 + 3 dead (2011)	Last fire in 1994 (wildfire)	Smith and Smith 2011, RFS 2015
Study area	29 (2012/13)	Wildfire 1994 Ecological burn 2012 (west end)	Ecosure 2015, RFS 2015

Location	Sub-population (size and age)	Fire details	Reference
Booralie Road Intersection	Immature saplings to 1 m, good condition	Ecological burn 2012 (western end only)	Nathan Smith 2015
Booralie Road to Kimbriki Road (Tumbledown Dick Hill)	2-3 m high mature to senescent	Wildfire 1994	Nathan Smith 2015
Tumbledown Dick Hill (Site 2 of Recovery plan)	Northern side of road – 1847 ± 301 seedlings Southern side – 2878 ± 496 seedlings Eastern most patch – 20 plants	Last burnt Jan 1994 Previous burn around 1975 (south side) and 1979 (most of north side).	Recovery Plan (2004) Survey undertaken in June 1994
Baha'i Temple	2-3 m high mature to senescent	Wildfire 1994	Nathan Smith 2015
Baha'i Temple (Site 5 of Recovery Plan)	Northern side of road – 281 adults, 544 dead adults, 428 seedlings Southern side – 1392 adults, c.193 seedlings	Jan 1994 except area around Temple and to the east not burnt for long time	Recovery Plan (2004) Survey undertaken in July-August 1994

Fire details sourced from RFS 2015 and site inspection

*Significance of the habitat within the study area to the viability of the species in the local area: Grevillea caleyi* is restricted to an 8km<sup>2</sup> area around Terrey Hills, generally occurring on ridgetops with laterite soils from 170m-240m in elevation. The species is strongly associated with Duffys Forest EEC, however it can also occur within other vegetation types namely Bloodwood–Scribbly Gum Woodland along ridge-tops associated with ironstone laterite. Habitat within the study area is very important to the viability of this species as it contains land that is part of the two largest known remnants. The potential mature population within this habitat is estimated to comprise >50% of that of the species (Auld and Scott 2013). The habitat is generally in good condition and extends into the adjoining national parks. There are only two other sites where *Grevillea caleyi* occurs in secure conservation tenure (Auld and Scott 2013).

### ***Microtis angusii***

*Population details:* *Microtis angusii* was originally recorded from one location along Mona Vale Road, at Ingleside. Intensive survey in recent years has confirmed additional sub-populations within the study area. Three sub-populations are identified at the western end (Terrey Hills), the Kimbriki Site (main population) and eastern sections (Tumburra Road to the Baha'i Temple), all on the northern side of Mona Vale Road. The peripheral sub-populations vary in size from one observed individual to 300 and are genetically more similar to each other than to the main or type sub-population (RBG 2015).

The population at the type location has increased steadily since surveys began in 2008 (RBG 2015). There have been two distinct periods of expansion between 1998-2002 and between 2008 and the present except for lower numbers in 2013. The highest number of plants (1,240) and with the widest distribution was recorded in September 2014. Population numbers can fluctuate considerably from year to year.

Plants are only visible above ground for part of the year with a single leaf appearing in autumn and flowering/fruitlet spikes in August to October/November. The remainder of the year plants persist as a tuber in the soil. The longevity of seed in the soil seedbank is limited, up to 5 -10 years.

*Significance of the habitat within the study area to the viability of the species in the local area:* The study area contains the only genetically confirmed population of *Microtis angusii*. Individual plants or sub-populations have recently been reported at other locations around Ingleside, in other suburbs of Sydney, and in one location west of the Blue Mountains (Flanagan *et al.* 2006; DECCW 2010b); however, identification is still awaiting confirmation from genetic analysis. *Microtis angusii* is morphologically difficult to distinguish from other species of *Microtis*.

Although habitat within the study area is weedy and disturbed it provides the conditions required for the life cycle of this critically endangered orchid. Habitat within the study area has been identified as having a moderate to high potential as orchid habitat (Eco Logical Australia 2016). Any loss of genetic diversity within the study area is likely to reduce resilience and robustness of the species. Known habitat within the study area is considered critical to the long-term survival of the species, including the type population that is likely to be removed by the proposal.

### ***Pimelea curviflora var. curviflora***

*Population details:* Known from one historical record within the study area at Tumbledown Dick Hill where recorded in 1996 as locally occasional. Flowering plants were noted growing in disturbed Duffys Forest on laterite with *Corymbia gummifera*, *Eucalyptus sieberi*, *Pimelea linifolia*, and *Acacia myrtifolia* (Figure 17). The species can often persist as rootstock underground with above ground plants not a reliable indication of population size. This area has been unburnt since 1994 and is densely vegetated. Seedlings are known to appear after fire. A recent ecological burn was restricted to the northern side of Mona Vale Road, where an additional two individuals were encountered in December 2016 (Figure 22).

*Significance of the habitat within the study area to the viability of the species in the local area:* There is inadequate population or habitat details to reliably determine the significance of the habitat. Where the species is present any habitat can be considered moderate significance. The 1996 record at

Tumbledown Dick Hill is similar to others in the region that it occurs in a small, unprotected patch of Duffys Forest EEC and has good connectivity with intact native vegetation to the south. There are relatively few local sites but larger populations are known from more widespread sandstone communities away from the locality both in northern and western Sydney. Suitable habitat along ridge-lines and on upper slopes in the local area is naturally restricted and vulnerable to development and ongoing impacts. The individuals observed at Tumbledown Dick Hill on the northern side of Mona Vale Road appear to have regenerated post-fire. The extent of this population is unknown.

### ***Persoonia hirsuta***

*Population details:* Two records in 1994 from Tumbledown Dick Hill and near the Baha'i Temple within or close to the study area (Smith and Smith 2000). The plant at the former site was subsequently destroyed. It is likely that both records represented single or few plants, however, this is typical for the species.

*Significance of the habitat within the study area to the viability of the species in the local area:* There are inadequate population or habitat details associated with the 1994 record to reliably determine the significance of habitat to be affected in relation to other local populations. This record is similar to others in that it occurs on unprotected land and the population size is likely to be very small. The occurrence within Duffys Forest EEC is atypical. If the species is present any habitat can be considered to be at least of low to moderate significance.

### ***Tetradlea glandulosa***

*Population details:* Known from a few records within the study area at Tumbledown Dick Hill in 1996 and 1998 and between Mona Vale Road and Wirreanda Road in 2011. Population size in 1998 was 120 plants and just 2 plants were recorded from the new location in 2011. The absence of fire in the vicinity of Tumbledown Dick Hill may be the reason for lack of sightings in recent years although habitat in the vicinity of Wirreanda Road is relatively open and suitable for the species. *Tetradlea glandulosa* is likely to be present at least in the soil seed bank.

*Significance of the habitat within the study area to the viability of the species in the local area:* There is limited population or habitat details associated with the 1994 record to reliably determine the significance of habitat to be affected in relation to other local populations. There appears to be a decline in population size at the Tumbledown Dick Hill but this is likely to be a temporary state due to lack of fire. Other populations within the locality may also be in decline for the same reason. The Duffys Forest EEC habitat for this species within the study area is atypical in comparison with its wider distribution in woodland and heath or scrub communities.

Habitat within the study area is unlikely to be of high significance to the viability of *Tetradlea glandulosa* in the local area in view of its habitat range and the relatively high number of local records within the local area, many of which were made in the last 20 years. Habitat is considered to be of low to moderate significance.

### ***Acacia bynoeana***

*Population details:* Not recorded from the study area to date. Potentially present in the soil seedbank.



*Significance of the habitat within the study area to the viability of the species in the local area:* In view of the restricted occurrence of this species on ridgetops and upper slopes, the lack of local records and typically low population size, any known or potential habitat may be significant to the viability of the species in the local area.

***Acacia terminalis* subsp. *terminalis***

*Population details:* No confirmed record from the study area to-date.

*Significance of the habitat within the study area to the viability of the species in the local area:* In view of the location (most records are closer to the coast) and lack of local records, any habitat present may be significant to the viability of the species in the local area.

***Callistemon linearifolius***

*Population details:* Not recorded from the study area to date.

*Significance of the habitat within the study area to the viability of the species in the local area:* In view of the lack of recent local records and typically low population size, any known or potential habitat present may be significant to the viability of the species in the local area.

***Darwinia biflora***

*Population details:* Not recorded from the study area.

*Significance of the habitat within the study area to the viability of the species in the local area:* Suitable habitat along ridge-lines and on upper slopes in the local area is naturally restricted and vulnerable to development and impacts generally. The relatively large number of records within the local area can be misleading with many records often relating to the same site and marked fluctuations in populations depending on fire history. On this basis any known or potential habitat within the study area is important and considered significant.

***Genoplesium baueri***

*Population details:* Not recorded from the study area.

*Significance of the habitat within the study area to the viability of the species in the local area:* In view of the lack of local records, low population size and poor knowledge base, any known or potential habitat is likely to be of significance to the viability of the species in the local area.

**Fauna**

**Giant Burrowing Frog**

*Population details:* The Giant Burrowing Frog is a large, long-lived species that does not breed every year. It prefers heath and woodland habitats, avoiding cleared areas (Lemckert and Brassil 2004). This species spends up to 95 per cent of its time in non-breeding habitat, and calling only occurs for one or two nights at a time (Rose 1974; Webb 1983). Foraging habitat occurs within the subject site, but no breeding habitat (Ecosure 2015). Potential breeding habitat for the Red-crowned Toadlet near

Wirreanda Road is unlikely to be suitable for the Giant Burrowing Frog due to the high levels of disturbance and limited non-breeding habitat immediately surrounding these areas (Figure 20). Breeding occurs exclusively in ephemeral drainage lines and non-breeding habitat occurs up to 500 metres of these sites.

*Significance of the habitat within the study area to the viability of the species in the local area:* The habitat within the subject site is not likely to be important to the survival of the Giant Burrowing Frog in the locality as the species is likely to occupy less disturbed non-breeding habitat around breeding sites in the nearby Ku-ring-gai Chase and Garigal Chase National Parks downstream of the subject site. It is likely that large areas of habitat are required to support a population of Giant Burrowing Frogs due to their tendency to occupy large, non-overlapping home ranges (Stauber 2006). It is therefore likely the habitat within the study area forms part of a larger area of habitat that supports the local population of Giant Burrowing Frogs. The current Mona Vale Road alignment already presents a barrier to dispersal of the species between higher quality habitat present in the Garigal and Ku-ring-gai Chase National Parks.

### **Red-crowned Toadlet**

*Population details:* The Red-crowned Toadlet is largely restricted to Hawkesbury Sandstone of the Sydney region. They occupy the talus slope below the ridgeline, typically those with shale capping. Surveys have identified the Red-crowned Toadlet near drainage lines below the road to the north and south of the subject site (Ecosure 2015) and near Harvey Road to the north of the study area (SMEC 2016).

Red-crowned Toadlets breed exclusively in ephemeral drainage lines. Large eggs are laid in moist areas within the drainage lines and washed downstream to pools following rainfall.

*Significance of the habitat within the study area to the viability of the species in the local area:* It is likely that Red-crowned Toadlets currently utilise ephemeral drainage lines within the study area for breeding although no direct observations have been made. However, completion of the breeding cycle may not be successful as these areas drain into roadside swales and may not retain water long enough for tadpoles to develop. During non-breeding periods they use surrounding leaf litter and vegetation for shelter. The study area provides suitable habitat for both breeding and non-breeding activities of the Red-crowned Toadlet.

### **Powerful Owl**

*Population details:* The Powerful Owl was not detected within the study area, but was found in a number of locations in close proximity to it, within the gully areas surrounding the study area (Figure 18). This species is likely to utilise the study area for foraging, but trees with the large hollows required for breeding are very rare within this area, with just a couple of trees located in the eastern section. Much of the study area contains foraging habitat, however no suitable breeding areas occur (Ecosure 2015).

*Significance of the habitat within the study area to the viability of the species in the local area:* Powerful Owls require large areas of vegetation for hunting and can occupy home ranges of up to 1,500 hectares in sub-optimal habitat. They can also occur in fragmented habitats. Given these large home ranges it is expected that only a small number of owls would utilise habitat within the 17.3 hectares of

vegetation in the subject site and that this habitat does not comprise a significant portion of the resources they require. Habitat within the study area is more likely to be suitable for primary prey species of the owls, including Ring-tailed Possums and Sugar Gliders, although occurrence of these species is likely to be higher the gullies outside the study area due to the higher productivity. Additional suitable habitat is available in the ~17,000 hectares of native vegetation within the neighbouring Garigal and Ku-ring-gai Chase National Parks. No suitable roosting or nesting habitat for the Powerful Owl was identified within the study area.

### **Eastern Pygmy-possum**

*Population details:* Eastern Pygmy-possum have been detected in the study area over numerous survey periods in the last two years. These records are distributed across the study area, there is a diversity of foraging resources and there are dense Banksia patches (particularly *B. ericifolia*). The records include a breeding female, adult males and Eastern Pygmy-possum nests (which are only constructed by breeding females) (Ecosure 2014; SMEC 2016). Moreover, the detection of a nulliparous sub-adult female in November 2015 indicates recruitment into the population. Eastern Pygmy-possum have small, relatively stable home-ranges (Harris *et al.* 2007; Law *et al.* 2013), so adult Eastern Pygmy-possum within the study area are likely to be resident there. Thus, a stable population appears to be present in the study area.

*Significance of the habitat within the study area to the viability of the species in the local area:* Given the widespread availability of suitable, Banksia-rich habitat in Ku-ring-gai NP and Garigal NP to the immediate north and south of the study area, respectively, the study area appears to be part of a large, viable population in the locality. Unfortunately, there have been no demonstrated recaptures on either side of Mona Vale Road, so it is not possible to assess whether Eastern Pygmy-possum cross the existing road. Therefore, it cannot be determined whether the Eastern Pygmy-possum population in the locality is currently subdivided by this potential movement barrier.

The Eastern Pygmy Possum occupies habitats that are rich in flowering Myrtaceous and Proteaceous trees and shrubs. Flowering *Banksia* spp. appear to be a particularly important foraging resource. Given the variety of foraging resources available (Appendix G) it is clear that the Eastern Pygmy-possum would forage extensively within the study area, particularly on the upper slopes where more nectar producing plants are most common (Law 2014).

Eastern Pygmy-possum shelter in tree hollows, fallen logs, stumps, under bark, rock crevices, within or under the leafy heads of *Xanthorrhoea* spp., burrows and accumulations of leaves between branches. However, breeding females prefer tree hollows, fallen logs and stumps (Ward 1990; Tullock and Dickman 2006; Law *et al.* 2013), presumably for nest construction (Rueegger *et al.* 2012). Hollow-bearing trees are available across much of the study area (Figure 18) and given the broad shelter requirements of the Eastern Pygmy-possum, apart from breeding females, there appears to be adequate shelter and breeding sites available.

### **Southern Brown Bandicoot**

*Population details:* In south-eastern Australian the Southern Brown Bandicoot occupies a variety of habitats including heathland, shrubland, dry sclerophyll forest, sedgeland and woodland (DEC 2006). Many of these habitats are prone to fire and it has been demonstrated that bandicoots are capable of surviving low-intensity burns (Hope 2012) and in some cases prefer regenerating habitats (DEC 2006).

The subject site is likely to be only utilised by Southern Brown Bandicoot for dispersal as suitable foraging, sheltering and breeding habitat does not occur in proximity to Mona Vale Road. Suitable habitat tends to occur further from the road in lower lying areas with a denser ground-cover layer. Some areas of the study area are quite rocky, which does not suit the foraging habits of this species.

*Significance of the habitat within the study area to the viability of the species in the local area:* The subject site is unlikely to provide important habitat for the Southern Brown Bandicoot (Ecosure 2015).

No individuals of the Southern Brown Bandicoot were recorded during the Ecosure or SMEC supplementary surveys. Although the Southern Brown Bandicoot was not identified during recent surveys, there are recent records of the species at Bobbin Head and West Head in Ku-ring-gai Chase National Park. Intensive trapping to the south of the subject site in Garigal National Park has not detected the species since 2000 (Ecosure 2015). Suitable habitat for this species occurs in the locality within both National Parks and some private property. The species is naturally rare and a lack of knowledge regarding population size, dynamics and importance of different habitat types has been acknowledged (DEC 2006).

### **Large-eared Pied Bat**

*Population details:* The Large-eared Pied Bat may utilise the study area for foraging, although the species prefers to forage in highly fertile woodlands and forests near watercourses. Additional foraging habitat occurs in the neighbouring national parks. Three possible calls of the Large-eared Pied Bat were identified during recent surveys in the road corridor (Ecosure 2015). There are other records of this species that have been recorded in the locality (NSW Atlas of Wildlife 2016). They are also known to occur in the locality although no roosting sites have been identified (Bonsen 2012). Potential roosting habitat along sandstone clifflines is unlikely to be affected.

Large-eared Pied Bats roost in caves, disused mine shafts, overhangs, road culverts, disused fairy martin nests and possibly tree hollows (DERM 2011). No roosting sites have been identified within or nearby the study area, however sandstone cliffs, overhangs and hollow trees may be used. Maternity sites are in dome caves, none of which occur in the study area.

*Significance of the habitat within the study area to the viability of the species in the local area:* Suitable habitat for the Large-eared Pied Bat is unlikely to be important due to the presence of other suitable foraging habitat nearby in the neighbouring Ku-ring-gai Chase and Garigal National Parks. No potential roosting or breeding sites have been identified in the study area.

### **Little Bentwing-bat**

*Population details:* Little Bentwing-bats are known to occur in moist eucalypt forest, rainforest, sclerophyll forest *Melaleuca* swamps, coast forest and *Banksia* scrub. They forage beneath the canopy in habitats with dense vegetation (OEH 2016). The Little Bentwing-bat was not identified within the study area, but was identified to the east of the study area in surveys for the Mona Vale Road East upgrade (Ecosure 2015).

*Significance of the habitat within the study area to the viability of the species in the local area:* The Little Bentwing-bat utilises caves, tunnels, tree hollows, abandoned mines, drains, culverts and bridges for roosting (OEH 2016). Only five maternity colonies are known to occur in Australia and these



support large number of microbats so it is very unlikely this species breeds within the study area. Habitat within the study area is unlikely to be essential to the survival of the Little Bentwing-bat in the locality as more suitable foraging habitat occurs outside the study area in habitats vegetation communities that are favoured by the species. Some potential roosting habitat occurs in tree hollows and culverts.

### **Eastern Bentwing-bat**

*Population details:* Eastern Bentwing-bats mainly use caves for roosting but are also known to use mines, storm water tunnels, buildings and man-made structures. Breeding occurs exclusively in caves (OEH 2016). It is unlikely that this species is utilising the study area for roosting as no preferred roosting habitat is present and no caves suitable as breeding sites occur within the locality.

*Significance of the habitat within the study area to the viability of the species in the local area:* The Eastern Bentwing-bat forages above the canopy of woodlands and forest. Suitable foraging habitat occurs within the study area and this species was identified in the road corridor during recent surveys by Ecosure (2015). Given the availability of additional suitable habitat in the locality and the high mobility of this species, it is unlikely habitat within the study area is important to the viability of the Eastern Bentwing-bat in the locality as individuals are unlikely to rely exclusively on resources therein. No maternity caves will be affected by the proposal.

### **Eastern Freetail-bat**

*Population details:* This species was not identified in the study area during recent surveys (Ecosure 2015). Eastern Freetail-bats are known to occur in dry sclerophyll forest, woodland, riparian vegetation, rainforest, wet sclerophyll forest, swamp forests and mangrove forests east of the Great Dividing Range (Ecosure 2015; OEH 2016).

The Eastern Freetail-bat roosts mainly in tree hollows but man-made structures and gaps underneath bark are also used (OEH 2016). Suitable hollow-bearing trees have been identified with the study area.

*Significance of the habitat within the study area to the viability of the species in the local area:* The neighbouring Ku-ring-gai Chase and Garigal National Parks contain additional suitable foraging and roosting habitat for the Eastern Freetail-bat. Habitat within the study area is unlikely to be important to the viability of the species in the locality as they are unlikely to rely exclusively on resources available within the study area.

### **Greater Broad-nosed Bat**

*Population details:* This species was not identified in the study area during recent surveys (Ecosure 2015). The Greater Broad-nosed Bat is known to occur in a variety of habitats including woodland, eucalypt forest and rainforest. It forages along creeks and rivers (OEH 2016). Tree hollows are usually used for roosting, however they have also been found in buildings. Breeding appears to occur in maternity groups in suitable trees (OEH 2016).

*Significance of the habitat within the study area to the viability of the species in the local area:* Suitable roosting habitat occurs in hollow-bearing trees within the study area and in neighbouring national parks. Preferred foraging habitat for this species only occurs outside the study area. Given the

availability of suitable habitat within the locality, habitat within the study area is unlikely to be essential for the persistence of this species.

### **Grey-headed Flying-fox**

*Population details:* Grey-headed Flying-foxes roost in camps with large numbers of individuals. These camps are usually located near water. No Grey-headed Flying-fox camps have been identified in the study area but three are known to occur close to the subject area; Warriewood (5 kilometres east), Balgowlah (12 kilometres south) and Gordon (10 kilometres south-east). Other camps are known to occur in the Sydney region (OEH 2016).

*Significance of the habitat within the study area to the viability of the species in the local area:* The Grey-headed Flying-fox is only likely to use the study area for foraging when suitable feed trees are in flower. This foraging habitat is considered to be critical to the survival of the Grey-headed Flying-fox as it supports a continuously occupied camp at Gordon (DECCW 2009). Additional foraging habitat is available in the neighbouring Garigal and Ku-ring-gai Chase National Parks as well as streetscapes and urban gardens.

### **Rosenberg's Goanna**

*Population details:* The Rosenberg's Goanna is found in heath, open forest and woodland habitats on sandy soil. Their diet includes invertebrates, small mammals, birds, eggs and also carrion. They require large areas of habitat for foraging with home ranges of up to 40 hectares measured for individuals on Kangaroo Island (King and Green 1999). Larger home ranges may be required within the study area due to competition with the Lace Monitor (*Varanus varius*). Rosenberg's Goannas shelter in burrows constructed under hollow logs, flat rocks or shrubs. They also frequently use rabbit warrens instead of digging their own burrow (King and Green 1999). The study area contains foraging and sheltering habitat for the Rosenberg's Goanna. Large areas of suitable habitat occur in the neighbouring Garigal and Ku-ring-gai Chase National Parks. Fallen logs and rocks are abundant and the European rabbit (*Oryctolagus cuniculus*) is known to occur in the study area although no warrens were observed in the subject site.

*Significance of the habitat within the study area to the viability of the species in the local area:* Termite mounds are a critical habitat component as they are used for nesting (Wilson & Swan 2010; OEH 2012). There were eleven termite mounds identified during surveys by Ecosure in 2014. Five of these were terrestrial termite mounds suitable for use by female Rosenberg's goannas. Three of these had evidence of recent excavation by varanid lizards, suggesting breeding activity (Ecosure 2015). Within the study area the Rosenberg's Goanna competes with the Lace Monitor for breeding sites (field observations SMEC 2016). Most large varanids use termite mounds for egg laying and incubation (King and Green 1999) and Lace Monitors are regularly observed in the study area.

## **5.4 DISCUSSION OF CONSERVATION STATUS**

### **5.4.1 Flora**

#### ***Grevillea caleyi***

*Local and Regional:* Most of the known range of *Grevillea caleyi* is within the locality (within 5

kilometre radius of the subject site) including the suburbs of Terrey Hills, Duffys Forest, Belrose and Ingleside areas (Table 29). There are over 300 records of this species within an 8 kilometres radius (DEC 2004). *Grevillea caleyi* is typically restricted to fragmented patches along three ridge-lines mostly on freehold and Crown lands. These patches are compromised by development, ongoing impacts associated with ridge-top/roadside habitats and adverse fire regimes. *Grevillea caleyi* is inadequately represented in conservation reserves (DEC 2004).

**Table 29: Local populations of *Grevillea caleyi***

Location	Land tenure	Habitat area	Population	Habitat condition
Sydney East Substation, Belrose (Site 21 of Recovery Plan)	Government utility	Known habitat 10 m <sup>2</sup> , potential habitat of 50 m <sup>2</sup>	1995 – 4 plants Post 1999 fire – 1700 seedlings	Poor
Oates Place, Belrose (Site 8 of Recovery Plan)	Council land	Known habitat 0.4 ha	28 dead adults, 44 adults, 27 seedlings (Sept 94)	Poor
Belrose Quarry, north & south (Site 6 of Recovery Plan)	NSW TAFE	Known habitat 3.2 ha	South – 63 dead plants, 74 seedlings (Jan 95) North – 715 seedlings (Jan 95)	Poor to average
Corner Forest Way & Mona Vale Road (Site 4 of Recovery Plan)	Edge of Garigal NP	Known habitat 12.75 ha	2 adults & c. 113 seedlings in four discrete patches (1994)	Good
Ryland Track, N. side Mona Vale Rd, opposite Austlink Corporate Park (Site 1 of Recovery Plan)	Ku-ring-gai NP	Known habitat 7.5 ha	3015 seedlings in 1994	Good
Duffys Forest (site 3 of Recovery Plan)	Crown land adjacent to Ku-ring-gai NP	Known habitat 2.6 ha	418 ± 82 (1994) 7% juveniles, 707 seedlings in 1998 after fire	Good
Frank Beckman Reserve, Terrey Hills (Site 7 of Recovery Plan)	Council sports reserve	Known habitat 0.3 ha	3 dead adults, 223 adults, 36 seedlings (1994)	Poor
J.J. Melbourne Hills Memorial Reserve (Site 12/13 of Recovery Plan)	Council land	Known habitat 1.5 ha	17 dead adults, 55 adults, 1 seedling (1994) in patches	Poor
Terrey Hills (Sites 10, 11, 14-19) of Recovery Plan)	Variable	Small patches or roadside remnants	Total of 6 dead adults, 64 adults, 21 seedlings (1994); 2000 seedlings at 2 sites in 1996 & 1998.	Mostly poor

Location	Land tenure	Habitat area	Population	Habitat condition
Namba Road, Duffys Hill (Site 20 of Recovery Plan)	Freehold	Known habitat 0.2 ha	103 adults, 1 juvenile (1997)	Moderate

Information sourced from Smith & Smith (2000) & Grevillea caleyi Recovery Plan (DEC 2004)

*State:* Restricted to northern Sydney. Listed as critically endangered under the TSC Act.

*Representation within conservation reserves:* The species is inadequately conserved within the formal conservation system. Four remnant sites occur at the edge of Ku-ring-gai Chase and Garigal National Parks, two of these are within the construction zone for this proposal and may be lost or seriously compromised by road widening. One of the other sites (Ryland Track) within Ku-ring-gai Chase National Park (Site 1 of the recovery plan) is a larger remnant with potential habitat of 7.5 ha. A fourth site is on a road verge, not naturally occurring (arising from accidental translocation of soil) and insecure (Auld and Scott 2013).

*Geographical limits:* Populations within the study area are close to the north-eastern limit of the species.

*Comparison with other local populations:* Habitat within the study area forms part of the two largest known remnants with a potential mature population estimated to comprise >50% of the total population of the species (Auld and Scott 2013). The habitat is in relatively good condition and extends slightly into the national parks. Population decline within the study area is likely due to the absence of fire for >20 years in most areas. Only a few other populations include habitat within Ku-ring-gai Chase and Garigal National Parks and these are also suffering population decline (Auld and Scott 2013). Other local populations are typically small (<3 ha) and in poor condition with high edge to core ratios.

*Key Threats:* Ongoing habitat loss through clearing for urbanisation and road construction is the primary threat. An estimated 85% of the original extent of habitat has been lost in this way (Scott *et al.* 1995). Adverse fire regimes (too frequent or too infrequent), weed invasion and physical disturbance from vehicles, trailbikes, horses and people are also key threats.

Many of the threats identified above are recognised as Key Threatening Processes (KTP) as listed under Schedule 3 of the TSC Act. The most relevant are:

- Clearing and fragmentation of native vegetation resulting in loss of biodiversity as a result of loss and/or degradation of habitat
- High frequency fire resulting in the disruption of the life cycle processes in plants and animals and loss of vegetation structure and composition
- Invasion of native plant communities by exotic perennial grasses
- Invasion and establishment of exotic vines and scramblers
- Invasion, establishment and spread of Lantana camara
- Human induced climate change



*Relevant Recovery or Threat Abatement Plans:* A recovery plan has been developed for *Grevillea caleyi* (DEC March 2004) and twenty-two (22) priority actions have been identified including:

- Implement appropriate fire management
- Threat and habitat management including fencing, bush regeneration and weed control, pathogen and runoff control
- Reservation and/or protection of remnant sites
- Undertake ecological research

The Saving our Species program one key management site for this species at Terrey Hills; which is located within the study area. The NSW Threatened Species Priority Action Statement sets out the following management objectives:

- Prevent access of recreational users to site
- Reduce and maintain weed densities at low levels
- Maintain appropriate fire regime for the species
- Ensure land management is sympathetic to the long-term requirements of the species
- Augment extant wild populations
- Track species abundance/condition over time

### ***Microtis angusii***

*Local and Regional conservation status:* *Microtis angusii* is only known and confirmed through genetic analysis from within or close to the study area. It is not conserved at these locations.

*Representation within conservation reserves:* None.

*Geographical limits:* The study area is at the currently known geographical limits of the species. Genetic studies by the Royal Botanic Gardens and Domain Trust (2015) indicate that the *Microtis angusii* present within and close to the study area may be a genetic variant of the more geographically widespread *Microtis uniflora*. EcoLogical have subsequently provided further information for the delisting of the threatened status of *Microtis angusii* in October 2016.

*Key Threats:* Road widening, degradation of habitat (from rubbish/soil dumping, construction of a sewage pipe and cement dam, soil compaction, road maintenance), weed invasion by exotic perennial grasses, rabbit grazing and unauthorised collecting have been identified as key threats (OEH Threatened Species Profile)

Some of the threats identified above are recognised as Key Threatening Processes (KTP) as listed under Schedule 3 of the TSC Act. The most relevant are listed below:

- Clearing and fragmentation of native vegetation resulting in loss of biodiversity as a result of loss and/or degradation of habitat
- Invasion of native plant communities by exotic perennial grasses.

*Relevant Recovery or Threat Abatement Plans:* A national recovery plan has been developed for *Microtis angusii* (DECCW 2010) and objectives include:

- Habitat/population protection and management
- Determine habitat requirements and ecological information

The Saving our Species program identifies one management site identified along Mona Vale Road. This management site is located within the study area and will be removed by the proposal. The NSW Threatened Species Priority Action Statement sets out the following management objectives for this species:

- Implement appropriate fire management
- Prevent access of recreational users to site
- Reduce and maintain weed densities at low levels
- Minimise impacts of road development
- Minimise accidental damage on roads/track edges
- Track species abundance and condition over time
- Establish ex-situ storage of plant material

### ***Pimelea curviflora var. curviflora***

*Local conservation status:* Recorded from the study area and around 10 additional sites at Ingleside, Duffys Forest, Terrey Hills, Belrose and North Seaforth. Within the locality most occurrences are within fragmented remnants of the Duffys Forest EEC. Most sightings are from the last 20 years but population size and current status is unknown for most records. Sites are on freehold or crown land with only two close to the edge of Ku-ring-gai Chase National Park; one at Duffys Forest and two individuals recorded at Terrey Hills in December 2016 (Figure 17). The species is inadequately conserved at the local level.

**Table 30: Local populations of *Pimelea curviflora var. curviflora* in Duffys Forest**

Location	Land tenure	Plant community & size of remnant	Habitat condition
Seaforth Oval	Garigal NP	Duffys Forest EEC 0.4 ha	Moderate to Good
Manly Dam Reserve	Council reserve	Duffys Forest EEC 2.6 ha	Average
Aquatic Drive Frenchs Forest	Crown land	Duffys Forest EEC	Average
Golden Grove Park, Beacon Hill	Council reserve	Duffys Forest EEC 1.8 ha	Average
Oates Place, Belrose	Council land	Duffys Forest EEC 0.6 ha	Poor

Location	Land tenure	Plant community & size of remnant	Habitat condition
Frank Beckman Reserve, Terrey Hills	Council sports reserve	Duffys Forest EEC 0.6 ha	Poor
NSW Gun Club, Duffys Forest	Mostly private	Duffys Forest EEC 13 ha	Mostly good
Durumbil Road, Duffys Forest	Private & Crown land	Duffys Forest EEC 13.7 ha	Average
Eurabba Road, Duffys Forest	Mostly private	Duffys Forest EEC (patches); 4.5 ha	Average
Malton Road	Lane Cove NP	Duffys Forest EEC 3.2 ha	Average

Information sourced from Smith & Smith (2000)

**Regional conservation status:** Regionally the species occurs in coastal areas of Sydney extending west through the Hills/Parramatta to Maroota with a few records in the Illawarra. Northern Sydney sites beyond the locality include Oxford Falls, Frenchs Forest, Berowra, Beacon Hill and Red Hill. Population size is variable with large fluctuations evident at sites related to time since fire and probably rainfall. Larger known records include >700 plants at Red Hill (Warringah Council pers. comm. to T. James, 2010) and 300 plants at Frenchs Forest (Smith and Smith 2000). In Western Sydney populations also vary from a few plants to hundreds with significant fluctuations from year to year. Away from the locality of the study area the taxon occurs in woodland or open-forest on sandstone (often with laterite) or in the Shale Sandstone Transition Forest critically endangered ecological community. Populations occur predominantly on freehold and crown lands. It is considered inadequately conserved.

**State conservation status:** Restricted to the Sydney region. Listed as vulnerable under the TSC Act.

**Representation within conservation reserves:** The species is poorly represented and conserved within the formal conservation system. It has been recorded from Marramarra National Park (1993), Garigal National Park (1992), Muogamarra Nature Reserve (1971) and Ku-ring-gai Chase National Park (2016).

**Geographical limits:** Populations within the study area are close to the northern limit of the taxon.

**Comparison with other local populations:** The 1996 record from the study area is similar to other records within the locality occurring in an unprotected small patch of the Duffys Forest EEC. This record has good connectivity with intact native vegetation to the south although not extensive (approximately 300 m wide). The record on the northern side of the road occurs in Ku-ring-gai Chase National Park but the extent of this population is unknown as it has regenerated post-fire. Larger populations are known from more widespread sandstone communities away from the locality both in northern and western Sydney.

**Key Threats:** Ongoing habitat loss through clearing for urbanisation, adverse fire regimes (too frequent or too infrequent), weed invasion and physical disturbance from vehicles, bikes, horses and people are also key threats.

Many of the threats identified above are recognised as Key Threatening Processes (KTP) as listed under Schedule 3 of the TSC Act. The most relevant are:

- Clearing and fragmentation of native vegetation resulting in loss of biodiversity as a result of loss and/or degradation of habitat
- High frequency fire resulting in the disruption of the life cycle processes in plants and animals and loss of vegetation structure and composition
- Invasion of native plant communities by exotic perennial grasses
- Invasion and establishment of exotic vines and scramblers
- Invasion, establishment and spread of *Lantana camara*
- Human induced climate change

*Relevant Recovery or Threat Abatement Plans:* At the time of this report there is no approved recovery plan or threat abatement plan for the species. The Saving our Species program identifies three key management sites; the study area is not located within these project areas. The NSW Threatened Species Priority Action Statement sets out the following management objectives for this species:

- Protect areas of known and potential habitat from clearing and fragmentation
- Introduce measures to prevent habitat degradation related to unrestricted access and/or trail maintenance
- Weed control.

### ***Persoonia hirsuta***

*Local:* Many of the local records can be attributed to relatively few sites on private and council land at Cromer, Collaroy and Oxford Falls.

*Regional:* The species is known from Singleton in the north to Bargo in the south and the Blue Mountains in the west. There is good representation in conservation reserves particularly in northern and far north-western areas, however, populations are vulnerable due to very small population size, susceptibility to fire and low reproduction success.

*Representation within conservation reserves:* Recorded from several reserves including Blue Mountains NP, Wollemi NP, Yengo NP, Dharug NP, Ku-ring-gai Chase NP, Marramarra NP, Royal NP and Bargo River SCA.

*Geographical limits:* The study area is not close to the geographical limits of this species.

*Key Threats:* Ongoing habitat loss through clearing for urbanisation, degradation of habitat through physical disturbance, too frequent fire and risk of local extinctions due to small population size are key threats.

*Relevant Recovery or Threat Abatement Plans:* At the time of this report there is no approved recovery plan or threat abatement plan for the species. The Saving our Species program identifies seven key management sites; the study area is not located within one of these sites. The NSW Threatened Species Priority Action Statement includes a targeted strategy for managing this species including



identifying sites on maps used for planning road maintenance works, protecting known habitat, developing fire plans and continuing research on the reproduction of *Persoonia*.

### ***Tetratheca glandulosa***

*Local conservation status:* Recorded previously from the study area (1996, 1998, 2011) and from >50 additional sites within 5 kilometres at Ingleside, Duffys Forest, Terrey Hills, Belrose and North Seaforth. Although sometimes found in the Duffys Forest EEC *Tetratheca glandulosa* is more commonly found in more extensive and less fragmented sandstone woodland and heath or scrub communities. Approximately 30% of the identified sites occur within the national park estate (mostly Ku-ring-gai Chase National Park). Although detailed information on current status is lacking it is presumed that these populations are relatively safe. Outside of the National Park many records are from urban/bushland interface zones and these populations are considered to be at moderate to high risk. The species is reasonably conserved at the local level although protection of the species outside of the national park is also important to long-term viability of the species within the locality.

*Regional conservation status:* The species occurs in northern and north-western areas of Sydney extending to the Central Coast. There are approximately 200 records within 5-10 kilometres of the study area and >150 populations across the Sydney region (OEH Threatened Species Profile).

*State conservation status:* Restricted to the Northern Sydney region. Listed as vulnerable under the TSC Act.

*Representation within conservation reserves:* Found within several national parks including some larger populations estimated to be in the order of 500-1,000 – Marramarra NP, Dharug NP, Muogomarra NR, Garigal NP, Berowra Valley NP and Ku-ring-gai Chase NP.

*Geographical limits:* Populations within the study area are not close to any geographical limits.

*Comparison with other local populations:* It appears that the number of plants is in decline within the study area if still present. A decline in numbers is most likely due to lack of fire particularly in the vicinity of Tumbledown Dick Hill. Other populations within the locality may similarly be in decline for the same reason. The Duffys Forest EEC habitat for this species within the study area is atypical in comparison with its wider distribution in woodland and heath or scrub communities. Based on database records population size is generally low (<50) although information is lacking for many sites. The Berowra Valley area is known to contain a population estimated as around 2,500 plants (OEH Priority Action Statement).

*Key Threats:* Ongoing habitat loss through clearing for urbanisation, adverse fire regimes (too frequent or too infrequent), weed invasion and physical disturbance from vehicles, bikes, horses and people are also key threats.

Many of the threats identified above are recognised as Key Threatening Processes (KTP) as listed under Schedule 3 of the TSC Act. The most relevant are:

- Clearing and fragmentation of native vegetation resulting in loss of biodiversity as a result of loss and/or degradation of habitat

- High frequency fire resulting in the disruption of the life cycle processes in plants and animals and loss of vegetation structure and composition
- Invasion of native plant communities by exotic perennial grasses
- Invasion and establishment of exotic vines and scramblers
- Invasion, establishment and spread of *Lantana camara*
- Human induced climate change

*Relevant Recovery or Threat Abatement Plans:* At the time of this report there is no approved recovery plan or threat abatement plan for the species. The Saving our Species program identifies three key management sites; the study area is not located within one of these sites, with Berowra Valley being the closest of these sites. The NSW Threatened Species Priority Action Statement identifies the following specific activities:

- Ensure sufficient vegetation buffers between development and populations
- Minimise habitat loss
- Maintain and improve connectivity between populations
- Protect habitat from degradation
- Restore degraded habitat

### ***Acacia bynoeana***

*Local conservation status:* There are three records of this species from the local area (1998, 2001) all within Ku-ring-gai Chase National Park, however, population size is typically small (1-5) and populations are vulnerable to local extinctions. There are no known recent sightings (within last 10 years) of these populations based on available databases with the most recent record in 2001 with plants (unspecified number) growing below power lines.

*Regional conservation status:* *Acacia bynoeana* is widespread within the Sydney region from Morisset in the north to Berrima and the Illawarra in the south, and to the Blue Mountains in the west. It is found within the national park reserve system in northern and western parts of its range but the adequacy of conservation is unknown largely due to small population size and lack of survey. It is important to protect the species across its known geographical and habitat range.

*Representation within conservation reserves:* *Acacia bynoeana* is known from Ku-ring-gai Chase NP, Marra NP, Blue Mountains NP, Royal NP, Castlereagh NR and Agnes Banks NR. It is also known from Lake Macquarie SRA.

*Geographical limits:* The study area is not close to the geographical limits of this species.

*Comparison with other local populations:* There are no known populations within the study area. Any population present is likely to be small in size similar to other local populations.

*Key Threats:* Ongoing habitat loss through clearing, fragmentation, habitat disturbance (including road, trail and powerline maintenance, recreational vehicles, bikes, horses and people), adverse fire regimes (too frequent or too infrequent) and weed invasion are the key threats.

*Relevant Recovery or Threat Abatement Plans:* At the time of this report there is no approved recovery plan or threat abatement plan for the species. The Saving our Species program identifies site specific management to reduce threats and promote recovery of the species. Five key management sites have been identified; the study area does not include one of these sites. The NSW Threatened Species Priority Action Statement identifies the following specific activities:

- Protect remaining habitat through identification on maps used for planning purposes and through education (e.g. able to identify the species)
- Protect known habitat from maintenance activities and recreation
- Investigate appropriate fire regime
- Weed control

### ***Acacia terminalis subsp. terminalis***

*Local conservation status:* There are no known local populations.

*Regional conservation status:* This subspecies is highly restricted to the northern shores of Sydney Harbour and south to Botany Bay. Recent records (2005) are from the Quarantine Station, Clifton Gardens, Dover Heights, Parsley Bay, Nielsen Park, Cooper Park, Chifley and Watsons Bay. The species is inadequately conserved.

*Representation within conservation reserves:* Few small populations in conservation reserves with most sites in council reserves.

*Geographical limits:* Any population in the study area would be at the northern limit of its known range (currently the northern limit is at North Head).

*Key Threats:* Ongoing habitat loss through clearing for urbanisation, habitat degradation from rubbish dumping, direct disturbance by people and park maintenance, adverse fire regimes, weed invasion and hybridisation with horticultural cultivars are identified as the key threats.

*Relevant Recovery or Threat Abatement Plans:* There is a national recovery plan for *Acacia terminalis subsp. terminalis* (DECCW 2010). The Saving our Species Program identifies five key management sites; the study area does not include a key management site. The NSW Threatened Species Priority Action Statement identifies the following activities:

- Ensure relevant personnel are able to identify the sub-species and are aware of locations
- Ensure appropriate fire regime (at least every 6-12 years)
- Protect known sites from clearing and degradation
- Establish monitoring programs
- Conduct surveys of all suitable habitat within Sydney Harbour and Botany Bay National Parks
- Undertake research into the biology and ecology of the sub-species

## ***Callistemon linearifolius***

*Local conservation status:* There are two local populations of *Callistemon linearifolius* of unknown size, one of which is very recent (2014) from Mona Vale Road near Ingleside close to the study area. It is inadequately conserved.

*Regional conservation status:* The species is known from the Georges River to Hawkesbury River in the Sydney area, north to Nelson Bay and with one record from the Illawarra. For the Sydney region recent records are limited to the Hornsby Plateau. There are currently only 5-6 populations remaining of the 22 populations historically recorded from Sydney.

*Representation within conservation reserves:* Three populations are known from Ku-ring-gai Chase NP, Lion Island NR and Spectacle Island NR. It is also recorded from Yengo NP. It is not adequately conserved across its geographical range.

*Geographical limits:* The study area is not close to the geographical limits of this species.

*Key Threats:* Ongoing habitat loss through clearing for urbanisation and a high risk of local extinction due to low population numbers are the primary threats.

*Relevant Recovery or Threat Abatement Plans:* At the time of this report there is no approved recovery plan or threat abatement plan for the species. Under the Saving Our Species Program *Callistemon linearifolius* has been assigned to the data-deficient management stream (no site-specific conservation projects). The NSW Threatened Species Priority Action Statement outlines a strategy to address key knowledge gaps including searching for new sites and research on fire requirements, as well as protection of known habitat.

## ***Darwinia biflora***

*Local conservation status:* There are 81 known occurrences of *Darwinia biflora* within 10 kilometres of the study area. Some of these populations are recorded as being small but the majority have no recorded population size details. At least one large population (which numbers in the thousands) is known from Berowra/Cowan.

*Regional conservation status:* Restricted to northern and north-western parts of the Sydney region. Poorly conserved in north-western parts of its range within The Hills Shire.

*Representation within conservation reserves:* Many local occurrences are within Ku-ring-gai National Park. Also known from Lane Cove NP (OEH estimate 5000 plants), Muogamarra NR and Marramarra NP (OEH estimate 500 plants).

*Geographical limits:* The study area is closest to the eastern geographical limit of this species (Cowan).

*Key Threats:* Ongoing habitat loss through clearing for urbanisation, habitat degradation, adverse fire regimes (too frequent or too infrequent) and weed invasion are the key threats.

*Relevant Recovery or Threat Abatement Plans:* There is an approved recovery plan for *Darwinia biflora* (2004). The NSW Threatened Species Priority Action Statement identifies site specific management to reduce threats and promote recovery of the species. Four key management sites have been identified;



the study area is not located within any of these areas, the Hornsby/Berowra conservation project being the closest. Specific activities include:

- Implement appropriate fire regimes
- Prevent mechanical damage and trampling by livestock
- Weed control
- Increase protection of sites

### ***Genoplesium baueri***

*Local conservation status:* There are 41 records within 10 kilometres of the study area, however, many of these populations have not been seen in recent years. Unlikely to be adequately conserved.

*Regional conservation status:* Most of the older records are from northern Sydney e.g. Asquith, Cowan, Gladesville and Wahroonga. Also known north to Port Stephens and south to Ulladulla but rarely seen.

*Representation within conservation reserves:* Known from Ku-ring-gai Chase NP and could occur in Berowra Valley RP, Royal NP and Lane Cove NP.

*Geographical limits:* The study area is not close to the geographical limits of this species.

*Key Threats:* Ongoing habitat loss through clearing for urbanisation, degradation of habitat through physical disturbance, weed invasion, excessive browsing (e.g. by rabbits), changes in hydrology and lack of knowledge are identified as key threats.

*Relevant Recovery or Threat Abatement Plans:* At the time of this report there is no approved recovery plan or threat abatement plan for the species. The NSW Threatened Species Priority Action Statement identifies the need for site specific management to reduce threats and promote recovery of the species. Four key management sites have been identified; the study area is not located within any of these areas, the Ku-ring-gai Chase NP conservation project being the closest. Specific activities identified include:

- Protect remaining habitat from clearing and development
- Determine appropriate fire regimes
- Undertake further surveys to locate any additional populations
- Restore natural hydrology
- Erect fencing to reducing browsing impacts

## **5.4.2 Fauna**

### ***Giant Burrowing Frog***

*State conservation status:* Listed as vulnerable under the TSC Act. It is also listed as endangered under the EPBC Act.

*Local conservation status:* There are 40 records of the Giant Burrowing Frog within ten kilometres of

the study area. The majority of these records are from within national parks or reserves.

*Regional conservation status:* Records of the Giant Burrowing Frog are spread across the Sydney Basin at low densities, with the major concentrations being around the Hawkesbury River catchment and in the Royal National Park.

*Representation within conservation reserves:* Known from Brisbane Water, Garigal, Ku-ring-gai Chase and Marramarra National Parks. They are also known to occur in the Ingleside Chase Reserve.

*Geographical limits:* The Giant Burrowing Frog appears to occur as two distinct populations over its range. The northern population is largely restricted to the Sydney Basin down to Ulladulla in the south (OEH 2016).

*Relevant Recovery or Threat Abatement Plans:* No recovery plan or threat abatement plan has been prepared for the Giant Burrowing Frog. This species been assigned to the landscape species management stream under the Saving Our Species program. No priority sites have been identified.

**Key threats:** Threats to the Giant Burrowing Frog include the following key threatening process listed under the TSC Act:

- Alteration of habitat following subsidence due to longwall mining
- Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands
- Anthropogenic climate change
- Bushrock removal
- Clearing of native vegetation
- High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition
- Infection of frogs by amphibian chytrid causing the disease chytridiomycosis.

Other threats to the Giant Burrowing Frog include reduction in water quality, disturbance of habitat by forestry operations, population fragmentation and disturbance of breeding habitat by recreational activities.

### ***Red-crowned Toadlet***

*State conservation status:* Listed as Vulnerable under the NSW TSC Act.

*Local conservation status:* There are 203 records of the Red-crowned Toadlet within ten kilometres of the study area. The majority of these records are from within national parks or reserves.

*Regional conservation status:* In the (former) Pittwater Council LGA the Red-crowned Toadlet has been recorded in Deep Creek Reserve, Narrabeen, Ingleside and Bayview. It is also known to occur in the (former) Warringah Council LGA.

*Geographical limits:* The Red-crowned Toadlet is restricted to the Sydney basin; south to Nowra, north to Pokolbin and west to Mount Victoria (OEH 2016). The study area is not at the geographical limits of

this species.

*Representation within conservation reserves:* Sixty-five percent of the known distribution of the Red-crowned Toadlet occurs in reserves (OEH 2016), including Garigal and Ku-ring-gai Chase National Parks.

*Relevant Recovery or Threat Abatement Plans:* No recovery plan or threat abatement plan has been prepared for the Red-crowned Toadlet. This species been assigned to the landscape species management stream under the Saving Our Species program. No priority sites have been identified.

*Key threats:* Threats to the Red-crowned Toadlet include the following key threatening process listed under the TSC Act:

- Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands
- Anthropogenic climate change
- Bushrock removal
- Clearing of native vegetation
- High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition
- Infection of frogs by amphibian chytrid causing the disease chytridiomycosis

Other threats to the Red-crowned Toadlet include reduction in water quality, disturbance of breeding habitat by recreational activities and disturbance of habitat by forestry operations (OEH 2016). In the Sydney Basin, extensive development has occurred on the ridgelines above preferred Red-crowned Toadlet habitat (Thumm and Mahony 1999). This urbanisation is likely to have resulted in changes to drainage and a decrease in water quality resulting in degradation of the toadlet habitat.

### ***Powerful Owl***

*State conservation status:* Listed as Vulnerable under the NSW TSC Act.

*Local and regional conservation status:* There are 363 records of the Powerful Owl within ten kilometres of the study area, including known breeding pairs. In the (former) Pittwater Council LGA the Powerful Owl has been recorded in Ingleside, Warriewood, Church Point and Bayview. It is also known to occur in the (former) Warringah Council LGA.

*Geographical limits:* It is widely distributed along the whole coast of New South Wales, mainly east of the Great Diving Range. Densities within these areas are low, particularly for inland populations. The subject site does not occur near the geographical limits of the Powerful Owl in NSW.

*Habitat requirements:* Powerful Owls require large areas of vegetation for hunting and can occupy home ranges of up to 1450 hectares in sub-optimal habitat. They can also occur in fragmented habitats. Given these large home ranges it is expected that few pairs of owls would utilise habitat within the study area and that this habitat does not comprise a significant portion of the resources they require. Habitat within the study area is more likely to be suitable for primary prey species of the owls, including Ring-tailed Possums and Sugar Gliders, although occurrence of these species is likely

to be higher in gullies due to the higher productivity. Additional suitable habitat is available in the 17,000 hectares of native vegetation within the neighbouring Garigal and Ku-ring-gai Chase National Parks. No suitable roosting or nesting habitat for the Powerful Owl was identified within the study area.

*Relevant Recovery or Threat Abatement Plans:* A recovery plan for the large forest owls, including the Powerful Owl, has been developed by DEC (2006). The recovery plan recommends:

- Minimisation of vegetation removal to protect potential foraging habitat (including ground, understorey, logs and trees)
- Retention of habitat (hollow bearing) trees
- Protection of wildlife corridors and forest at a landscape level
- Exclusion zones around known nest and roost sites.

This species been assigned to the landscape species management stream under the Saving Our Species program. No priority sites have been identified.

*Key threats:* Threats to the Powerful Owl include the following key threatening process listed under the TSC Act:

- Clearing of native vegetation
- High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition
- Infection of native plants by *Phytophthora cinnamomi*
- Loss of hollow-bearing trees
- Predation by the European red fox (*Vulpes vulpes*)
- Predation by the feral cat (*Felis catus*)

Other threats to the Powerful Owl include road mortality, disturbance of nest sites and secondary poisoning.

### ***Eastern Pygmy-possum***

*State conservation status:* Listed as vulnerable under the NSW TSC Act.

*Local and regional conservation status:* The occurrence of other local populations was discussed in Section 5.2.1. This analysis revealed that most Eastern Pygmy-possum records in the locality occurred on private or council land, some of which is likely to be subject to future residential development proposals. Accordingly, many of these records were obtained in studies commissioned by local councils (e.g. Law 2013). Other records were obtained by Ecosure (2015) associated with the Mona Vale Rd East upgrade. Fewer records have come from Ku-ring-gai NP and Garigal NP, however, this is likely to reflect a comparatively lower survey effort. Law (2013, 2014) suggests that the Eastern Pygmy-possum is largely confined to upslope habitats, avoiding deep gullies and it appears locally extinction in smaller coastal reserves. Given the amount of upper slope woodland and sandstone heath, it is likely that a fairly large and important Eastern Pygmy-possum population(s) occurs in the locality,



including extensive habitat within Ku-ring-gai NP and Garigal NP. Thus, potential and known Eastern Pygmy-possum habitat appears to be widespread in the locality and well-represented within local conservation reserves.

The study area occurs within the Sydney Basin Bioregion, which extends from about Batemans Bay north to Nelson Bay and west to near Mudgee. This bioregion contains a variety of important sites used to study the Eastern Pygmy-possum, such as Royal NP, Heathcote NP, Barren Grounds NR and Jervis Bay NP (Harris and Goldingay 2005; Tulloch and Dickman 2006; Harris *et al.* 2007) in the southern part of the region. To the south, the Atlas of NSW Wildlife contains Eastern Pygmy-possum records from Budderoo NP, Morton NP, Dharawal NP and Dharawal NR in addition to the aforementioned conservation areas. To the north of the study area, records come from Brisbane Waters NP, Marramarra NR and Marramarra NP. To the west there are higher elevation records in Blue Mountains NP, Kanangra-Boyd NP and Yerranderie SCA. Although records are fairly sparse from within all conservation reserves, this is likely to be a reflection of survey effort and the species' low detection rate. Extensive areas of upper slope woodland and heath on sandstone occur within the conservation reserves discussed and other reserves in the region. There are also scattered records of the Eastern Pygmy-possum from private and other public lands within the region. Thus, the Sydney Basin Bioregion appears to be a stronghold of the Eastern Pygmy-possum within the State.

*Representation within conservation reserves:* It is estimated that 45% of the Eastern Pygmy-possums NSW distribution is within conservation reserves (OEH 2015 – Saving Our Species).

*Geographical limits:* The distribution of the Eastern Pygmy-possum extends from southern Queensland to eastern South Australia and Tasmania. In NSW it extends from the coast inland to the western slopes (e.g. Pilliga, Wagga Wagga. It is only found at higher elevations along the coast north of Newcastle.

The distribution and abundance of the Eastern Pygmy-possum in NSW was reviewed by Bowen and Goldingay (2000). They reviewed studies that amounted to 315,000 Elliott trap nights (though many trapnights were probably not well targeted) and 57,000 pitfall trapnights, which produced 154 captures. Undoubtedly many additional records have been obtained in the intervening 15 years (e.g. Blandon *et al.* 2002; Harris and Goldingay 2005; Tulloch and Dickman 2006), however, it is unlikely that the general conclusions would alter despite its low detection rate. It can be concluded that the Eastern Pygmy-possum is patchily distributed, particularly outside the Sydney Basin Bioregion, and its overall abundance is low.

The study area is not at the distribution limits of the Eastern Pygmy-possum.

*Key Threats:* KTPs affecting the Eastern Pygmy-possum are recognised as (OEH 2014: species profile):

- Loss and fragmentation habitat through land-clearing for agriculture, forestry and urban development.
- Changed fire regimes that affect the abundance of flowering proteaceous and myrtaceous shrubs, particularly banksias.
- Declining shrub diversity in forests and woodlands due to overgrazing by stock and rabbits.
- Predation from cats, dogs and foxes.

- Loss of nest sites due to removal of firewood.
- Mortality on roads through habitat and movement areas.

*Habitat Requirements:* The Eastern Pygmy-possum is found in a broad range of habitats, including rainforest, sclerophyll forest and woodland, and heath. Woodland and heath appear to be preferred across much of its range. Because the species feeds heavily on nectar, a high diversity of Myrtaceous and Proteaceous trees and shrub characterises important habitat. The most important populations appear to be associated with a high density of *Banksia* spp. While tree hollows are important for shelter, particularly for breeding females, a variety of other structures may also be used (see above).

*Recovery Plans and Threat Abatement Plans:* There is no recovery plan for the Eastern Pygmy-possum. The only threat abatement plan applying to KTPs affecting the Eastern Pygmy-possum is “Predation by the Red Fox (*Vulpes vulpes*)”. The proposal is not expected to increase the operation of this KTP. Wild dog and fox control baiting is currently being undertaken in Garigal NP. This baiting should benefit the viability of the Eastern Pygmy-possum population(s) in the study area by reducing the mortality rate. Mortality rates are a key factor influencing the viability of populations of many mammal species (Oli 2004).

A variety of priority actions are also intended to benefit the Eastern Pygmy-possum, including:

- Surveys of distribution and abundance.
- Control of feral predators, including cats (*Felis catus*).
- Fire management, particularly seeking a fire frequency of >10 years to maintain habitat values.
- Encouraging research on the ecology, movements, habitat use and genetics of Eastern Pygmy-possum populations.
- Encouraging and supporting land managers to undertake management actions that benefit the Eastern Pygmy-possum.

The Eastern Pygmy-possum has been assigned to the landscape species management stream of the Saving Our Species program. No priority management sites have been identified (OEH 2016). The Saving Our Species program also includes the following actions:

- Negotiating conservation agreements to protect known habitat, preferably in perpetuity using funding mechanisms such as Biobanking. Areas with hollow-bearing trees and an abundance of Myrtaceous and Proteaceous trees and shrubs, particularly with Banksias, are to be targeted. To date, no priority sites for the Eastern Pygmy-possum have been identified.
- Community education to reduce the demand for firewood
- Investigate options for improving road safety, such as the installation of road crossing structures such as underpasses and overpasses

*Significance of the study area:* The southern boundary of the subject site is flanked by Garigal NP, while Ku-ring-gai NP occurs to the north and directly abuts the subject site in its western third. Thus, the study area is part of an important movement corridor between two conservation reserves that both contain large areas of known and potential Eastern Pygmy-possum habitat. Most Eastern Pygmy-possum records obtained by Ecosure (2014) came from the western third of the study area, where it

abuts the conservation reserves. During the recent surveys by SMEC (2016) nests constructed by breeding females were also observed within this area. Thus, the Eastern Pygmy-possum habitat within the subject site area is of critical importance to the local population(s) and as much of it is within conservation reserves, it has a high level of long-term security.

Mona Vale Rd already operates in the area between the two national parks. In addition to causing habitat fragmentation, the heavy traffic load is likely to cause an unknown level of mortality due to vehicle strike. Moreover, the habitat in northern two-thirds of the subject site occurs as a fairly narrow strip between the existing road and rural residential type development. This area also provides some north-south connectivity to Ku-ring-gai NP and, therefore, to Garigal NP to the south of Mona Vale Rd (Figure 18). In this part of the subject site the Eastern Pygmy-possum is threatened by habitat fragmentation, altered fire regimes resulting in a reduction in Banksia abundance, mortality due to vehicle strike and predation by feral and domestic carnivores. Weed invasion appears to be minor within the study area and within the conservation reserves, being largely confined to small patches along the existing Mona Vale Rd.

The occurrence of other local populations was discussed in Section 5.2.1. The Ingleside Escarpment is within one kilometre of the study area and a significant Eastern Pygmy-possum population has been documented there (Law 2013; Ecosure 2015). This population(s) occurs on a mixture of private, council and other public lands (e.g. powerline easement). Council reserves, such as Ingleside Park, have a moderate level of long-term protection. However, private land that currently provides habitat is vulnerable to future residential development that may result in further habitat loss and fragmentation within the locality. The Ingleside Escarpment along Mona Vale Rd is also subject to a road upgrade proposal, which already has development approval. Moreover, the habitat at the top of the escarpment is already subject to additional clearing to facilitate the Ingleside residential release. Therefore, the Eastern Pygmy-possum is threatened by habitat fragmentation, altered fire regimes resulting in a reduction in Banksia abundance, mortality due to vehicle strike and predator by feral and domestic predators. However, weed invasion is generally minimal within areas of known and potential habitat.

While there are differences in the exact plant species assemblages across the study area and in comparison to the Ingleside Escarpment, the habitats can be generally defined as heathy woodland and sandstone heath. Both areas are high in the diversity of Myrtaceous and Proteaceous trees and shrubs and contain several Banksia species (the most common being *B. ericifolia*, *B. serrata* and *B. marginata*) In areas where unsuitable fire regimes have been implemented or allowed, Banksia species have become less abundant and other species, such as she-oaks (e.g. *Allocasuarina littoralis* or *Allocasuarina distyla*) have become dominant. Moreover, the midstorey along small drainage lines or large seepages tends to become dominated by Black Wattle (*Callicoma serratifolia*) and/or Christmas Bush (*Ceratopetalum gummiferum*) rather than Banksia.

### **Southern Brown Bandicoot**

*State conservation status:* The Southern Brown Bandicoot is listed as Endangered under the NSW TSC Act. The south-eastern Australian sub-species, *Isoodon obesulus obesulus*, which occurs in NSW, is listed as Endangered under the Commonwealth EPBC Act.

*Local and regional conservation status:* Within NSW there are considered to be two primary areas

where *Isoodon obesulus obesulus* occurs; just north of Sydney (in Ku-ring-gai Chase and Garigal National Parks) and in the far south-east of the state (including National Parks, reserves and forests around Yambulla, Nadgee and Green Cape). There are a few other scattered records from National Parks, State Forests and private properties (DEC 2006).

*Geographical limits:* The subject site lies within the limits of the northern Sydney population. The Hawkesbury River forms the northern extent of the *Isoodon obesulus obesulus* sub-species. North of the Hawkesbury River the Northern Brown Bandicoot (*Isoodon macrourus*) occurs.

*Representation within conservation reserves:* The northern Sydney population appears to be restricted to Ku-ring-gai Chase and Garigal National Parks, although the lack of records in Garigal National Park, despite recent intensive trapping effort, suggests further restriction to the north of Mona Vale Road. No Southern Brown Bandicoots were detected by Ecosure or SMEC during recent surveys. The majority of records of the Southern Brown Bandicoot are from conservation areas which may reflect their shy nature and tendency to occur in more undisturbed habitat. Significant effort has been put into monitoring and maintaining the Southern Brown Bandicoot population in northern Sydney by OEH and NPWS including monitoring programs and fox baiting.

*Recovery Plans and Threat Abatement Plans:* The Department of Environment and Conservation (NSW) has prepared a recovery plan for the Southern Brown Bandicoot (DEC 2006).

*Key threats:* Recognised threats to the Southern Brown Bandicoot include the following key threatening process listed under the TSC Act:

- Clearing of native vegetation
- High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition
- Infection of native plants by *Phytophthora cinnamomi*
- Predation by the European red fox (*Vulpes vulpes*)
- Predation by the feral cat (*Felis catus*)

Other threats to the Southern Brown Bandicoot include predation by dogs (*Canis lupus familiaris*), habitat fragmentation, road mortality and habitat modification (through grazing, weed invasion etc) (OEH 2016).

The Southern Brown Bandicoot has been assigned to the site-managed species management stream under the Saving Our Species program. Three management sites have been identified:

- Garigal/Ku-ring-gai (Hornsby, Ku-Ring-Gai, Pittwater LGAs)
- Woronora Plateau (Campbelltown, Shellharbour, Sutherland, Wingecarribee, Wollondilly, Wollongong LGAs)
- South East Forests (Bega Valley LGA)

Part of the study area lies within the Garigal/Ku-ring-gai management site (OEH 2016).

*Significance of the study area:* The lack of records of the Southern Brown Bandicoot, not only during



recent surveys associated with this proposal but also extensive surveys undertaken in Garigal National Park, suggest the subject site is not significant to this species. It is unlikely that the study area is used by the species for breeding, shelter or foraging. Suitable habitat is available in Ku-ring-gai Chase National Park to the north of the subject site. There are numerous records of the Southern Brown Bandicoot from this area, none less than one kilometre from the subject site. Fauna underpasses and a vegetated land bridge proposed in Section 7.1 to be implemented as part of the proposal will provide an improved connectivity between suitable habitat in Garigal and Ku-ring-gai Chase National Parks.

### ***Large-eared Pied Bat***

*State conservation status:* The Large-eared Pied Bat is listed as vulnerable under the TSC Act. It is also listed as vulnerable under the EPBC Act.

*Local and regional conservation status:* Some of the largest concentration of Large-eared Pied Bat populations in NSW appear to be in the sandstone escarpments of the Sydney basin (DERM 2011). The species has been observed using St Michaels Cave at Avalon (Pittwater Council). There are few records of this species within ten kilometres of the study area.

*Geographical limits:* The Large-eared Pied Bat has a continuous distribution from Shoalwater Bay in Queensland to Ulladulla in New South Wales. Distribution in the sandstone areas of the Sydney Basin is uncommon and patchy (DERM 2011). The study area is not at the geographical limit of this species.

*Representation within conservation reserves:* Much of the habitat in which the Large-eared Pied Bat occurs in New South Wales is located in conservation reserves (DERM 2011). DERM (2011) does not list Ku-ring-gai Chase or Garigal National Parks as conservation reserves on which the species occurs.

*Recovery Plans and Threat Abatement Plans:* The Queensland Department of Environment and Resource Management has prepared a national recovery plan for the Large-eared Pied Bat (DERM 2011).

*Key threats:* Recognised threats to the Large-eared Pied Bat include:

- Destruction of and interference with maternity and other roosts
- Mining of roosts
- Mine induced subsidence of cliff lines
- Disturbance from human recreational activities
- Habitat disturbance by other animals, including livestock and feral animals
- Predation by introduced predators
- Vegetation clearance in the proximity of roosts
- Fire in the proximity of roosts
- Loss of genetic diversity

Some of these threats are listed as key threatening processes in New South Wales:

- Alteration of habitat following subsidence due to longwall mining

- Bushrock removal
- Clearing of native vegetation
- Predation by the European red fox (*Vulpes vulpes*)
- Predation by the feral cat (*Felis catus*)

*Significance of the study area:* Suitable habitat for the Large-eared Pied Bat occurs in the neighbouring Ku-ring-gai Chase and Garigal National Parks. Given the availability of suitable habitat in the locality it is unlikely that any habitat within the study area is important to the survival of the Large-eared Pied Bat.

### ***Little Bentwing-bat***

*State conservation status:* The Little Bentwing-bat is listed as vulnerable under the TSC Act.

*Local and regional conservation status:* There are 26 records of the Little Bentwing Bat within ten kilometres of the study area. Within the (former) Pittwater LGA they have been recorded in Katandra Bushland Sanctuary, Angophora Reserve and Burrendong Place. Other records of the species occur across northern Sydney.

*Geographical limits:* Occurs down the east coast from Cape York in Queensland to Wollongong in New South Wales. The study area is not near the limit of distribution (OEH 2016).

*Recovery Plans and Threat Abatement Plans:* No recovery plan or threat abatement plan has been prepared for the Little Bentwing-bat. This species has been assigned to the landscape species management stream under the Saving Our Species Program. No priority management sites have been identified.

*Key threats:* Threats to the Little Bentwing-bat include the following key threatening process listed under the TSC Act:

- Bushrock removal
- Clearing of native vegetation
- High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition
- Removal of dead wood and dead trees
- Predation by the European red fox (*Vulpes vulpes*)
- Predation by the feral cat (*Felis catus*).

Other threats to the species include disturbance of colonies (particularly maternity colonies), exotic pathogens and lack of knowledge of population dynamics (OEH 2016).

*Significance of the study area:* Suitable habitat for the Little Bentwing-bat occurs in the neighbouring Ku-ring-gai Chase and Garigal National Parks. Given the availability of suitable habitat in the locality it is unlikely that any habitat within the study area is important to the survival of the Little Bentwing-bat.

### ***Eastern Bentwing-bat***

*State conservation status:* The Eastern Bentwing-bat is listed as Vulnerable under the NSW TSC Act.

*Local and regional conservation status:* There are 93 records of the Eastern Bentwing-bat within ten kilometres of the study area and it was recorded by Ecosure during the 2015 surveys. Other records are numerous and widespread across the north of Sydney. They have been recorded in a number of suburbs in the (former) Pittwater Council LGA. St Michaels Cave in Avalon is used by this species but is unlikely to be used as a maternity cave.

*Geographical limits:* Occurs along the east and north-west Australian coast (OEH 2016). The study area is not near the limit of distribution.

*Recovery Plans and Threat Abatement Plans:* No recovery plan or threat abatement plan has been prepared for the Eastern Bentwing-bat. This species has been assigned to the landscape species management stream under the Saving Our Species Program. No priority management sites have been identified.

*Key threats:* Recognised threats to the Eastern Bentwing-bat include the following key threatening process listed under the TSC Act:

- Clearing of native vegetation
- High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition.

Other threats to the Eastern Bentwing-bat include disturbance of caves, introduction of exotic pathogens and blocking of cave entrances for human safety or by vegetation (OEH 2016).

*Significance of the study area:* Given the availability of additional suitable habitat in the locality and the high mobility of this species, it is unlikely habitat within the study area is important to the viability of the Eastern Bentwing-bat in the locality.

### ***Eastern Freetail-bat***

*State conservation status:* The Eastern Freetail-bat is listed as Vulnerable under the NSW TSC Act.

*Local and regional conservation status:* There are 12 records of the species within ten kilometres of the study area. Pittwater Council identifies only one record of this species in Bayview. There are numerous records of this species across the Sydney Basin, however they are more concentrated on the Cumberland Plain west of Sydney.

*Geographical limits:* Occurs in forest, woodland and swamp forests along the east coast from southern Queensland to southern New South Wales. The subject site is not at the limit of the distribution of the species.

*Recovery Plans and Threat Abatement Plans:* No recovery plan or threat abatement plan has been prepared for the Eastern Freetail-bat. This species has been assigned to the landscape species management stream under the Saving Our Species Program. No priority management sites have been

identified.

*Key threats:* Recognised threats to the Eastern Freetail-bat include the following key threatening process listed under the TSC Act:

- Clearing of native vegetation
- High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition
- Loss of hollow-bearing trees.

Other threats to the Eastern Freetail-bat include application of pesticides in or near foraging areas and artificial light sources (OEH 2016).

*Significance of the study area:* Given the availability of additional suitable habitat in the locality and the high mobility of this species, it is unlikely habitat within the study area is important to the viability of the Eastern Freetail-bat in the locality.

### **Greater Broad-nosed Bat**

*State conservation status:* The Greater Broad-nosed Bat is listed as Vulnerable under the NSW TSC Act.

*Local and regional conservation status:* There are only 3 records of this species within ten kilometres of the study area and few other records around the northern beaches of Sydney including Garigal and Ku-ring-gai Chase National Park.

*Geographical limits:* It occurs below 500 metres in gullies and river systems from north-east Victoria to the Atherton Tableland. The subject site is not at the limit of the distribution of the species.

*Recovery Plans and Threat Abatement Plans:* No recovery plan or threat abatement plan has been prepared for the Greater Broad-nosed Bat. This species has been assigned to the landscape species management stream under the Saving Our Species Program. No priority management sites have been identified.

*Key threats:* Recognised threats to the Greater Broad-nosed Bat include the following key threatening process listed under the TSC Act:

- Clearing of native vegetation
- Loss of hollow-bearing trees.

Other threats to the Greater Broad-nosed Bat include application of pesticides in or near foraging areas and changes to water regimes (OEH 2016).

*Significance of the study area:* The Greater Broad-nosed Bat may use the study area for roosting but is likely to forage outside the study area along creeklines in the adjacent Nationals Parks. It is therefore unlikely they rely on habitat within the study area to survive in the locality.



## ***Grey-headed Flying-fox***

*State conservation status:* The Grey-headed Flying-fox is listed as Vulnerable under the NSW TSC Act. It is also listed as Vulnerable under the Commonwealth EPBC Act.

*Local and regional conservation status:* There are 680 records of the Grey-headed Flying-fox within ten kilometres of the study area. Many flying-fox camps are known to occur in northern Sydney (Balgowlah, Gordon, Warriewood and Avalon) and it is likely that individuals from all of these camps could utilise the study area. Records of this species are widespread across the Sydney Basin.

*Geographical limits:* The Grey-headed Flying-fox is distributed along the coast of New South Wales. Sydney supports a resident population due to the constant availability of food and suitable roosting sites (DECCW 2009). The subject site is not at the limit of the distribution of the species.

*Recovery Plans and Threat Abatement Plans:* A draft recovery plan has been prepared for the Grey-headed Flying-fox (DECCW 2009).

*Key threats:* The following key threatening processes are considered relevant to the Grey-headed Flying-fox and the proposal:

- Clearing of native vegetation

Other threats to the Grey-headed Flying-fox include habitat loss, destruction associated with commercial horticulture, competition with Black Flying-foxes, conflict with humans, electrocution on powerlines and netting, climate change and disease (DECCW 2009).

*Significance of the study area:* The Grey-headed Flying-fox is a highly mobile species that migrates in response to the availability of food resources (OEH 2016). Many camps in Sydney are continuously occupied. The foraging habitat within the study area meets the criteria for habitat critical to the survival of the Grey-headed Flying-fox as it supports a continuously occupied camp within 10 kilometres (DECCW 2009).

## ***Rosenberg's Goanna***

*State conservation status:* The Rosenberg's Goanna is listed as Vulnerable under the NSW TSC Act.

*Local and regional conservation status:* There are 123 records of this species within ten kilometres of the study area. They have been identified within the study area; both north and south of the existing Mona Vale Road. The northern Sydney population of Rosenberg's Goannas is considered important within the locality.

*Geographical limits:* The population of Rosenberg's Goannas that occurs in northern Sydney is isolated from other populations. The main stronghold for the Rosenberg's Goanna is on Kangaroo Island in South Australia. Other populations are known to occur south of Sydney and there are some records north of the Hawkesbury River and in the Blue Mountains. The study area is not at the geographical limits of the species.

*Recovery Plans and Threat Abatement Plans:* No recovery plan or threat abatement plan has been prepared for the Rosenberg's Goanna. The Rosenberg's Goanna has been assigned to the landscape

species management stream of the Saving Our Species program. No priority management sites have been identified (OEH 2016).

*Key threats:* Threats to the Rosenberg's Goanna include the following key threatening process listed under the TSC Act:

- Bushrock removal
- Clearing of native vegetation
- Removal of dead wood and dead trees

Other threats to the Rosenberg's Goanna may include habitat modification (including the removal of termite mounds), road mortality and predation by feral carnivores.

*Significance of the study area:* Rosenberg's Goannas require large areas of vegetation to hunt for prey including invertebrates, mammals, birds, eggs and other reptiles. They are also known to feed on carrion (King and Green 1999). Termite mounds are used for nesting. Garigal and Ku-ring-gai Chase National Parks (approximately 17,000 hectares in total) adjacent to the subject site provide suitable habitat for the Rosenberg's Goanna. It is expected that given their large home ranges, all individuals that utilise the subject site rely on resources within the national parks for survival.

## 5.5 DISCUSSION OF THE LIKELY EFFECT OF THE PROPOSAL AT LOCAL AND REGIONAL SCALES

The proposal involves widening the existing road for a distance of around 3.3 kilometres between McCarrs Creek Road, Terrey Hills and Powder Works Road. Widening is also proposed along ancillary roads including Wirreanda Road, Tumburra Street and Addison Road. A link road is proposed at the eastern end from the junction of Powderworks Road and Mona Vale Road to Bungendore Road (Figure 1). The following direct impacts on affected threatened species habitat are likely to occur within the construction impact area:

- Clearing of native vegetation
- Removal of 22 termite mounds that are potential breeding habitat for Rosenberg's Goanna
- Removal of 135 hollow bearing trees
- Loss of individual plants including underground storage organs and seed in the soil seed bank
- Likely changes to existing drainage based on drainage concept design

It is estimated that around 17.9 hectares of native vegetation will be directly impacted with the exact extent dependant on finalisation of a detailed design and construction methods. Removal of vegetation is likely to directly impact threatened flora, in particular the Duffys Forest EC and known populations of Angus's Onion Orchid (*Microtis angusii*), Caley's Grevillea (*Grevillea caleyi*) and *Pimelea curviflora* var. *curviflora*. The vegetation to be removed also provides habitat for a number of threatened fauna species such as Eastern Pygmy-possum, Red-crowned Toadlet and Giant Burrowing Frog. Vegetation to be removed is mainly in linear strips along Mona Vale Road and in the road reserve around Wirreanda Road, Tumburra Street and Addison Road and from the junction of Powderworks Road and Mona Vale Road to Bungendore Road. The construction footprint is shown in Figure 2 and

includes a buffer of 6 metres to account for additional impacts (direct and indirect) that may occur due to ancillary sites, stormwater retention areas, service easements and various edge-effects.

Indirect impacts may also occur beyond the construction clearing footprint and include the following:

- Changes to drainage and soil moisture levels downslope of the construction zone
- Movement of sediment downslope of the construction zone
- Introduction and spread of weed species downslope of the construction zone
- Dust deposition on vegetation and soils during construction

Edge effects occur within a clearly defined zone of disturbance where changes can include increases in soil temperature, wind velocity, transfer of dust, seeds, insects and disease from adjoining areas, altered soil moisture levels and surface runoff rates with increased rates of erosion and transport of soil and nutrients, and increased invasion by diseases and exotic species (Saunders *et. al.* 1991). Such changes or “edge effects” have a degrading impact on native vegetation. A study on urban remnants in Sydney by Dostal (2000) found that “edge effects” often dominate within the first 20 m - 40 m although they were also recorded up to 100 m depending on the site. Much of the length of the road upgrade adjoins downslope protected areas within Garigal or Ku-ring-gai National Parks that will be vulnerable to such indirect impacts. For the purposes of this assessment, a 6 m buffer within the subject site (construction boundary) has been incorporated to include the likely impacts as a result of edge effects.

### **5.5.1 Significance within a local context**

#### **Flora**

##### ***Grevillea caleyi***

*Grevillea caleyi* within the study area occurs almost exclusively in the Duffys Forest Ecological Community (DFEC) with a small number of plants found in Bloodwood-Scribbly Gum Woodland (an unlisted community). The study area contains approximately 7 hectares of DFEC. Located at the eastern and western ends of the study area, it is mostly in good condition. This habitat is part of the two largest known remnants with a potential mature population estimated to comprise >50% of the total population of the species (Auld and Scott 2013). The targeted survey reported in Ecosure (2015) identified 29 plants from the study area, considerably less than the 77 plants recorded by Smith and Smith in 2011. In 1994 plants were recorded in their thousands (2,878±496 and 1,847±301 for the western and eastern sites respectively) as documented in the Recovery Plan (Auld and Scott 2004).

Lack of fire is likely to be the main factor causing this decline with most areas unburnt since a wildfire in 1994. In these areas plants were noted as mature to senescent (pers. comm. N. Smith 2015). This is likely to be a temporary state, however, with extensive seedling recruitment expected from the soil seed bank following future fires. This boom and bust-type cycle is likely to be representative of the general ecology of the species, with overall population numbers highly responsive to fire frequency (too frequent or too infrequent).

This recruitment cycle was confirmed following more recent ecological burns in the vicinity of the Booralie Road intersection (2012) and more recently (around August 2015) on the northern side of

Mona Vale Road adjacent to Ku-ring-gai National Park in the western part of the study area (Site 2 of the Recovery Plan). Small seedlings were observed at the latter site just four months after the August 2015 burn in December. A rapid count of seedlings during December provided a density value of around 0.35 plants/m<sup>2</sup> (similar to that recorded in 2004 as documented in the Recovery Plan), though a more detailed survey of this location and its surrounds in February 2016 revised this estimate down to 0.23 plants/m<sup>2</sup>.

Immature saplings to 1 m high, some flowering, were also observed around the Terrey Hills traffic lights during the Ecosure surveys following the 2012 burn.

On the basis of the above post-fire surveys, it is likely that the potential population size within the study area is in the several thousands based on a coarse extrapolation of the extent of *G. caleyi* habitat present (i.e. Duffys Forest EEC).

Clearing a total of 3.4 hectares of DFEC would occur within the study area affecting both the western (in vicinity of Tumbledown Dick Hill) and eastern patches (in vicinity of the Baha'i Temple). The proposal will result in the removal of 75 above ground individuals of *G. caleyi* that were confirmed to be within the construction impact zone during the February 2016 surveys. Population numbers (from the seedbank) likely to be affected, however, may be considerably higher in view of the potential for regeneration after fire (as per the recruitment cycle mentioned above). In the site inspection referred to above (December 2015) seedlings regenerated at a density of 0.35 plants/m<sup>2</sup> with some plants as close as 4 m from the existing Mona Vale Road. More detailed survey of this location and its surrounds in February 2016 revised this estimate down to 0.23 plants/m<sup>2</sup>.

A recent report to the NSW Scientific Committee (Auld and Scott 2013) identifies the widening of Mona Vale Road from Terrey Hills to Ingleside as a major threat and stated that '*Given that plants occur only within 10-20 m of the existing road verge (and not downslope off the ridgetop laterite soils) the road widening could potentially result in a worst case scenario of removal or serious disruption of habitat of some 5,000 mature plants, thus reducing or eliminating 45-60% of the potential mature population of the species*'. This worst case scenario is unlikely to occur due to ongoing road refinements that have minimised clearing in such areas, however, significant impacts may still occur. For example, clearing is likely to be limited to approximately 0.13 hectares of *Grevillea caleyi* habitat in the most recently burned area (August 2015) containing an estimated 455 seedlings based on a density of 0.35/m<sup>2</sup>. This is however likely to be somewhat of an overestimate as few plants occur within four metres of the road. Further to this, a more detailed survey of this location and its surrounds in February 2016 revised this estimate down to 0.23 plants/m<sup>2</sup>.

With the inclusion of a 6 m buffer zone within the subject site (construction impact area), all ancillary clearing and indirect impacts are likely considered in the above impact assessment. Potential indirect impacts including movement of stormwater, sediment and weeds downslope from the impact zone. However, impacts may extend further than 6 m from the construction edge, although these should be minimised if best practice mitigation measures are implemented.

In addition to the impacts of this proposal other populations known to be affected or likely to be affected by proposed development in the near future include the last relatively large site at Belrose owned by TAFE (Auld and Scott 2013) and land owned by the Baha'i Faith (adjacent to study area). These sites are included in the Ingleside Planning Precinct, which is currently under investigation for

future housing development. This precinct covers approximately 700 hectares and includes several local populations for *G. caleyi*. In the event that both the Mona Vale Road West Upgrade and the Ingleside release area were realised there is a real possibility of a dramatic reduction in the area of occupancy of this species. This would relate primarily to direct removal for roads, house plots and other infrastructure, but also secondarily to the ongoing frequency of fire. With the implementation of nearby largescale residential development, it is likely that fire regimes in the area would be significantly altered (become less frequent) in view of protecting suburbs and their occupants. This may be tempered somewhat through improved consultation between OEH and RFS with view to undertaking periodic hazard reduction burns at ecologically advantageous intervals. In the case of *G. caleyi* optimal fire frequency is likely to be in the region of 8-12 years (DEC 2006).

### ***Microtis angusii***

Following recent surveys, *Microtis angusii* is now known to occur in three sub-populations within the study area along the northern side of Mona Vale Road and ancillary roads (e.g. Wirreanda and Addison Roads). These are comprised of the main population (Kimbriki Site), a small sub-population at the western end (Terrey Hills) and a larger one in the eastern sections (Tumburra Road to the Baha'i Temple).

The type location (Kimbriki Site) has been monitored since 1998 including a more intensive study in recent years by the Royal Botanic Gardens in accordance with the National Recovery Plan for the species (DECCW 2010) and commissioned by Roads and Maritime to gain a better understanding of the species. Numbers are known to fluctuate considerably from year to year with a peak of 1,240 individuals recorded in 2014. Fluctuations appear to be strongly related to rainfall and soil moisture (Newby *et al.* 2014). The peripheral sub-populations vary in size from one observed individual to 300 and are genetically more similar to each other than to the type sub-population (Newby *et al.* 2015). Individuals at the type location are genetically unique and need to be protected alongside the other sub-populations.

The Kimbriki Site will be completely removed by the proposal. As such, the proposal will result in the extinction of the type (main) population of *M. angusii*. To date there is no reliable confirmation of numbers of *M. angusii* within the other sub-populations. Five out of seventeen specimens sent to the National Herbarium of NSW for identification from morphological features were identified as *M. angusii*, however, full genetic analysis is still not completed (Royal Botanic Gardens, September 2015). Figure 1.6 in the final report from the Royal Botanic Gardens (September 2015) shows the distribution of samples that align with *M. angusii* during phylogenetic analysis.

A total of 1469 *M. angusii* individuals have the potential to be removed as a result of the proposal. This includes all the sub-populations recorded by RBG (2015) including the main (type) population. The loss of these sub-populations may have an adverse effect on the local viable population through reduction in size and extent, and loss of genetic diversity, although this must now be viewed in the context of a larger and wider occurring population size based on the results from ELA (2015).

Prior to the ELA (2015) results, the local *M. angusii* population size was roughly estimated to be about 1,300 – 1,500 plants but with considerable variation expected from year to year. The ELA (2015) survey results suggest that this local population is likely to exceed 2,000 plants which may be an underestimate given that the ELA study area encompassed only about 50 percent of the Mona Vale Road



study area. Nevertheless, direct impacts include loss of individuals at several locations, loss of genetic diversity and loss of habitat for pollinators. Indirect impacts on the species may also result from reduced growth and flowering driven by changes in soil moisture and unknown degree of edge effects.

### ***Pimelea curviflora var. curviflora***

*Pimelea curviflora var. curviflora* was only known from one record within the study area at Tumbledown Dick Hill where it was recorded in 1996. This site has been unburnt since 1994 and is densely vegetated, a condition state considered unfavourable to the species. In December 2016 the species was recorded in the study area in Ku-ring-gai Chase National Park at Terrey Hills (Figure 17). The Duffys Forest EEC and Bloodwood-Scribbly Gum Woodland, on lateritic soils within the study area, both provide potential habitat. The species is also recorded from similar habitat in the local area including at Ingleside, Duffys Forest and Terrey Hills.

Based on the observation of individuals regenerating after fire and the assumption that the species may still be present as plants, rootstock or seed in the vicinity of earlier records, the proposed activity may remove at least part of a small population and associated habitat of the species.

Due to the inclusion of a 6 m buffer zone within the subject site (construction impact area), all ancillary clearing and indirect impacts are also included in the above impact assessment. Potential indirect impacts include movement of stormwater, sediment and weeds downslope from the impact zone. These impacts may extend beyond the 6 m buffer, although this should be minimised if best practice mitigation measures are implemented.

Detailed information about cumulative impacts is not available, however, incremental loss of known and potential habitat is likely both locally and across the region with ridge-top habitat favoured for development. The species is cryptic, making location of plants difficult and there is also a predominance of known sites on private or crown land. A typical example is the recent loss of a small population at the junction of Willandra Road and Penrhyn Drive, Beacon Hill for a residential development in 2010. Plants known from private land to the north of the developed land are also at risk from potential development. The population on private land at Belrose (owned by TAFE) is similarly threatened (Auld and Scott 2013).

### ***Persoonia hirsuta***

Two records (likely single plants) of *Persoonia hirsuta* are known from 1994 at Tumbledown Dick Hill and near the Baha'i Temple within/close to the study area (Smith and Smith 2000). The plant at Tumbledown Dick Hill was subsequently destroyed. The Bloodwood-Scribbly Gum Woodland and heath communities, on lateritic or clay-influenced soils within the study area, provide potential habitat.

Based on the assumption that the species may still be present as plants, rootstock or seed in the vicinity of the earlier record, the proposed activity may remove at least part of a small population and associated habitat of the species.

Due to the inclusion of a 6 m buffer zone within the construction impact area, all ancillary clearing and the majority of indirect impacts are included in the above impact assessment. Potential indirect impacts including movement of stormwater, sediment and weeds downslope from the impact zone,

however, may extend further than the 6 m although these should be minimised if best practice mitigation measures are adequately implemented.

Detailed information about cumulative impacts is not available, however, incremental loss of known and potential habitat is likely both locally and across the region with ridge-top habitat favoured for development and the predominance of known sites on private or crown land (often in road reserves) particularly in the local area at Cromer, Collaroy and Oxford Falls.

### ***Tetratheca glandulosa***

*Tetratheca glandulosa* is known from a few records within the study area at Tumbledown Dick Hill from 1996 and 1998 and between Mona Vale Road and Wirreanda Road in 2011 (Population size in 1998 was 120 plants and just two plants were recorded from the new location in 2011) (Figure 16). The absence of fire in the vicinity of Tumbledown Dick Hill may be the reason for lack of sightings in recent years. The species is likely to be present at least in the soil seed bank.

Based on the assumption that the species may still be present as plants, rootstock or seed in the vicinity of the earlier records, the proposed activity may remove at least part of a small population and associated habitat of the species.

Due to the inclusion of a 6 m buffer zone within the construction impact area, all ancillary clearing and the majority of indirect impacts are included in the above impact assessment. Potential indirect impacts including movement of stormwater, sediment and weeds downslope from the impact zone, however, may extend further than the 6 m although these should be minimised if best practice mitigation measures are adequately implemented.

Detailed information about cumulative impacts is not available, however, incremental loss of known and potential habitat is likely both locally and across the region with ridge-top habitat favoured for development.

### ***Acacia bynoeana***

Potential habitat for *Acacia bynoeana* is found in Bloodwood-Scribbly Gum Woodland, Sandstone Heath and Rocky Sandstone Heath within the study area. The extent of Bloodwood-Scribbly Gum Woodland (2,776 ha) and Sandstone Heath/Rocky Sandstone Heath (c. 1,200 ha) is relatively large within the local area.

Based on the assumption that the species may still be present as plants, rootstock or seed, the proposed activity may remove or modify at least part of a small population and associated habitat of the species.

In view of the restricted occurrence of this species on ridgetops and upper slopes, the lack of local records and typically low population size, any population and associated habitat may be significant to the viability of the species in the local area but unlikely to be so when considered at a regional scale.

Although detailed information about cumulative impacts is not available, cumulative impacts of clearing and modification of potential habitat is likely both locally and across the region with ridge-top habitat favoured for development.

### ***Acacia terminalis* subsp. *terminalis***

Potential habitat for *Acacia terminalis* subsp. *terminalis* is found in Bloodwood-Scribbly Gum Woodland, Sandstone Heath and Rocky Sandstone Heath within the study area. The location of the potential sighting (Smith and Smith 2001) is within one of the Duffys Forest translocation areas and adjacent to Yellow-top Ash Mallee which is included in the Sandstone Heath community and likely to be the preferred habitat. The extent of Bloodwood-Scribbly Gum Woodland (2,776 ha) and Sandstone Heath/Rocky Sandstone Heath (c. 1,200 ha) is relatively large within the local area.

The tentative record of *Acacia terminalis* subsp. *terminalis* south of Mona Vale Road in the vicinity of Tumbledown Dick Hill occurs just outside of the subject site (construction impact zone). The other two records are located between Mona Vale Road and Wirreanda Road both within the subject site. Assuming that this taxon is present as plants or seed in the latter site, the proposed activity is likely to remove a small population and associated habitat.

Due to the inclusion of a 6 m buffer zone within the construction impact area, all ancillary clearing and the majority of indirect impacts are included in the above impact assessment. Additional indirect impacts are considered to be minimal due to upslope position and implementation of best practice mitigation measures.

In view of the 'inland' location (most records closer to the coast) and lack of local records, any population and associated habitat may be significant to the viability of the species in the local area and across its known range.

### ***Callistemon linearifolius***

Although there are no records of this species from the study area, there is a recent 2014 record from nearby Ingleside. Potential habitat occurs in the Duffys Forest EEC and Peppermint-Angophora Forest communities within the study area. The extent of Duffys Forest within the local area (5 kilometres) totals 296 hectares but there are few sites undisturbed and protected long-term in conservation reserves. The extent of Peppermint-Angophora Forest locally is significantly larger at 1,832 ha.

Based on the assumption that the species is present as plants, rootstock or seed, the proposed activity may remove or modify at least part of a small population and associated habitat of the species.

In view of the lack of recent local records, high historical loss and typically low population size, any population and associated habitat present may be significant.

### ***Darwinia biflora***

Potential habitat for *Darwinia biflora* is found in Bloodwood-Scribbly Gum Woodland, Sandstone Heath and Rocky Sandstone Heath within the study area. The extent of Bloodwood-Scribbly Gum Woodland (2,776 ha) and Sandstone Heath/Rocky Sandstone Heath (c. 1,200 ha) is relatively large within the local area.

Based on the assumption that that the species is present as plants, rootstock or seed, the proposed activity may remove or modify at least part of a small population and associated habitat of the species.

Suitable habitat along ridge-lines and on upper slopes in the local area is naturally restricted and

vulnerable to development and impacts generally. The relatively large number of records within the local area can be misleading with many records often relating to the same site and marked fluctuations in populations depending on fire history. On this basis any population and associated habitat within the study area is important and considered significant at a local level but less significant at a regional scale.

Although detailed information about cumulative impacts is not available, cumulative impacts of clearing and modification of potential habitat is likely both locally and across the region with ridge-top habitat favoured for development.

### ***Genoplesium baueri***

Potential habitat for *Genoplesium baueri* is found in the Duffys Forest EEC, Peppermint-Angophora Forest communities, Bloodwood-Scribbly Gum Woodland, Sandstone Heath and Rocky Sandstone Heath within the study area. The extent of Duffys Forest within the local area (5 kilometres) totals 296 hectares but there are few sites undisturbed and protected long-term in conservation reserves. The extent of Peppermint-Angophora Forest (1832 ha), Bloodwood-Scribbly Gum Woodland (2,776 ha) and Sandstone Heath/Rocky Sandstone Heath (c. 1,200 ha) is relatively large within the local area and regionally.

Adopting the precautionary approach and assuming that the species is present the proposed activity may remove or modify at least part of a small population and associated habitat of the species.

In view of the lack of local records, high historical loss, low population size and poor knowledge base, any population and associated habitat is likely to be of significance to the viability of the species in the local area and on a regional scale (main occurrence within northern Sydney).

## **Fauna**

### **Giant Burrowing Frog**

The Giant Burrowing Frog was identified along the Caley Trail in Garigal National Park approximately 500 m to the south of the subject site. Within the study area there is suitable non-breeding habitat for this species and additional breeding and non-breeding habitat occurs in the locality. The proposal would require the removal of some suitable non-breeding habitat for the Giant Burrowing Frog. Additional breeding habitat may be indirectly affected by changes to drainage and water quality (Aurecon 2016).

The majority of suitable habitat for the Giant Burrowing Frog in the locality occurs outside the subject site in the neighbouring Garigal and Ku-ring-gai Chase National Parks. The condition of habitat within the national parks is higher as it has been exposed to less historic disturbance. The amount of potential suitable non-breeding habitat to be removed by the proposal is approximately 12.5 ha. The Giant Burrowing Frog is known to avoid cleared areas (Lemckert and Brassil 2004) so it is likely that the majority of suitable habitat for this species that remains in the locality occurs in parks and reserves. It is also likely that large areas are required to support a population of Giant Burrowing Frogs due to their tendency to occupy large, non-overlapping home ranges (Stauber 2006).

Impacts of the proposal on the Giant Burrowing Frog are summarised in Table 31.

**Table 31: Impacts of the proposal on the Giant Burrowing Frog**

Impact	Relevant KTPs	Outcome
Habitat loss	Clearing of Native Vegetation	Approximately 12.5 ha of known and potential habitat would be removed. Habitat loss minor relative to local availability.
Habitat fragmentation	Clearing of Native Vegetation	Habitat already fragmented by existing road. Individuals unlikely to cross the existing road.
Habitat alteration	<p>Infection of native plants by <i>Phytophthora cinnamon</i></p> <p>Invasion and establishment of exotic vines and scramblers</p> <p>Invasion, establishment and spread of <i>Lantana camara</i></p> <p>Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants</p> <p>Invasion of perennial grasses</p> <p>Removal of bushrock</p> <p>Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands</p>	<p>Risk of infection unknown, but could be managed to a negligible level.</p> <p>Some weed species (e.g. Lantana, garden escapees) already present.</p> <p>Risk of further establishment along new habitat edges following clearing. Can be managed through construction mitigation measures.</p> <p>Pavement discharge diversions to avoid changes in flow through breeding habitat</p>
Erosion and sedimentation	None	<p>Alteration of breeding habitat</p> <p>Minimise by implementation of a CMP</p>
Edge effects	<p>Invasion and establishment of exotic vines and scramblers</p> <p>Invasion, establishment and spread of <i>Lantana camara</i></p> <p>Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants</p>	Edge effects already exist, but will change location and some new edge created by realignment of road corridor (see weed impacts above).
Mortality during clearing	None	Difficult to locate frogs in non-breeding habitat so will be difficult to monitor and manage.



Impact	Relevant KTPs	Outcome
Mortality due to vehicle strike	None	Already in operation, but may increase due to greater traffic volume (induced traffic from better road design) and increased vehicle speeds. Can be reduced by crossing structures and exclusion fencing.
Mortality due to feral and domestic predators (dogs, cats, foxes)	Predation by the Red Fox	Already in operation. Can be reduced by predator control (currently being undertaken by NPSW).

### Red-crowned Toadlet

The occurrence of Red-crowned Toadlets is based on the availability of suitable breeding habitat in ephemeral drainage lines. Studies in the area have identified the Red-crowned Toadlet near Wirreanda Road and to the south of the study area in Garigal National Park. Within the locality suitable habitat for the Red-crowned Toadlet is available in Ku-ring-gai Chase and Garigal National Parks, which are adjacent to the subject site. Drainage lines flowing into Wirreanda Creek to the north and Deep Creek to the south contain suitable breeding habitat. Habitat within the national parks is in better condition due to low levels of disturbance although given the relatively small home ranges of this species, those present within the national parks are likely to comprise different sub-populations.

The proposal would require the removal of approximately 1.43 hectares of suitable breeding and non-breeding habitat for the Red-crowned Toadlet. This may result in localised disturbance to Red-crowned Toadlet colonies that occupy drainage lines within the subject site. Large areas of better quality habitat are available in nearby national parks and reserves and it is likely that larger colonies of toadlets are associated with more suitable breeding habitat in these areas. Breeding habitat outside the study area may be affected by changes to drainage and water quality (Aurecon 2016).

The Mona Vale Road East upgrade will remove foraging habitat for the Red-crowned Toadlet. It is likely that the individuals that occur in the Mona Vale Road East study area do not interact with the populations in the study area for this proposal. The development of the Ingleside Precinct is more likely to contribute to the decline of the species within the locality as it is likely Red-crowned Toadlet breeding habitat will be removed.

Impacts of the proposal on the Red-crowned Toadlet are summarised in Table 32.

**Table 32: Impacts of the proposal on the Red-crowned Toadlet**

Impact	Relevant KTPs	Outcome
Habitat loss	Clearing of Native Vegetation	Approximately 1.43 ha of known and potential habitat would be removed.

Impact	Relevant KTPs	Outcome
Habitat fragmentation	Clearing of Native Vegetation	Habitat already fragmented by existing road, but intensity would increase due to widening. Unlikely to be crossing existing road.
Habitat alteration	<p>Infection of native plants by <i>Phytophthora cinnamom</i></p> <p>Introduction and Establishment of Exotic Rust Fungi of the order Pucciniales pathogenic on plants of the family Myrtaceae</p> <p>Invasion and establishment of exotic vines and scramblers</p> <p>Invasion, establishment and spread of <i>Lantana camara</i></p> <p>Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants</p> <p>Invasion of perennial grasses</p> <p>Removal of bushrock</p> <p>Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands</p>	<p>Risk of infection unknown, but could be managed to a negligible level.</p> <p>Some weed species (e.g. Lantana, garden escapees) already present. Risk of further establishment along new habitat edges following clearing. Can be managed through construction mitigation measures and hydrological management.</p> <p>Pavement discharge diversions to avoid changes in flow through breeding habitat</p>
Erosion and sedimentation	None	<p>Alteration to breeding habitat</p> <p>Minimise by implementation of a CMP</p>
Edge effects	<p>Invasion and establishment of exotic vines and scramblers</p> <p>Invasion, establishment and spread of <i>Lantana camara</i></p> <p>Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants</p>	Edge effects already exist, but will change location and some new edge created by realignment of road corridor (see weed impacts above).
Mortality during clearing	None	This species is difficult to detect outside breeding periods but pre-clearing surveys prior and during construction are recommended in Section 7.1.

Impact	Relevant KTPs	Outcome
Mortality due to vehicle strike	None	Already in operation, but may increase due to greater traffic volume (induced traffic from better road design) and increased vehicle speeds.
Mortality due to feral and domestic predators (dogs, cats, foxes)	Predation by the Red Fox	Already in operation. Can be reduced by predator control (currently being undertaken by NPSW).

### Powerful Owl

The Powerful Owl was not recorded within the study area, but was found in the gullies on either side of the current alignment. This species is considered highly likely to utilise the study area for foraging on occasion (Ecosure 2015), with the subject site providing habitat for relevant prey species. Suitable breeding and foraging habitat for this species occurs with the study area and some of this habitat will be removed by the proposal.

The Powerful Owl is likely to only utilise the study area for hunting on occasion. They are a highly mobile species capable of occupying fragmented habitat over a very large home range. The Powerful Owl is known to use more densely vegetated gullies for roosting and nesting, though this habitat type has not been identified within the study area. Suitable habitat is available to support prey species of the Powerful Owl including Ring-tailed Possums and Sugar Gliders, although these species are more likely to occur in greater densities in the neighbouring gullies due to the higher productivity of feed trees.

The Mona Vale Road East upgrade and development of the Ingleside precinct will remove additional areas of hunting habitat for the Powerful Owl and suitable habitat for its preferred prey species.

### Eastern Pygmy Possum

The Eastern Pygmy-possum is known to the locality (NSW Atlas of Wildlife; Law 2013) and was identified by Ecosure and SMEC during targeted surveys. These records were distributed along the existing road, but were concentrated in the west, around Kimbriki Road. Records were obtained on both sides of the existing road. It is unknown whether the existing road acts as a movement barrier for the species. Eastern Pygmy-possums were not marked, so the number of individuals detected is not known.

One nest box within ten metres of the existing road produced an adult female with six offspring (Ecosure 2014). Ecosure (2014) also found several Eastern Pygmy-possum nests within nest boxes, which were still present during recent surveys by SMEC. Well-constructed nests are only made by breeding females (Ward 1990). Clearly, the Eastern Pygmy-possum breeds within the study area.

The proposal would affect living and breeding habitat occupied by the Eastern Pygmy-possum. Potential direct impacts arising from the proposal include habitat loss, increased fragmentation of habitat associated with the existing road (wider corridor proposed), direct mortality due to vehicle

strike and an increased risk of predation.

The study area lies between Ku-ring-gai Chase NP and Garigal NP, which both have extensive areas of *Banksia*-rich known and potential Eastern Pygmy-possum habitat. These areas have the potential to support large and significant populations of these species. As discussed above, these populations may provide a stabilising effect on Eastern Pygmy-possum populations elsewhere in the locality where habitat is more limited (e.g. the Ingleside Escarpment). The study area mediates any exchange of individual Eastern Pygmy-possums and gene flow between these conservation reserves and to the Ingleside Escarpment. Therefore, the study area is very important to the long-term viability of the species in the locality. The conservation reserves have long-term security of tenure and these reserves, and the connection formed by the present study area, will become increasingly important to the conservation of the Eastern Pygmy-possum in the locality as other lands become developed in the future (e.g. the Ingleside Planning Precinct).

In the context of habitat availability within locality, the loss of approximately 18.9 hectares of habitat due to the proposal is not considered to be particularly important in its own right. Ku-ring-gai Chase NP is almost 15,000 hectares in area, while Garigal NP covers about 2,200 ha, although the entire areas of these reserves would not be suitable for the Eastern Pygmy-possum as they prefer ridgeline vegetation. Potential habitat also occurs on private and other public lands in the locality.

Impacts of the proposal on the Eastern Pygmy-possum are summarised in Table 33.

**Table 33: Impacts of the proposal on the Eastern Pygmy-possum**

Impact	Relevant KTPs	Outcome
Habitat loss	Clearing of Native Vegetation	Approximately 18.9 of known and potential habitat would be removed. Habitat loss minor relative to local availability.
Habitat fragmentation	Clearing of Native Vegetation	Habitat already fragmented by existing road, but intensity would increase due to widening. Can potentially be mitigated via crossing structures.
Edge effects	Invasion and establishment of exotic vines and scramblers Invasion, establishment and spread of <i>Lantana camara</i> Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants	Edge effects already exist, but will change location and some new edge created by realignment of road corridor (see weed impacts above).

Impact	Relevant KTPs	Outcome
Habitat alteration	<p>Infection of native plants by <i>Phytophthora cinnamom</i></p> <p>Introduction and Establishment of Exotic Rust Fungi of the order Pucciniales pathogenic on plants of the family Myrtaceae</p> <p>Invasion and establishment of exotic vines and scramblers</p> <p>Invasion, establishment and spread of <i>Lantana camara</i></p> <p>Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants</p> <p>Invasion of perennial grasses</p> <p>Loss of hollow-bearing trees</p> <p>Removal of dead wood and dead trees</p> <p>Removal of bushrock</p>	<p>Risk of infection unknown, but could be managed to a negligible level.</p> <p>Some weed species (e.g. <i>Lantana</i>, garden escapees) already present. Risk of further establishment along new habitat edges following clearing. Can be managed through implementation of mitigation measures.</p> <p>Loss of shelter sites. Can be temporarily compensated by installation of nest boxes.</p>
Erosion and sedimentation	None	Minimise by implementation of a CMP
Mortality during clearing	None	Can be managed via pre-clearing surveys and/or staged clearing protocols.
Mortality due to vehicle strike	None	Already in operation, but may increase due to greater traffic volume (induced traffic from better road design) and increased vehicle speeds. Can be reduced by crossing structures and exclusion fencing.
Mortality due to feral and domestic predators (dogs, cats, foxes)	Predation by the Red Fox	Already in operation. Can be reduced by predator control (currently being undertaken by NPSW) and by proper design of crossing structures and re-establishment of vegetation.

### Southern Brown Bandicoot

Although the Southern Brown Bandicoot was not identified during recent surveys, there are recent records of the species at Bobbin Head and West Head in Ku-ring-gai Chase National Park. Intensive trapping to the south of the subject site in Garigal National Park has not detected the species since 2000 (Ecosure 2015). Suitable habitat for this species occurs in the locality within both National Parks



and some private property. The species is naturally rare and a lack of knowledge regarding population size, dynamics and importance of difference habitat types (DEC 2006) is acknowledged.

### **Microbats**

The proposal would result in the removal of 17.3 hectares of vegetation that may provide suitable foraging habitat for the Large-eared Pied Bat, Little Bentwing-bat, Eastern Bentwing-bat and Eastern Freetail-bat. None of these species are expected to rely exclusively on resources within the study area for foraging and are likely to utilise additional suitable habitat in the neighbouring national parks.

Removal of trees with small hollows and fissures may affect species that utilise trees for roosting and breeding including the Little Bentwing-bat, Eastern Freetail-bat and Greater Broad-nosed Bat. No roosting sites for the Large-eared Pied Bat or Eastern Bentwing-bat were encountered during surveys; it is unlikely that important roosting sites for these species will be removed by the proposal. No known maternity colonies for any of these species will be disturbed or removed.

The Mona Vale Road East upgrade and Ingleside Planning Precinct will also result in the removal of foraging habitat for all microbat species known to occur in the locality. No known caves that are used by maternity colonies will be removed or disturbed by these projects.

### **Grey-headed Flying-fox**

The Grey-headed Flying-fox was observed foraging in the study area as well as flying overhead during recent surveys. The closest camp occurs at Warriewood, approximately five kilometres from the subject site (Ecosure 2015). Other camps within travelling distance are known to occur. Some suitable foraging habitat for the Grey-headed Flying-fox will be removed by the proposal.

No Grey-headed Flying-fox camps have been identified in the study area but three are known to occur close to the subject area. The proposal would not disturb any flying-fox camps.

The Grey-headed Flying-fox is only likely to use the study area for foraging when suitable feed trees are in flower. The proposal would require the removal of up to 18.9 hectares of flowering and fruiting myrtaceous habitat which provide some foraging habitat for the species along Mona Vale Road. Large areas of additional foraging habitat in good condition are available in the neighbouring Garigal and Ku-ring-gai Chase National Parks as well as streetscapes and urban gardens.

### **Rosenberg's Goanna**

Rosenberg's Goanna has been identified with the study area by Ecosure in December 2013 and SMEC in 2015 (Figure 18). They rely on termite mounds for breeding, several of which have been identified within the study area, with some quite close to the existing road. The proposal will result in the removal of 22 termite mounds that may be used for nesting by varanid lizards as well as some potential foraging and sheltering habitat. Widening of the road will also increase the barrier between suitable areas of habitat.

Rosenberg's Goannas are known to have large home ranges, therefore it is unlikely any individuals in the locality rely solely on habitat within the study area to survive. To the north and south of the subject site is a combined 17,000 hectares of native vegetation within Ku-ring-gai Chase and Garigal National Parks containing suitable nesting, foraging and sheltering habitat for the species. Due to high levels of

disturbance along the existing road, habitat further from the road that will not be affected by the proposal is in better condition than habitat within the study area.

### **5.5.2 Discussion of connectivity**

#### **Flora**

All affected populations and associated habitat are already fragmented by Mona Vale Road, side roads and some residential or rural development. The proposed activity will marginally increase the distance between remnants and associated populations on either side of Mona Vale Road. The distance between populations of threatened species along the northern and southern sides will also increase in respect of *Microtis angusii* and *Grevillea caleyi*. Due to the level of existing fragmentation any increase as a result of the proposed activity is unlikely to have a significant impact on gene flow. *Microtis angusii* is most at risk through the complete removal of the Kimbriki Road population.

Habitat fragmentation has the potential to have an adverse impact upon retained native vegetation adjoining the construction footprint through a reduction in patch size. Fragmentation can reduce species richness and can alter interactions between species, such as pollination, seed dispersal and foraging. A reduction in patch size can result in the loss of species that are area sensitive, meaning they demonstrate significant decreases in probability of occurrence as habitat area decreases because they have certain minimum physical area requirements that are not met in smaller patches. Some of these area sensitive species may also be 'edge sensitive'.

Linear infrastructure such as roads can result in the genetic isolation of existing populations of some plant species that comprise a particular ecosystem. Populations that become isolated, both physically and genetically, may face an increased risk of extinction. Genetic isolation of plant populations can occur if the 'gap' resulting from road easement limits or prevents normal pollination and seed dispersal mechanisms from taking place. Easements, may, for example, limit myrmecochory dispersal mechanisms of some species of *Acacia* wherein some particular types of forest, ants are unwilling to cross easement gaps. It should be noted, however, that there is a general paucity of existing scientific literature on the potential isolation impacts to temperate Australian sclerophyllous vegetation from linear infrastructure.

It is considered that the plant species that may become isolated or subject to a reduced gene flow between fragments (by the proposed road widening), are few in number, given:

- The pollination and dispersal mechanisms that are known to operate in the dry and moist sclerophyll forests (recorded in the study area). For example, bird (e.g. honeyeater) and insect pollinators of temperate eucalypt forests are highly mobile and would not likely view relatively small easement gaps (<100 m) as significant barriers to movement.
- Field observations on the floristics of forested habitats already subject to existing fragmentation adjoining the existing road alignment exhibited similar species composition and numbers along both forest edges and interiors, suggesting no significant barrier effects had occurred.
- All affected populations and associated habitat are already fragmented by Mona Vale Road, side roads and some residential or rural development. The proposed activity will marginally increase the distance between remnants and associated populations on either side of Mona Vale Road. The distance between populations of threatened species along the northern and southern sides

will also increase in respect of *Microtis angusii* and *Grevillea caleyi*. Due to the level of existing fragmentation the likely increase as a result of the proposed activity is unlikely to have a significant impact on gene flow. *Microtis angusii* is most at risk with likely pollinators including some less mobile insects (ants) and genetic analysis indicating gene flow is currently occurring between sites.

- Duffys Forest within and adjoining the study area is already fragmented by Mona Vale Road, side roads (e.g. access road to Baha'i Temple) and some residential or rural development. The proposed activity will increase the distance between remaining patches of DFEC on either side of Mona Vale Road by less than 50 metres and marginally between remnants along each side of the road.

## **Fauna**

The subject site lies within the Sydney suburbs of Terrey Hills and Ingleside. Mona Vale Road is a major road through the locality that separates Ku-ring-gai Chase and Garigal National Parks.

There is existing evidence of mortality of numerous native fauna species (including threatened species) on Mona Vale Road as a result of collision with vehicles (SMEC 2011; Ecosure 2015). SMEC 2011 identified hotspots for roadkill within the study area and locality.

Roads are known to have detrimental effects upon many fauna species, with creation of movement barriers being a major impact. The existing formation of Mona Vale Road has resulted in a cleared width generally of 10 to 25 m, which currently results in habitat fragmentation, a barrier to individual movement and, therefore, a reduction in habitat connectivity for many fauna species. In addition to the direct barrier effect, if sufficiently high levels of road mortality occur the effective barrier to gene flow is enhanced, in addition to the direct impact of the mortality on population processes.

Road widening and loss of habitat associated with realignment on the northern side of the proposal area would further increase the barrier effect of Mona Vale Road. The of upgrade the existing road or construction of new road sections, with associated road shoulders/bike paths and bus stops would create a cleared width of generally 35 metres, but up to 60 metres in places and present a complete connectivity barrier. Additionally, the installation of solid concrete Jersey kerbs in the median would increase the severity of habitat fragmentation, reduce rates of fauna movement, increase road mortality (compounded by increased traffic and vehicle speeds) and reduce rates of gene flow for some threatened fauna species. This will be alleviated in some areas through the inclusion of fauna crossing structures. Roads and Maritime will investigate during detailed design if 'F' Type Jersey kerbs with a 300mm x 500mm gap at the bottom could be used.

The western third of the subject site directly abuts Ku-ring-gai Chase NP to the north and Garigal NP to the south. The remainder of the alignment also abuts Garigal NP, but it is bordered by private land subject to rural residential scale development on its north side. However, this area of private land in turn abuts Ku-ring-gai Chase NP to the north and several potential movement corridors occur within this land, for example, along Tumburra St, Addison Road and through the grounds of the Baha'i Temple.

Amongst the threatened fauna species, Rosenberg's Goanna and the Eastern Pygmy-possum (see below) are considered to be the species most at risk of an increased fragmentation impact from the proposal. The degree of impact upon these species is not currently well defined due to several

unknown factors of the species' ecology. This includes the lack of available research regarding rates of movement and response to increased gap widths and traffic volume and speed.

The relevant research that is available for this topic indicates that small mammal species may show an aversion to crossing even relatively small road gaps at low traffic volumes (e.g. Goosem 2001, 2002). It is currently unknown to what extent the Eastern Pygmy-possum crosses the existing road though it is likely that there is very little movement currently occurring. On the basis that the road would be widened by the proposal it is therefore likely that this barrier effect would remain or increase. This would act to further prevent genetic exchange across the road, with potential implications for long term viability of the local population.

Should individuals attempt crossing the upgraded road the potential for vehicle strike would be increased. This would further increase the overall barrier effect and subsequent impact upon the genetic viability of the separated (north and south) populations.

As part of the suite of amelioration measures for this proposal it is proposed to install new connectivity structures across the road. This would include a land bridge and two fauna underpasses plus significant fauna-proof fencing. The proposed land bridge would provide safe passage across Mona Vale Road between Ku-ring-gai Chase and Garigal National Parks (Figure 25) for a suite of fauna species, both ground-dwelling and arboreal. The bridge would be revegetated with appropriate local species to provide shelter and attract fauna onto the bridge.

Fauna underpasses and associated fauna-proof fencing would facilitate the movement of a variety of ground-dwelling native fauna include Swamp Wallabies and other small ground-dwelling mammals.

### **5.5.3 Consideration of threatening processes**

#### **Flora**

##### ***Grevillea caleyi***

Ongoing habitat loss through clearing for urbanisation and road construction is the primary threat. An estimated 85% of the original extent of habitat has been lost in this way (Scott *et.al* 1995). Adverse fire regimes (too frequent or too infrequent), weed invasion and physical disturbance from vehicles, bikes, horses and people are also key threats.

Many of the threats identified above are recognised as Key Threatening Processes (KTP) as listed under Schedule 3 of the TSC Act. The most relevant are listed below.

- Clearing and fragmentation of native vegetation resulting in loss of biodiversity as a result of loss and/or degradation of habitat
- High frequency fire resulting in the disruption of the life cycle processes in plants and animals and loss of vegetation structure and composition
- Invasion of native plant communities by exotic perennial grasses
- Invasion and establishment of exotic vines and scramblers
- Invasion, establishment and spread of *Lantana camara*

The recovery plan for *Grevillea caleyi* (DEC 2004) identifies 22 priority actions including:

- Implement appropriate fire management
- Threat and habitat management including fencing, bush regeneration and weed control, pathogen and runoff control
- Reservation and/or protection of remnant sites
- Undertake ecological research

*Grevillea caleyi* has been assigned into the site-managed species stream under the Saving our Species program and one key management site for this species has been identified at Terrey Hills; part of which is located within the proposal area. The NSW Threatened Species Priority Action Statement sets out the following management objectives:

- Prevent access of recreational users to site
- Reduce and maintain weed densities at low levels
- Maintain appropriate fire regime for the species
- Ensure land management is sympathetic to the long-term requirements of the species
- Augment extant wild populations
- Track species abundance/condition over time

### ***Microtis angusii***

Known and potential habitat will be removed as a result of the proposed activity which is a key threatening process, *Clearing of Native Vegetation*, as listed under Schedule 3 of the TSC Act (1995). Other key threatening processes listed under the TSC Act that are of particular relevance include:

- Invasion of native plant communities by exotic perennial grasses.

The *Microtis angusii* national recovery plan (DECCW 2010) includes the following objectives:

- Habitat/population protection and management
- Determine habitat requirements and ecological information.

*Microtis angusii* has been assigned into the site-managed species stream under the Saving our Species program and one management site has been identified along Mona Vale Road; the entire management site is located within the proposal area. The NSW Threatened Species Priority Action Statement sets out the following management objectives for this species:

- Prevent access of recreational users to site
- Reduce and maintain weed densities at low levels
- Minimise impacts of road development
- Minimise accidental damage on roads/track edges
- Track species abundance and condition over time
- Establish ex-situ storage of plant material.



### ***Pimelea curviflora* var. *curviflora***

Known and potential habitat will be removed as a result of the proposed activity which is a key threatening process, *Clearing of Native Vegetation*, as listed under Schedule 3 of the TSC Act (1995). Other key threatening processes listed under the TSC Act that are of particular relevance include:

- High frequency fire resulting in the disruption of the life cycle processes in plants and animals and loss of vegetation structure and composition.
- Invasion of native plant communities by exotic perennial grasses.
- Invasion, establishment and spread of *Lantana camara*.

At the time of this report there is no approved recovery plan or threat abatement plan for the species. Under the Saving our Species program, this species has been assigned to the site-managed species management stream. Three key management sites have been identified; the study area is not located within these project areas. The NSW Threatened Species Priority Action Statement sets out the following management objectives for this species:

- Protect areas of known and potential habitat from clearing and fragmentation
- Introduce measures to prevent habitat degradation related to unrestricted access and/or trail maintenance
- Weed control.

### ***Persoonia hirsuta***

Known and potential habitat will be removed as a result of the proposed activity which is a key threatening process, *Clearing of Native Vegetation*, as listed under Schedule 3 of the TSC Act (1995). Other key threatening processes listed under the TSC Act that are of particular relevance include:

- High frequency fire resulting in the disruption of the life cycle processes in plants and animals and loss of vegetation structure and composition
- Invasion of native plant communities by exotic perennial grasses
- Invasion, establishment and spread of *Lantana camara*.

At the time of this report there is no approved recovery plan or threat abatement plan for the species. Under the Saving our Species program *Persoonia hirsuta* has been assigned to the site-managed species management stream. Seven key management sites have been identified; the study area is not located within these project areas. The NSW Threatened Species Priority Action Statement includes a targeted strategy for managing this species including identifying sites on maps used for planning road maintenance works, protecting known habitat, developing fire plans and continuing research on the reproduction of *Persoonia*.

- Protect populations and remaining habitat through identification on maps used for planning purposes, on-site markers and through education (e.g. able to identify the species)
- Protect known habitat from maintenance activities and recreation
- Maintain connectivity between populations

- Develop fire management plans for populations
- Searches in suitable habitat in proposed development areas.

### ***Tetratheca glandulosa***

Ongoing habitat loss through clearing for urbanisation, adverse fire regimes (too frequent or too infrequent), weed invasion and physical disturbance from vehicles, bikes, horses and people are also key threats. Many of the threats identified above are recognised as Key Threatening Processes (KTP) as listed under Schedule 3 of the TSC Act. The most relevant are listed below.

- Clearing and fragmentation of native vegetation resulting in loss of biodiversity as a result of loss and/or degradation of habitat
- High frequency fire resulting in the disruption of the life cycle processes in plants and animals and loss of vegetation structure and composition
- Invasion of native plant communities by exotic perennial grasses
- Invasion, establishment and spread of *Lantana camara*.

At the time of this report there is no approved recovery plan or threat abatement plan for the species. Under the Saving our Species program *Tetratheca glandulosa* has been assigned to the site-managed species management stream. Three key management sites have been identified; the study area is not located within these project areas with Berowra Valley being the closest. The NSW Threatened Species Priority Action Statement identifies the following specific activities:

- Ensure sufficient vegetation buffers between development and populations
- Minimise habitat loss
- Maintain and improve connectivity between populations
- Protect habitat from degradation
- Restore degraded habitat.

### ***Acacia bynoeana***

Ongoing habitat loss through clearing, fragmentation, habitat disturbance (including road, trail & powerline maintenance, recreational vehicles, bikes, horses and people), adverse fire regimes (too frequent or too infrequent), small population size, incomplete knowledge and weed invasion are the key threats.

At the time of this report there is no approved recovery plan or threat abatement plan for the species. The Saving our Species program identifies five key management sites for this species, which has been assigned to the site-managed species management stream. The study area is not located within any of these areas. The NSW Threatened Species Priority Action Statement identifies the following specific activities:

- Protect remaining habitat through identification on maps used for planning purposes and through education (e.g. able to identify the species)
- Protect known habitat from maintenance activities and recreation

- Investigate appropriate fire regime
- Weed control.

#### ***Acacia terminalis subsp. terminalis***

Ongoing habitat loss through clearing for urbanisation, habitat degradation from rubbish dumping, access by people and park maintenance, adverse fire regimes, weed invasion and hybridisation with horticultural cultivars are identified as the key threats.

A national recovery plan has been prepared for *Acacia terminalis* subsp. *terminalis* (DECCW 2010). The Saving our Species Program identifies five key management sites for this species, which has been assigned to the site-managed species management stream. The study area is not located within any of these areas. The NSW Threatened Species Priority Action Statement identifies the following activities:

- Ensure relevant personnel are able to identify the sub-species and are aware of locations
- Ensure appropriate fire regime (at least every 6-12 years)
- Protect known sites from clearing and degradation
- Establish monitoring programs
- Conduct surveys of all suitable habitat within Sydney Harbour and Botany Bay National Parks
- Undertake research into the biology and ecology of the sub-species.

#### ***Callistemon linearifolius***

Ongoing habitat loss through clearing for urbanisation and a high risk of local extinction due to low population numbers are the primary threats.

At the time of this report there is no approved recovery plan or threat abatement plan for the species. Under the Saving Our Species Program *Callistemon linearifolius* has been assigned to the data-deficient management stream (no site-specific conservation projects). The NSW Threatened Species Priority Action Statement outlines a strategy to address key knowledge gaps including:

- Searching for new sites
- Research on fire requirements
- Protection of known habitat.

#### ***Darwinia biflora***

Ongoing habitat loss through clearing, habitat degradation, adverse fire regimes (too frequent or too infrequent), weed invasion and rubbish dumping are the key threats.

An approved recovery plan has been prepared for *Darwinia biflora* (2004). Under the NSW Saving Our Species Program. *Darwinia biflora* has been assigned to the site-managed species management stream and four key management sites have been identified. The study area is not located within any of these areas, the Hornsby/Berowra conservation project being the closest. Specific activities include:

- Implement appropriate fire regimes
- Prevent mechanical damage and trampling by livestock
- Weed control
- Increase protection of sites.

### ***Genoplesium baueri***

Ongoing habitat loss through clearing for urbanisation, degradation of habitat through physical disturbance, weed invasion, excessive browsing (e.g. by rabbits), changes in hydrology and lack of knowledge are identified as key threats.

At the time of this report there is no approved recovery plan or threat abatement plan for the species. Under the NSW Saving Our Species program *Genoplesium baueri* has been assigned to the site-managed species management stream. Four key management sites have been identified; the study area is not located within any of these areas, the Ku-ring-gai Chase NP conservation project being the closest. Specific activities identified include:

- Protect remaining habitat from clearing and development
- Determine appropriate fire regimes
- Undertake further surveys to locate any additional populations
- Restore natural hydrology
- Erect fencing to reducing browsing impacts.

## **Fauna**

### **Amphibians**

The Giant Burrowing Frog and Red-crowned Toadlet have similar habitat requirements and are therefore susceptible to similar threats. The following key threatening processes are considered a threat to threatened frogs within the study area:

- Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands (KTP): Changes to hydrology can significantly impact breeding sites for the Giant Burrowing Frog and Red-crowned Toadlet that rely on ephemeral drainage lines for egg-laying. Hydrological investigations (Aurecon 2016) indicate that the flow regimes are anticipated to change significantly as a result of the proposal.
- Bushrock removal (KTP): Bushrock contributes to the breeding habitat of both the Giant Burrowing Frog and Red-crowned Toadlet. Removal of bushrock by the proposal may remove or modify suitable breeding habitat. Bushrock may also be used for sheltering.
- Clearing of native vegetation (KTP): Giant Burrowing Frogs and Red-crowned Toadlets use vegetation for shelter. Giant Burrowing Frogs dig burrows and Red-crowned Toadlets shelter in leaf litter and in clumps of vegetation. Removal of native vegetation would reduce sheltering and foraging sites for threatened frogs in the study area.
- High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition (KTP): Loss of vegetation structures reduces

sheltering habitat for the Giant Burrowing Frog and Red-crowned Toadlet is leaf litter and amongst low vegetation. It may also remove accumulations of leaf litter in breeding habitat.

- Infection of frogs by amphibian chytrid causing the disease chytridiomycosis (KTP): Chytrid poses a threat to the Giant Burrowing Frog and Red-crowned Toadlet. Due to the high levels of disturbance in the study area it is possible this disease is already present. If not present, with the implementation of mitigation measures, it is unlikely the proposal will introduce chytrid into the subject site.

A management plan for flora and fauna in Pittwater Council (Smith and Smith 2000) also identifies the Plague Minnow as a threat to the Giant Burrowing Frog and Red-crowned Toadlet. This fish species is unlikely to occur in the subject site due to the ephemeral nature of the drainage lines.

No recovery plan has been prepared for these species. Both species have been assigned to the landscape species management stream under the Saving Our Species program. No priority sites have been identified for either species. Other threats to the Giant Burrowing Frog and Red-crowned Toadlet that are relevant to the proposal include reduction in water quality, population fragmentation, disturbance of breeding habitat by recreational activities and vehicle collisions.

### **Powerful Owl**

Clearing of native vegetation (KTP): Native vegetation provides nesting, roosting and hunting habitat for the Powerful Owl. It also provides habitat for prey species of the owl. The proposal will result in the clearing of 14.6 hectares of open woodland that may provide suitable habitat for the Powerful Owl.

High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition (KTP): Loss of vegetation structures reduces roosting habitat for the Powerful Owl. The species is unlikely to roost in the study area, however, roosting sites are likely to occur nearby in more densely vegetated gullies.

Infection of native plants by *Phytophthora cinnamomi* (KTP): Infection with *Phytophthora cinnamomi* changes the structure of vegetation communities. Powerful Owls require dense canopy vegetation for roosting and nesting sites. The Powerful Owl is unlikely to roost or nest in the subject site.

Loss of hollow-bearing trees (KTP): Powerful Owls nest in large hollows. The proposal will require the removal of 12 hollows that may provide suitable nesting sites for the Powerful Owl and other smaller hollows that may provide shelter and nesting sites for prey species of the owl.

Predation by the European red fox (*Vulpes vulpes*) and feral cat (*Felis catus*) (KTPs): Introduced carnivores are a threat to Powerful Owls, particularly juveniles, and their prey species. The proposal is unlikely to increase the occurrence of these predators in the locality.

A recovery plan for the large forest owls, including the Powerful Owl, has been developed by DEC (2006). Other recognised threats to the owl include road mortality, disturbance of nest sites and secondary poisoning. Increased traffic speeds and volumes may be a threat to the Powerful Owl. No nest sites are known have been identified in the study area. The Powerful Owl has been assigned to the landscape species management stream of the Saving Our Species program. No priority management sites have been identified (OEH 2016).



## Southern Brown Bandicoot

The Department of Environment and Conservation (NSW) has prepared a recovery plan for the Southern Brown Bandicoot (DEC 2006). Threats to the Southern Brown Bandicoot are discussed below.

Clearing of native vegetation (KTP): The Southern Brown Bandicoot uses native vegetation for shelter, foraging and breeding. The proposal is unlikely to remove any native vegetation that would be used by the Southern Brown Bandicoot.

High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition (KTP): It has been demonstrated that bandicoots are capable of surviving low-intensity burns (Hope 2012) and in some cases prefer regenerating habitats (DEC 2006); however, they still require dense undergrowth for sheltering and breeding.

Infection of native plants by *Phytophthora cinnamomi* (KTP): Infection with *Phytophthora cinnamomi* changes the structure of vegetation communities. Changes to vegetation structure may alter habitat available to the Southern Brown Bandicoot.

Predation by the European red fox (*Vulpes vulpes*) (KTP), feral cat (*Felis catus*) (KTP) and domestic dogs: Feral (and native) carnivores are a major threat to the Southern Brown Bandicoot. The proposal is unlikely to increase the presence of these predators in the study area.

Increased traffic speeds and volumes may be a threat to dispersing Southern Brown Bandicoots that move through the study area. There is unlikely to be a resident population of bandicoots that regularly attempts to cross Mona Vale Road as part of regular foraging movements.

The Southern Brown Bandicoot has been assigned to the site-managed species management stream under the Saving Our Species program. Three management sites have been identified:

- Garigal/Ku-ring-gai (Hornsby, Ku-Ring-Gai, Pittwater LGAs)
- Woronora Plateau (Campbelltown, Shellharbour, Sutherland, Wingecarribee, Wollondilly, Wollongong LGAs)
- South East Forests (Bega Valley LGA)

Part of the study area lies within the Garigal/Ku-ring-gai management site (OEH 2016).

## Microbats

Similar threats face each of the microbat species included in this report; the Large-eared Pied Bat, Little Bentwing-bat, Eastern Bentwing-bat, Eastern Freetail-bat and Greater Broad-nosed Bat. Each of these threats to microbats are discussed below.

Clearing of native vegetation (KTP): Each of these microbat species forages around the canopy amongst vegetation for insects. Clearing of native vegetation reduces opportunities for foraging and may also result in the disturbance or removal of roosting sites or maternity roosts.

Loss of hollow-bearing trees (KTP): The Little Bentwing-bat, Eastern Freetail-bat, Greater Broad-nosed Bat and possibly the Large-eared Pied Bat use hollow-bearing trees for roosting.

High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition (KTP): Changing fire regimes can alter the structure of foraging habitat and disturb roosting sites.

Predation and hybridisation of feral dogs (*Canis lupus familiaris*), Predation by the European red fox (*Vulpes vulpes*) and Predation by the feral cat (*Felis catus*) (KTPs): Introduced predators can prey on roosting bats in caves, tree hollows and man-made structures.

A recovery plan has been prepared for the Large-eared Pied Bat (DERM 2011). Identified threats for this species mostly relate to the destruction and disturbance of maternity colonies and roost sites, neither of which have been identified in the study area.

The Little Bentwing-bat, Eastern Bentwing-bat, Eastern Freetail-bat and Greater Broad-nosed Bat have been assigned to the landscape species management stream under the Saving Our Species Program. No priority management sites have been identified for these species. The Large-eared Pied Bat has been assigned to the data-deficient species management stream as there is insufficient information available on the species' distribution and ecology to guide effective management (OEH 2016).

### **Eastern Pygmy Possum**

The following describes known threats to the Eastern Pygmy-possum and discusses how the proposal would affect the operation of these threats on this species:

Clearing native vegetation (KTP). The Eastern Pygmy-possum uses native vegetation for foraging and for shelter. The proposal entails clearing approximately 18.9 hectares of native vegetation. As discussed above, this is only a very small proportion of the amount of known and potential habitat in the locality, which includes some suitable habitat within two large national parks adjacent to the site. The impact on this species as a result of habitat loss as a result of this proposal on the Eastern Pygmy-possum is considered to be low. However, it is worth noting that the Eastern Pygmy-possum primarily uses upper slope bushland throughout the Ingleside escarpment which provides habitat and would likely function as a corridor for the movement of individuals (Law 2014). The subject site extends along a ridgeline which provides suitable foraging and denning habitat for the species.

Habitat fragmentation: Habitat fragmentation, resulting in the subdivision of populations and a reduction or loss of gene flow, can be a consequence of the clearing native vegetation KTP. In this case, however, there is an existing movement barrier and it is not known whether the Eastern Pygmy-possum crosses the current alignment of Mona Vale Rd. The proposal entails widening this road corridor and increased traffic (induced traffic) and vehicle speeds are likely to result. Thus, the proposal would affect potential movement corridors between two national parks either directly at the western end of the subject site or via private land to the north of the subject site in the mid to eastern sections of the subject site.

Loss of hollow-bearing trees (KTP): The Eastern Pygmy-possum uses tree hollows for shelter and for breeding. The proposal requires the removal of 135 hollow-bearing trees, resulting in the loss of shelter and breeding sites for the Eastern Pygmy-possum. Significant areas with hollow-bearing trees would remain adjacent to the subject site.

Removal of dead wood and dead trees (KTP): The Eastern Pygmy-possum use fallen logs and dead

trees for shelter and for breeding. The proposal would require the removal of dead trees and fallen logs.

**Bushrock Removal (KTP):** The Eastern Pygmy-possum is known to shelter occasionally in rock crevices. The subject site contains areas of exposed rock, therefore, shelter sites used by the Eastern Pygmy-possum may be removed by the proposal. However, breeding females construct nests and are not likely to use rock crevices for this purpose. Significant areas with rocky outcrops would remain adjacent to the subject site.

**Predation and hybridisation of feral dogs (*Canis lupus familiaris*), Predation by the European red fox (*Vulpes vulpes*) and Predation by the feral cat (*Felis catus*) (KTPs):** Dogs mainly attack medium to large species, such as macropods. The Red Fox and feral cats are more likely to be threats to the Eastern Pygmy-possum. However, the proposal is not likely to increase the exposure of the Eastern Pygmy-possum to these species.

**High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition (KTP):** More generally, changed fire regimes that affect the abundance of flowering Proteaceous and Myrtaceous shrubs is a threat to the Eastern Pygmy-possum. *Banksia ericifolia*, an important nectar resource, is particularly sensitive to too frequent fires (e.g. Bradstock *et al.* 1996). Fires at infrequent intervals may also result in the loss of *Banksia* species, which tend to be fire obligates. Optimum fire intervals for *B. ericifolia*, for example, are 10-30 years (Bradstock and O'Connell (1988)). However, the proposal is not expected to have any bearing on local fire regimes.

**Weed invasion, including the KTPs i) invasion and establishment of exotic vines and scramblers, ii) invasion, establishment and spread of *Lantana camara*, iii) loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants, and iv) invasion of perennial grasses.** A minor degree of weed invasion is already present in the study area. Weed species are mostly confined to the existing road edge, particularly near Kimbriki waste station. Additional species may be transported into the subject site on machinery. Weed establishment is most likely to occur along habitat edges disturbed during construction and along the decommissioned section of the existing road opposite the rock outcrop.

**Infection of native plants by *Phytophthora cinnamomi* and introduction and establishment of exotic Rust Fungi of the order Pucciniales pathogenic on plants of the family Myrtaceae (both KTPs):** These pathogens may already be present in the study area or may be introduced in the future by other means (e.g. a landscape supplier is present near the proposal area). However, these pathogens may be transported into the subject site on machinery if suitable hygiene standards are not met.

The Eastern Pygmy-possum has been assigned to the landscape species management stream of the Saving Our Species program. No priority management sites have been identified (OEH 2016).

### **Grey-headed Flying-fox**

A draft recovery plan has been prepared for the Grey-headed Flying-fox (DECCW 2009). Threats to the Grey-headed Flying-fox are discussed below.

**Clearing of native vegetation (KTP):** Removal of canopy trees reduces foraging habitat for the Grey-

headed Flying-fox. Camps are also affected by vegetation removal but no camps have been identified in the study area.

Other threats to the Grey-headed Flying-fox include habitat loss, destruction associated with commercial horticulture, competition with Black Flying-foxes, conflict with humans, electrocution on powerlines and netting, climate change and disease (DECCW 2009). The proposal is unlikely to increase the impact of these threats on the Grey-headed Flying-fox within the study area.

The Grey-headed Flying-fox has been assigned to the landscape species management stream of the Saving Our Species program. No priority management sites have been identified (OEH 2016).

### **Rosenberg's Goanna**

Threats to the Rosenberg's Goanna include four key threatening process listed under the TSC Act. The effect of each of these and their relevance to the proposal is discussed below.

Bushrock removal (KTP): Rosenberg's Goannas dig burrows for shelter and are known to use flat rocks to conceal the entrance to these burrows. Rocks are also used for basking (King and Green 1999). The proposal would require the removal of bushrock, which would remove some suitable burrowing and basking habitat for the Rosenberg's Goanna.

Clearing of native vegetation (KTP): Native vegetation is used by the Rosenberg's Goanna for foraging and provides habitat for the species upon which they prey. Varanids are known to spend a lot of time foraging for prey and investigating the surrounding environment (King and Green 1999). Vegetation removal would provide less foraging opportunities for individuals.

Removal of dead wood and dead trees (KTP): As with rocks, logs are used to conceal burrow entrance and can be used for basking (King and Green 1999). The proposal would require the removal of dead wood and trees, which would remove some suitable burrowing and basking habitat for the Rosenberg's Goanna.

Other threats to the Rosenberg's Goanna may include habitat modification (including the removal of termite mounds), road mortality and predation by feral carnivores. Rosenberg's Goannas use termite mounds for breeding. Removal of termite mounds would decrease breeding habitat and increase competition between the Rosenberg's Goanna and the Lace Monitor (present within the study area in large numbers) for these breeding sites. Road mortality has been recognised as a threat to fauna near major roads (SMEC 2001). Fencing and crossing structures will provide some mitigation for increased traffic speeds and volumes. Although feral carnivores pose a threat to the Rosenberg's Goanna, particularly juveniles, the proposal is unlikely to increase the impact of this threat.

No recovery plan has been prepared for the Rosenberg's Goanna. The Rosenberg's Goanna has been assigned to the landscape species management stream of the Saving Our Species program. No priority management sites have been identified (OEH 2016).

#### **5.5.4 Cumulative impacts**

Within the region, a number of other projects have the potential to impact threatened species that occur within the study area (Table 34). For most species, a broader understanding of the distribution

and abundance in the locality and the region is required to provide a quantitative assessment of the cumulative impacts.

**Table 34: Projects contributing to cumulative impacts**

Project	Impact
Mona Vale Road East upgrade	This is a similar undertaking to the proposal and involves the duplication of Mona Vale Road about 1 kilometre east of the proposal area. This upgrade would impact flora and fauna populations along the Ingleside Escarpment (including <i>Microtis angusii</i> , Rosenberg’s Goanna, Eastern Pygmy-possum, Powerful Owl, Little Lorikeet, Regent Honeyeater, Little Eagle, Grey-headed Flying-fox and three species of microbat). Potential cumulative impacts include removal of habitat, increase in mortality from vehicle strike and reduction in connectivity.
The Ingleside Planning Precinct	This planning precinct is located in the vicinity of the Mona Vale Road East proposal area. Current investigations cover an area of about 700 ha and would provide 4,000-4,700 dwellings. The precinct is currently zoned non-urban and includes both private and public lands. About one-third of the area is in State Government ownership. A substantial part of the area is covered by heath and woodland and Banksia species are common. Therefore, potentially affected flora and fauna populations include <i>Microtis angusii</i> , Rosenberg’s Goanna, Eastern Pygmy-possum, Powerful Owl, Little Lorikeet, Regent Honeyeater, Little Eagle, Grey-headed Flying-fox and three species of microbat. Potential cumulative impacts include removal of habitat and reduction in connectivity.
Northern Beaches Hospital and associated roadworks	This site is about 7 kilometres south of the proposal area. A number of threatened species were identified including the White-bellied Sea-eagle, Powerful Owl, Red-crowned Toadlet, Eastern Bentwing-bat and Grey-headed Flying-fox. Potential habitat for a number of other threatened species was present. Potential cumulative impacts include removal of habitat, increase in mortality from vehicle strike and reduction in connectivity

## 5.6 DESCRIPTION OF FEASIBLE ALTERNATIVES

Mona Vale Road follows a route of mostly ridgeline habitat through an otherwise dissected sandstone landscape. This route was likely chosen historically as it provides one of the only relatively easily constructed routes to the Mona Vale area from the northern suburbs. The route therefore is by definition along a rare feature in the local context. Since the route was first developed, the surrounding sandstone landscape has been largely dedicated to the reserve system (Ku-ring-gai Chase and Garigal National Parks) or developed for urban and some limited semi-rural uses. In this context feasible alternatives to the route are generally likely to be limited.

Detailed considerations of feasible alternatives were undertaken by Roads and Maritime over a number of years and these are documented in a number of key reports:



- Mona Vale to Macquarie Park Strategy (RTA 2009)
- Mona Vale Road – Terrey Hills to Ingleside Preliminary Environmental Investigation (Roads and Maritime Services 2012c) May 2012
- Mona Vale Road Upgrade: McCarrs Creek Road to Powder Works Road Options Report (Roads and Maritime Services 2012d) October 2012
- Mona Vale Road Upgrade: McCarrs Creek Road to Powder Works Road Project Options Assessment – Value Management Workshop Report (ACVM 2013) February 2013
- Mona Vale Road Upgrade: McCarrs Creek Road to Powder Works Road Preferred Option Report (Roads and Maritime Services 2013c) August 2013.

A detailed discussion of the findings of these reports and associated investigations and consultation processes are provided in the accompanying Review of Environmental Factors (REF). The Director General’s Requirements specify that readers be referred to this document for these details. However, a summary of the consideration of alternatives is provided below.

Roads and Maritime sought to meet the proposal objectives while avoiding major technical, social and environmental constraints where possible. An iterative process was used to develop several route options based on a number of inputs, including field investigations, engineering designs, community submissions and technical workshops. Hence, a number of route options were developed and placed on display in October 2012. Submissions from the community and stakeholders were collected and used to inform the refinement of the options.

A value management workshop was held in February 2013 to evaluate options and to recommend a preferred route. Attendees included technical specialists and project team members from Roads and Maritime, consultant specialists, representatives from Warringah and Pittwater Council, OEH and community representatives. Considerations in this workshop included minimising impacts on TECs, threatened species and the National Parks, improving flora and fauna connectivity and minimise impacts on water quality as well as social and economic considerations.

Route options considered included the following:

- The do nothing option – this was likely to be accompanied with increased travel times and increasing accidents over time
- A widening within the existing corridor – which has significant geotechnical constraints, decreases faunal connectivity and would require some acquisition of Garigal National Park land
- A northern alignment – considered to have the least impact on vegetation fragmentation and faunal connectivity
- A split carriageway – this was considered to have relatively high impacts on vegetation fragmentation and faunal connectivity.

A consideration of these alternatives resulted in the selection of the current route design (the Northern Alignment). This route option was chosen based on social, economic and environmental considerations which in summary were:

- Ranks well with community feedback received on the three route options

- Provides the most flexibility to design around potential constructability issues
- Minimises the amount of national park land acquisition required
- Allows for the old road to be consolidated into Garigal National Park
- Avoids impact to the culturally sensitive area
- Provides the best opportunities for fauna connectivity between the national parks
- Provides simpler traffic staging during construction, minimising inconvenience to road users
- Provides two lanes in each direction for motorists, as well as wider shoulders for on-road cyclists.

A relatively large number of records of *Grevillea caleyi* occur within the preferred route option and the ridgeline habitat of the route supports approximately 6 hectares of Duffys Forest EEC (the preferred habitat for this species) and approximately 6 hectares of known habitat. As such, approximately 3 hectares of this habitat will be retained. Thus the route avoids some of the known habitat of the species and Duffys Forest EEC. *Grevillea caleyi* is considered fire sensitive and maintaining appropriate fire regimes (in the order of between 7-30 years) is important for this species. Loss of individual plants, the associated seedbank (and reduced genetic diversity) and the loss of habitat associated with the current route will require ameliorative measures (see Section 7).

As shown on Figure 20, the alignment has been chosen to minimise impacting breeding habitat for Giant Burrowing Frog and Red-crowned Toadlet. The road design has also incorporated a number of water run-off implementations that result in no change to the hydrological regime in breeding and non-breeding habitat for those species (Aurecon 2016).