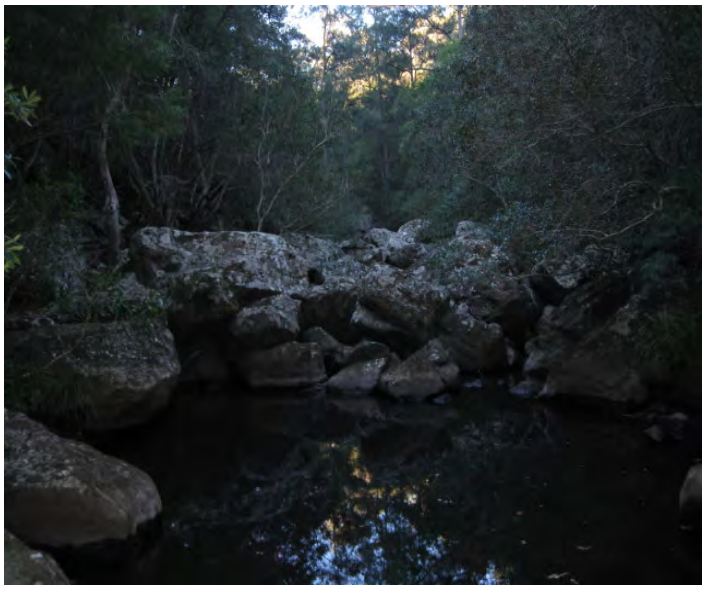
NORTH NOWRA LINK ROAD

Biodiversity Assessment

Prepared for
Shoalhaven City Council

January 2011



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BIODIVERSITY ASSESSMENT

PREPARED FOR	**Shoalhaven City Council**
PROJECT NO	**10CANFED - 0018**
DATE	**January 2011**

ACKNOWLEDGEMENTS

This document has been prepared by Eco Logical Australia Pty Ltd with support from Shoalhaven City Council.

Contents

List of Figures

List of Tables

Abbreviations

ABBREVIATION	DESCRIPTION
CEMP	Construction Environmental Management Plan
DBH	Diameter at breast height
DECC	NSW Department of Environment and Climate
DECCW	NSW Department of Environment, Climate Change and Water
DEWHA	Commonwealth Department of Environment, Water, Heritage and the Arts
DGRs	Director General's requirements
DoP	NSW Department of Planning
EMP	Environmental Management Plan
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
EP&A Act	*Environment Planning and Assessment Act 1979*
GBF	Giant Burrowing Frog
Gn1	Genotype 1
ha	Hectares
KMA	Kevin Mills & Associates
LGA	Local Government Area
NES	Matter of national environmental significance
NPWS	NSW National Parks and Wildlife Service
NPW Act	*National Parks and Wildlife Act 1974*
SCC	Shoalhaven City Council
TSC Act	*Threatened Species Conservation Act 1995*

1 Introduction

1.1 BACKGROUND

This report responds to the Director General's Requirements (DGRs) and provides an assessment of the biodiversity values associated with each of the three road route options for the North Nowra Link Road. This report forms part of Shoalhaven City Council's environmental assessment under Part 3A of the *Environment Planning and Assessment Act 1979* (EP&A Act). The role of this report is to undertake an assessment of the biodiversity values and evaluate the potential environmental impacts associated with each of the three route options.

1.2 DESCRIPTION OF THE PROJECT

Shoalhaven City Council is proposing to construct a new link road ('North Nowra Link Road') to alleviate significant traffic congestion in the North Nowra/Bomaderry area. This proposal is part of the strategic planning of the Shoalhaven City Council for Nowra City. The proposed North Nowra Link Road is a single lane, two way road with a maximum speed limit of 80km/h. The road corridor will be 30 metres wide for the majority of its length, possibly narrowing to 20 metres wide in areas of ecological significance, where required to ameliorate the potential impacts on the environment. Three potential route options are under consideration and are discussed below in section 1.5.

1.3 STUDY AREA

The study area for the proposed North Nowra Link Road is located in the North Nowra and Bomaderry region of the Shoalhaven municipality as shown in **Figure 1**. North Nowra is one of a number of residential precincts that form part of the broader Nowra Bomaderry area. The proposal area is located on the northern side of the Shoalhaven River and to the west of the Princes Highway and is intersected by Bomaderry Creek, which runs from the north to the south east of the study area. The study area is predominately Crown Land, freehold lands (both privately and publicly owned) and Bomaderry Creek Regional Park, which is managed by the NSW National Parks and Wildlife Service, itself a part of the NSW Department of Environment, Climate Change and Water (DECCW).

Within the study area woodland with a heathy understory is the most common type of vegetation. The underlying soils are often shallow and dry, but can be quite moist when they are deeper because of seepage across the subterranean rock surface. Sedgeland occurs sporadically on the plateau and on poorly drained sites with shallow soils over the sandstone bedrock. Most of the bushland is on nutrient-poor sandstone soils. The area contains a high diversity of flora and fauna species. Those species listed as threatened under State or Commonwealth legislation are discussed in section 4.

The study area is intersected by Bomaderry Creek, a tributary to the Shoalhaven River. It is approximately 15km from the mouth of the Shoalhaven River on the East Coast of NSW. As a result it is influenced by tidal flows.

Figure 1: Location of the study area.

1.4 PROJECT JUSTIFICATION

Illaroo Road provides the only major access route to North Nowra. Since the 1970's, traffic volumes on Illaroo Road and the Princes Highway have increased substantially, growing at three to four per cent per annum. This growth has exacerbated vehicle queuing, traffic congestion and traffic safety problems. Traffic models show that with projected growth in North Nowra, the main intersection of the Princes Highway and Illaroo Road will become saturated with traffic in the near future. A link road would ameliorate this congestion in the short term and would form part of future road infrastructure.

The North Nowra Link Road Project has been developed to satisfy the following objectives:

- To relieve existing traffic congestion, improve safety on Illaroo Road and to cater for future traffic generated by the proposed release of residential land in the Nowra Bomaderry Structure Plan, satisfying State strategic planning objectives; and
- To reduce congestion at the Illaroo Road/Princes Highway intersection.

In addition to the project objectives, it is anticipated that the North Nowra Link Road will provide the following benefits:

- Provide the North Nowra area with a second access for emergency services; and
- Reduce congestion on the Princes Highway and by so doing, defer the need to supplement existing bridge crossings over the Shoalhaven River.

1.5 ROUTE OPTIONS – LINK ROAD CORRIDORS

Following a review of a Preliminary Environmental Assessment study, the NSW Minister for Planning determined on 15 December 2006 that three route corridor options should be examined for the proposed North Nowra Link Road. As such, this biodiversity assessment considers the three possible route options for the North Nowra Link Road and provides an analysis of the biodiversity values associated with each option. **Figure 3** shows the proposed alignment for the following three options:

- Northern – West Cambewarra Road Option;
- Central – Pitt Street – Narang Road option; and
- Southern – Illaroo Road – West Bunberra Street Option.

1.5.1 Northern Option

The road corridor for the northern option runs parallel to West Cambewarra Road on the northern boundary of the Bomaderry Creek Regional Park. The overall length of the road is approximately 1.73km and will possibly require a 75 metre five span bridge to cross Bomaderry Creek. The northern option will result in the clearing of approximately 4.52 hectares of vegetation (see **Figure 4**). Of that, 0.9 hectares is situated within the Bomaderry Creek Regional Park.

1.5.2 Central Option

The central option follows an existing unsealed services road and electricity transmission line between Pitt Street and Narang Road as shown in **Figure 2**. The total length of this route is approximately 1.81km and requires a 75 metre three span bridge to cross Bomaderry Creek. The central option will result in the clearing of approximately 2.31 hectares of vegetation (see **Figure 5**). Of that, 1.6 hectares

is situated within the Bomaderry Creek Regional Park. The area of vegetation to be cleared for the central route corridor accounts for the transmission line cleared zone.

The central option will have a 30 metre wide corridor for most of its length, and will narrow to 20 metres where necessary to avoid ecologically sensitive areas. The clearance zone for a 30 metre wide road reserve would be 25 metres wide. For a 20 metre wide road reserve the clearance zone would be 20 metres wide. Clearing is required to be on a permanent on-going maintenance basis to maintain the road reserve to Australian Road Standards. This would only involve slashing of vegetation from within the designated road reserve and slashing would not extend beyond the reserve boundary.

Figure 2: Existing unsealed road and electricity transmission line on the central route corridor

1.5.3 Southern Option

The road corridor for the southern option would link Illaroo Road to West Bunberra Street and follow the southern boundary of the Bomaderry Creek Regional Park. This option would be approximately 1.82km in length and requires a 105 metre three span concrete box girder bridge to span the gorge at Bomaderry Creek. The southern option will result in the clearing of approximately 4.14 hectares of vegetation (see **Figure 6**). Of that, 0.3 hectares is situated within the Bomaderry Creek Regional Park.

Figure 3: Route option corridors and the Bomaderry Creek Regional Park

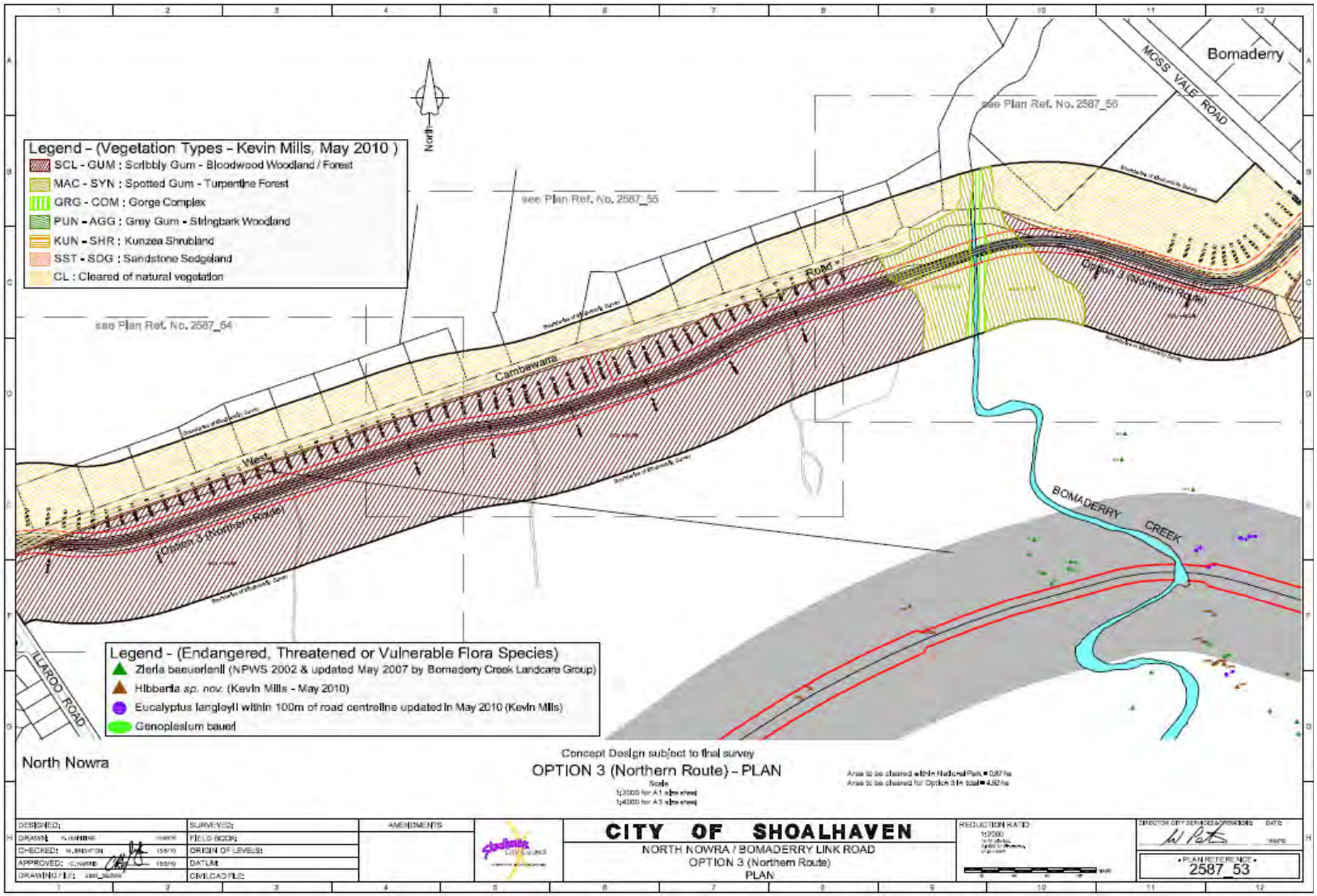

Figure 4: Northern Route Option

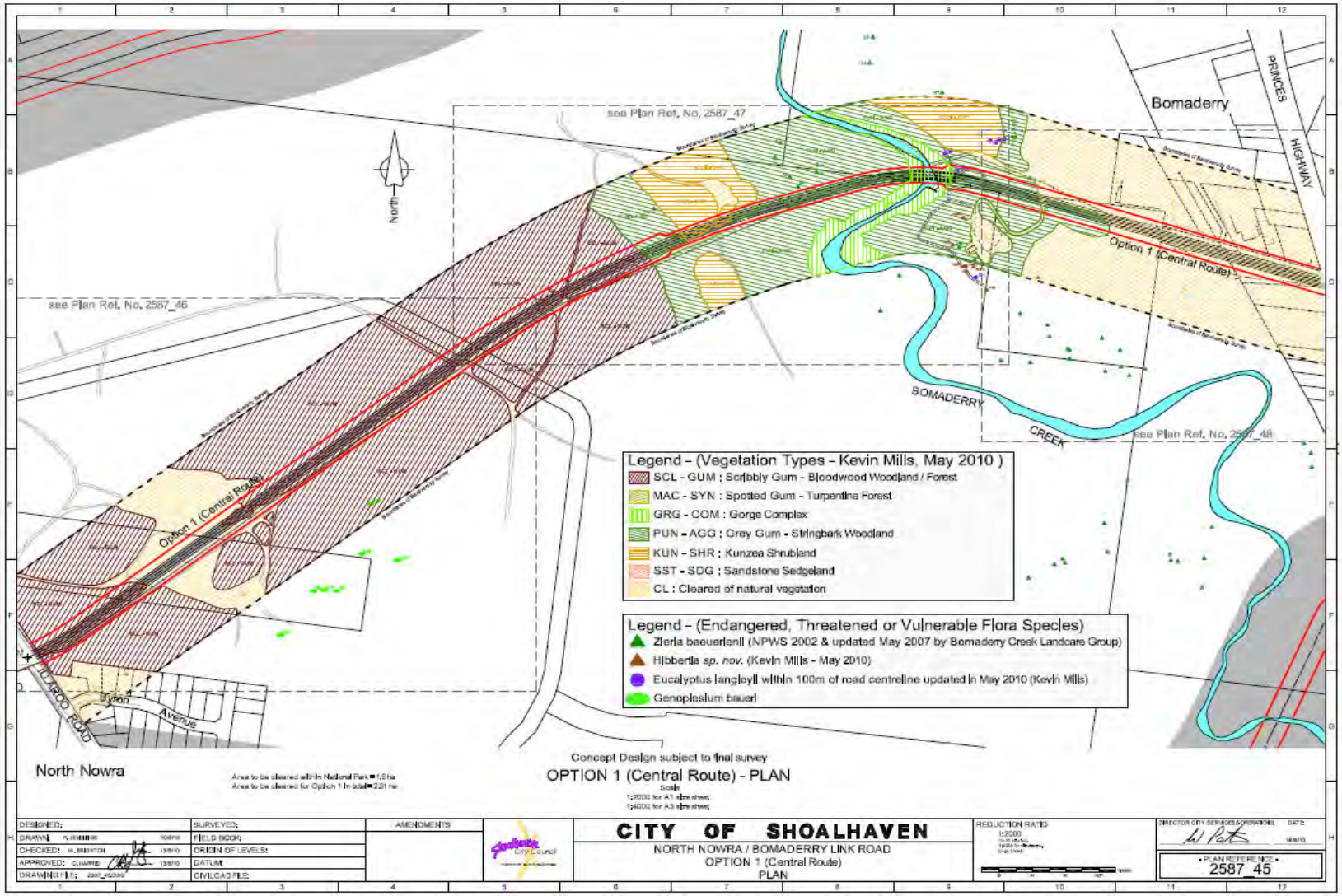

Figure 5: Central Route Option

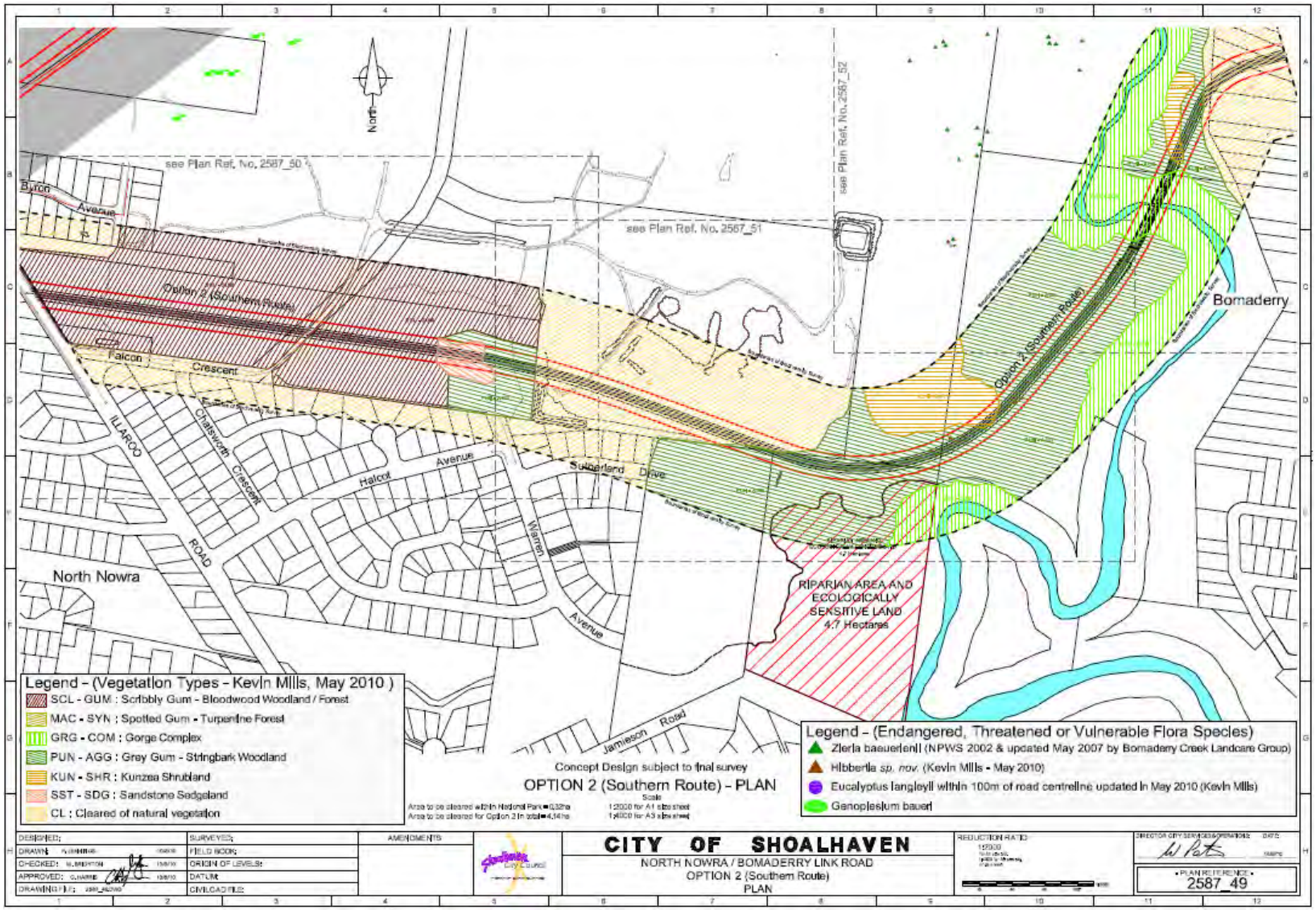

Figure 6: Southern Route Option

1.6 LEGISLATIVE REQUIREMENTS

1.6.1 State Legislative Requirements

The Nowra Bomaderry Structure Plan (SCC 2008) was endorsed by the NSW Department of Planning in February 2008. This document identifies the North Nowra Link Road as a major part of proposed infrastructure to service the projected growth of North Nowra, which in part satisfies the requirements of the South Coast Regional Strategy (2006-2031) for Nowra and Bomaderry.

A Concept Plan for the North Nowra Link Road was authorised by the State Minister for Planning to proceed to the environmental assessment phase under Part 3A of the NSW EP&A Act. Shoalhaven City Council has prepared an Environmental Assessment for review and approval by the NSW Department of Planning (DoP) to proceed with publicly exhibiting the proposal. The DoP has issued Director-General's Requirements for the Environmental Assessment, in consultation with the DECCW, who have provided detailed assessment requirements for the biodiversity assessment. This Biodiversity Assessment has been developed to satisfy the DGRs and forms part of the Environmental Assessment prepared under Part 3A of the NSW EP&A Act. The DGRs as they relate to biodiversity are as follows and form the basis of this assessment:

"Biodiversity – the Environmental Assessment must include a detailed flora and fauna impact assessment in accordance with DEC's Guidelines for Threatened Species Assessment (draft). This assessment must clearly identify and consider any direct and indirect impacts on critical habitats, threatened species, populations or ecological communities listed under both State and Commonwealth legislation recorded along the nominated routes and surrounding area, such as Zieria baeuerlenii and Eucalyptus langleyi. The Environmental Assessment must also consider the potential impacts of the route options on the conservation values and integrity of the Bomaderry Creek Regional Park, particularly as a result of fragmentation impacts and edge effects. Measure to avoid or mitigate impacts associated with the option(s) must be identified with an assessment of the feasibility, effectiveness and reliability of these proposed measures".

1.6.2 Commonwealth Legislative Requirements

The Commonwealth *Environment Protection & Biodiversity Conservation Act 1999* (EPBC Act) establishes a process for assessing the environmental impact of activities and developments where 'matters of national environmental significance' (NES) may be affected. The North Nowra Link Road was determined to be a controlled action under the EPBC Act on 10 January 2010. At this time it was also determined that the project would be assessed by accredited assessment under Part 3A of the NSW EP&A Act. As well as meeting the DGRs mentioned above, this Biodiversity Assessment has been developed to satisfy the following requirements issued under the EPBC Act:

"In order for Shoalhaven City Council to address this DGR to a level considered adequate for EPBC Act purposes the following EPBC Act listed threatened species should be assessed in the context required by this DGR (i.e.: fully consider the range of potential direct and indirect impacts and species and their habitats, measures to avoid or mitigate these impacts and the feasibility, effectiveness and reliability of those proposed measures).

- ***Bomaderry Zieria*** *(Zieria baeuerlenii)*
- ***Albatross Mallee*** *(Eucalyptus langleyi)*
- ***Spotted-tailed Quoll*** *(Dasyurus maculatus maculatus)*
- ***Grey-headed flying- fox*** *(Pteropus poliocephalus)*
- ***Giant Burrowing Frog*** *(Heleioporus australiacus)*

It should also be noted that other EPBC Act listed threatened species and ecological communities may occur in the area and potentially be subject to impacts as a result of the proposed link road. In addressing this DGR, Shoalhaven City Council should either assess the potential for impacts as a result of the proposed link road on any other threatened species or ecological communities that may occur in the area and/or provide adequate information (i.e. methodology and results of surveying) to demonstrate that no other EPBC Act listed threatened species or ecological communities occur in the area or a likely to be subject to any impact as a result of the proposed link road".

2 Methods

2.1 DATA AND LITERATURE REVIEW

The following information and databases were reviewed prior to field surveys:

- Atlas of NSW Wildlife; and
- EPBC Protected Matters Search Tool.

A search of the online EPBC Protected Matters Search Tool (DEWHA 2009a) and Atlas of NSW Wildlife (DECCW 2009a) was performed. The search of the EPBC Protected Matters Search Tool used a radius of 5 km around the study area. The search of the Atlas of NSW Wildlife covered the area within a 10km radius of the Bomaderry Creek Regional Park.

Species from both searches were combined to produce a list of threatened species that may possibly occur within the study area (see **Table 1**).

A total of twenty-eight listed threatened species and zero listed threatened ecological communities were identified from the search undertaken using the DEWHA online Protected Matters Search Tool. A total of eight threatened species and one ecological community listed under the TSC Act were identified from the search using the Atlas of NSW Wildlife. An analysis of this list of threatened species and communities is provided below.

Using database or other records, presence or absence of suitable habitat, features of the proposed site, results of field surveys and professional judgement, the likelihood of occurrence of listed species has been determined and is presented in the table below. Five terms for the likelihood of occurrence of species used are defined as follows:

"Known" = the species or ecological community was or has been observed on the site

"Likely" = a medium to high probability that a species uses or ecological community occurs on the site

"Potential" = suitable habitat for a species or ecological community occurs on the site, but there is insufficient information to categorise the species or ecological community as likely to occur, or unlikely to occur

"Unlikely" = a very low to low probability that a species uses or ecological community occurs on the site

"No" = habitat on the site and in the vicinity is unsuitable for the species or ecological community

Table 1: Threatened flora and fauna species with potential to occur within the study area.

Birds

Scientific name	Common name	EPBC Act Status	TSC Act Status	Likelihood of Occurrence	Assessment Methodology
Anthochaera phrygia	Regent Honeyeater	Endangered	Endangered	Unlikely – There is a low probability that the Regent Honeyeater occurs within the study area due to its known distribution and the absence of suitable habitat. In additional to this, there are no records of the species from within the study area.	A desktop study and literature review was undertaken to determine if the Regent Honeyeater was likely to occur within the study area. Targeted surveys were not considered necessary given the lack of suitable habitat.
Lathamus discolor	Swift Parrot	Endangered	Endangered	Unlikely – There is a low probability that the Swift Parrot occurs within the study area due to its known distribution and the absence of suitable habitat. In additional to this, there are no records of the species from within the study area.	A desktop study and literature review was undertaken to determine if the Swift Parrot was likely to occur within the study area. Targeted surveys were not considered necessary given the lack of suitable habitat.
Callocephalon fimbriatum	Gang-gang Cockatoo		Vulnerable	Known – The Gang-gang Cockatoo has been recorded within the study area.	The NSW Atlas of Wildlife has records of the Gang-gang Cockatoo within the Bomaderry Creek Regional Park and suitable foraging habitat exists within the study area. Given that this species has a large home/foraging range the assessment of potential impacts has conservatively assumed the presence of the species as a visitor to the study area, and as such no targeted surveys are considered necessary.

Neophema chysogaster	Orange-bellied Parrot	Critically Endangered	Critically Endangered	Unlikely – There is a low probability that the Orange-bellied Parrot occurs within the study area due to its known distribution and the absence of suitable habitat. In additional to this, there are no records of the species from within the study area.	A desktop study and literature review was undertaken to determine if the Orange-bellied Parrot was likely to occur within the study area. Targeted surveys were not considered necessary given the lack of suitable habitat.
Rostratula australis	Australian Painted Snipe	Vulnerable	Endangered	Unlikely – There is a low probability that the Australian Painted Snipe occurs within the study area due to its known distribution and the absence of suitable habitat. In additional to this, there are no records of the species from within the study area.	A desktop study and literature review was undertaken to determine if the Australian Painted Snipe was likely to occur within the study area. Targeted surveys were not considered necessary given the lack of suitable habitat.
Lophoictinia isura	Square-tailed Kite		Vulnerable	Known – The Square-tailed Kite has been recorded within the study area.	The Square-tailed Kite has been recorded within the study area and suitable habitat occurs throughout the region. Given that this species has a large home/foraging range the assessment of potential impacts has conservatively assumed the presence of the species as a visitor to the study area, and as such no targeted surveys are considered necessary.
Calyptorhynchus lathami	Glossy Black-cockatoo		Vulnerable	Known – The Glossy Black-cockatoo has been recorded within the study area.	The Glossy Black-cockatoo has been recorded within the study area. Habitat surveys have been undertaken to locate hollow bearing trees and feed trees. Given that this species has a

					large home/foraging range and that it has been recorded within the study area, the assessment of potential impacts has conservatively assumed the presence of the species as a visitor to the study area, and as such no targeted surveys are considered necessary.
Tyto novaehollandiae	Masked Owl		Vulnerable	Known – The Masked Owl has been recorded within the study area.	The NSW Atlas of Wildlife has records of the Masked Owl occurring within the Bomaderry Creek Regional Park. Recent surveys also recorded the species within the study area and identified areas of suitable habitat. Given that this species has a large home/foraging range and that it has been recorded within the study area, the assessment of potential impacts has conservatively assumed the presence of the species as a visitor to the study area, and as such no targeted surveys are considered necessary.
Ninox strenua	Powerful Owl		Vulnerable	Known – The Powerful Owl has been recorded within the study area.	Recent field surveys recorded the Powerful Owl within the study area and identified areas of suitable foraging habitat. Given that this species has a large home/foraging range and that it has been recorded within the study area, the assessment of potential

					impacts has conservatively assumed the presence of the species as a visitor to the study area, and as such no targeted surveys are considered necessary.
Tyto tenebricosa	Sooty Owl		Vulnerable	Known – The Sooty Owl has been recorded within the study area.	Recent field surveys recorded the Sooty owl within the study area and identified areas of suitable foraging habitat. Given that this species has a large home/foraging range and that it has been recorded within the study area, the assessment of potential impacts has conservatively assumed the presence of the species as a visitor to the study area, and as such no targeted surveys are considered necessary.
Petroica boodang	Scarlet Robin		Vulnerable	Potential – The Scarlet Robin has a low potential to occur within the study area given that there is only a small amount of suitable habitat.	Only a very small area of suitable habitat for the Scarlet Robin occurs within the study area and it is unlikely that the species would be a frequent visitor. As such, targeted surveys are not considered necessary.
Petroica phoenicea	Flame Robin		Vulnerable	Potential – The Flame Robin has a low potential to occur within the study area given that there is only a small amount of suitable habitat.	Only a very small area of suitable habitat for the Flame Robin occurs within the study area and it is unlikely that the species would be a frequent visitor. As such, targeted surveys are

					not considered necessary.
Glossopsitta pusilla	Little Lorikeet		Vulnerable	Potential – The Little Lorikeet has a low potential to occur within the study area given that there is only a small amount of suitable habitat.	Only a very small area of suitable habitat for the Little Lorikeet occurs within the study area and it is unlikely that the species would be a frequent visitor. As such, targeted surveys are not considered necessary.
Daphoenositta chrysoptera	Varied Sittella		Vulnerable	Potential – The varied Sittella has a low potential to occur within the study area given that there is only a small amount of suitable habitat.	Only a very small area of suitable habitat for the Varied Sittella occurs within the study area and it is unlikely that the species would be a frequent visitor. As such, targeted surveys are not considered necessary.

Frogs

Scientific name	Common name	EPBC Act Status	TSC Act Status	Likelihood of Occurrence	Assessment Methodology
Heleioporus australiacus	Giant Burrowing Frog	Vulnerable	Vulnerable	Potential – Habitat suitable for the Giant Burrowing Frog is known to occur within the study area.	The species has never been positively recorded within the study area. However, potential habitat for the species occurs. Surveys for the Giant Burrowing Frog have been undertaken by Eco Logical Australia on two occasions and failed to record the species. Additional surveys are being undertaken during the 2010/2011 season. The results of these surveys will form an appendix to this report

					once they are complete.
Litoria aurea	Green and Gold Bell Frog	Vulnerable	Endangered	Unlikely – There is a low probability that the Green and Golden Bell Frog occurs within the study area due to its known distribution and the absence of suitable habitat. In additional to this, there are no records of the species from within the study area.	A desktop study and literature review was undertaken to determine if the Green and Golden Bell Frog was likely to occur within the study area. Targeted surveys were not considered necessary given the lack of suitable habitat.
Litoria littlejohni	Littlejohn's Tree Frog	Vulnerable	Vulnerable	Unlikely – There is a low probability that the Littlejohn's Tree Frog occurs within the study area due to its known distribution and the absence of suitable habitat. In additional to this, there are no records of the species from within the study area.	A desktop study and literature review was undertaken to determine if the Littlejohn's Tree Frog was likely to occur within the study area. Targeted surveys were not considered necessary given the lack of suitable habitat.
Mixophyes balbus	Southern Barred Frog	Vulnerable	Endangered	Unlikely – There is a low probability that the Southern Barred Frog occurs within the study area due to its known distribution and the absence of suitable habitat. In additional to this, there are no records of the species from within the study area.	A desktop study and literature review was undertaken to determine if the Southern Barred Frog was likely to occur within the study area. Targeted surveys were not considered necessary given the lack of suitable habitat.

Mammals

Scientific name	Common name	EPBC Act Status	TSC Act Status	Likelihood of Occurrence	Assessment Methodology
Chalinolobus dwyeri	Large-eared Pied Bat,	Vulnerable	Vulnerable	Unlikely – There is a low probability that the Large-eared Pied Bat occurs	A desktop study and literature review was undertaken to determine if the

Scientific name	Common name	EPBC Act Status	TSC Act Status	Likelihood of Occurrence	Assessment Methodology
	Large Pied Bat			within the study area due to its known distribution and the absence of suitable habitat. In additional to this, there are no records of the species from within the study area.	Large-eared Pied Bat was likely to occur within the study area. Targeted surveys were not considered necessary given the lack of suitable habitat.
Myotis macropus	Large-footed Myotis		Vulnerable	Known – The Large-footed Myotis has been recorded within the study area.	The species has previously been recorded in 1996 and suitable habitat is known to occur within the gorge at Bomaderry Creek. Given that the species is known to occur, targeted surveys were not determined necessary.
Dasyurus maculatus maculatus (SE mainland population)	Spot-tailed Quoll, Spotted-tailed Quoll, Tiger Quoll (southeastern mainland population)	Endangered	Vulnerable	Potential – This species has potential to occur within the study area given the presence of suitable habitat.	There are records of the species in the Atlas of NSW Wildlife within a 10 km radius of the study area and suitable habitat occurs throughout the region. However, the species has never been recorded within the study area. Although the species has never been recorded, a conservative approach has been taken in the assessment by assuming that it does occur in the study area and is likely to use areas of suitable habitat. If the species does occur (as is assumed for the purposes of assessment) then the impact is considered to be minimal because of

Scientific name	Common name	EPBC Act Status	TSC Act Status	Likelihood of Occurrence	Assessment Methodology
					the very small amount of habitat that will be impacted by the project. As such, targeted surveys were not considered necessary. Notwithstanding this, SCC has agreed to carry out targeted surveys in early 2011 in order to conclusively determine the likely presence of the species.
Isoodon obesulus	Southern Brown Bandicoot	Endangered	Endangered	Unlikely – There is a low probability that the Southern Brown Bandicoot occurs within the study area due to its known distribution and the absence of suitable habitat. In additional to this, there are no records of the species from within the study area.	A desktop study and literature review was undertaken to determine if the Southern Brown Bandicoot was likely to occur within the study area. Targeted surveys were not considered necessary given the lack of suitable habitat.
Petrogale penicillata	Brush-tailed Rock-wallaby	Vulnerable	Endangered	Unlikely – There is a low probability that the Brush-tailed Rock-wallaby occurs within the study area due to its known distribution and the absence of suitable habitat. In additional to this, there are no records of the species from within the study area.	A desktop study and literature review was undertaken to determine if the Brush-tailed Rock-wallaby was likely to occur within the study area. Targeted surveys were not considered necessary given the lack of suitable habitat.
Potorous tridactylus tridactylus	Long-nosed Potoroo (SE mainland)	Vulnerable	Vulnerable	Unlikely – There is a low probability that the Long-nosed Potoroo occurs within the study area due to its known	A desktop study and literature review was undertaken to determine if the Long-nosed Potoroo was likely to

Scientific name	Common name	EPBC Act Status	TSC Act Status	Likelihood of Occurrence	Assessment Methodology
				distribution and the absence of suitable habitat. In additional to this, there are no records of the species from within the study area.	occur within the study area. Targeted surveys were not considered necessary given the lack of suitable habitat.
Pteropus poliocephalus	Grey-headed Flying-fox	Vulnerable	Vulnerable	Known – The Grey-headed Flying Fox has been recorded within the study area.	The NSW Atlas of Wildlife has a record of the species within the study area and suitable habitat is known to occur. Surveys will be undertaken in early 2011 to determine if the population within the study area is a maternal camp.
Petaurus australis	Yellow-bellied Glider		Vulnerable	Known – The Yellow-bellied Glider has been recorded within the study area.	The species has previously been recorded within the study area and suitable habitat is known to occur. Surveys were undertaken to map feed trees and hollow bearing tress.
Cercartetus nanus	Eastern Pygmy-possum		Vulnerable	Potential - The Eastern Pygmy-possum has potential to occur within the study area given the presence of suitable habitat.	Suitable habitat for the Eastern Pygmy-possum occurs within the study area. However, anecdotal evidence suggests that the species does not occur. Although the species has never been recorded within the study area a conservative approach has been taken in the assessment by assuming that it does occur and is likely to use areas of suitable habitat. If the species does

Scientific name	Common name	EPBC Act Status	TSC Act Status	Likelihood of Occurrence	Assessment Methodology
					occur (as is assumed for the purposes of assessment) then the impact is considered to be minimal because of the very small amount of habitat that would be impacted by the project. As such, targeted surveys were not considered necessary. Notwithstanding this, SCC has agreed to carry out targeted surveys in early 2011 in order to conclusively determine the likely presence of the species.

Ray-finned fish

Scientific name	Common name	EPBC Act Status	TSC Act Status	Likelihood of Occurrence	Assessment Methodology
Macquaria australasica	Macquarie Perch	Endangered		Unlikely – There is a low probability that the Macquarie Perch occurs within the study area due to its known distribution and the absence of suitable habitat. In additional to this, there are no records of the species from within the study area.	A desktop study and literature review was undertaken to determine if the Macquarie Perch was likely to occur within the study area. Targeted surveys were not considered necessary given the lack of suitable habitat.
Prototroctes maraena	Australian Grayling	Vulnerable		Unlikely – There is a low probability that the Australian Grayling occurs within the study area due to its known distribution and the absence of	A desktop study and literature review was undertaken to determine if the Australian Grayling was likely to occur within the study area. Targeted

				suitable habitat. In additional to this, there are no records of the species from within the study area.	surveys were not considered necessary given the lack of suitable habitat.

Reptiles

Scientific name	Common name	EPBC Act Status	TSC Act Status	Likelihood of Occurrence	Assessment Methodology
Hoplocephalus bungaroides	Broad-headed Snake	Vulnerable	Endangered	Unlikely – There is a low probability that the Broad-headed Snake occurs within the study area due to its known distribution and the absence of suitable habitat. In additional to this, there are no records of the species from within the study area.	A desktop study and literature review was undertaken to determine if the Broad-headed Snake was likely to occur within the study area. Targeted surveys were not considered necessary given the lack of suitable habitat.

Plants

Scientific name	Common name	EPBC Act Status	TSC Act Status	Likelihood of Occurrence	Assessment Methodology
Cryptostylis hunteriana	Leafless Tongue-orchid	Vulnerable	Vulnerable	Unlikely – There is a low probability that the Leafless Tongue-orchid occurs within the study area due to its known distribution and the absence of suitable habitat. In additional to this, there are no records of the species from within the study area.	A desktop study and literature review was undertaken to determine if the Leafless Tongue-orchid was likely to occur within the study area. Targeted surveys were not considered necessary given the lack of suitable habitat.
Cynanchum elegans	White-flowered Wax Plant	Endangered	Endangered	Unlikely – There is a low probability that the White-flowered Wax Plant occurs within the study area due to its	A desktop study and literature review was undertaken to determine if the White-flowered Wax Plant was likely to

Scientific name	Common name	EPBC Act Status	TSC Act Status	Likelihood of Occurrence	Assessment Methodology
				known distribution and the absence of suitable habitat. In additional to this, there are no records of the species from within the study area.	occur within the study area. Targeted surveys were not considered necessary given the lack of suitable habitat.
Eucalyptus langleyi	Albatross Mallee	Vulnerable	Vulnerable	Known – The Albatross Mallee has been recorded within the study area.	A desktop study and literature review was undertaken to determine if the Albatross Mallee was likely to occur within the study area. In addition to this targeted surveys were also undertaken to determine the location and number of individuals present.
Melaleuca biconvex	Biconvex Paperbark	Vulnerable	Vulnerable	Unlikely – There is a low probability that the Biconvex Paperbark occurs within the study area due to its known distribution and the absence of suitable habitat. In additional to this, there are no records of the species from within the study area.	A desktop study and literature review was undertaken to determine if the Biconvex Paperbark was likely to occur within the study area. Targeted surveys were not considered necessary given the lack of suitable habitat.
Pterostylis gibbossa	Illawarra Greenhood	Endangered	Endangered	Unlikely – There is a low probability that the Illawarra Greenhood occurs within the study area due to its known distribution and the absence of suitable habitat. In additional to this, there are no records of the species from within the study area.	A desktop study and literature review was undertaken to determine if the Illawarra Greenhood was likely to occur within the study area. Targeted surveys were not considered necessary given the lack of suitable habitat.

Scientific name	Common name	EPBC Act Status	TSC Act Status	Likelihood of Occurrence	Assessment Methodology
Pterostylis pulchella	Pretty Greenhood	Vulnerable	Vulnerable	Unlikely – There is a low probability that the Pretty Greenhood occurs within the study area due to its known distribution and the absence of suitable habitat. In additional to this, there are no records of the species from within the study area.	A desktop study and literature review was undertaken to determine if the Pretty Greenhood was likely to occur within the study area. Targeted surveys were not considered necessary given the lack of suitable habitat.
Rhizanthella slateri	Eastern Underground Orchid	Endangered	Vulnerable	Unlikely – There is a low probability that the Eastern Underground Orchid occurs within the study area due to its known distribution and the absence of suitable habitat. In additional to this, there are no records of the species from within the study area.	A desktop study and literature review was undertaken to determine if the Eastern Underground Orchid was likely to occur within the study area. Targeted surveys were not considered necessary given the lack of suitable habitat.
Thelymitra sp. *Kangaloon*	Kangaloon Sun-orchid	Critically Endangered		Unlikely – There is a low probability that the Kangaloon Sun-orchid occurs within the study area due to its known distribution and the absence of suitable habitat. In additional to this, there are no records of the species from within the study area.	A desktop study and literature review was undertaken to determine if the Kangaloon Sun-orchid was likely to occur within the study area. Targeted surveys were not considered necessary given the lack of suitable habitat.
Thesium australe	Austral Toadflax	Vulnerable	Vulnerable	Unlikely – There is a low probability that the Austral Toadflax occurs within the study area due to its known distribution and the absence of suitable habitat. In additional to this,	A desktop study and literature review was undertaken to determine if the Austral Toadflax was likely to occur within the study area. Targeted surveys were not considered

Scientific name	Common name	EPBC Act Status	TSC Act Status	Likelihood of Occurrence	Assessment Methodology
				there are no records of the species from within the study area.	necessary given the lack of suitable habitat.
Triplarina nowraensis	Nowra Heath-myrtle	Endangered	Endangered	Unlikely – There is a low probability that the Nowra Heath-myrtle occurs within the study area due to its known distribution and the absence of suitable habitat. In additional to this, there are no records of the species from within the study area.	A desktop study and literature review was undertaken to determine if the Nowra Heath-myrtle was likely to occur within the study area. Targeted surveys were not considered necessary given the lack of suitable habitat.
Zieria baeuerlenii	Bomaderry Zieria	Endangered	Endangered	Known – The Bomaderry Zieria has been recorded within the study area.	A desktop study and literature review was undertaken to determine if the Bomaderry Zieria was likely to occur within the study area. In addition to this targeted surveys were also undertaken to determine the location and number of individuals present.
Genoplesium baueri	Bauer's Midge Orchid		Vulnerable	Known – The Bauer's Midge Orchid has been recorded within the study area.	A desktop study and literature review was undertaken to determine if the Bauer's Midge Orchid was likely to occur within the study area. In addition to this local experts and the NSWPWS provided information regarding the location of the species within the study area. Additional targeted surveys were not considered necessary.

Scientific name	Common name	EPBC Act Status	TSC Act Status	Likelihood of Occurrence	Assessment Methodology
Hibbertia sp. nov. 'Menai'			Endangered	Known – This species has been recorded within the study area.	A desktop study and literature review was undertaken to determine if this species was likely to occur within the study area. In addition to this targeted surveys were also undertaken to determine the location and number of individuals present.

Ecological Communities

Name	Common Name	EPBC Act Status	TSC Act Status	Likelihood of Occurrence	Assessment Methodology
Lowland Rainforest of the NSW Coast and Sydney Bioregion	N/A		Endangered Ecological Community	Potential – the rainforest in the lower gorge at Bomaderry Creek has potential to qualify as Lowlands Rainforest because of the presence of subtropical species and the high plant diversity.	Given the presence of subtropical species and the high plant diversity at the base of the gorge at Bomaderry Creek the Biodiversity Assessment has assumed that this ecological community is likely to occur. No additional surveys were determined necessary.

2.2 FIELD SURVEYS

A flora and fauna assessment was completed by Kevin Mills and Associates (KMA) in 2008. This report provides summary information of the comprehensive assessments that were previously undertaken by *Kevin Mills and Associates* in 2006/08. The survey efforts undertaken by KMA provide detailed vegetation surveys to update previously identified and mapped vegetation communities and an analysis of detailed fauna surveys previously conducted between 1990 and 1999. A supplementary Flora and Fauna Report was prepared by KMA in August 2010. This supplementary report provides comprehensive threatened species habitat and vegetation community mapping (see **Figures 4, 5 & 6**). This Biodiversity Assessment uses information from all of the above reports prepared by KMA.

Flora surveys and threatened species habitat mapping was conducted along the three route corridors. The aim of the surveys was to describe the floristic composition, structure and condition of the natural vegetation and to map specific threatened species habitat within the study area.

In August 2009, surveys were undertaken by Eco Logical Australia along each of the three route options for hollow bearing trees (HBTs) and feed trees of Yellow-bellied Glider and Glossy Black-cockatoo (see **Figure 7**). These surveys were undertaken to address deficiencies identified by DECCW in the previous assessment.

Surveys were conducted between 11-14 August 2009 for a total of 25 person hours. Survey sites were limited to those areas directly affected by road construction along the three 30m wide route options. Comparative surveys for hollow-bearing trees and feed trees were also undertaken in nearby areas. Five 50x50m (0.25ha) quadrats were surveyed for HBT and feed trees to gauge the presence and abundance of these resources beyond the three route options. Comparative quadrat sites were selected to be representative of the age, quality and type of predominant vegetation.

Tree hollows were assigned a size class (small: <5cm; medium: 5-15cm; and large: >15cm) and a hollow type (branch, trunk, base or chimney). Yellow-bellied Glider feed-trees were identified by characteristic V-shaped incisions on the trunk or branches. Glossy Black-cockatoo feed trees were identified by the presence of characteristically chewed cones beneath She-oak trees. All HBT and feed-trees were identified to species level and their location recorded with a handheld Garmin GPS. Surveys for HBT and feed trees were not undertaken across the entire site given that areas outside of the designated road corridors will not be directly impacted by the North Nowra Link Road.

Additional feed tree surveys were undertaken in May 2010 by KMA. These surveys traversed all three route options within a 200 metre wide corridor for each of the proposed routes. KMA recorded feed trees by marking stands of Black She-oak on a colour aerial photograph in the field. Stands were identified from previous and current field inspections and from aerial photographs. Black She-oak is a coloniser of disturbed land, so that the distribution pattern in the area is largely determined by past disturbance, hence the line of trees along West Cambewarra Road and the extensive stands on the old gravel pit near Pitt Street.

The Giant Burrowing Frog (GBF) was first recorded for its potential to occur in the vicinity of the proposed North Nowra Link Road (central option) in 1992 when it was thought that a possible call of an individual was detected during the initial surveys for the proposed road. The observers were Dr Alan York, a botanist with the NSW State Forests and Mr Garry Daly a field herpetologist with local experience.

Two reports by Mitchell McCotter and KMA provide an assessment of the species and or summaries of the different surveys that have been conducted at the site. KMA (2008) has recorded the chronology of

these survey efforts conducted to date and the conclusions drawn. Mitchell McCotter (1993) provides a vegetation map of the subject land that identifies the spatial extent of the vegetation communities. KMA (2007 and 2008) provides greater floristic detail and improved definitions of the vegetation communities present.

Other incidental and coordinated surveys (including above) in the vicinity of the original GBF observation have occurred in the last 15 years. However, the available reports do not indicate the timing and survey undertaken. Eco Logical Australia as a result is unable to conduct a comparative analysis to determine the adequacy of these surveys against the guidelines provided by the Commonwealth and State government.

The surveys for the GBF have been undertaken by either experienced herpetologists or qualified consultants and have not resulted in any positive record of the species in the potential habitat within the study area.

In September 2009 an inspection of the study area was undertaken by Ross Wellington from Eco Logical Australia over an 8 hour period to investigate GBF habitat. The survey was undertaken during fine, sunny and humid conditions and all three route options were traversed as well as the internal unsealed tracks that dissect the subject land. Perpendicular transects were also undertaken at approximately 100m intervals along the central route in order to detect any unmapped soaks, depressions or ephemeral drainage lines that may constitute breeding habitat for the species. Additionally, an area on the western margin of the Bomaderry Creek gorge north and south of the preferred route creek crossing was traversed including some random meanders where detected habitat looked suitable for breeding purposes and where moisture retention and or ground water flows appeared to be indicated by surface ground cover vegetation.

Ross Wellington has over 30 years of experience in the field and is considered an authority in herpetology. Ross has had direct involvement in the development of the threatened species recovery plan for the GBF.

An intermittent/ephemeral stream was detected in the down slope section near Bomaderry Creek and was followed and inspected for suitable habitat or evidence of breeding. Suitable breeding and broader foraging habitat was identified within the study area and adjacent to the proposed central route corridor as shown in **Figure 8**.

An additional nocturnal survey for the GBF was undertaken in March 2010, focusing on the potential habitat either side of the central route option. The survey was undertaken by David Coombes from Eco Logical Australia, following about 15mm of rain during the previous two days, with last rainfall during the morning of the survey after an unseasonably warm period throughout March which extend into May 2010. Surface soils were still moist to wet and depressions contained pools of water. Otherwise, survey conditions were warm and still. The survey was undertaken between 7pm and 9.30pm.

Call playback for the GBF was used at four sites in the surveys area and consisted of five minutes of call playback followed by 15 minutes of listening for responses. Listening for calls was undertaken throughout the survey period. Spotlight searches for frogs and tadpoles were undertaken using a 55w handheld spotlight, generally along tracks and through other areas of potential breeding habitat and around the site of a previous GBF record. Spotlighting was interspersed with periods of listening for calls, both with and without call playback. Following the above surveys, a vehicle-based survey for the species was also undertaken while driving slowly along the length of the central track from Bomaderry Creek to Illaroo Road North Nowra (approx. 1km).

No evidence of GBF was recorded during the surveys. However, a range of other frog species were recorded, including: the Common Eastern Froglet (*Crinia signifera*), Bibron's Toadlet (*Pseudophryne bibronii*) and *Uperoleia* sp. The Whistling Treefrog (*Litoria verreauxii*) was also heard offsite to the north. No tadpoles of any species were observed during the survey.

David Coombes is a qualified ecologist with over 15 years of experience in ecological survey, assessment and natural resource management.

GBF surveys were also undertaken by Shoalhaven City Council in 1992. No GBF were recorded.

Other species of conservation significance recorded during the survey period were the Grey-headed Flying-fox (*Pteropus poliocephalus*), Yellow-bellied Glider (*Petaurus australis*), Masked Owl (*Tyto novaehollandiae*) and Powerful Owl (*Ninox strenua*) (see **Figure 8**). These species are all listed as vulnerable under the TCS Act, while the Grey-headed Flying-fox is also listed as vulnerable under the EPBC Act.

Surveys were undertaken by the NSW National Parks and Wildlife Service in February 2010 for Bauer's Midge Orchid (*Genoplesium baueri*) within the Bomaderry Creek Regional Park.

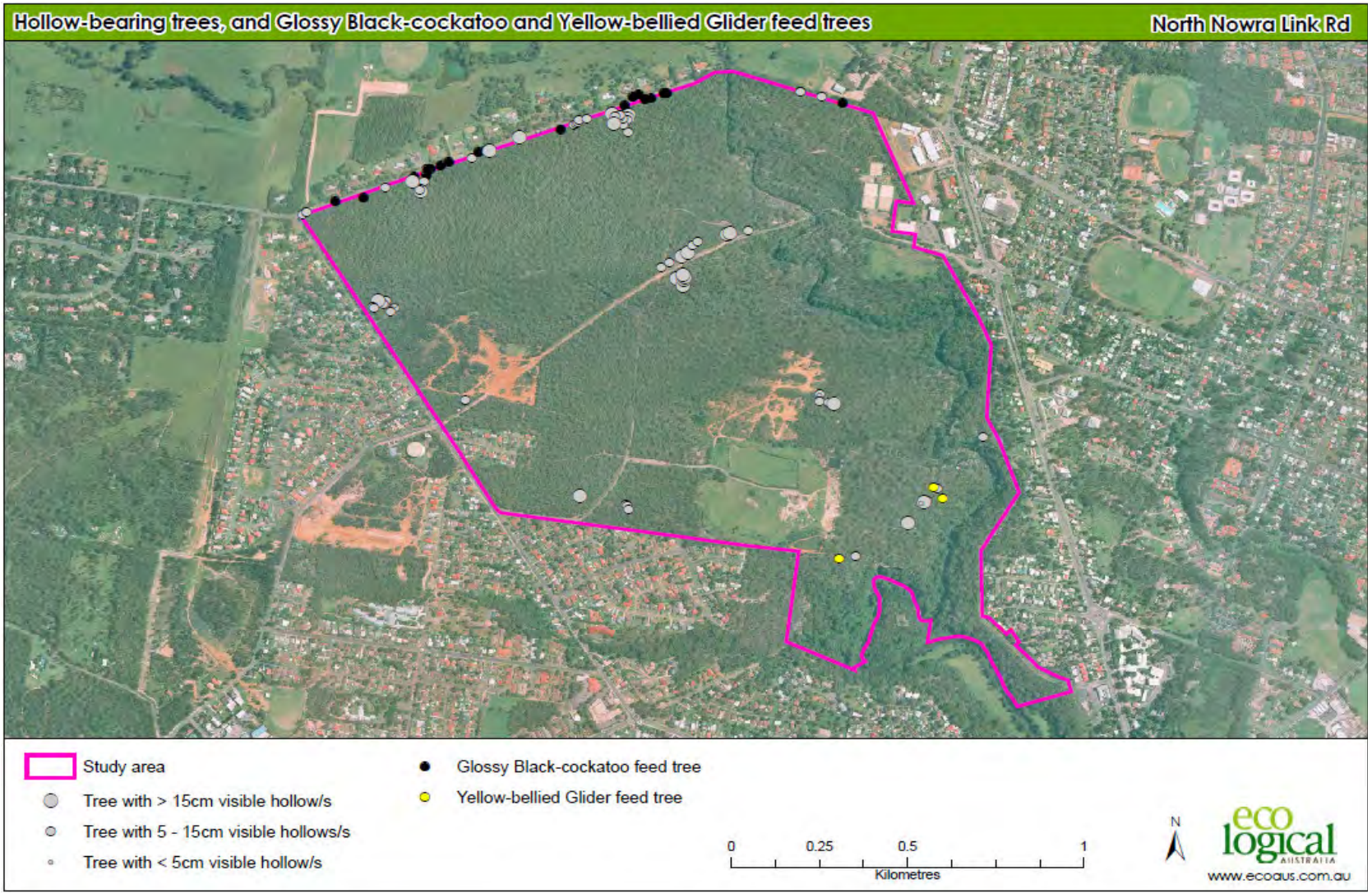

Figure 7: Potential habitat trees

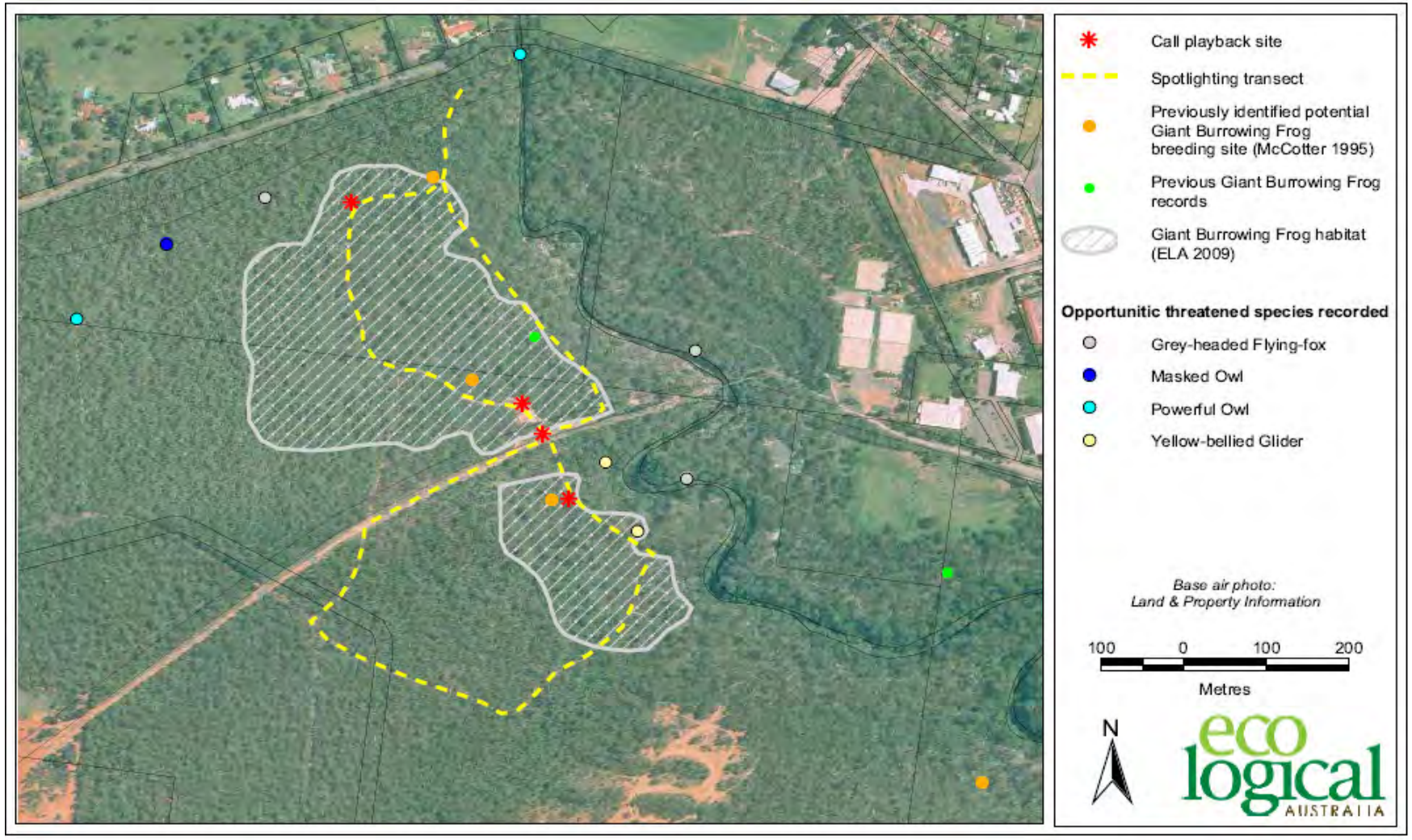

Figure 8: Giant Burrowing Frog habitat and threatened species records

3 Existing Environment

The Shoalhaven City Council is located approximately 160km south of Sydney on the South Coast of NSW. The South Coast Region's coastline and associated estuaries, lakes and wetlands are amongst the most scenic and pristine in NSW. The South Coast contains areas of high conservation value containing over 200 threatened plants, animals and ecological communities.

Nowra and Bomaderry form the major urban areas in north Shoalhaven and are situation on the Shoalhaven River approximately 15km from the coast.

The study area is approximately 223 ha in area. This includes the 50 ha compensatory conservation offset land currently owned by Shoalhaven City Council which is proposed to be dedicated to DECCW and included within the Bomaderry Creek Regional Park. There is limited connected vegetation to the southern and western sections of the study area. This equates to an additional 30 ha of bushland within the immediate area. The nearest bushland outside the study area is Tapitallee Nature Reserve over 1km to the west and Wogamia Nature Reserve 3km to the south-west. Both Nature Reserves lie adjacent to the Shoalhaven River.

Urban development associated with Nowra and Bomaderry townships surround the study area. It is primarily bordered by residential development associated with Bomaderry to the east along with the Princes Highway, to the south and west by residential developments associated with Nowra township and to the north by West Cambewarra Road.

The Bomaderry Creek has a natural rock formation with plate-like cantilevers in parts of the riparian areas that have been identified as being used for aboriginal shelters. Towards the southern end of the study area Bomaderry Creek passes through a deep gorge that is characterised by moist and partially alluvial soils that support a diverse range of plant species. In general, the Bomaderry Creek area has high plant species diversity, reflecting the presence of sandstone soils that usually support a high diversity of plant species, and the gorge that supports very different moist forest vegetation.

The gradient of the study site is generally level. Most of the area has a gradient in the order of 1-2%. Gradient increases within 30-40 metres of the creek, and at the creek there are some vertical or near vertical banks which vary in height throughout the study area.

The study area varies in its ecological condition and floristic diversity, ranging from barren areas devoid of ecological value to high quality undisturbed areas within the Bomaderry Creek Regional Park. The study area also contains extensive areas of land owned and managed by the Shoalhaven City Council that are of equivalent biodiversity value and quality to the Regional Park.

The plant communities occurring in the study area are summarised below, in **Table 2**, followed by a general description of each community.

As mentioned above the Central option follows an existing unsealed services road and electricity transmission line between Pitt Street and Narang Road. The existing road is cleared and provides no habitat values for threatened species. The road has resulted in the fragmentation of the study area and

a large portion of the Bomaderry Creek Regional Park. Although the road is not subject to regular traffic flow, it presents a physical barrier to flora and fauna.

Table 2: Plant Communities occurring in the Study Area

Community	Dominant Species	Occurrence/Route Option(s)
Gorge complex - Coachwood Warm Temperate Rainforest	*Ceratopetalum apetalum* *Backhousia myrtifolia*	In the base of the gorge, along the banks of the creek. Only on the southern route.
Spotted Gum – Turpentine Tall Forrest	*Corymbia maculata* *Eucalyptus saligna* *Eucalyptus botryoides* *Syncarpia glomulifera*	On the upper slopes of the gorge, just below the cliff line. Occurs on all three routes.
Grey Gum – Stringybark Forest/Woodland	*Eucalyptus punctata* *Eucalyptus agglomerate*	On gentle slopes above the gorge, usually on rocky ground. Occurs on all three route options.
Scribbly Gum – Casuarina Forrest/Woodland	*Eucalyptus sclerophylla* *Allocasuarina littoralis* *Corymbia gummifera*	Across the plateau on all route options.
Scribbly Gum – Bloodwood Woodland	*Eucalyptus sclerophylla* *Corymbia gummifera* *Eucalyptus consideniana*	Across the plateau on all route options.
Kunzea Shrubland	*Kunzea ambigua* *Leptospermum sejunctum*	On broad rock outcrops above the gorge. On the Central route option.
Sandstone Sedgeland	*Melaleuca thymifolia* *Viminaria juncea* *Leptospermum* spp.	On the plateau, on shallow, moist soils covering broad areas of bedrock. Near to the Central route option.

*Note: The various plant communities occurring on each route option are shown in **Figures 4-6**.*

Gorge Complex - Coachwood Warm Temperate Rainforest

Coachwood Warm Temperate Rainforest (see **Figure 9**) occurs on deep, moist and partial alluvial soils in the gorge of Bomaderry Creek, where it is protected from fire. The main occurrence in the study area is along the base of the gorge, about 50 metres downstream from the crossing of the Central route option. Lower in the gorge, subtropical rainforest elements occur within the community (KMA 2010).

This community occurs on the Southern route and just below the Central route. Some plants from the community occur along the whole length of the riparian zone of Bomaderry Creek, these species can be found on the Central and Northern routes, but there is no rainforest structure (KMA 2010).

Figure 9: Gorge Complex - Coachwood Warm Temperate Rainforest

Spotted Gum – Turpentine Tall Forest

Spotted Gum – Turpentine Forest (**Figure 10**) occurs on deep, moist soil below the cliff line. It also extends above the cliff in a few places, albeit with shorter growing trees and a drier understory. This forest community occurs on all three route options, but is best developed in the wide gorge around the Southern option (KMA 2010).

Figure 10: Spotted Gum – Turpentine Tall Forest

Grey Gum – Stringybark Forest/Woodland

Grey Gum – Stringybark Forest/Woodland (see **Figure 11**) occurs on the rocky eastern and western edges of the Bomaderry Creek gorge. It is quite distinct from the Spotted Gum Tall Forest below the cliff line, but merges more gradually with the Scribbly Gum woodland to the west of the gorge. This

community occurs on all routes, growing on the edge of the gorge to the east and west of Bomaderry Creek (KMA 2010).

Figure 11: Grey Gum – Stringybark Forest/Woodland

Scribbly Gum – Casuarina Forrest/Woodland

Scribbly Gum – Casuarina Forrest/Woodland is similar to and closely associated with the Scribbly Gum – Bloodwood Woodland described below. Both communities occur on the plateau and the demarcation between the two communities is not always distinct. The Scribbly Gum – Casuarina Forrest/Woodland contains taller and denser trees and the structure tends towards forest. This community occurs mainly in the north-western part of the Bomaderry Creek bushland; it is on the western parts of the Northern and Central routes (KMA 2010).

Scribbly Gum – Bloodwood Woodland

Scribbly Gum – Bloodwood Woodland (see **Figure 12**) occurs across the plateau. It is more common and has a wider distribution than any other community in the Bomaderry Creek region. It is the most common plant community on all three routes, extending across most of the area west of the gorge (KMA 2010).

Figure 12: Scribbly Gum – Bloodwood Woodland

Kunzea Shrubland

Kunzea Shrubland (see **Figure 13**) occurs on the rocky eastern and western edges of Bomaderry Creek gorge. It occurs within the Grey Gum – Stringybark Forest/Woodland, as discrete patches on rock outcrops. This community occurs on a broad rock outcrop on the Central route, just west of the gorge, extending to the north (KMA 2010).

Figure 13: Kunzea Shrubland

Sandstone Sedgeland

Sandstone Sedgeland (see **Figure 14**) occurs occasionally on the plateau, on poorly drained sites with shallow soils over the sandstone bedrock. This community occurs mainly to the west of the gorge where broad sandstone surfaces are close to the surface; the community is close to the Central route (KMA 2010).

Figure 14: Sandstone Sedgeland

The area of each plant community and individual threatened species that would be cleared for each of the three route options is outlined in **Table 3**.

Figure 15: Rock formations at Bomaderry Creek.

Table 3: Areas of each plant community and amount of threatened species that would be cleared on each route option (KMA 2010)

Plant Community/Threatened Species	Southern Route	Central Route	Northern Route	Occurrence within the offset
Gorge Complex – Coachwood Warm Temperate Rainforest	0.25 ha	0.10 ha	0.07 ha	In the base of the gorge, along the banks of the creek.
Spotted Gum – Turpentine Tall Forest	nil	nil	0.43 ha	On the upper slopes of the gorge.
Grey Gum – Stringybark Forest Woodland	2.13 ha	0.96 ha	nil	On the plateau and on gentle slopes above the gorge, usually on rocky ground.
Scribbly Gum – Casuarina Forest Woodland and Scribbly Gum – Bloodwood Forest Woodland	1.46 ha	1.16 ha	4.02 ha	On the plateau.
Kunzea Shrubland	0.13 ha	0.09 ha	nil	On the plateau on broad rock outcrops
Sandstone Sedgeland	0.17 ha	nil	nil	On the plateau, on shallow, moist soils covering broad areas of bedrock.
Hibbertia sp.*nov. 'Menai'*	23 individuals	9 individuals	nil	Potential
Eucalyptus langleyi	nil	2 individuals	nil	Known
Genoplesium baueri	9 individuals	nil	nil	Potential
Zieria baeuerlenii	nil	nil	nil	Known
Total Clearing	**4.14 ha**	**2.31 ha**	**4.52 ha**	

Detailed information relating to the area of vegetation communities and the amount of threatened species present within the proposed 50 hectare offset is contained in the Revocation and Offsets Assessment at **Appendix E.** The various vegetation communities and their location within the study area including the proposed offset are shown in **Figure 16**.

3.1 BOMADERRY CREEK REGIONAL PARK

Bomaderry Creek Regional Park was established in 2002 under the *National Parks and Wildlife Act 1974* (NPW Act). The Park is managed by the South Coast Region of the National Parks and Wildlife Service of NSW, and currently covers an area of 82 hectares. The Bomaderry Creek Regional Park is bounded east and north by Shoalhaven City Council land and to the west by Crown Land. Some of the Council land (i.e. the land adjacent to Bomaderry Creek) is zoned for conservation under the Local Environmental Plan, however, it does not form part of the regional park and subsequently is not afforded the same level of environmental protection. The Crown land on the plateau is generally zoned for residential uses.

The Bomaderry Creek Regional Park has high biodiversity values and contains suitable habitat for a number of threatened flora and fauna species. The Park is significant for its natural heritage, Aboriginal spiritual connection and contemporary European heritage in reference to the former dam that serviced Bomaderry for many years.

The Bomaderry Creek Regional Park encompasses a small section of the Bomaderry Creek. The majority of the creek within the study area falls within the adjacent Council land to the north and east of the Regional Park. However, approximately 50 hectares of high quality Council land is proposed to be included as part of the Bomaderry Creek Regional Park as an offset (refer section 8). Commensurate with the objectives of the NPW Act, this will result in the entire length of the creek within the study area being incorporated into Bomaderry Creek Regional Park.

As mentioned above, all three route options traverse the Bomaderry Creek Regional Park and will require revocation of between 0.3 to 1.6 hectares depending on the route option that is selected. All three options will fragment remnant vegetation to varying degrees.

Clearing of native vegetation is a key threatening process under the TSC Act, which can result in fragmentation. Fragmentation could potentially impact native flora and fauna within the Bomaderry Creek Regional Park. Impacts associated with fragmentation are discussed below in section 6.

In addition to the removal of habitat and fragmentation, road construction can have indirect impacts on the environment, such as weed invasion, vegetation die-back and adverse impacts from motor vehicle use. Impacts of this nature are referred to as 'edge effects' as they occur along the edge of a habitat area and are a result of an adjoining activity (*KMA* 2008). Potential edge effects associated with the construction of the North Nowra Link Road are discussed below in section 6.

The threatened species, Bomaderry Zieria and Albatross Mallee occur primarily within the eastern and north-eastern sections of the Bomaderry Creek Regional Park (including the 50 ha parcel of offset land which will become part of the Regional Park) near Bomaderry Creek.

Albatross Mallee is found in Bomaderry Creek Regional Park within the habitat associations of Grey-Gum – Stringybark Forest / Woodland and Spotted Gum Blackbutt Forest vegetation communities. The Spotted Gum Blackbutt Forest is a riparian vegetation community running the length of Bomaderry Creek in the study area.

KMA (2010) recorded the Bomaderry Zieria within the Grey Gum – Stringybark Forest / Woodland found within Bomaderry Regional Park. However, it has also been recorded in a number of other vegetation communities' including Scribbly Gum – Bloodwood Woodland / Open Woodland, Coachwood / Ironwood Warm Temperate Rainforest and Kunzea Shrubland. This suggests that the Bomaderry Zieria can occur in a number of vegetation associations within the confines of the protected Bomaderry Creek Regional Park despite a habitat preference for Grey Gum – Stringybark Forest / Woodland. All four of the vegetation communities mentioned above are part of the additional offsets land being added to the Regional Park and as part of this project will increase the potential habitat for this species.

These vegetation communities and their positions within Bomaderry Creek Regional Park can be seen in **Figure 16**

Given the high biodiversity value of the Bomaderry Creek Regional Park it is considered to be of high conservation value. The high conservation value of the park is attributed to the individual conservation value of the riparian and vegetation corridors that provide an important habitat resource for a range of threatened flora and fauna. The conservation value of these particular attributes, are significant on a local scale from both a biodiversity perspective and in the form of public amenity. On a regional scale the conservation value of the Bomaderry Creek Regional Park and its attributes is important, given the presence of a number of threatened flora species endemic to the area. The conservation value of the park, its associated vegetation and riparian corridors and threatened species will be further enhanced through the inclusion of 50ha of existing SCC land into the park as an offset.

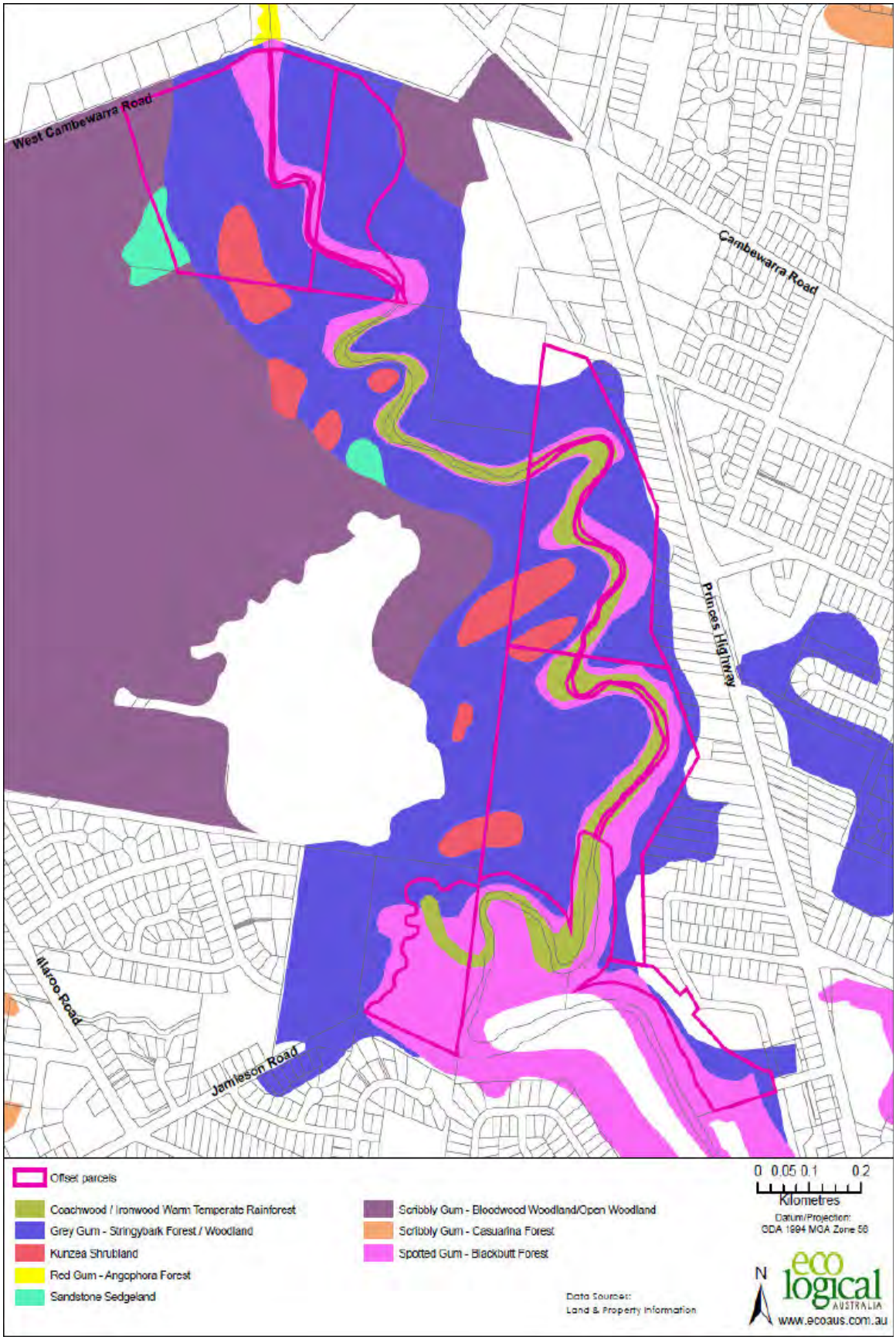

Figure 16: Vegetation communities within Bomaderry Creek Regional Park (source KMA 1998)

4 Threatened Species and Communities

4.1 THREATENED FLORA

4.1.1 Albatross Mallee – *Eucalyptus langleyi*

The *Eucalyptus langleyi* grows to 6m, with smooth, grey, green or pink bark that sheds in ribbons and regenerates from rootstock after fire (NSW DECC 2009a). The species is listed as vulnerable under both the TSC and EPBC Acts. In December 2010 the NSW Scientific Committee made a determination under the TSC Act to list the population of *Eucalyptus langleyi* north of the Shoalhaven River in the Shoalhaven local government area as an Endangered Population.

The main occurrence of the *Eucalyptus langleyi* is to the south-west of Nowra as far as Yarramunmun Creek. It is also found to a limited extent north of the Shoalhaven River in the vicinity of Bomaderry Creek. It is found in Mallee Shrubland on poorly-drained, shallow, sandy soils on sandstone (NSW DECC 2009a).

Two individual *Eucalyptus langleyi* were recorded during the vegetation surveys at Bomaderry Creek. The proposed bridge design for the Central route will result in the bridge being above the two individuals and it is doubtful these would survive.

An additional fifteen individuals were recorded within the study area on the eastern side of Bomaderry Creek as shown in **Figures 19** and **20**. However, these individuals fall outside the construction footprint for all three of the proposed route options. These individuals occur between 25 to 100 metres to the north of the centre line of the proposed Central route development footprint.

The total population of *Eucalyptus langleyi* is many thousands of plants, and some of the known stands contain several hundred specimens. A study by KMA (2002) surveyed the stands to the southwest of Nowra and counted over 4,000 plants in 13 stands. A paper by Kevin Mills on the distribution and ecology of *Eucalyptus langleyi* is at **Appendix C.**

The presence of two individual *Eucalyptus langleyi* within the proposed development footprint for the Central route indicates that there will be impacts to this species through the permanent shading and changes to soil moisture in that area as a result of the construction of a bridge.

An initial avoidance strategy for this species was used for the design of the proposed road, resulting in the avoidance of the majority of individuals within the vicinity of the construction footprints. No individuals will be impacted either directly or indirectly by the Northern or Southern routes. Potential impacts on two individuals due to the construction of the Central route is unlikely to threaten the species with local extinction as these individuals only represent a small part of the overall population within the region. However, mitigation measures aimed at minimising the potential for indirect impacts associated with the construction of the Central route are discussed below in section 6.

As mentioned above, the construction of the North Nowra Link Road will potentially impact two individual *Eucalyptus langleyi.* Both of these individuals form part of the population that has recently been listed as an Endangered Population under the TSC Act. The total population size of the

Eucalyptus langleyi population north of the Shoalhaven River in the Shoalhaven LGA was originally estimated to be 32 plants. However, a survey undertaken by Barrett et al in 2008 found that only 20 of these individuals were still alive. Although two individuals from the Endangered Population will potentially be impacted, it is not likely to place the population at risk of extinction. The majority of the Endangered Population occurs on land that is currently owned and managed by SCC. As discussed below in section 8, SCC intend on transferring approximately 50 hectares of land into the Bomaderry Creek Regional Park. This will mean that the majority of individuals in the population would be located within a state managed reserve and therefore would be afforded greater protection and the risk of extinction will be reduced. The inclusion of these individuals into the reserve will also greatly enhance the long term conservation of the population.

Although two individuals from this population may potentially be impacted, all of the remaining individuals will remain in situ and will not be impacted either directly or indirectly by the construction of the North Nowra Link Road. The vegetation clearance associated with the North Nowra Link Road will be limited to the construction corridor. As such, the surrounding bushland will not be adversely impacted and disturbance to areas of habitat suitable for *Eucalyptus langleyi* will be minimal.

Note: Previous information provided to DEWHA in the EPBC Act referral showed individual Eucalyptus langleyi specimens on the western side of Bomaderry Creek, adjacent to the Central route corridor. Recent surveys undertaken by Kevin Mills in May 2010, confirmed that the species is not present on the western side of the gorge. As such, all figures have been updated to make accurate reference to known specimens within the study area.

4.1.2 Bomaderry Zieria – *Zieria baeuerlenii*

Zieria baeuerlenii occurs in only one location north-west of Nowra. The population occurs in a total of 57 colonies in six discrete clusters. These clusters are confined within a 0.5 km x 1.0 km area of bushland, and are found on both sides of Bomaderry Creek (NSW DECC 2009b). The species is listed as endangered under both the TSC and EPBC Acts.

The species occurs on skeletal sandy loam overlaying sandstone, on a rocky plateau amongst sandstone boulders in either shrubby open forest, shrubby woodland or closed scrub. Seed production has never been observed in the *Zieria baeuerlenii* and all evidence collected to date suggests that the species has lost its capacity to reproduce sexually. The plants are known to resprout following fire (NSW DECC 2009b).

The presence of *Zieria baeuerlenii* was recorded adjacent to the proposed development footprint for the central route and within the immediate surrounds as shown in **Figure 19**. Two plants were recorded in the initial 30 metre road corridor within the 200 metre wide assessment corridor for the central route option. The corridor design has since been modified to avoid impacts to these individuals as shown in **Figure 20**. These individuals are part of a large cluster about 13 metres north of the centreline of the central route.

The construction footprints for the Northern and Southern routes are a considerable distance from any known individual specimens (see **Figure 19**) and construction activities will not result in any direct or indirect impact on this species at these locations.

Figure 17: Bomaderry Zieria – *Zieria baeuerlenii*

As mentioned above, construction activities for the Central route will pass nearby two individuals and particular attention will be given to the design and construction of the road in this area, specifically increased moisture and nutrients from runoff and stormwater from the road. As discussed below in section 6, potential impacts associated with runoff and stormwater will be addressed through the development of an Erosion and Sediment Control Plan followed by a Soil and Water Management Plan. The potential for direct mortality of individual plants is unlikely given the construction of the road will not result in their removal. Indirect impacts will be mitigated accordingly through a range of measures designed specifically to reduce the likelihood of impacts on *Zieria baeuerlenii*, such as fauna accessible fencing restraining human activity yet with strategically placed locked gates allowing NPWS and Rural Fire Service access for improved control.

Although the Central route is in proximity to two individual plants, the construction and operation of the North Nowra Link Road will not result in mortality. The fact that the road corridor has been refined to avoid direct impacts and that a range of mitigation measures will be implemented to avoid indirect impacts, it is unlikely that any of the known specimens in and around the Central route will be impacted.

The boundary of the construction corridor for the Central route is approximately 10 metres from the nearest *Zieria baeuerlenii* colony. Whilst the clearing of land required for construction will remove a number of trees that may provide shade for the nearby *Zieria baeuerlenii* colony, it is expected that impacts associated with the potential exposure to heat and sunlight would be minor given that the trees to be cleared are to the south of all of the known *Zieria baeuerlenii* records. Previous studies have recorded the species from within a few metres of the construction corridor for the Central route. However, during a recent site visit by Eco Logical Australia on 16 August 2010, the closest *Zieria baeuerlenii* colony was recorded approximately 10 metres away from the construction corridor. Whilst extensive ground work was not undertaken, the absence of the previously recorded plants suggests that they have either died since originally being recorded or that the GPS coordinates were inaccurate. In any event, a number of mitigation measure aimed at reducing potential impacts associated with shading and exposure will be implemented (see section 6).

The reduction in available habitat for *Zieria baeuerlenii* varies depending on the route option selected. The species is known to occur in areas of Grey Gum –Stringybark Forest/Woodland. Therefore, the reduction in available habitat for the species would be approximately 0.96 hectares for the Central route

and 2.11 hectares for the Southern route. A reduction in available habitat is not likely to result from the construction of the Northern route given the absence of Grey Gum –Stringybark Forest/Woodland.

Barratt (1997) suggested that a major threat to the species was fire. The greatest fire-related threat to *Zieria baeuerlenii* is bushfire prevention or suppression activities, such as establishing fire-breaks, overly frequent fuel reduction burns, and accidental damage from rake-hoe lines, broader control lines and vehicles moving off established tracks (NPWS 2002).

One colony is known to have survived at least three fires since 1968 with plants growing well 12, 15 and 30 years after fire. Barratt (2007) recorded: "Regrowth was observed following the fire in E13 where the site had been totally burnt, but no more details were recorded." Barratt (2007) states that fire is not likely a concern for the survival of the species, and he qualifies this: "Too frequent burning may be a concern, but this species' apparent capacity to quickly respond vegetatively may allay such fears." *Zieria baeuerlenii* should be subject to burning no more than once every 7 years (NPWS 2006).

There is an average of 600 bushfires per year in the Shoalhaven LGA, and the main sources of ignition are arson and accidental ignition (SBFMC 2009). Fire history of Bomaderry Creek Regional Park indicates fire of greater intensity and control difficulty during late spring, summer and early autumn, though periods of drought may extend this from late August to June (NPWS 2006).

Plants observed within 18 months of fire showed good growth from underground rootstock (NPWS 2002). However, this regrowth appeared to be preferentially grazed before mature foliage on unburnt plants (Barratt 1999 cited in NPWS 2002), the impacts of which are not fully understood. As such, should a fire occur in an area known to contain *Zieria baeuerlenii* (within the vicinity of the Central route) then it may be necessary to erect herbivore proof fencing around the plants allowing the regrowth an opportunity to fully mature.

Current understanding of the species suggests that the species can survive repeated lower intensity fires, although more frequent fire may prevent stem layering reproduction.

Increased traffic flow and pedestrians may reduce arson and car dumping along the proposed Central route option for the North Nowra Link Road, reducing the likely event of bushfire and an impact on *Zieria baeuerlenii*.

Conversely, an increase in traffic may increase the frequency of fire and alter the current fire regime. Although the major source of fire is likely to be through control fuel reduction activities (NPWS 2002) which will be largely unchanged as a result of the proposal, discarded cigarette butts and improved access has the potential to increase fire frequency.

To reduce the potential for impacts associated with fire on threatened plant species, in particular, the *Zieria baeuerlenii*, a fire management plan for the Bomaderry Creek Regional Park will be developed. The plan will be developed in accordance with the existing Shoalhaven Bush Fire Risk Management Plan (SCC, 2000). The plan will detail management and fire control measures that will be implemented along the North Nowra Link Road. These measures will be aimed at reducing the likelihood of adverse impacts on threatened species.

Signage will also be installed along the road indicating that littering is an offence, as per the Shoalhaven City Council Roadside Environmental Management Plan, to reduce the chance of bushfire ignition resulting from dumped cigarette butts and glass.

Figure 18: Dumped stolen car near the central route corridor.

The construction of the North Nowra Link Road also has the potential to create more accessibility to the reserve and, in particular, in proximity to several colonies of *Zieria baeuerlenii* should the Central route be constructed. There has been an 'ever-increasing' problem with illegal dumping at the council owned land at Bomaderry Creek (SCC, 2004). It is likely that an increase in traffic as a result of the link road may dissuade people from dumping rubbish. This would be due to the fact that the area will be less isolated given an increase in regular traffic flow and that perpetrators would increase their likelihood of getting caught.

Although rubbish dumping activity, particularly of garden waste, in the location of the species has potentially to have an adverse impact, unless rubbish dumping occurs directly in the vicinity of known specimens or their potential habitat, it is unlikely that impacts would occur. In the event that dumped rubbish impacts the species, improved access to the site would allow the rubbish to be removed by Council and subsequent remedial action taken.

Trampling and vandalism is not considered a major impact on the species and it is considered unlikely that vehicles will stop along the North Nowra Link Road and increase the current passive use of the reserve for activities such as walking. The colonies of *Zieria baeuerlenii* close to the proposed Central route have been the subject of previous vandalism (Barratt 2007) and it is not expected construction of the North Nowra Link Road would increase the incidences of vandalism in the area. However, fencing will be erected to ensure that the potential for vandalism is minimal.

Reproduction appears to be exclusively by vegetative spread and there is virtually no pollen viability and seed production (Sharma, 2001), although it is unclear whether vegetative spread is via stem layering or rhizomatous growth (NPWS, 2002). Due to this vegetative reproduction, disturbance to the movement of pollinators and seed dispersal vectors is not considered important. While the presence of the proposed road may present a physical barrier to a species which reproduces vegetatively, there is currently a maintained service road for significant urban infrastructure along the line of the proposed Central route, so any barrier a road represents is already permanently in place.

The issue of fragmentation for this species is unlike the majority of species when considering how it reproduces. Fragmentation of colonies or individuals are not foreseen to impact on long-term survival

as the species reproduces vegetatively with no associated risk, nor increased risk, of inbreeding depression.

The major concern in relation to fragmentation for this species is the splitting of colonies of individuals which belong to the same genotype. Twenty (20) separate genotypes have been identified and mapped (Barratt 1997) for the species, with each of these genotypes having been propagated at the Booderee Botanic Gardens. Given that there are 20 distinct clones present, it suggests that the species previously reproduced sexually, and may have since become inbred and sterile (Sharma, 2001).

The current proposal does not split any genotypes nor isolate individuals from the rest of their genotype. The Central route traverses close to only one genotype (Gn1) which will be the focus of increased conservation and mitigation efforts.

No individual *Zieria baeuerlenii* will be lost as a result of construction activities. However, indirect impacts may affect plants adjacent to the Central route (see **Figure 20**). A range of measures have been developed to mitigate potential impacts on the species as a result of the construction of the Central route and are discussed in detail in section 6.

As mentioned above, Zieria baeuerlenii was recorded adjacent to the proposed development footprint for the Central route and within the immediate surrounds, and the corridor design has been modified to avoid impacts to two individuals previously recorded in the initial 30 metre road corridor. As such, it cannot be foreshadowed that the proposal will adversely affect long-term viability of the population given the range of mitigation measures that will be implemented, including, fire management activities, avoidance strategies, fencing and water run-off controls.

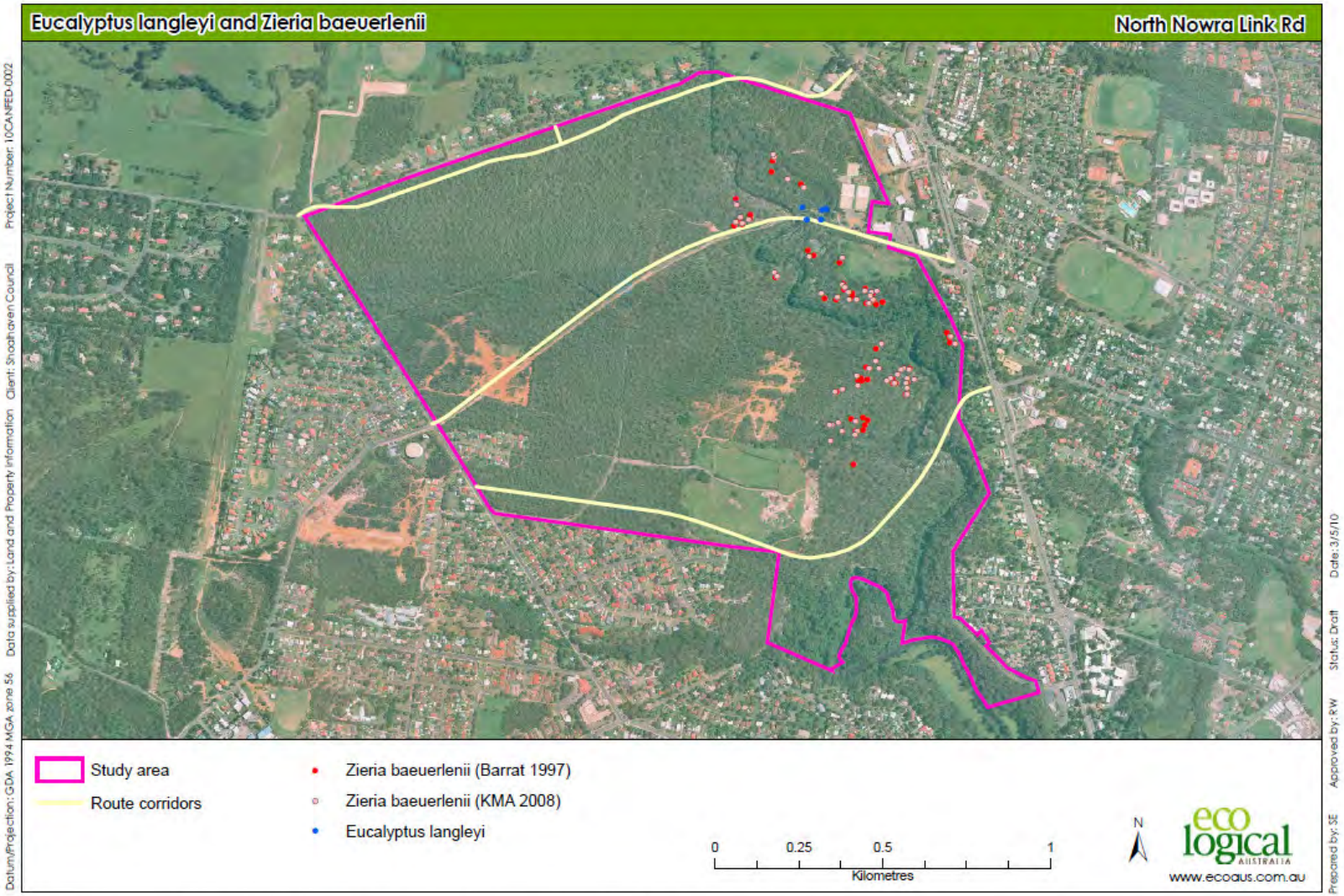

Figure 19: Location of *Zieria baeuerlenii* and *Eucalyptus langleyi* within the study area

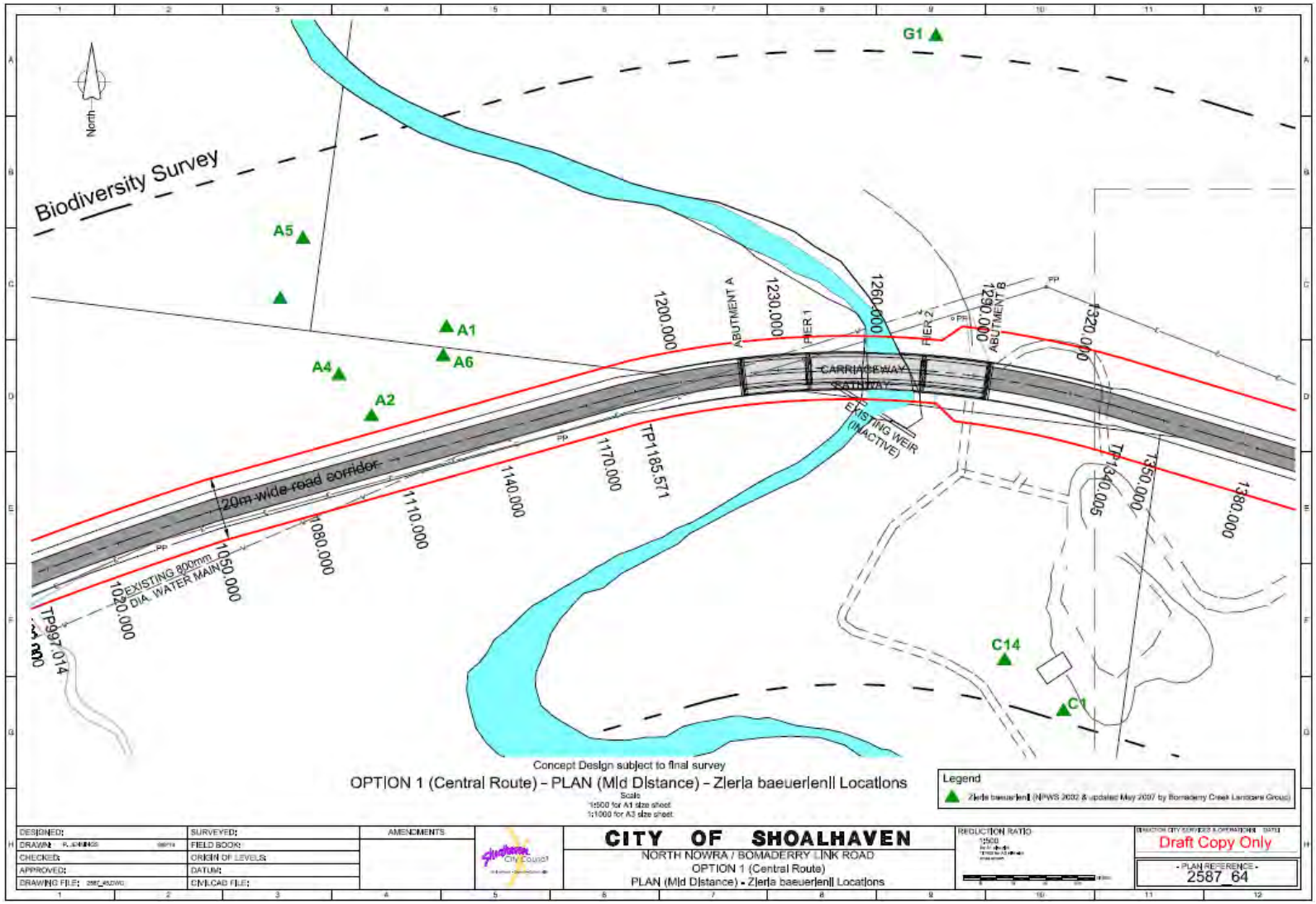

Figure 20: Central route option - Mid Distance – Zieria locations

4.1.3 Bauer's Midge Orchid – *Genoplesium baueri*

The *Genoplesium baueri* is a terrestrial orchid that grows to approximately 6-15cm in height and is yellowish-green or reddish in appearance. The species grows in sparse sclerophyll forest and moss gardens over sandstone and has been recorded from locations between Ulladulla and Port Stephens (DECCW 2009). The species is listed as vulnerable under the TSC Act and is not listed under the EPBC Act.

Over 200 *Genoplesium baueri* are known from only 13 sites across its range. This species would be considered to have a fairly broad regional distribution but individuals are usually found in highly localized populations which potentially understate the threatened nature of the species. This species grows in sparse sclerophyll forest and moss gardens over sandstone.

In the Southern Rivers region where the study area is located, the *Genoplesium baueri* is known to be associated with;

- Red Bloodwood – Hard-leaved Scribbly Gum – Silvertop Ash heathy open forest on sandstone plateau of the lower Shoalhaven Valley;
- Red Bloodwood – Scribbly Gum heathy woodland on sandstone plateau;
- Red Bloodwood – Grey Gum shrubby open forest on shale-sandstone interface of the lower Shoal haven valleys; and
- Banksia – Red Bloodwood – Hard-leaved Scribbly Gum heathy open woodland on sandstone plateau.

In Bomaderry Creek Regional Park, *Genoplesium baueri* has been recorded within the Scribbly Gum – Bloodwood Woodland / Open Woodland vegetation community. This vegetation community comprises the majority of the central and western sections of the Regional Park.

Surveys undertaken by NSW Parks and Wildlife in February 2010 have recorded 23 individuals from 12 clusters from within the site. Of these 23 individuals, 14 (from 7 clusters) are in the vicinity of the Central route option and 1 specimen may be impacted (direct or indirect) due to clearing associated with the construction of the Central route (see **Figure 21**).

An additional 9 specimens (from 5 clusters) may potentially be impacted by clearing activities associated with construction the Southern route (see **Figure 22**). These individuals were recorded by an Australian Native Orchid Society Conservation Officer in April 2010.

In addition to the individuals that were recorded in the study area, there are 3 sites approximately 5-10km west of Nowra and one site at St. George's Basin that contain this species (NPWS Atlas of NSW Wildlife).

Given that only a small number of individual specimens may potentially be impacted by the construction of the Central or Southern route, adverse impacts on the species are not considered likely as the species is known to occur more broadly throughout the Shoalhaven region. The potential for indirect impacts, should the Central or Southern route proceed will be mitigated as discussed below in section 6.

4.1.4 *Hibbertia* sp. Nov. "Menai"

This species is an undescribed species listed as endangered under the TSC Act. This taxon occurs in two regions separated by over 100km one of which occurs across the Toorooroo Plateau and nearby to

the west of Nowra. Little information has been recorded for the south coast population near Nowra in terms of habitat preference, longevity, seed biology and most aspects of its ecology (DECCW 2010). It appears to propagate by seed and as with most *Hibbertia* species it is probably pollinated by bees.

The habitat for this species appears to be dry sclerophyll forest or woodland associations in sandy soils over sandstone.*KMA d*iscovered a total of 45 plants that closely resemble this yet undescribed taxon within the study area, of which 23 individuals occur on the Southern route and 11 individuals occur near the Central route. No *Hibbertia* sp. Nov "Menai" were recorded within the construction footprint for the Northern route option.

This species is abundant in the Shoalhaven region, occurring across a large natural area west of Nowra, including thousands of plants within the Colymea State Conservation Area (KMA 2010). The population within the study area is extremely small in comparison to the abundance of the species to the west of Nowra, where there are possibly tens of thousands of plants (KMA 2010). A paper providing an overview of the current knowledge and distribution and conservation status of this species is at **Appendix D**.

Suitable habitat for the species within the study area was not searched systematically, however, there are likely to be hundreds of plants in the area. A detailed assessment of the likely impacts on this species is contained within the KMA Supplementary Report at **Appendix B**.

The specimens of *Hibbertia* sp. Nov "Menai" within the Bomaderry Creek Regional Park are likely to be linked genetically to the plants to the west all the way to Colymea. KMA recorded specimens to the west of Nowra, and suggests that there is suitable habitat in the area between north Nowra and Colymea, both to the north and south of the Shoalhaven River, where the taxon is likely to occur (Kevin Mills pers. comm.).

Considering the relatively small amount of vegetation loss due to the proposal and large amount of suitable habitat in the area, it is not foreseen that the proposal could have an adverse impact on this species.

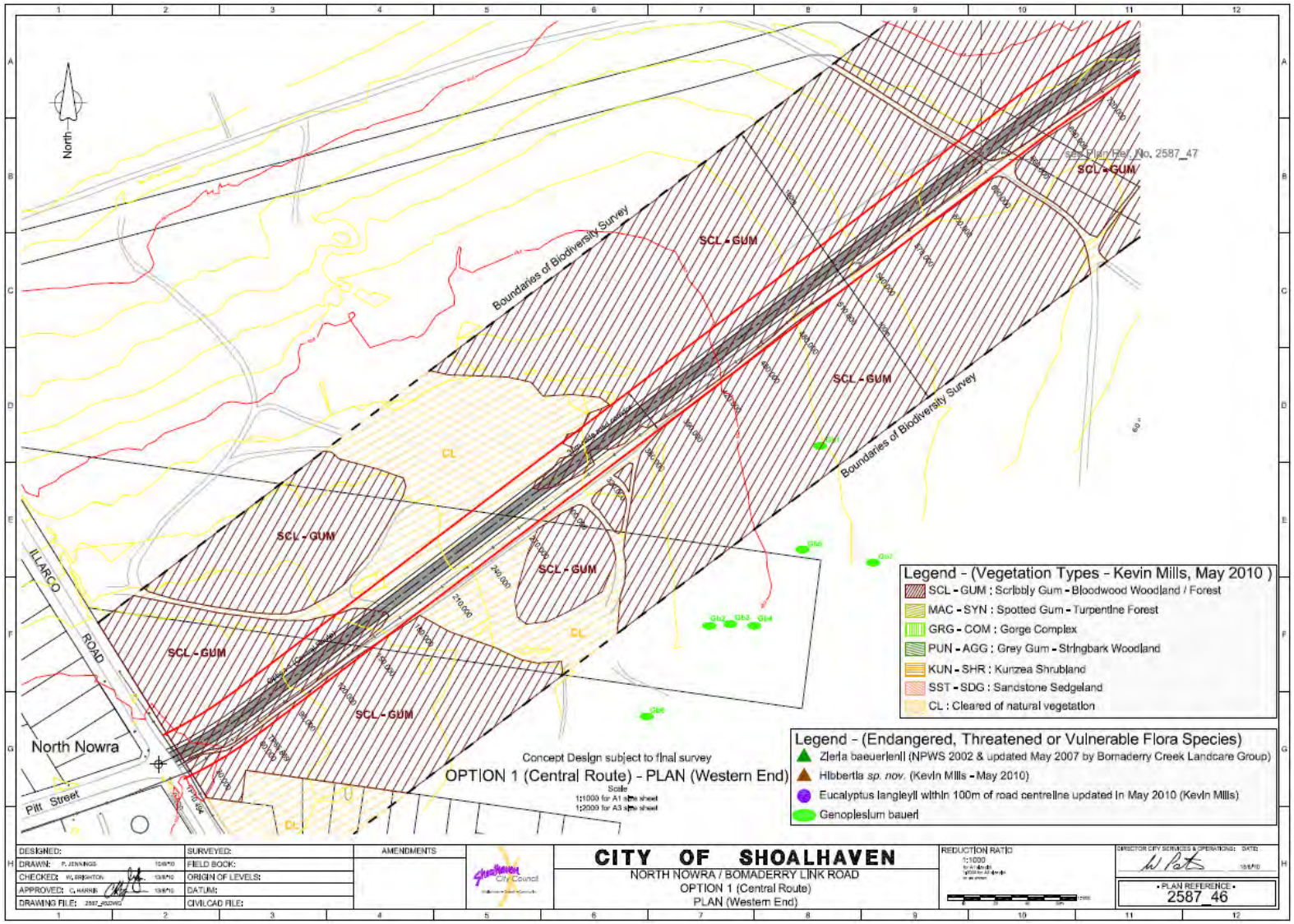

Figure 21: Location of *Genoplesium baueri* near the Central route corridor

Figure 22: Location of *Genoplesium baueri* recorded by the Australian Native Orchid Society - (locations may contain more than one individual)

4.2 THREATENED FAUNA

4.2.1 Giant Burrowing Frog – *Heleioporus australiacus*

The GBF is listed as a vulnerable species under both the TSC and EPBC Acts. The GBF is a large, rotund member of the ground frog family Myobatrachidae reaching up to 100mm total length. It is a powerfully built species with muscular hind limbs and enlarged tubercles on the feet well suited to burrowing (DECCW 2009c).

Most records for the GBF occur in dry sclerophyll forests, although it has been reported to use wet habitats for breeding sites. The species is found in heath, woodland and open forest with sandy soils (DEWHA 2009a).

The species has been found from near sea level up to 1000 metres, from the coast to almost 100 km inland along the escarpment of the Great Dividing Range. There is a notable disjunction in records between Jervis Bay and the Eden District, which might be due to either the rarity of the species or the limited survey effort in the region. Across its range, the GBF appears to be dependent on areas with native vegetation as no GBF's have been recorded from cleared lands (DEWHA 2009a).

A single possible call was heard (Garry Daly DECCW 2009c) from within the study area in 1992. Nonetheless, the species has never been positively recorded in the study area since although there have been a number of subsequent investigations. However, the proposed route traverses an area containing potential moist sandstone habitat.

Incidental and coordinated surveys in the vicinity of the original GBF observation have occurred since 1992. Available reports do not provide an indication of survey timing and effort that would enable a valid judgment about the adequacy, or otherwise, of the surveys undertaken.

As such, in September 2009 an inspection of the subject land was undertaken over an 8 hour period to investigate GBF habitat within the study area. A nocturnal survey was also undertaken in March 2010. Suitable breeding and broader foraging habitat was identified within the site and adjacent to the Central route corridor (see **Figure 8** in section 2).

The total area of sub-optimal GBF habitat within the study area is approximately 13.67 hectares. Direct impacts on sub-optimal GBF habitat will be limited to the clearing of approximately 0.22 hectares on the northern side of the Central route corridor (see **Figure 23**). There is also the potential for indirect impacts including, road mortality, potential water quality and hydrologic changes in the area over which the GBF are likely to range. Many of these indirect factors can be avoided or mitigated as discussed below in section 6.

During the March 2010 survey, timing and weather conditions were within the accepted parameters to enable detection of the species and the area had experienced above average temperatures and rainfall during recent months. While the survey conditions were conducive to promoting GBF activity, conditions were not optimal, which would have involved high levels of rainfall to encourage breeding (calling) activity.

A single survey even under optimum conditions is probably inadequate to enable the species to be discounted from occurring in the area. Garry Daly has attempted (unsuccessfully) to detect the species in the area on a number of subsequent occasions, including times when the species was known to be calling at other sites in the Shoalhaven Region.

While the habitat is suitable for the species, it is more limited in size and quality than other known habitat in the Shoalhaven Region (e.g. Vincentia and Booderee National Park). The potential breeding sites observed during the survey were also relatively small and would appear to be rarely inundated, thus providing sub-optimal breeding habitat.

Sub-optimal breeding habitat (known as sandstone sedge) occurs within Bomaderry Creek Regional Park and lies adjacent to the northern edge of the Central route. This primarily wet habitat is relatively small compared to other habitats in the Shoalhaven region and appears to be rarely inundated, which is required for the breeding process. Furthermore, most records for the GBF across the region occur in dry sclerophyll forest type habitats. The Central route, including the construction of the bridge will remove a small section of this sub-optimal breeding habitat. It is also important to note that no individuals of this species have been recorded within the study area (excluding the possible call heard by Gary Daly in 1992).

While definitive conclusions on the presence of the GBF cannot be drawn on the basis of all of the surveys undertaken, the results of surveys to date along with observations of habitat quality support the concept that if the GBF still occurred in the area surveyed, the population size would be extremely small.

Excluding the 0.22 hectares of sub-optimal habitat that will be removed due to the construction of the Central route, the remaining area of sub-optimal GBF habitat as shown in **Figure 23**, is proposed for inclusion within the Bomaderry Creek Regional Park as part of a 50 hectare offset. This measure will ensure that if the species is present an area of habitat will be afforded a high level of protection. Potential indirect impacts on GBF habitat will be mitigated through a range of measures as discussed below in section 6. The mitigation measures outline in section 6 will alleviate potential direct and indirect impacts on this species should it occur near any of the route options, which is unlikely.

Although the impacts to a small area of sub-optimal GBF habitat (0.22 hectares) cannot be avoided should the Central route be constructed, the 50 hectare offset that is being proposed by council (see section 8) will provide adequate compensation given that the balance of the area identified as sub-optimal habitat will be contained within the offset site.

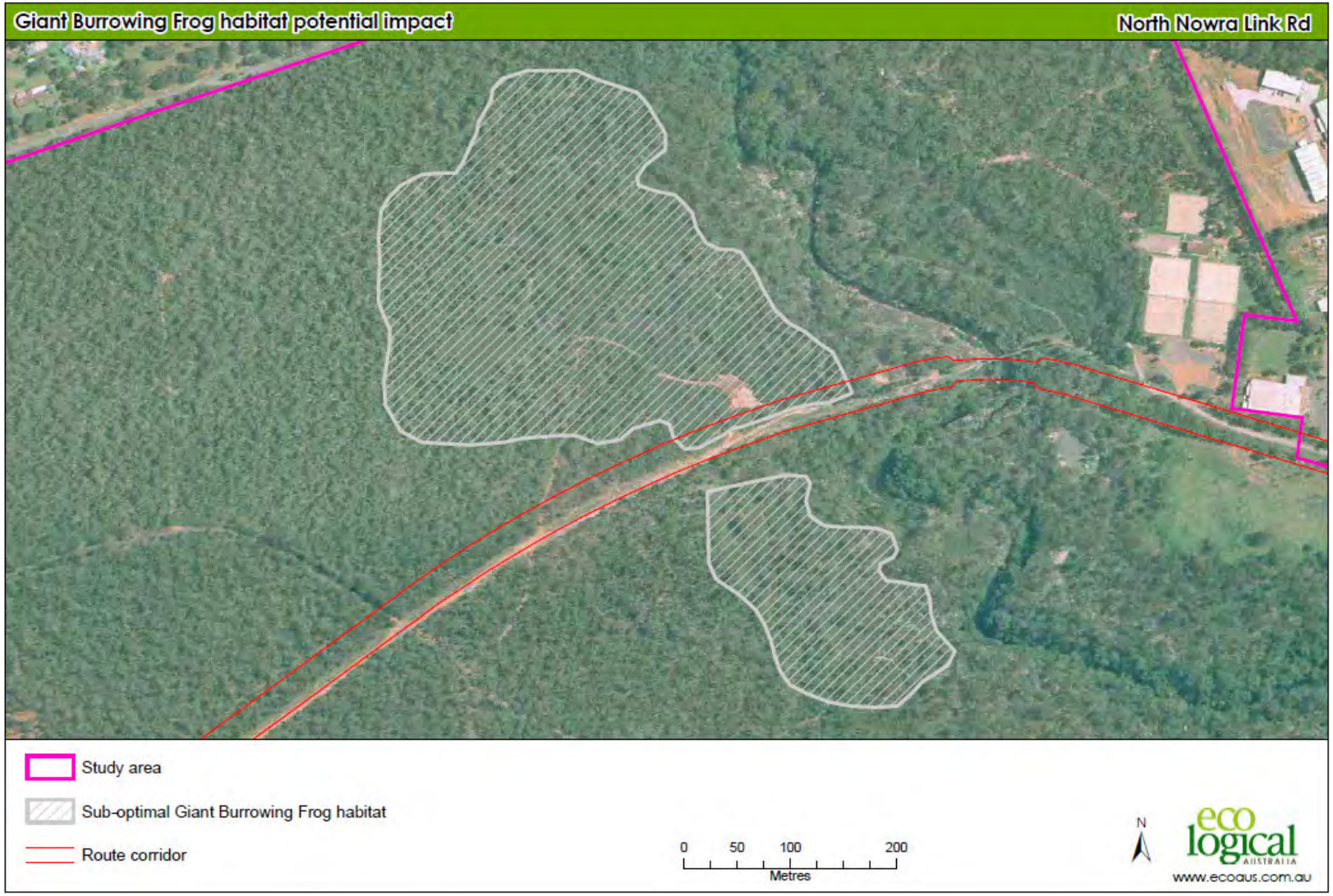

Figure 23: Sub-optimal Giant Burrowing Frog habitat

4.2.2 Grey-headed Flying-fox – *Pteropus poliocephalus*

The Grey-headed Flying-fox is listed as vulnerable under both the EPBC Act and TSC Act. The species is known to occur along the eastern coast of Australia from Bundaberg in Queensland to Melbourne in Victoria (DEC 2005). Due to the high mobility of the species, there are no separate or distinct populations as individuals move between camps and throughout its geographic distribution (DEWHA 2009b). The most recent national count of Grey-headed Flying-fox numbers was conducted in 2005 and estimated 674,000 individuals (DEWHA 2009b).

The species inhabits a wide range of habitats including rainforest, mangroves, paperbark forests, wet and dry sclerophyll forests and cultivated areas (Churchill 1998, Eby 1998). The Grey-headed Flying-fox is a canopy-feeding frugivore and nectarivore which utilise a range of vegetation types. Its primary food source is the pollen and nectar of native trees, in particular eucalypts (including the genera *Eucalyptus, Corymbia* and *Angophora*), melaleuca and banksia, and the species will also utilise a range of rainforest fruits (DECC 2005, Eby 1998). Urban gardens and fruit crops also provide foraging habitat for the Grey-headed Flying-fox.

The species roosts in aggregations of various sizes on exposed branches of trees which are often located in gullies, typically close to water, in vegetation with a dense canopy (Churchill 1998). Grey-headed Flying-fox roosting camps are generally located within 20 km of a regular food source, although they can travel up to 50 km in a night to forage (DECC 2005).

Thirty-nine camps used by Grey-headed Flying-foxes are currently known in the south-east region of NSW, the majority of which occur along the coastal lowlands and ranges (Eby and Law 2008). A small number of camps in the Sydney metropolitan area are occupied continuously, and the majority of these have been established in recent years, apparently in response to increasing volumes of food in the gardens and streetscapes of Sydney. All camps associated with native vegetation in the region have less consistent patterns of occupation and the majority are occupied occasionally or rarely (Eby and Law 2008).

The main threat to the survival of the species is habitat loss and disturbance through clearing foraging habitat and roosting locations for development and farming (DEWHA 2009b). Loss of important areas of habitat has caused increased fragmentation of suitable habitat, resulting in the species having to travel greater distances for food or resorting to alternative sources such as food crops (DEWHA 2009b). Other threats to the species include unregulated shooting and electrocution on powerlines.

The study area is known to contain suitable habitat for the Grey-headed Flying-fox (see **Figure 25**) and KMA (2010) identified the species as an itinerant visitor during the summer months to the forests in the area. The Atlas of NSW Wildlife has a record of the species occurring at south-eastern corner of the study area. This location is approximately 1km from the construction footprint for the Southern route corridor and as such direct impacts on the species are not considered likely. However, there is potential for indirect impacts to occur during the construction phase, in particular through increased noise during the breeding season.

The species has not been recorded at any other locations within the study area. Both the Northern and Central routes are not expected to impact on the Grey-headed Flying-fox or on important habitat areas for the species. Whilst the species may use the habitat within these areas for foraging, the amount of land that is required to be cleared only represents a very small proportion of the overall foraging habitat in the region. The construction of either the Central or Northern route is not expected to result in adverse impacts on the Grey-headed Flying-fox.

4.2.3 Spotted-tailed Quoll – *Dasyurus maculatus*

The Spotted-tailed Quoll is listed as vulnerable the TSC Act and as endangered under the EPBC Act. It is a medium-sized marsupial carnivore with dark brown fur and white spots which are present on the body and tail. It occupies a range of environments within a disjunct distribution along the east coast of Australia, extending from south-eastern Queensland through NSW and Victoria to Tasmania (DECCW 2009c).

This species is found in a variety of habitats, including sclerophyll forest and woodlands, coastal heathlands and rainforests (DECCW 2009c). Occasional sightings are made in open country, grazing lands, rocky outcrops and other treeless areas. This species feeds on a wide variety of birds, reptiles, mammals and invertebrates and uses several 'latrines' within its territory for defecation (DECCW 2009c). It is essentially terrestrial, but is also an agile climber (DECCW 2009c).

Nesting occurs in rock shelters, hollow logs, caves or tree hollows and they use numerous dens within the home range. Estimates of home ranges vary from 800 ha to 20 km^2 and individuals may move several kilometres in a night. It is a highly mobile species and there are numerous records of overnight movements of several kilometres (DECCW 2009c).

Spotted-tailed Quoll was not detected during field surveys. However, field surveys for this project were not specifically targeted at finding the Spotted-tailed Quoll. All stands of forest and woodland within the study area provide potential habitat for the species. There are records of the species in the Atlas of NSW Wildlife within a 10 km radius of the study area, suggesting that there is potential for the species to utilise the area. However, the presence of the species within the study area has not been confirmed. Due to the species mobility and large home ranges, adverse impacts due to the clearing of a small amount of potential foraging habitat (for any of the three route options) are not considered likely.

As mentioned above, the Spotted-tailed Quoll has a large home range and is active at night spending most of its time on the ground searching for food. The large home range of this species, particularly for males, makes them susceptible to road mortality in forested areas fragmented by roads (DEWHA, 2010). Associated with roads is a tendency to scavenge road-killed carcasses which may increase the potential for road mortality. A study by Lunney and Matthews (2001) determined that 7% of Atlas of NSW Wildlife records for the Quolls came from road-kills. This either highlights their cryptic nature and difficultly in spotting this species in the wild, and or a vulnerability of Quolls to being killed on the road.

Ecological surveys within the study area could not confirm the presence of the Spotted-tailed Quoll, but did confirm the presence of potential suitable habitat.

Eco Logical Australia considers that the potential for Spotted-tailed Quoll to be struck by vehicles is relatively low given the range of mitigation measures to be implemented and the unlikely presence of the species within the study area. Proposed mitigation measures, their feasibility of implementation and effectiveness are outlined in section 6 and details the specific strategies to be implemented to reduce direct and indirect impacts on Spotted-tailed Quoll including the potential for road-kill. Most notably these mitigation measures include road signage to warn of threatened wildlife in the area, speed limit reductions, light coloured road surface and an elevated bridge design to provide facilitate fauna movement via and underpass. The proposed mitigation measures combined with the fact that the species is considered unlikely to occur within the study area, the fragmented nature of the habitat and the surrounds, suggest that impacts are not likely.

4.2.4 Large-footed Myotis – *Myotis macropus*

Large-footed Myotis is known to roost close to water in caves, mine shafts, hollow-bearing trees, stormwater systems, buildings, under bridges and in dense foliage. The species forages over streams and pools catching insects and small fish by raking their feet across the water surface and is listed as vulnerable under the TSC Act (DECC 2008).

The species was previously recorded in the gorge at the southern end of the study area (Parnaby 1996) and may be a resident in this area, utilising habitat features such as pools along Bomaderry Creek and possibly, caves for roosting. All three route options will cross the gorge containing potential habitat for the species. However, suitable habitat areas are generally located at the bottom of the gorge and bridge design will ensure that potential habitat areas are not impacted directly or indirectly by the construction of the North Nowra Link Road. All three route options are unlikely to result in adverse impacts on the Large-footed Myotis.

4.2.5 Masked Owl – *Tyto novaehollandiae*

The Masked Owl is listed as vulnerable under the TSC Act. They occur in undulating wet-dry forests of the coast and dry eucalypt forests of the tablelands, with optimal habitat including a mosaic of sparse (grassy) and dense (shrubby) groundcover on gentle terrain (DECC 2006).

Roosts are located in live or occasionally dead hollow eucalypts, dense foliage in gullies and caves and recesses in cliffs (DECC 2006). They require mature forest or woodland with large hollow trees and dense trees or shrubs for fledglings to shelter in. Hollows greater than 40 cm wide and 100 cm deep in trees at least 90 cm diameter breast height (DBH) are used. Masked Owls are faithful to traditional nest trees but may use alternative hollows within the breeding territory in different years (DECC 2006). Home ranges are estimated to be 400-1000 ha, varying with habitat productivity (DECC 2006).

It is a specialist predator of terrestrial mammals, including rodents and rabbits in disturbed areas and dasyurids in forested areas (DECC 2006). Arboreal mammals (e.g. Sugar Glider), birds and bandicoots also supplement the diet. The species forages preferentially in ecotones within forests or along forest edges but also in open areas, and usually hunts from a perch at or near ground level, sometimes near the edges of roads (DECC 2006).

The Masked Owl is threatened by a number of processes including habitat clearing and fragmentation, loss of mature hollow bearing trees, predation on fledglings, secondary poisoning from pesticides, disease, and being hit by vehicles (DECC 2005). A combination of grazing and regular burning is also a threat, affecting the quality of ground cover for mammal prey, particularly in open, grassy forests (DECC 2005).

The Masked Owl is known to occur throughout the region and has a large foraging territory. The Atlas of NSW Wildlife shows that the species has been recorded in the Bomaderry Creek region and recent surveys recorded the species within the study area (see **Figure 8** in section 2). All stands of forest and woodland within the study area provide suitable foraging habitat for the species. It is likely that the Masked Owl is a frequent visitor to the study area. However, all stands of forest and woodland within the area only form foraging habitat for one pair of owls (KMA 2010). Given the habitat available within the study area, Bomaderry Creek Regional Park may also function as part of core permanent home range for this species. However, only a small area of suitable foraging habitat would be lost depending on the route option that is selected.

Targeted surveys aimed at locating breeding pairs within the study area were not undertaken. In the event that a breeding pair was found to be utilising the site as a foraging resource, it is considered that

the small amount of habitat to be lost would not alter the viability of the habitat in the study area and it would continue to provide suitable habitat for one pair of owls.

Whilst vehicle strike is considered a threat to this species under the NSW threatened species profile, the threat is not considered as significant as the loss of hollow bearing trees and clearing of habitat. Eco Logical Australia considers the threat of road-kill on this species as a result of the North Nowra Link Road to be unlikely.

Proposed mitigation measures, their feasibility of implementation and effectiveness are outlined in section 6 of this report. The mitigation measures outline specific strategies that are to be implemented to reduce direct and indirect impacts on Masked Owl including the potential for road-kill. Most notably these mitigation measures include road signage to warn of threatened wildlife in the area, speed limit reductions and light coloured road surface increasing the visibility of fauna at night.

Given that the species has a large foraging territory and home range and that only a small amount of habitat suitable for the species would be impacted by clearing for any of the three route options, adverse impacts on the species are unlikely.

4.2.6 Powerful Owl - *Ninox strenua*

The Powerful Owl is the largest owl in Australasia and is listed as vulnerable under the TSC Act. Adults reach 60 cm in length, have a wingspan of up to 140 cm and weigh up to 1.45 kilograms. It inhabits woodland and open sclerophyll forest, tall open wet forest and rainforest. This species requires large areas of forest or woodland habitat in which to breed and forage but is also known to hunt over fragmented landscapes (DECCW 2009b).

The species roosts by day in dense vegetation and nests in large tree hollows, typically trees of 80 – 240cm DBH. Prey items include small to medium sized mammals and birds, many of which are themselves dependant on tree hollows for shelter and reproduction (DECCW 2009d).

The Powerful Owl was recorded in the north-western corner of study area during field surveys undertaken by Eco Logical Australia in March 2010 (see **Figure 8** in section 2). The species is likely to be a frequent visitor to the study area and the Bomaderry Creek in general. Foraging habitat suitable for the species occurs throughout the study area. Potential nest trees are almost certainly restricted to the gorge area, mostly *Corymbia maculata*. However, the vegetation required to be cleared for the three route options only represents a small part of the suitable habitat available throughout the broader region.

The Powerful Owl has a large home range (c.450 to 1,000 hectares) and as such, the construction of the North Nowra Link Road is unlikely to have an adverse impact on the species, regardless of the route option that is selected.

4.2.7 Sooty Owl - *Tyto tenebricosa*

The Sooty Owl is listed as vulnerable under the TSC Act. Sooty Owls are associated with tall wet old growth forest on fertile soil with a dense understorey and emergent tall Eucalyptus species. Pairs roost in the daytime amongst dense vegetation, in tree hollows and sometimes in caves.

The Sooty Owl is typically associated with an abundant and diverse supply of prey items and a selection of large tree hollows. The species occupies the easternmost one-eighth of NSW, occurring on the coast, coastal escarpment and eastern tablelands. There is no seasonal variation in its distribution.

The Sooty Owl was recorded in the south of study area during field surveys undertaken by Eco Logical Australia in March 2010. The species is likely to be an infrequent visitor to the study area and the Bomaderry Creek in general. Foraging habitat suitable for the species occurs throughout the study area.

Given that the species has a large foraging territory and home range and that only a small amount of habitat suitable for the species would be impacted by clearing for any of the three route options, adverse impacts on the species are unlikely as a result of the construction and operation of the North Nowra Link Road are not considered likely.

4.2.8 Yellow-bellied Glider – *Petaurus australis*

The Yellow-bellied Glider is listed as vulnerable under the TSC Act. The species inhabits tall, mature moist eucalypt forests along the coast and ranges of eastern Australia. Its range extends from central Queensland to southern Victoria.

The Yellow-bellied Glider feeds primarily on plant and insect exudates, including nectar, sap, honeydew and manna with pollen and insects providing protein. They live in small family groups of two - six individuals and den in hollows of large trees. They are highly mobile with ability to glide between trees 100 metres apart and have home ranges varying between 20 hectares to 85 hectares to allow for the dispersed and seasonally variation in food resources. The study area contains a large amount of suitable habitat for the Yellow-bellied Glider which includes feed trees and denning sites suitable for the species (see **Figure 24**).

The Yellow-bellied Glider has a large home range, and occurs throughout the Shoalhaven Region. The species has previously been recorded at various locations within the study area. The Grey Gum - Stringybark Forest / Woodland around the gorge is the core area of habitat for the species (KMA 2010). However, other suitable trees within Bomaderry Creek Regional Park also serve as potential habitat. There is a considerable amount of suitable habitat for the species within the 50 ha parcel of offset land being added to the Regional Park to compensate for the loss of 2.31 hectares from the construction of the Central route option.

The northern route option has suitable habitat on the edge of the road corridor and the central and southern options have suitable habitat on both sides of the proposed road corridor.

The exact density of Yellow-bellied Gliders within the study area is not known, however, it is expected to be relatively low considering the total area of the bushland within and surrounding the study area and the urban development's bordering the bushland.

In August 2009 a survey was undertaken by Eco Logical Australia to map feed trees for the Yellow-bellied Glider within the study area (see **Figure 7** in section 2). Additional surveys were also undertaken in May 2010 by KMA (see **Figure 24**). All three route options were traversed and feed trees were mapped within the vicinity of the proposed road corridors.

It was found that the northern and central corridors are not likely to impact on feed trees. However, the southern option may require feed trees to be cleared. Although feed trees may be impacted by the construction of the southern route, it is unlikely that this will result in adverse impacts on the Yellow-bellied Glider as it only represents a small part of the species overall habitat in within the study area and the region in general.

Although the southern route option is likely to indirectly impact on the use of feed trees and potential denning trees, there is sufficient habitat within the study area containing suitable feed trees and denning sites (hollow bearing trees) that will not be impacted by construction of the link road.

Taking into account the size of the home range (20-ha) and the ability of the species to move within their range, the resulting indirect impacts are likely to be minor and more than compensated for by the protection of the land (50ha) proposed to be included into the Regional Park.

The northern and central route would not impact on feed trees or den sites for the species and adverse impacts associated with the construction of these route options are not considered likely.

The construction of the road (for all three options) has some fragmentation potential depending on the route option that is selected. The southern and northern routes potentially provide the greatest impact by the introduction of fragmentation whereas the central route in some locations may increase existing fragmentation effects. This combined with moving vehicles has the potential to reduce the movement of this species across Bomaderry Regional Park from the bushland on one side of the road to the other. Despite the ability of the gliders to be able to traverse the 30m from the bushland on one side of the road reserve to the other, the frequency and ability to glide may be reduced because the movement of cars and cleared nature of the road reserve.

To mitigate against the potential fragmentation impacts mentioned above, Shoalhaven City Council (see Section 6) will provide overpasses for arboreal species in the form of rope bridges or gliding poles (designed and constructed in consultation with experts). Similar glider poles and rope bridges have been proven to be successful elsewhere as described below in see Section 6. Other mitigation practices include measures to reduce noise pollution and reduce vehicular speed.

4.2.9 Eastern Pygmy-Possum - Cercartetus nanus

The Eastern Pygmy Possum is a tiny member of the possum family, growing to only 15-43 grams in weight. The species are known to be active climbers with almost bare, prehensile tails, and big forward pointing ears. The Eastern Pygmy-possum is found in south-eastern Australia, from southern Queensland to eastern South Australia and in Tasmania. It inhabits a broad range of habitats including, rainforest, sclerophyll forests and woodlands and heath.

Habitat suitable for this species occurs throughout the study area. However, anecdotal evidence suggests that the species has never been recorded.

Suitable habitat for the Eastern Pygmy Possum is known to occur throughout the Shoalhaven region and the area of suitable habitat that exists within the study area only represents a small portion of the overall habitat availability within the broader region. As such, the clearing of vegetation associated with all three route options for the North Nowra Link Road is not expected to have an adverse impact on the Eastern Pygmy-possum. However, in order to conclusively determine the likely presence of the species within the study area, SCC will undertake targeted surveys in early 2011.

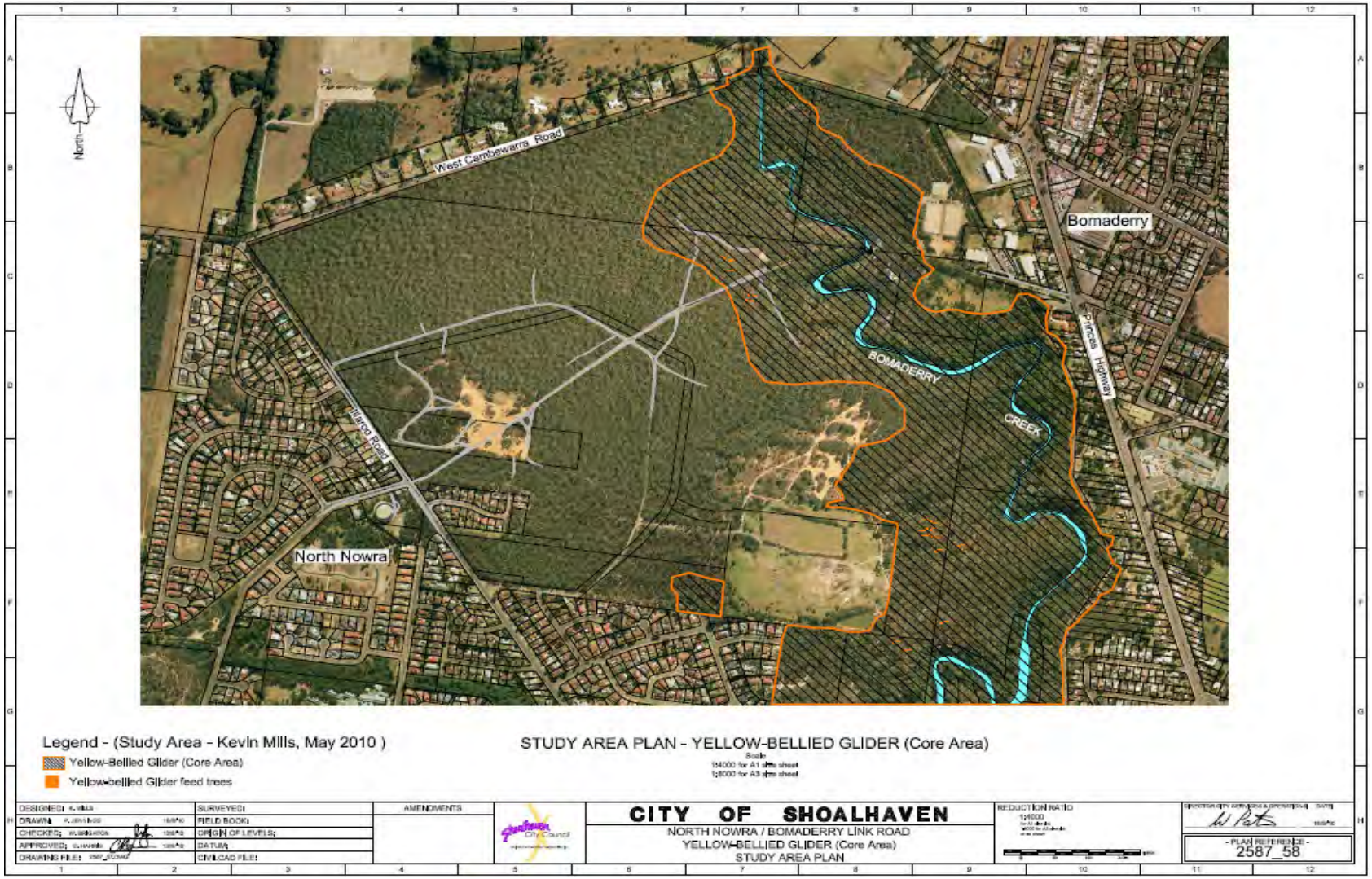

Figure 24: Yellow-bellied Glider habitat

4.2.10 Glossy Black-cockatoo – *Calyptorhynchus lathami*

The Glossy Black-cockatoo is listed as vulnerable under the TSC Act. It inhabits open forest and woodlands of the coast and the Great Dividing Range up to 1000 m in which stands of she-oak species, particularly Black She-oak (*Allocasuarina littoralis*), Forest She-oak (*A. torulosa*) or Drooping She-oak (*A. verticillata*), occur. It feeds almost exclusively on the seeds of several species of she-oak (*Casuarina* and *Allocasuarina* species), shredding the cones with its bill. The species is dependent on large hollow-bearing eucalypts for nest sites and one or two eggs are laid between March and August.

The Glossy Black-cockatoo has previously been recorded in the study area and habitat suitable for the species is located at various locations throughout the site (see **Figure 25**). The main concentration of hollow-bearing trees and feed trees are situated along the northern and central route corridors (see **Figure 7** in section 2). It is anticipate that approximately 0.01 hectares of habitat would be cleared for the construction of the northern route and similarly approximately 0.175 hectares for the construction of the central route. No habitat suitable for the species is likely to be cleared for the construction of the southern route option.

The site was surveyed for hollow-bearing trees (see **Figure 7** in section 2) which are a known nesting resource for this species. The main concentration of hollow-bearing trees is on the northern and central routes.

As mentioned above, the species is known to feed almost exclusively on she-oak. The distribution of Black She-oak is largely determined by previous disturbance. Given that the species is known to colonise disturbed areas, there is a line of feed trees occurring on the northern route along West Cambewarra Road due to the previous disturbance associated with clearing (KMA 2010). The linear row of feed trees along West Cambewarra Road is representative of the feed trees known along the northern route option. The mapped occurrence of feed trees for this species was determined by undertaking habitat surveys of the entire study area.

Given the presence of potential nest trees within the site, it is possible that resident breeding pairs occur. However, targeted surveys were not undertaken to determine the presence of resident breeding pairs. It was not considered necessary to undertake surveys for breeding pairs given the small amount of habitat proposed to be removed as a result of the proposed North Nowra Link Road.

The amount of foraging and nesting habitat likely to be removed for the northern or central options only represents a small part of the habitat within the Shoalhaven region. As such, it is unlikely that the construction of any of the potential route options would result in adverse impacts for the Glossy Black-cockatoo.

4.2.11 Gang-gang Cockatoo – *Callocephalon fimbriatum*

The Gang-gang Cockatoo utilises in tall mountain forests and woodlands, particularly in heavily timbered and mature wet sclerophyll forests during summer, and in winter they may occur at lower altitudes in drier more open eucalypt forests and woodlands, and often found in urban areas. The Gang-gang Cockatoo is listed as vulnerable under the TSC Act.

The Gang-gang Cockatoo is known to occur within the study area and is likely to be a regular visitor to the area during the winter months when the species ranges widely (KMA 2008). The Atlas of NSW Wildlife has records of the species throughout the Bomaderry Creek Region suggesting that the species is common throughout the area. Foraging habitat for the species has been recorded from all three route locations within the study area. Foraging habitat includes all areas of woodland and forest, and nesting could occur in the taller forest in the gorge KMA 2010).

Both the central and southern routes have trees that would be suitable for nesting in the vicinity of their construction footprints. However, the breeding season for the Gang-gang Cockatoo extends from October to January and given that the species is only likely to be a visitor to the area during the winter months, it is not likely that the species is using the site for breeding. Nevertheless, potential nesting trees will not be directly impacted by the construction activities for any of the three route options. Consequently, targeted surveys for nesting pairs within the study area were not undertaken.

Clearing potential foraging habitat along all three route corridors is unlikely to adversely impact Gang-gang Cockatoo. The species is known to range widely throughout the region and the potential habitat areas that will be cleared as a result of construction activities only represents a small part of the overall foraging habitat that is available throughout the region.

4.2.12 Square-tailed Kite – *Lophoictinia isura*

The Square-tailed Kite is a reddish, medium sized, long-winged raptor and is listed as vulnerable under the TSC Act. The species ranges along coastal and sub-coastal areas from south-western to northern Australia, Queensland, NSW and Victoria. It is a summer breeding migrant in the south-east, including the NSW south Coast, arriving in September and leaving by March. The species is found in a variety of timbered habitats including dry woodlands and open forest (DECC 2009).

The Square-tailed Kite has previously been recorded within the study area and is a known summer breeding visitor to the Nowra – Jervis Bay region (KMA 2008). There is suitable habitat for the species throughout the study area. However, this area of habitat is part of a very large foraging area for the species, covering thousands of hectares (KMA 2008). As such, clearing vegetation associated with all three route options for the North Nowra Link Road is not expected to have an adverse impact on the Square-tailed Kite.

4.2.13 Scarlet Robin - *Petroica boodang*

The Scarlet Robin is a small member of the Australian robin family that reaches approximately 13cm in length and is listed as vulnerable under the TSC Act. The species ranges from south-east Queensland to south-east South Australia and also occurs in parts of Western Australia and Tasmania. The species is known to occur in dry eucalypt forests and woodlands where the understory is grassy with few scattered shrubs (DECCW 2010).

The study area contains small patches of vegetation that may potentially provide suitable habitat for the Scarlet Robin. However, the area predominately consists of a dense understory that lacks areas of open grassland with few scattered shrubs and therefore does not provide suitable habitat for the species. As such, if the species does occur, it is only expected to be an infrequent visitor to the area.

Habitat suitable for this species is known to occur throughout the Shoalhaven region and the small area of potential habitat that exists within the study area only represents a very small portion of the overall habitat availability in the broader region. As such, the clearing of vegetation associated with all three route options for the North Nowra Link Road is not expected to have an adverse impact on the Scarlet Robin.

4.2.14 Flame Robin - *Petroica phoenicea*

The Flame Robin is a small member of the Australian robin family that reaches approximately 14cm in length and is listed as vulnerable under the TSC Act. The species is endemic to south-east Queensland and ranges from the Queensland border to south-east South Australia. The species also occurs in Tasmania. The species is known to occur in tall moist eucalypt forests and woodlands with an open understory (DECCW 2010).

The study area contains small patches of vegetation that may potentially provide suitable habitat for the Flame Robin. However, the area predominately consists of a dense understory that lacks areas of open grassland and therefore does not provide suitable habitat for the species. As such, if the species does occur, it is only expected to be an infrequent visitor to the area.

Habitat suitable for this species is known to occur throughout the Shoalhaven region and the small area of potential habitat that exists within the study area only represents a very small portion of the overall habitat availability within the broader region. As such, the clearing of vegetation associated with all three route options for the North Nowra Link Road is not expected to have an adverse impact on the Flame Robin.

4.2.15 Little Lorikeet - *Glossopsitta pusilla*

The Little Lorikeet is a small bright green parrot, with a red face surrounding its black bill and extending to the eye. The species is listed as vulnerable under the TSC Act. The Little Lorikeet is distributed widely across the coastal and great divide regions of eastern Australia. NSW is known to contain a larger portion of the species core habitat (DECCW 2010). The Little Lorikeet inhabits open eucalyptus forests and woodlands and forages predominately in the canopy.

Nomadic movements are common for the Little Lorikeet and the species is often only a transient visitor to an area. The study area contains small patches of vegetation that provides suitable habitat for the species. However, it is only likely to be an infrequent seasonal visitor to the study area.

Habitat suitable for this species is known to occur throughout the Shoalhaven region and the area of potential habitat that exists within the study area only represents a small portion of the overall habitat availability within the broader region. As such, the clearing of vegetation associated with all three route options for the North Nowra Link Road is not expected to have an adverse impact on the Little Lorikeet.

4.2.16 Varied Sittella - *Daphoenositta chrysoptera*

The varied Sittella is a small songbird with a sharp upturned bill, short tail and yellow eyes that grows to approximately 10cm in length. The species occurs across most of mainland Australia excluding areas of treeless deserts or open grasslands. Its distribution across NSW is continuous from the coastal region to the west. The species inhabits eucalypt forests and woodlands, especially those containing rough-barked species, smooth barked gums, mallee and Acacia woodland (DECCW 2010).

The study area contains small patches of vegetation that may potentially provide suitable habitat for the species. However, the majority of the study area contains vegetation that is not suitable habitat for the Varied Sittella. As such, if the species does occur, it is only expected to be an infrequent visitor to the area.

Habitat suitable for this species is known to occur throughout the Shoalhaven region and the small area of potential habitat that exists within the study area only represents a small portion of the overall habitat availability within the broader region. As such, the clearing of vegetation associated with all three route options for the North Nowra Link Road is not expected to have an adverse impact on the Varied Sittella.

4.2.17 Lowlands Rainforest in the NSW North Coast and Sydney Bioregion

Lowlands Rainforest is listed as an endangered ecological community under the TSC Act. Lowland rainforest is an ecological community of subtropical rainforest and structurally complex forms of dry rainforest (DECC 2009). The community is usually in an undisturbed state and has a closed canopy, characterised by a high diversity of trees. The southern route option for the North Nowra Link Road may contain Lowland Rainforest within the gorge at Bomaderry Creek. KMA (2008) suggests that small

stands of rainforest in the lower gorge at Bomaderry Creek could qualify as Lowlands Rainforest because of the presence of subtropical species and the high plant diversity. This area of rainforest only occurs along the southern route and, if present, may potentially be indirectly impacted by the construction of the bridge for the southern route. The northern and central routes will not impact on any endangered ecological communities.

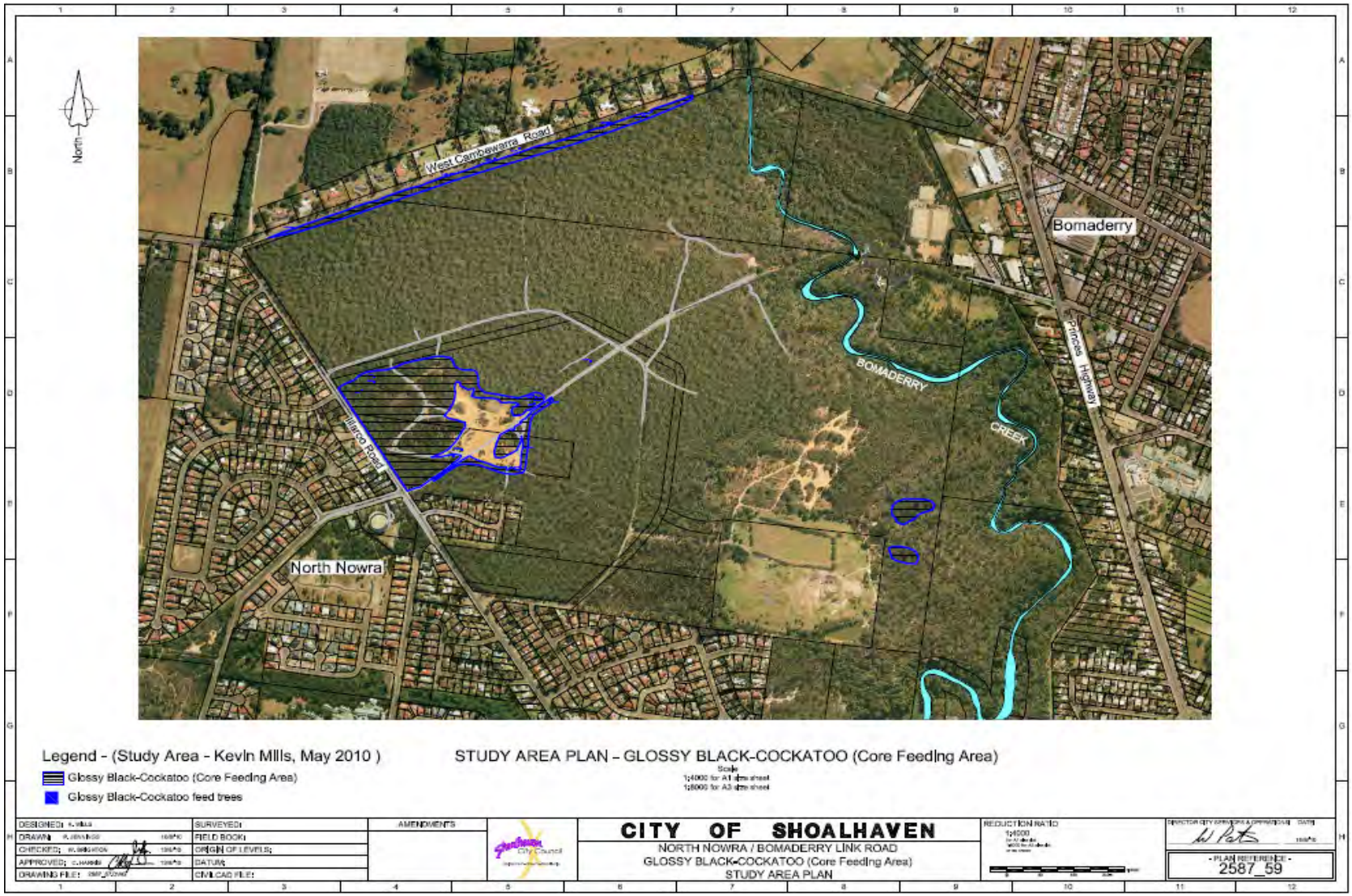

Figure 25: Glossy Black-cockatoo – Core feeding area

5 Construction and Operational Impacts

5.1 CONSTRUCTION IMPACTS

As discussed above, no direct impacts are expected or likely to occur on listed threatened species as a result of the construction of the North Nowra Link Road. However, impacts on two individual Albatross Mallee are likely, as a consequence of the construction of the bridge for the central route. The bridge will result in the permanent shading of these two specimens and as such, it is not expected that they will survive.

Additional to this, the construction of the North Nowra Link road has the potential to have indirect impacts on a number of other threatened flora and fauna species. Indirect impacts include things such as, noise pollution, stormwater run-off, sedimentation and the clearing of potential threatened fauna species habitat. In order to reduce the likelihood of indirect impacts occurring, a range of mitigation measures will be implemented by Council (see section 6). The effectiveness of the proposed mitigation measures is discussed below in section 6.

Although the project has potential to result in indirect impacts to a number of threatened species, given the mitigation measures proposed and that any indirect impacts would be minimal, it is not expected that the conservation value of a threatened species or their habitat will be adversely impacted by the construction of the North Nowra Link Road.

The construction of the North Nowra Link Road is not expected to have an adverse impact on the conservation value of the Bomaderry Creek Regional Park. Although a small portion of the park will be cleared (this varies depending on the route selected) to facilitate construction, any adverse impacts associated with this will be outweighed by the benefits afforded through the inclusion of 50ha of existing SCC land to the Bomaderry Creek Regional Park as an offset.

A riparian corridor exists along the Bomaderry Creek. Construction impacts in this area are not likely as the bridge will be designed to span the riparian corridor. As such, the conservation value of the riparian corridor will not be impacted by the construction of the North Nowra Link Road.

The construction impacts on vegetation corridors will vary depending on the route that is selected. The small amount of land to be cleared for each route is not expected to result in adverse impacts to the conservation value of vegetation corridors given that 50ha of existing SCC land will be transferred into the Bomaderry Creek Regional Park as an offset. This will provide a net benefit for vegetation corridors and enhance their conservation value within the Bomaderry Creek Regional Park.

5.2 OPERATIONAL IMPACTS

The potential operational impacts associated with the North Nowra Link Road, include things such as road kill, noise and light pollution from cars. The potential for operational impacts is minimised through a range of mitigation measures (see section 6) which ensure that any potential for impacts is significantly reduced i.e. fauna bridges, dense pavement material to reduce noise and reduced speed limits.

Given the range of mitigation measures that will be implemented, it is not expected that the conservation value of a threatened species or their habitat will be adversely impacted by the operation of the North Nowra Link Road.

An existing service road along the central route permanently fragments vegetation and may create a barrier to some flora and fauna movement. Although the operation of the North Nowra Link Road will result in an increase in traffic flow through the area, it is not expected to create a more significant barrier to flora and fauna than what currently exists. The existing road consists of hard packed gravel and rock, with a slashed area of varied widths on either side of the road along the majority of its length (see **Figures 26 & 27**).

The operation of the North Nowra Link Road is not expected to have an adverse impact on the conservation value of the Bomaderry Creek Regional Park. Although a small portion of the park will be cleared (this varies depending on the route selected) during construction, any adverse impacts to conservation value the Bomaderry Creek Regional Park will be outweighed by the benefits afforded through the inclusion of 50ha of existing SCC land to the Bomaderry Creek Regional Park as an offset.

A riparian corridor exists along the Bomaderry Creek. Operational impacts in this area are not likely as the bridge will be designed to span the riparian corridor. As such, the conservation value of the riparian corridor will not be impacted by the operation of the North Nowra Link Road.

Operational impacts on vegetation corridors are not expected to have an adverse impact on their conservation value. Given that only the small amount of land is required to be cleared for each option and that 50ha of existing SCC land will be transferred into the Bomaderry Creek Regional Park as an offset, a net benefit to the conservation value of the vegetation corridors is expected.

Figure 26: Slashed vegetation along the cleared service track

Figure 27: Slashed vegetation along the cleared service track

6 Mitigation

The proposed development has been designed to avoid and/or minimise impacts on identified areas of environmental importance. An Environmental Management Plan (EMP) will be developed through ongoing consultation with relevant regulators, expert groups and individuals, and will inform the construction phases of the project in order to minimise environmental impacts.

6.1 AVOIDANCE AND MITIGATION MEASURES

A range of mitigation measures during construction will be implemented by the Shoalhaven City Council and further measures will be considered as part of the final road design and development of the EMP. Shoalhaven City Council is committed to the measures outlined below and to the on-going development of mitigation measures aimed at minimising environmental impacts.

Council will prepare an EMP for approval by the General Manager including education of workers (both contractors and Council staff) in the approvals and conditions requiring compliance (including flora, fauna, Aboriginal and European archaeological issues, soil erosion, sediment controls, noise, air quality management and bushfire risks), details of the environmental management procedures during the construction and measures relating to waste management and minimisation.

Construction will also be undertaken in accordance with an Environmental Management System based on ISO 14001 and at a minimum include all of the mitigation measures outlined within this document.

Depending on the route option selected for the project, between 2.3–4.5 hectares of vegetation will be lost when constructing the North Nowra Link Road, with the central route having the least amount of vegetation loss. All vegetation and trees outside the immediate construction zone will be protected by fencing from unauthorised access during the construction phase of the project. A landscape plan will be prepared based upon natural endemic vegetation to mitigate the loss of habitat and feed trees for impacted fauna. This will be maintained within the road reserve in perpetuity to assist wildlife survival.

6.1.1 Threatened Flora Species

As discussed above, depending on the selected route option, there are a number of threatened flora species that may be directly or indirectly impacted by the construction of the North Nowra Link Road. The mitigation measures listed below, aim to minimise impacts on these species and restrict environmental degradation.

Bomaderry Zieria (*Zieria baeuerlenii*)

As discussed in section 4.1.2, only the central route option has potential to indirectly impact the *Zieria baeuerlenii* within the study area. Both the northern and southern route options are a considerable distance away from the known locations of the species. Potential indirect impacts to *Zieria baeuerlenii* adjacent to the central route will be focused on one particular genotype (Gn1) of the species and occur from the proposed construction activities and ongoing impacts associated with human activity. As mentioned above, impacts as a result of fragmentation are not considered likely as the species reproduces vegetatively and not sexually.

The following mitigation measures have been committed to by Council and will be implemented to totally avoid direct impact and minimise the potential for indirect impacts on *Zieria baeuerlenii*:

- Plants nearby to the central road corridor (Gn1) will be permanently fenced in the vicinity of the road.
- Where possible, large trees that provide shade for *Zieria baeuerlenii* along the central route will be retained.
- Compensatory planting of shade trees near the central route corridor.
- Minimal stopping areas will be provided along the road and reinforced through the use of fauna permeable fencing along the roadside to reduce the potential risk of fire from arsonists.
- During the construction of the road any nearby plants will be fenced prior to construction and clearly marked as "no-go" areas. Additionally, Council will ensure best practice field operations are aligned to the EMP ensuring acute awareness of all persons involved with the construction of the road.
- Road verge management will be undertaken in such a way as to maintain low fuel loads to reduce the risks of incidental fires.
- Weed management measure to reduce edge effects (see section 6.1.4 for detail)
- Erosion and sedimentation control measures (see section 6.1.3 for detail).

In addition to the above mentioned mitigation measures, Council is committed to dedicating adjacent existing Council land to the Bomaderry Creek Regional Park as an offset to compensate for the revocation of land under DECCW tenure for the construction of the central route option. The inclusion of this land into the Regional Park has a number of benefits for *Zieria baeuerlenii*, including:

- Increasing known colonies in the regional park from 60% to 97%;
- increasing known genotypes within the regional park from 60% to 100%; and
- increasing critical habitat from 51% to 88%.

For further detail on the proposed offset see section 8.

The remaining two colonies of *Zieria baeuerlenii* on Council's land below the Narang Road Tennis courts are not situated within the proposed offset area. These two colonies could be protected through various means, subject to further negotiation with DECCW as part of the project approval.

Council will consider the possibility of funding DECCW for the ongoing management and conservation of this species. This funding could be used for:

- weed management within the habitat for the species, particularly for *Bryophyllum* and *Lantana camara*; and
- introduction of individuals into suitable areas either in the Bomaderry Creek area or elsewhere from propagated individuals kept at Booderee Botanical Gardens.

Details of this arrangement may be considered further during the development of the EMP and would be subject to further discussions with regulatory authorities.

Additionally, all known genomes of the species have been propagated and are currently maintained in pots at Booderee Botanic Gardens. Council will endorse and support a proposal to propagate and introduce individuals into suitable areas within the expanded 50 hectares area that Council is proposing to add to the Bomaderry Creek Regional Park as part an offset. Such a step has the potential of providing major conservation benefit by creating a widened area of occurrence for the species, which will help to guard against loss or significant reduction in the species existence. Council welcomes consultation to undertake further studies with a view to providing support and assistance to introducing individuals as part of the central route project.

Albatross Mallee (*Eucalyptus langleyi*)

As discussed in section 4.1.1, two *Eucalyptus langleyi* are likely to be impacted due to the construction of the bridge along the central route. The potential loss of two *Eucalyptus langleyi* is unlikely to significantly impact the local occurrence of the species given that these individuals only represent a small part of the overall population within the region.

No specific mitigation strategies are considered necessary or have been proposed other than increasing the amount of habitat under DECCW tenure and management by handing over the offset land. Mitigation measures that aim to reduce impacts on *Zieria baeuerlenii* such as minimising stopping opportunities along the road, fencing the road and weed management activities will all serve to increase the security for *Eucalyptus langleyi* as well.

Bauer's Midge Orchid (*Genoplesium baueri*)

As discussed in section 4.1.3, *Genoplesium baueri* occurs within the vicinity of the central and southern route corridors and a small number of individuals may potentially be indirectly impacted by construction activities. Although no mitigation measure have been developed specifically for the species, mitigation measures proposed for *Zieria baeuerlenii,* such as fencing and limited stopping areas, will also increase security for the species.

***Hibbertia* sp. nov. 'Menai'**

As discussed in section 4.1.4, *Hibbertia* sp. nov. 'Menai' is known to occur within the proposed construction corridors for the central and southern routes. Given the species abundance in the area and the small number of individuals potentially impacted by the proposal, no specific mitigation measures have been developed. However, mitigation measures that will be implemented to mitigate impacts on *Zieria baeuerlenii* will also help reduce the potential impacts on *Hibbertia* sp. nov. 'Menai' specimens.

6.1.2 Threatened Fauna Species

The North Nowra Link Road has potential to impact on habitat for a range of threatened species, including, Grey-headed Flying-fox, Yellow-bellied Glider and Spotted-tailed Quoll. However, habitat cleared to construct the road is a small part of the habitat in the region. To ensure that impacts are minimise, mitigation measures specific for each species have been developed. These mitigation measures were developed in consultation with the *Fauna Sensitive Road Design Manual (QLD Government, 2010)* which provides an outline of the preferred practices for mitigating impacts on fauna that are associated with the construction of roads.

Grey-headed Flying-fox

While direct impacts will not occur, indirect impacts are considered unlikely. The following mitigation measures will be implemented to minimise the potential indirect impacts on Grey-headed Flying-fox and its habitat within the study area:

- Speed limit reduced to 60km/hr for the eastern end of the road near the creek crossing to reduce potential fauna collisions.
- Dense and light coloured pavement material used to mitigate noise impact and enable contrast of fauna in headlights at night.
- Clearing/construction methods to ensure no adverse impacts to adjacent habitats.
- Induction for construction workers regarding surrounding conservation values of the Bomaderry Creek Regional Park.

Yellow-bellied Glider

Although direct impacts will not occur and indirect impacts are considered unlikely, the following mitigation measures will be implemented to minimise the potential for indirect impacts on Yellow-bellied Glider and its habitat within the study area:

- Develop strategies within the road design that mitigates habitat fragmentation, including:
    - The road will be designed to leave the ground for a considerable distance at either side of the Creek crossing. Bridge structures will generally be elevated where possible. This elevation provides free underpass access for species that rely upon the environment adjacent to Bomaderry Creek.
    - Overpasses in the form of rope bridges or gliding poles with take-off and landing points will be designed and constructed in consultation with experts and best practice.
- Speed limit reduced to 60km/hr for the eastern end of the road near the creek crossing to reduce potential fauna collisions.
- Light coloured road surfaces to enable contrast of fauna in headlights at night.
- Dense pavement material used to mitigate noise impact.
- Bridge design will acknowledge the objectives of the Bomaderry Creek classification as a Category 1 Environmental Corridor. It will be necessary for part of the bridge foundations to be located within the environmental corridor with a neutral effect following careful construction. The objective would be to maintain movement of terrestrial and aquatic species.
- Pre-clearing surveys to check tree hollows for threatened fauna species.
- Clearing supervised by a qualified ecologist to ensure minimal impact, rescue/move displaced/injured fauna.
- Timing of clearing/excavation to avoid high rainfall periods (increased erosion risk etc) and high bushfire risk periods.
- Clearing/construction methods to ensure no adverse impacts to adjacent habitats.
- Induction for construction workers regarding surrounding conservation values of the Bomaderry Creek Regional Park.
- Road signage to warn of wildlife crossing.

Spotted-tailed Quoll

Although direct impacts will not occur and indirect impacts are considered unlikely, the following mitigation measures will be implemented to minimise the potential for indirect impacts on Spotted-tailed Quoll and its potential habitat within the study area:

- Develop strategies within the road design that avoids habitat fragmentation, including:
    - The road will be designed to leave the ground for a considerable distance at either side of the Creek crossing. Bridge structures will generally be elevated where possible. This elevation provides free underpass access for species that rely upon the environment adjacent to Bomaderry Creek.
- Speed limit reduced to 60km/hr for the eastern end of the road near the Creek crossing to reduce potential fauna collisions.
- Light coloured road surfaces to enable contrast of fauna in headlights at night.
- Dense pavement material used to mitigate noise impact.
- Bridge design will acknowledge the objectives of the Bomaderry Creek classification as a Category 1 Environmental Corridor. It will be necessary for part of the bridge foundations to be

located within the environmental corridor with a neutral effect following careful construction. The objective would be to maintain movement of terrestrial and aquatic species.
- Pre-clearing surveys to check tree hollows and hollowed logs on the ground for quoll
- Clearing supervised by a qualified ecologist to ensure minimal impact, rescue/move displaced/injured fauna.
- Timing of clearing/excavation to avoid high rainfall periods (increased erosion risk etc) and high bushfire risk periods.
- Clearing/construction methods to ensure no adverse impacts to adjacent habitats.
- Induction for construction workers regarding surrounding conservation values of the Bomaderry Creek Regional Park.
- Road signage to warn of wildlife crossing.

Giant Burrowing Frog

As discussed above in section 4.2.1, potential habitat for the GBF occurs adjacent to the central route corridor. Although the species was not recorded during surveys a small area of sub-optimal habitat will be directly impacted by construction activities for the central route option (0.22 hectares).

Provided below is an assessment of the potential impacts on GBF habitat as a result of the construction of the central route option and an outline of GBF specific mitigation measures that will be implemented in the event of the species being present:

Habitat loss / fragmentation

A division of sub-optimal habitat will occur from the proposal and a small direct loss of habitat will occur (0.22 hectares). The road will not provide a complete barrier to movement as is the case for many wildlife species due to the limited habitat within the Bomaderry Creek Regional Park and mitigated bridge design over the creek gorge allowing non-impeded movement for terrestrial and aquatic species.

Road Kill

It is unlikely that road kill will be a factor for this species. This is primarily due to the lack of known records that would confirm the species presence in the study area, but also because the potential breeding habitat exists only on the northern side of the central route eliminating the need to traverse the road to access additional area of habitat. Bridge design will also allow the species to move between habitats should it be found to occur.

One of the mitigation measures to be implemented for the development is the bridge design. The high construction design will allow movement of GBF below the bridge along the gorge and Bomaderry Creek riparian zone. The bridge will not significantly impact on the species ability to move through potential habitat or provide a physical barrier for the species.

Indirect effect on vegetation"

There may be indirect loss of habitat adjacent to the road as a result of incremental removal or degradation of habitat. This can result from the altered hydrological, nutrient and microclimatic conditions along the road verge. Impacts such as water run-off, regular disturbance regimes being altered, invasive species invasions and erosion may occur. The level of impact is also directly related (positively correlated) to the size of the fragmentation (development / road) and the vehicle usage of the road. However, the fact that only limited habitat for the species is present in Bomaderry Creek Regional

Park and that no individuals have been recently recorded suggests that it is highly unlikely that the proposal will adversely impact this species ability to move between areas of suitable habitat.

Environmental Management Plan

As a primary measure, an Environmental Management Plan (EMP) intended to be a working and changing guiding document will be implemented during and post construction to limit direct and indirect impacts from the proposal on this species. This plan will guide the construction process and on-ground crew to limit impacts during and post construction.

Runoff, sedimentation and erosion:

An Erosion and Sediment Control Plan and a Soil and Water Management Plan will be prepared prior to construction. These plans will include measures addressing potential indirect impacts to GBF along the Bomaderry Creek, and underneath and adjacent to the road (including bridge) by limiting and controlling the potential runoff from construction works. The measures will channel water away from suitable habitat and may include the installation of silt traps, landscape contouring and alteration of the gradient and landform.

Given the mitigation measures to be implemented during and post construction and the fact that no individuals have been recorded in the study area indicates that it is highly unlikely that the proposal will impact on the ability of this species to move between areas of suitable habitat or use the small patches of remaining habitat.

There is a proposal to transfer some Council land to DECCW ownership, as compensation for the revocation of land under DECCW tenure for the construction of the central route. The transfer of this land will increase potential habitat for the species (in the event that it inhabits the area) within the DECCW tenure.

Effectiveness of proposed mitigation measures

The proposed mitigation measures in combination are expected to be highly effective in mitigating short and long term and indirect impacts of the North Nowra Link Road.

The mitigation measures designed for pre-construction and during the construction process will help to minimise unavoidable direct impacts. The combination measures; educating the construction workers, pre-construction surveys of hollow bearing trees, supervision of qualified ecologists during clearing events and timing of construction periods are all typical mitigation measures for construction projects in environmental sensitive areas. They have been shown to be highly effective in minimising direct and indirect impacts to threatened fauna and flora.

Many of the post construction mitigation measures intend to alleviate impacts on Bomaderry Creek Regional Park. Measures such as the detailed road and bridge design have built on concepts and ideas used for similar projects. The rope bridges, glider poles and elevated bridge structures intend to alleviate fragmentation and allow movement of arboreal species between habitats on either sides of the road. Wildlife crossing signs, reduced speed limits and lighter coloured road surfaces will ensure motorists are aware of potential threatened fauna in the area and allow greater vision at night to prevent collisions.

6.1.3 Runoff, sedimentation and erosion

An Erosion and Sediment Control Plan followed by a Soil and Water Management Plan as part of final design will be detailed to mitigate against erosion and water quality issues. Water quality safeguards will include rehabilitation, sedimentation ponds, erosion controls where surface runoff is concentrated and other conventional measures for water sensitive design. Specialist consultants have been engaged by the project design team to identify water quality targets compatible with the aquatic ecosystems in Bomaderry Creek and to protect the social and aesthetic values of the community.

Soft engineering techniques will be included to protect drainage channels and to dissipate stormwater flows without causing erosion that could otherwise impact on *Zieria baeuerlenii* and other threatened plant species. Detailed stormwater design would ensure both surface and subsurface water flows do not have a detrimental impact on threatened flora, in particular the *Zieria baeuerlenii*.

Mitigation and management measures will be detailed during the construction design phase to ensure that surface runoff is directed to appropriately engineered discharge points so soil erosion is minimised.

6.1.4 Edge effects /Fragmentation and Increased weed invasion

Stringent weed management measures will be implemented during and post construction to ensure weed invasion and edge effects do not increase across the study area. These measures will include the control of runoff that may contain weed seeds and washing down vehicles to prevent the spread of weeds between areas, specific arrangements will be detailed in the EMP.

Council has demonstrated a commitment to consider funding (in conjunction with the 50 hectares of offset land) for weed management throughout the expanded regional park.

Potential edge effects on the Bomaderry Creek Regional Park will be managed accordingly through the development of an EMP. The EMP will outline weed management activities and appropriate measures to ensure that construction activities for the North Nowra Link Road have minimal indirect impacts.

Widening the service road to a single lane, two way road with a road reserve corridor of 30 metres (20 metres in areas of ecological significance) may increase fragmentation effects on the Bomaderry Creek Regional Park and subsequently, have an impact on threatened fauna. Potential impacts associated with the development of the road include:

- increased fragmentation effects through the loss and degradation of vegetation and fauna habitat; and
- the possibility of direct mortality of wildlife due to collision with vehicles.

To reduce the potential for impacts associated with fragmentation of the Bomaderry Creek Regional Park, measure such as maintaining overhanging trees and building fauna bridges and glider poles will be implemented. Specific detail in relation to these measures will be developed in the EMP. Overhanging trees will only be maintained where it is clear that they will not compromise road safety and/or become incompatible with the existing powerlines. The practicality of maintaining these trees will be fully assessed in the EMP.

The implementation of mitigation measures such as rope bridges and glider poles will help alleviate these two direct impacts. A study by Ball and Goldingay (2008) showed that Squirrel Gliders are capable of using glider poles to reconnect habitat of 70m distance and have the potential to provide connectivity across roads. Bax (2006) showed that a canopy bridge over the Karuah Bypass was successful in allowing gliders and other arboreal mammals to cross between bushland remnants.

As part of a research project involving the Botanic Gardens, Melbourne University, Monash University, VicRoads and the NSW Roads and Traffic Authority a rope bridge was installed on the Hume Freeway at Violet Town in north-eastern Victoria to allow native animals such as Squirrel Gliders and possums to cross the road safely. The fauna bridge was fitted with cameras at either end to record and monitor usage. In the first year since being built the 24-hour cameras have recorded 50 ringtail possum crossings, including a piggy-backing pair. Another 50 partial crossings by ringtail possums, seven partial crossings by Brushtail possums and four partial crossings by squirrel gliders have been recorded.

Fauna bridges have been constructed at different locations around NSW to maintain habitat connections for threatened populations and to minimise the impact of road construction on the environment. In particular a number of fauna bridges have been construction along the Pacific Highway. The use of fauna bridges is a proven and effective mitigation measure aimed at reducing fragmentation impacts.

Building habitat connections like fauna bridges across roads or similar linear infrastructure may help maintain healthy and genetically diverse native animal populations by reducing the fragmentation and connectivity impacts generally associated with this type of infrastructure.

The construction of a fauna bridge as a component of the North Nowra Link Road would be specifically targeted at reducing potential fragmentation effects and connectivity impacts on the Yellow-bellied Glider and other native species, such as possums.

7 Comparative Assessment

Potential impacts associated with the construction of the three route options for the North Nowra Link Road were consider in this assessment and are summarised below.

Northern option

The northern route option was found to contain potential habitat for a range of threatened fauna species, including; the Glossy Black-cockatoo, Gang-gang Cockatoo, Square-tailed Kite, Masked Owl, Powerful Owl, Large-footed Myotis, Yellow-bellied Glider and Spotted-tailed Quoll. However, the amount of suitable habitat for these species only represents a small part of the overall habitat availability within the broader region. The route is also located near the northern boundary of the remnant bushland, meaning that the road would fragment the patch into one small patch of remnant vegetation north of the road and a much larger remnant south of the road. As such, adverse impacts on these species as a result of construction of northern route option are not considered likely. No threatened flora species were recorded within the construction corridor for the northern option.

The northern route option will require the revocation of approximately 0.9 hectares of the Bomaderry Creek Regional Park. The impacts on the conservation values and integrity of the park associated with the construction and operation of the northern route are discussed in the Revocation and Biodiversity Offset Assessment at **Appendix E**.

Central option

Four threatened flora species were recorded within the construction footprint for the central route option; the Albatross Mallee, Bomaderry Zieria, Bauer's Midge Orchid and *Hibbertia* sp. nov. 'Menai'.

Two individual Albatross Mallee are likely to be impacted by the bridge for the central route through permanent shading and changes to soil moisture. However, adverse impacts on the local population of the species are not considered likely as these individuals only represent a small part of the overall population within the region. To ensure that the broader population of Albatross Mallee within the study area is not adversely impacted, a range of mitigation measures will be implemented.

One individual Bauer's Midge Orchid may be indirectly impacted by constructing the central route option. However, it is not expected that this will result in adverse impacts on the species.

Eleven individual *Hibbertia* sp. nov 'Menai' were recorded within or near the construction footprint for the central route. Although 9 of these individuals are expected to be directly impacted by the proposal, adverse impacts are not considered likely given the species abundance in the region.

Two individual *Zieria baeuerlenii* from genotype 1 (Gn1) were recorded in the initial 30 metre road corridor within the 200 metre wide assessment corridor for the central route option. The road corridor was originally 30 metres wide commensurate with the standard design requirements for a sub arterial road. However, the road has been designed to a reduced width of 20 metres to avoid these individuals and a range of mitigation measures will be implemented to ensure no direct impact occur.

Fragmentation for this species is unlike the majority of species, as *Zieria baeuerlenii* reproduces vegetatively, not sexually and is not known to produce seed. Construction of the central route will not create a new barrier to the potential dispersal of the species as a maintained service road exists along the route alignment. Furthermore, Bomaderry Creek creates a barrier to the east.

Habitat for a number of threatened fauna species was recorded within the central route corridor. In particular, habitat suitable for the GBF was recorded on the northern side of the central route. Although no individual GBF were recorded in recent surveys, a range of mitigation measures will be implemented to ensure that should the species occur, adverse impacts would not be likely.

Habitat for a range of other threatened fauna species was also recorded throughout the central route study area, including; the Glossy Black-cockatoo, Gang-gang Cockatoo, Square-tailed Kite, Masked Owl, Powerful Owl, Large-footed Myotis, Yellow-bellied Glider and Spotted-tailed Quoll. However, the amount of suitable habitat for these species impacted by construction activities only represents a small part of the overall habitat availability within the broader region. As such, adverse impacts as a result of the central route option are unlikely.

The construction of the central route will bisect habitat for a range of threatened flora and fauna species. However, given that the existing service road and powerline easement that runs parallel to the central route corridor has already bisected this habitat it is not expected that the construction of the central route will create any additional fragmentation impacts.

The central route option will require the revocation of approximately 1.6 hectares of the Bomaderry Creek Regional Park. The impacts on the conservation values and integrity of the park associated with the construction and operation of the central route are discussed in the Revocation and Biodiversity Offset Assessment at **Appendix E**. To compensate for the loss of approximately 1.6 hectares of the Regional Park, Shoalhaven City Council are proposing a 50 hectare offset as discussed below in section 8.

Southern Option

Two threatened flora species are likely to be impacted by the construction of the southern route option, the *Hibbertia* sp. nov. 'Menai' and Bauer's Midge Orchid.

Twenty-three individual *Hibbertia* sp. nov. 'Menai' specimens are likely to be directly impacted by the construction of the southern route option. However, given the species abundance in the region, adverse impacts affecting the vulnerability of the species are unlikely.

Nine individual Bauer's Midge Orchid may be impacted by the construction of the southern route option.

One threatened ecological community, the Lowland Rainforest of the NSW Coast and Sydney Bioregion, has potential to occur within the southern part of the gorge at Bomaderry Creek. There is potential for indirect impacts to occur as a result of the construction of the bridge for the southern option.

One threatened fauna species, the Grey-headed Flying-fox, was recorded within the vicinity of the southern route option. A potential flying-fox camp occurs in the south-eastern corner of the study area and there is potential for indirect impacts to occur as a result of construction activities associated with the southern route option.

The southern route option was also found to contain potential feed trees for Yellow-bellied Glider. However, the potential loss of a small number of feed trees is not likely to result in adverse impacts on the species.

Habitat for a range of other threatened fauna species was also recorded, including; Gang-gang Cockatoo, Square-tailed Kite, Masked Owl, Powerful Owl, Large-footed Myotis and Spotted-tailed Quoll. However, the amount of suitable habitat for these species affected by construction activities only represents a small part of the overall habitat availability within the broader region. As such, adverse impacts as a result of the southern route option on these species are unlikely.

The southern route option will require the revocation of approximately 0.3 hectares of the Bomaderry Creek Regional Park. The impacts on the conservation values and integrity of the park associated with the construction and operation of the southern route are discussed in the Revocation and Biodiversity Offset Assessment at **Appendix E**.

7.1 IDENTIFICATION OF A PREFERRED ROUTE FOR BIODIVERSITY

The biodiversity impacts associated with each of the three route options have been assessed and a preferred option has been identified in terms of its overall biodiversity outcomes.

Although all three route options have a range of potential benefits, in terms of impacts upon a listed threatened species or community, the northern route option has the least impact and provides the best biodiversity outcome. This is due to the fact that no threatened flora species are present and that the threatened species habitat within the construction corridor only represents a small part of the overall habitat availability within the broader region.

Both the central and southern route options have potential to directly impact a number of threatened flora species. However, the environmental impacts associated with the central route are considered negligible given the range of mitigation measures that will be implemented and that the central route concept has been assessed and is outweighed by the provision of land offered for the revocation of 1.6 hectares of the Bomaderry Creek regional Park.

Although the northern route option provides the best biodiversity outcome when compared to the central and southern routes, environmental impacts associated with all three routes are considered to be low provided that the specific mitigation measures are implemented.

7.2 IDENTIFICATION OF AN OVERALL PREFERRED ROUTE

The three route options have been assessed with key consideration of potential environmental impacts on biodiversity and threatened species. The Environmental Assessment will also assess the project against the following key environmental factors:

- Traffic Benefits and Impacts;
- Impacts on Aboriginal Heritage;
- Noise Impacts; and
- Visual Amenity.

The overall assessment for the selection of a preferred route has taken into account the costs of the project and socio-economic factors, as well as feedback from the community. On balance the Central route option has been selected as the preferred route for the North Nowra Link Road.

8 Proposed Offsets

With consideration of the predicted residual biodiversity impacts associated with the Central route option, Shoalhaven City Council has committed to providing 50 hectares of compensatory land for inclusion into the Bomaderry Creek Regional Park (see **Figure 28**) as conservation offset with the approval of the Central Route corridor.

This is one of the most significant conservation measures proposed and involves the dedication of land to DECCW which will increase the size and biodiversity values of the Bomaderry Creek Regional Park. This offset will compensate for the necessary revocation of a small amount of DECCW land as well as compensating for impacts to the biodiversity values of the area.

The additional 50 hectares will expand the area of the park from 82 hectares to 132 hectares, an increase of 61 per cent. The additional 50 hectares will be delivered in three parcels of 4 hectares, 18 hectares and 28 hectares. These are located to the north, east and south of the existing park, respectively. The land parcels are owned by Council and are on both sides of the gorge, including a substantial length of the gorge itself. Much of this land proposed to be included in the Regional Park as an offset was previously included in the draft Critical Habitat report prepared by NPWS 2002.

The eastern portion of land contains a large number of *Zieria baeuerlenii* individuals and 8 of the known 20 genotypes (see **Figure 29**). The inclusion, protection and management of these plants within the Bomaderry Creek Regional Park will greatly enhance the long term conservation of this species. The proposed offset would bring all known genotypes under conservation protection and consistent management by DECCW. This would include fire management, signage, access and weed control.

The proposed offset will also greatly enhance the long term conservation of the population of *Eucalyptus langleyi* north of the Shoalhaven River in the Shoalhaven LGA which is listed as an Endangered Population under the TSC Act. The transfer of 50 hectares into the Bomaderry Creek Regional Park will mean that the majority of the Endangered Population is located within the reserve.

Council will consider contributing to the funding for ongoing management of *Zieria baeuerlenii*. This financial contribution could be increased and used to help fund the ongoing management of the dedicated lands and broader reserve.

Parts of the lots offered for conservation offset are zoned residential. Council intends rezoning all lands to be dedicated to Environmental Protection Zone and be gazetted as DECCW tenure. If the full offer of 50 hectares is accepted, the ratio of compensatory habitat would be greater than 20 times larger than the area needing to be excised from the Park for the construction of the central route.

The proposed offset strategy of dedicating surrounding Council land to the regional park so that the whole area can be managed by DECCW will help to simplify fire management within the regional park, regulate access through appropriately marked and patrolled areas, effectively manage human activity and educate the public about the biodiversity values of the regional park.

A comprehensive Revocation and Biodiversity Offset Assessment has been prepared (see **Appendix E**). This report provides detailed information relating to the floristic and species

diversity, habitat quality, vegetation types and conservation values within the proposed offset area and will inform the NSW Part 3A Environmental Assessment for the North Nowra Link Road. The report also discusses the environmental benefits associated with the inclusion of the land within the Bomaderry Creek Regional Park and how a higher level of environmental protection will positively impact on the biodiversity values of the Bomaderry Creek region. The report outlines the various zonings of the council land offered as an offset.

Biometric Assessment Methodology

The Biometric assessment methodology used in Biobanking is directly linked to offset outcomes. The 50 hectare parcel of land proposed as an offset is greater than the likely requirement that would be determined using the biometric assessment methodology. As such, the biometric methodology was not applied to the assessment methods used for this project to assess impacts on connectivity.

The Biobanking scheme aims to encourage and secure investment in conservation by providing both the legal and financial mechanisms to ensure the long-term conservation of biodiversity values at Biobank sites. Organisations with conservation goals can rely on the scheme's robust nature to ensure the longevity of their investments in biodiversity outcomes. Having 50 hectares of offset land be dedicated to Bomaderry Creek Regional Park, means a secure investment in conservation land is being made for the long-term. Again, the amount of conservation land would be far greater than what Biobanking would dictate, therefore, offering a greater conservation outcome.

There is no legislative or policy requirement for a proponent to use Biobanking as the preferred method of assessment. However, proponents can voluntarily use Biobanking to minimise and offset their impacts on biodiversity.

It is also worth noting that whilst the Biobanking method is useful in determining biodiversity offsets, in this instance a greater offset area was considered appropriate compensation for the proposal.

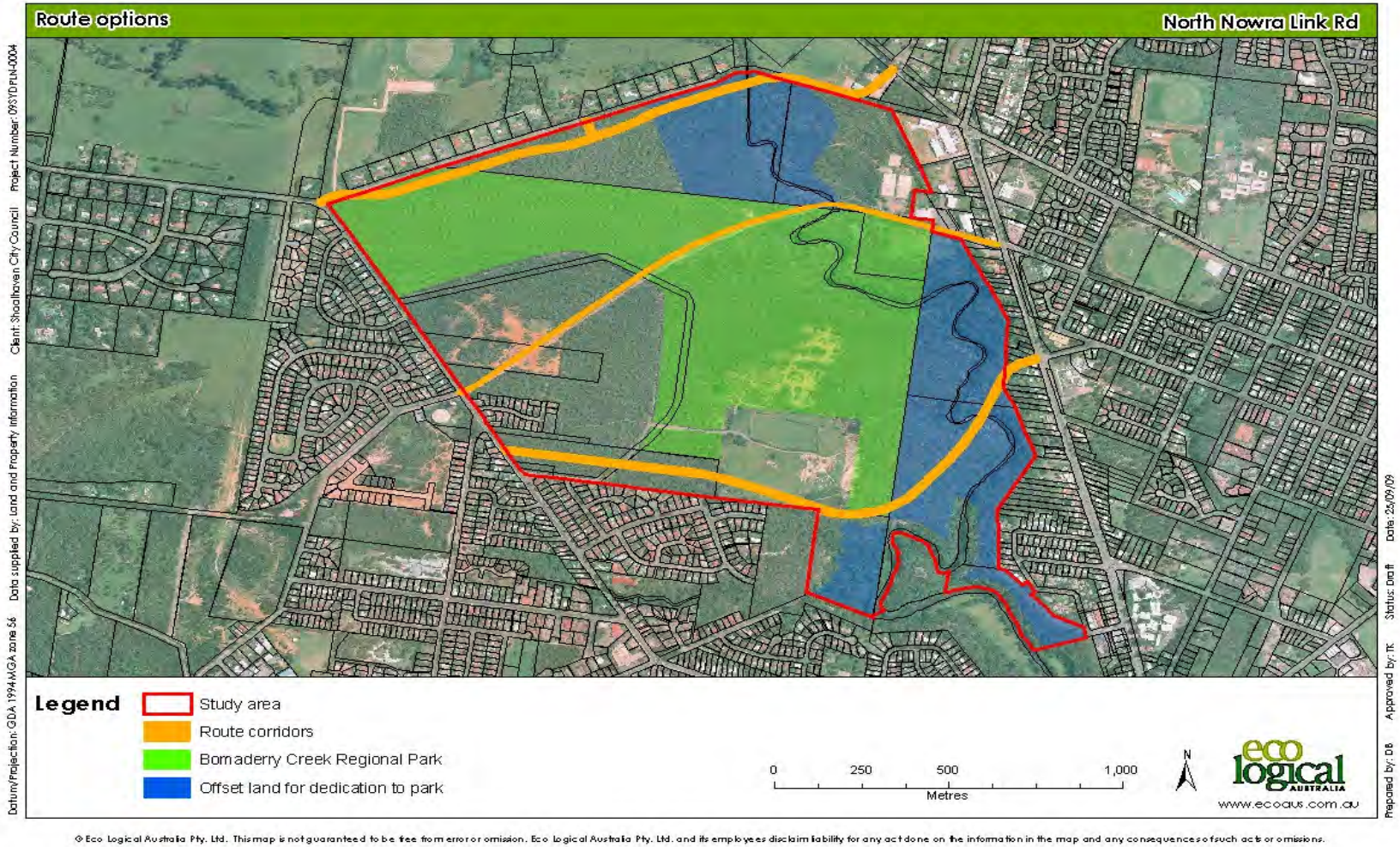

Figure 28: Biodiversity offset for dedication to the Regional Park

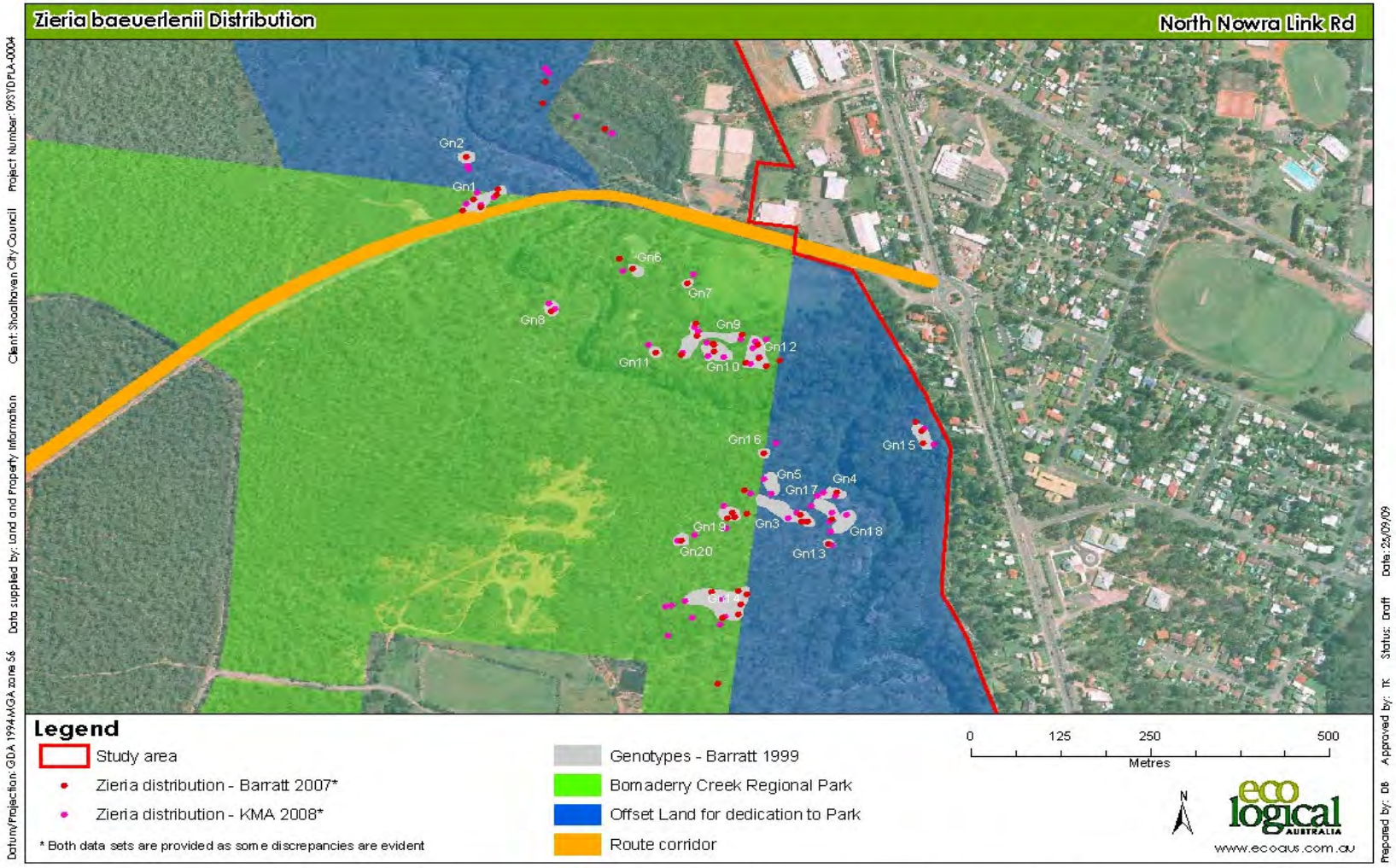

Figure 29: *Zieria baeuerlenii* genotype locations within the study area

9 Conclusions

Based on the studies undertaken and information available, the biodiversity impacts associated with each of the three route options have been assessed against the Director General's Requirements. The assessment of the biodiversity values and potential environmental impacts associated with each of the three route options has found that impacts to biodiversity and in particular State and National threatened species can be expected from each of the three route options.

While the northern route option provides the best biodiversity outcome of the options available, all three route options present a range of potential impacts to listed threatened species. Both the central and southern route options have potential to impact a number of threatened flora species. However, the environmental impacts associated with each of these routes are considered negligible given the range of mitigation measure that can be implemented.

Council has stated a committed to further detailed environmental and engineering work to optimise mitigation in the detailed road design phase. Additionally, Council's commitment to providing up to 50 hectares of compensatory land for inclusion into the Bomaderry Creek Regional Park, as conservation offset outweighing the assessed conservation loss, and in consideration of minimal impact after mitigation measures the approval of the Central Route corridor, provides a most significant biodiversity benefit. The dedication of this land to conservation will increase the size and biodiversity values of the Bomaderry Creek Regional Park by more than 60%.

Although the northern route option provides the best biodiversity outcome when compared to the central and southern routes, environmental impacts associated with all three routes are considered to be low provided that the specific mitigation measures are implemented.

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Appendix A – Identifying potential effects of the proposal on threatened species, populations or ecological communities, or their habitats.

An assessment of potential effects of the proposal has been conducted on threatened species, populations and ecological communities, or their habitats. Threatened species or ecological communities are those listed on Schedules 1, 1A and 2 of the TSC Act and Schedules 4, 4A and 5 of the Fisheries Management Act which may be impacted by the proposal. This assessment considers 6 factors, which allows Eco Logical Australia to undertake a qualitative analysis of the likely impacts of the action. The threatened species and ecological communities that are the subject to this assessment include:

Ecological Communities

- Lowlands Rainforest in the NSW Coast and Sydney Bioregion – potential to occur

Flora

- *Eucalyptus Langleyi* (Albatross Mallee) – known to occur; ‘
- *Hibbertia* sp. Nov. ‘Menai’ – known to occur
- *Genoplesium baueri* (Bauer’s Midge Orchid) – known to occur; and
- *Zieria baeuerlenii* (Bomaderry Zieria) – known to occur;

Birds

- *Calyptorhynchus lathami* (Glossy Black-cockatoo) – known to occur;
- *Callocephalon fimbriatum* (Gang-gang Cockatoo) – known to occur;
- *Lophoictinia isura* (Square-tailed Kite) – known to occur;
- *Ninox strenua* (Powerful Owl) – known to occur;
- *Tyto novaehollandiae* (Masked Owl) – known to occur; and
- *Tyto tenebricosa* (Sooty Owl) – known to occur.

Mammals

- *Dasyurus maculatus* (Spotted-tailed Quoll) – potential to occur;
- *Myotis macropus* (Large-footed Myotis) – known to occur;
- *Pteropus poliocephalus* (Grey-headed Flying-fox) – known to occur;
- *Petaurus australis* (Yellow-bellied Glider) – known to occur;

Amphibians

- *Heleioporus australiacus* (Giant Burrowing Frog) – potential to occur

Lowlands Rainforest in the NSW Coast and Sydney Bioregion

Lowlands Rainforest is listed as an endangered ecological community under the TSC Act. Lowland rainforest is an ecological community of subtropical rainforest and structurally complex forms of dry rainforest (DECC 2009).

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

This endangered ecological community may be indirectly impacted by the construction of the southern route. However, mitigation and management measures implemented during and post construction as outlined in section 6 will alleviate potential indirect impacts to this community.

No part of the community will be directly impacted by any of the route options. Given that there will be a relatively small impact footprint from the proposed activities, and the size of other remnant vegetation stands in the area, the action is unlikely to adversely affect the life cycle of this ecological community.

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

Lowland rainforest is an ecological community of subtropical rainforest and structurally complex forms of dry rainforest (DECC 2009). The community is usually in an undisturbed state and has a closed canopy, characterised by a high diversity of trees. The southern route option for the North Nowra Link Road may contain Lowland Rainforest within the gorge at Bomaderry Creek. KMA (2008) suggests that small stands of rainforest in the lower gorge at Bomaderry Creek could qualify as Lowland Rainforest because of the presence of subtropical species and the high plant diversity.

Mitigation and management measures implemented during and post construction as outlined in section 6 will alleviate potential indirect impacts to this community. Additionally, no part of the community if it's likely to exist will be directly impacted by any of the route options. Therefore, it is unlikely that the proposal will adversely affect the habitat of this ecological community.

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

Lowland Rainforest and its variations have a large distribution expanding from the NSW North Coast, encompassing the Sydney bioregional and extending south to Ulladulla. The proposal is not occurring at the limits of the known distribution for this ecological community.

How is the proposal likely to affect current disturbance regimes?

The proposal has only a small potential to impact indirectly on this species if the southern route is chosen. Mitigation and management measures implemented during and post construction will help to alleviate potential impacts. As such, the impacts are unlikely to influence the disturbance regimes for this ecological community.

Therefore, the proposal is unlikely to affect the current disturbance regime of the Lowland Rainforest ecological community.

How is the proposal likely to affect habitat connectivity?

The proposal has only a small potential to impact indirectly on this species if the southern route is chosen. Mitigation and management measures implemented during and post construction will help to

alleviate this potential impacts. As such, no direct impacts will occur to this ecological community and therefore limiting the potential to impact on the habitat connectivity.

It is unlikely the proposal will adversely impact on the habitat connectivity for this ecological community.

How is the proposal likely to affect critical habitat

No critical habitat for Lowlands Rainforest in the NSW Coast and Sydney Bioregion has been identified by the Director-General of the National Parks & Wildlife Service (NSW) on the Register of Critical Habitat

Conclusion:

It not considered likely that adverse impacts to Lowlands Rainforest in the NSW Coast and Sydney Bioregion will occur from the proposal.

Albatross Mallee (*Eucalyptus langleyi*)

The species is listed as vulnerable under both the TSC and EPBC Acts. In December 2010 the NSW Scientific Committee made a determination under the TSC Act to list the population of *Eucalyptus langleyi* north of the Shoalhaven River in the Shoalhaven local government area as an Endangered Population.

This species would not be directly impacted by the northern or the southern route, only by the central route. Suitable habitat, however, occurs along the northern and southern route.

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

Two individual *Eucalyptus langleyi* were recorded during the vegetation surveys at Bomaderry Creek which are likely to be impacted as a result of construction activities for the central route option. Both of these individuals form part of the population north of the Shoalhaven River that is listed as an Endangered Population under the TSC Act. The total population size of the endangered *Eucalyptus langleyi* population north of the Shoalhaven River in the Shoalhaven LGA was originally estimated to be 32 plants. However, a survey undertaken by Barrett et al in 2008 found that only 20 of these individuals were still alive. Although two individuals from the Endangered Population will potentially be impacted, it is not likely to place the population at risk of extinction or affect the species ability to reproduce. Given that there will be a relatively small impact footprint from the proposed activities, and the size of other remnant vegetation stands in the area, the action is unlikely to adversely affect the life cycle of this species

The majority of the Endangered Population occurs on land that is currently owned and managed by SCC. SCC intend on transferring approximately 50 hectares of land into the Bomaderry Creek Regional Park. This will mean that the majority of individuals in the population would be located within a state managed reserve and therefore would be afforded greater protection and the risk of extinction will be reduced. The inclusion of these individuals into the reserve will also greatly enhance the long term conservation of the population.

Although two individuals from this population may potentially be impacted, all of the remaining individuals will remain in situ and will not be impacted either directly or indirectly by the construction of the North Nowra Link Road. The vegetation clearance associated with the North Nowra Link Road will be limited to the construction corridor. As such, the surrounding bushland will not be adversely impacted and disturbance to areas of habitat suitable for *Eucalyptus langleyi* will be minimal.

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

Bomaderry Creek Regional Park (82 ha) comprises suitable habitat for *Eucalyptus langleyi*. Approximately 1.8ha of this Regional Park will be lost due to the construction of the proposed central route corridor. This accounts for a relatively small proportion of the overall suitable habitat (82 ha) in the immediate area.

Therefore, it is unlikely that the proposal will adversely affect the habitat for *Eucalyptus langleyi*.

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

The main occurrence of *Eucalyptus langleyi* is to the south-west of Nowra as far as Yarramunmun Creek. It is also found to a limited extent north of the Shoalhaven River in the vicinity of Bomaderry Creek. The proposal is considered to occur near the vicinity of the northern extent for this species. The total population of *Eucalyptus langleyi* is many thousands of plants, and some of the known stands contain several hundred specimens. A more recent study by Kevin Mills & Associates (2002) surveyed the stands to the southwest of Nowra and counted over 4,000 plants in 13 stands.

However the impacts to the species near its northern extent are minimal with only two individuals likely to be directly impacted and the remaining population in this area mitigated against indirect impacts. It is, therefore, not considered likely that the proposal will adversely affect this species at the limit of its known distribution.

How is the proposal likely to affect current disturbance regimes?

Fire is considered part of this species current disturbance regime as with most Australian vegetation, particularly Eucalyptus species. The disturbance regime may be minimally altered due to the impacts from the proposal.

Wildfire will potentially be reduced as a result of lower rates of arson and dumped stolen cars within the reserve as a result of regular traffic flow and presence of people to dissuade arsonists. However, controlled fires (such as hazard reduction burns) will be largely unchanged as a result of the proposal, through continuing and pre-designated control activities during fire events (NPWS 2002).

Therefore, it is unlikely that the proposal will adversely affect the current disturbance regimes for *Eucalyptus langleyi*.

How is the proposal likely to affect habitat connectivity?

A maintained service road exists along the line of the proposed central route which already fragments the habitat. However, the proposal will further divide the bushland within the study area.

Individuals require pollinators and seed dispersal vectors to play a role in the lifecycle of the species. The proposed road is not likely to affect the movement of pollinators and seed dispersal thus maintaining the ability to be connected to adjacent and surrounding habitat.

Therefore, it is unlikely that the proposal will adversely affect the habitat connectivity for this species.

How is the proposal likely to affect critical habitat

No critical habitat for *Eucalyptus langleyi* has been identified by the Director-General of the National Parks & Wildlife Service (NSW) on the Register of Critical Habitat.

Conclusion:

No individuals will be impacted either directly or indirectly by the northern or southern routes. Potential impacts to two individuals due to the construction of the central route are unlikely to result in adverse impacts on this species. However, mitigation measures aimed at minimising the potential for indirect impacts associated with the construction of the central route will be implemented.

Bauer's Midge Orchid (*Genoplesium baueri*)

The species is listed as vulnerable under the TSC Act and is not currently listed under the EPBC Act.

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

Only a small number of individuals may potentially be indirectly impacted by the proposal and management measures will be implemented during and post construction to mitigate against indirect impacts to individuals and potential habitat. Given that there will be a relatively small impact footprint from the proposed activities, and the size of other remnant vegetation stands in the area, the action is unlikely to adversely affect the life cycle of a viable local population to put it at risk of extinction.

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

The species grows in sparse sclerophyll forest and moss gardens over sandstone and has been recorded from locations between Ulladulla and Port Stephens. Surveys undertaken by NSW National Parks and Wildlife in February 2010, within the Bomaderry Creek Regional Park recorded 7 clusters containing 14 individual specimens within the vicinity of the route corridor. However, only a small number of individuals may potentially be indirectly impacted as a result of the proposal.

Therefore, it is unlikely that the proposal will adversely impact on the habitat of this species.

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

This species has a broad distribution with records from locations between Ulladulla and Pert Stephens. The proposal will not occur at the limit of its known distribution.

How is the proposal likely to affect current disturbance regimes?

The proposal is likely to result in the loss of one individual of this species and potential indirect impacts will be mitigated against as outlined in section 6 of this report. It is unlikely that the proposal will adversely impact the current disturbance regime for this species.

How is the proposal likely to affect habitat connectivity?

The construction of a road through Bomaderry Regional Park will fragment the immediate available habitat. However, there is a permanently maintained service road already existing along the proposed route.

Considering the above, the distribution of this species from Ulladulla to Port Stephens, the relatively small amount of available habitat being lost within Bomaderry Regional Park and the movement patterns of this species likely to be influence by pollinator and seed dispersal factors, it is unlikely that the proposal will adversely affect habitat connectivity for this species.

How is the proposal likely to affect critical habitat

No critical habitat for *Genoplesium baueri* has been identified by the Director-General of the National Parks & Wildlife Service (NSW) on the Register of Critical Habitat.

Conclusion:

Genoplesium baueri has been reduced to 200+ plants across its range, therefore, all locations and individuals are of conservation significance. One individual would potentially be lost and a small number of individuals may be indirectly impacted as a result of the construction of the southern route.

***Hibbertia* sp. nov. 'Menai'**

This species is an undescribed species listed as endangered under the TSC Act. This taxon occurs in two regions separated by over 100km one of which occurs across the Toorooroo Plateau and nearby to the west of Nowra.

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

Little information has been recorded for the south coast population near Nowra in terms of habitat preference, longevity, seed biology and most aspects of its ecology (DECC 2010). It appears to propagate by seed and with most *Hibbertia* spp it is probably pollinated by bees.

Considering the relatively small amount of vegetation loss due to the proposal and large amount of suitable habitat in the area, it is unlikely that the proposal will have an adverse impact on this species.

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

The habitat for this species appears to be dry sclerophyll forest or woodland associations in sandy soils over sandstone. A number of plants have been recorded within the southern route (23) and central route (11).

Considering the relatively small amount of vegetation loss due to the proposal and large amount of suitable habitat in the area, it is unlikely that the proposal will have an adverse impact on this species.

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

This taxon occurs in two regions separated by over 100km one of which occurs across the Toorooroo Plateau and nearby to the west of Nowra. This proposal will occur at the limit of the known distribution for one of the regions. However, it is unlikely that the proposal will adversely affect the species at this limit of its distribution.

How is the proposal likely to affect current disturbance regimes?

It is unlikely that the proposal will adversely impact the current disturbance regime for this species.

How is the proposal likely to affect habitat connectivity?

There is a permanently maintained service road already existing along the proposed central route. It is regarded that the proposed action will not further isolate or fragment potential habitat for this species.

It is unlikely that the proposed action will adversely affect the habitat connectivity for this species.

How is the proposal likely to affect critical habitat

No critical habitat for this species has been identified by the Director-General of the National Parks & Wildlife Service (NSW) on the Register of Critical Habitat.

Conclusion:

Large numbers of the species grow west of Nowra. The number individuals likely to be lost as a result of either the southern or central route options only represent a small portion of the overall population within the region. No individuals were recorded within the construction footprint for the northern option. As

such, the construction of the North Nowra Link Road is not expected to result in adverse impacts on the species.

Bomaderry Zieria (*Zieria baeuerlenii*)

This species is listed as endangered under both the TSC and EPBC Acts. *Zieria baeuerlenii* occurs in only one location north-west of Nowra (Bomaderry Regional Park). The population occurs in a total of 57 colonies in six discrete clusters. These clusters are confined within a 0.5 km x 1.0 km area of the bushland, and are found on both sides of Bomaderry Creek (NSW DECC 2009b).

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

Zieria baeuerlenii does not reproduce sexually nor produce seed. Therefore, the movement of pollinators and seed dispersal vectors is not important. Fragmentation is considered a risk to the species because of the potential for the splitting of colonies of individuals. However, fragmentation of colonies or individuals is unlikely to impact on long-term survival as the species reproduces vegetatively with no associated risk, nor increased risk, of inbreeding depression.

Twenty separate genotypes have been identified and mapped (Barratt 1997) for the species, with each of these genotypes having been propagated at the Booderee Botanic Gardens. The current proposal does not split any genotypes nor isolate individuals from the rest of their genotype. The central route traverses close to one genotype (Gn1) which will be the focus of increased conservation and mitigation efforts.

Thus, it is unlikely that the proposal will adversely affect the lifecycle of this species.

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

Zieria baeuerlenii occurs in only one location, Bomaderry Regional Park, north-west of Nowra. The population occurs in a total of 57 colonies in six discrete clusters. These clusters are confined within a 0.5 km x 1.0 km area of the bushland, and are found on both sides of Bomaderry Creek (NSW DECC 2009b). The species is listed as endangered under both the TSC and EPBC Acts.

The presence of *Zieria baeuerlenii* was recorded adjacent to the proposed development footprint for the central route and within the immediate surrounds. Two individual *Zieria baeuerlenii* were recorded in the initial 30 metre road corridor within the 200 metre wide assessment corridor for the central route and the corridor design has since been modified to avoid impacts to these individuals.

The magnitude of clearing required for the proposal is minor with mitigation and management measures being implemented during and post construction (section 6). A small net loss of up to 2.8 ha of bushland from the 82 ha available within Bomaderry Regional Park will occur. Thus, it is unlikely that the proposal will adversely affect the available habitat for this species.

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

Zieria baeuerlenii is only known from the study area in the bushland around Bomaderry Creek. Thus the proposal falls within the area considered the limit of its known distribution. However, it is unlikely that the proposal will adversely affect individuals and the populations of this species at the limit of its known distribution. To reduce the risk of indirect impacts, a range of measures have been developed to mitigate potential impacts on the species along the central route.

How is the proposal likely to affect current disturbance regimes?

Barratt (1997) suggested that a major threat to the species was fire. Current understanding of the species suggests that the species can survive repeated lower intensity fires, although more frequent fire may prevent stem layering reproduction. The plants are known to resprout following fire (NSW DECC 2009b).

The impact of the proposal will potentially be reduced as a result of lower rates of arson and dumped stolen cars within the reserve as a result of regular traffic flow and presence of people to dissuade arsonists. The major impact from fire is likely to be through control activities during fire events (NPWS 2002) which will be largely unchanged as a result of the proposal.

Considering the above, the proposal is unlikely to adversely affect the disturbance regimes for *Zieria baeuerlenii.*

How is the proposal likely to affect habitat connectivity?

The issue of fragmentation for this species is unlike the majority of species. As *Zieria baeuerlenii* does not reproduce sexually nor produce seed, the movement of pollinators and seed dispersal vectors is therefore not important. Fragmentation of colonies of individuals is unlikely to impact on long-term survival as the species reproduces vegetatively with no associated risk, nor increased risk, of inbreeding depression.

The construction of a road may be seen to be a barrier to a species which reproduces vegetatively. However, as there is a permanently maintained service road along the line of the proposed central route, this barrier to the species is already operating.

The major concern in relation to fragmentation for this species is the splitting of colonies of individuals which belong to the same genotype. Twenty separate genotypes have been identified and mapped (Barratt 1997) for the species, with each of these genotypes having been propagated at the Booderee Botanic Gardens. The current proposal does not split any genotypes nor isolate individuals from the rest of their genotype. The central route traverses close to only one genotype (Gn1) which will be the focus of increased conservation and mitigation efforts.

It is, therefore, unlikely that the proposal will adversely affect habitat connectivity for *Zieria baeuerlenii.*

How is the proposal likely to affect critical habitat

At this time of this report, no critical habitat for Bomaderry Zieria has been identified by the Director-General of the National Parks & Wildlife Service (NSW) on the Register of Critical Habitat.

However, a recommendation for the identification of Critical Habitat for the Bomaderry Zieria (*Zieria baeuerlenii*) has been submitted to the Director-General of the National Parks & Wildlife Service (NSW) to be included on the Register of Critical Habitat. The status of this recommendation at the time of this report is 'pending finalisation'.

Conclusion:

It is unlikely that the proposal will adversely affect the *Zieria baeuerlenii.*

Glossy Black-cockatoo (*Calyptorhynchus lathami*)

The Glossy Black-cockatoo is listed as vulnerable under the TSC Act.

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

The species is dependent on large hollow-bearing eucalypts for nest sites and one or two eggs are laid between March and August. Concentrations of hollow-bearing trees and feed trees have been identified in the northern section of the study area and within the central route corridor (see **Figure 4** in section 2).

However, it is anticipated that only approximately 0.175 hectares will be cleared for the construction of the central route. This represents a very small proportion of the available nesting habitat within the study area that will be cleared for the construction of the road. Given that there will be a relatively small impact footprint from the proposed activities, and the size of other remnant vegetation stands in the area, the action is unlikely to adversely affect the life cycle of a viable local population to put it at risk of extinction.

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

It inhabits open forest and woodlands of the coast and the Great Dividing Range up to 1000 m in which stands of She-oak species, particularly Black She-oak (*Allocasuarina littoralis*), Forest She-oak (*A. torulosa*) or Drooping She-oak (*A. verticillata*), occur. It feeds almost exclusively on the seeds of several species of She-oak (*Casuarina* and *Allocasuarina* species), shredding the cones with its bill. The species is dependent on large hollow-bearing eucalypts for nest sites and one or two eggs are laid between March and August. The main habitat utilized by this species is the stands of Black She-oak that are mainly associated with the disturbed area in the north-western part of the Bomaderry Creek bushland.

The Glossy Black-cockatoo has previously been recorded in the study area and habitat suitable for the species is located throughout the region. Concentrations of hollow-bearing trees and feed trees have been identified in the northern section of the study area and within the central route corridor. It is anticipated that approximately 0.175 hectares of habitat will be cleared for the construction of the central route which is a small part of the overall foraging habitat within the region. A number of mitigation and management measures which will be implemented during and post construction (section 6) will help alleviate direct and indirect impacts to this species.

Therefore, it is unlikely that the proposal will adversely affect the habitat for this species.

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

The species is widespread throughout suitable forest and woodland habitats, from the central Queensland coast to East Gippsland in Victoria, and inland to the southern tablelands and central western plains of NSW.

The proposal is not at the limit of the known distribution for this species.

How is the proposal likely to affect current disturbance regimes?

The Glossy Black-cockatoo is a wide ranging species with the ability to traverse large distances. The proposal will not affect the current disturbance regime for this species.

How is the proposal likely to affect habitat connectivity?

The Glossy Black-cockatoo is a wide ranging species with the ability to traverse large distances. It is anticipated that 0.175 hectares of suitable habitat being lost will not impact on the habitat connectivity for this species.

It is unlikely that the proposal will have an adverse affect on the habitat connectivity for this species

How is the proposal likely to affect critical habitat

No critical habitat for *the* Glossy Black-cockatoo has been identified by the Director-General of the National Parks & Wildlife Service (NSW) on the Register of Critical Habitat.

Conclusion:

The amount of foraging habitat that is likely to be removed for the proposal options only represents a small part of the overall foraging habitat within the region. As such, it is unlikely that the proposal would result in adverse impacts for the Glossy Black-cockatoo.

Gang-gang Cockatoo (*Callocephalon fimbriatum*)

The Gang-gang Cockatoo utilises in tall mountain forests and woodlands, particularly in heavily timbered and mature wet sclerophyll forests during summer, and in winter they may occur at lower altitudes in drier more open eucalypt forests and woodlands, and often found in urban areas. The Gang-gang cockatoo tends to favour growth attributes for nesting and roosting (DECC 2009) and is listed as vulnerable under the TSC Act.

The clearing of potential foraging habitat along all three route corridors is not likely to adversely impact the Gang-gang Cockatoo. The species is known to range widely throughout the region and the potential habitat areas that will be cleared as a result of construction activities only represents a small part of the overall foraging habitat that is available throughout the region

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

The Gang-gang Cockatoo inhabits tall mountain forests and woodlands, particularly in heavily timbered and mature wet sclerophyll forests during summer, and in winter they may occur at lower altitudes in drier more open eucalypt forests and woodlands, and often found in urban areas. Potential nest trees occur in the vicinity of the proposed construction footprint.

Given that there will be a relatively small impact footprint from the proposed activities, and the size of other remnant vegetation stands in the area, the action is unlikely to adversely affect the life cycle of a viable local population to put it at risk of extinction

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

The Gang-gang Cockatoo is known to occur within the study area and is likely to be a regular visitor to the area during the winter months when the species ranges widely (Mills et al 2008). Potential foraging habitat includes essentially all of the woodland and forest in the area.

Given that there will be a relatively small loss of potential foraging habitat due to the proposed action and the amount remnant vegetation constituting suitable habitat in the area, the proposal is unlikely to adversely affect the habitat for this species

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

The Gang-gang Cockatoo is distributed from southern Victoria through south- and central-eastern New South Wales. In New South Wales, the Gang-gang Cockatoo is distributed from the south-east coast to the Hunter region, and inland to the Central Tablelands and south-west slopes.

This proposal does not occur at the known distribution limit for this species.

How is the proposal likely to affect current disturbance regimes?

The clearing of vegetation and degradation of habitat which may reduce the abundance of optimal foraging and roosting habitat is considered a major threat to the species. Given the abundance of suitable foraging and nesting habitat in the area, the small loss of suitable habitat due to the proposal and the ability for this species to traverse large distances, it is unlikely that the proposal will adversely affect the current disturbance regimes for this species.

How is the proposal likely to affect habitat connectivity?

The proposed action will not further isolate or fragment potential habitat for the Gang-gang Cockatoo, given that it is unlikely to isolate available foraging areas within the study area. This is primarily due to the high mobility of this species, the widespread distribution of potential habitat within local area and the already existing utilities maintenance track dividing the bushland within the central route.

How is the proposal likely to affect critical habitat

No critical habitat for the Gang-gang Cockatoo has been identified by the Director-General of the National Parks & Wildlife Service (NSW) on the Register of Critical Habitat.

Conclusion:

The amount of suitable habitat that is likely to be removed represents a small part of the overall foraging habitat within the region. As such, it is unlikely that the proposal would result in adverse impacts to the Gang-gang Cockatoo.

Square-tailed Kite (*Lophoictinia isura*)

The Square-tailed Kite is a reddish, medium sized, long-winged raptor and is listed as vulnerable under the TSC Act. It is a summer breeding migrant in the south-east, including the NSW south Coast, arriving in September and leaving by March. The species is found in a variety of timbered habitats including dry woodlands and open forest (DECC 2009).

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

The Square-tailed Kite is a summer breeding migrant in the south-east, including the NSW south Coast, arriving in September and leaving by March. It has previously been recorded within the study area and is a known summer breeding visitor to the Nowra – Jervis Bay region (KMA. 2008). There is suitable habitat for the species throughout the study area. However, this area of habitat is part of a very large foraging area for the species, covering thousands of hectares (KMA 2008).

Therefore, it is unlikely that the proposal will adversely affect the lifecycle of this species.

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

This species is known to forage over a huge territory including woodland, forests and open areas. All the woodland and forested areas within the study area have been classed as suitable foraging habitat for the Square-tailed Kite. Given the abundance of suitable foraging and nesting habitat in the area, the small loss of suitable habitat due to the proposal and the ability for this species to traverse large distances, it is unlikely that the proposal will adversely affect the current disturbance regimes for this species.

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

The species ranges along coastal and subcoastal areas from south-western to northern Australia, Queensland, NSW and Victoria.

This proposal does not occur at the limit of the known distribution for this species.

How is the proposal likely to affect current disturbance regimes?

Clearing, logging, burning, and grazing of habitats resulting in a reduction in nesting and feeding resources are current disturbance regimes contributing to the threats to this species. Given the abundance of suitable foraging and nesting habitat in the area, the small loss of suitable habitat due to

the proposal and the ability for this species to traverse large distances, it is unlikely that the proposal will adversely affect the current disturbance regimes for this species.

How is the proposal likely to affect habitat connectivity?

This species is known to forage over a huge territory including woodland, forests and open areas. It is regarded that the proposed action will not further isolate or fragment potential habitat for the Square-tailed Kite, given that it is unlikely to isolate available foraging areas within the study area. This is primarily due to the high mobility of this species and the widespread distribution of potential habitat within local area and surrounding region.

How is the proposal likely to affect critical habitat

No critical habitat for the Square-tailed Kite has been identified by the Director-General of the National Parks & Wildlife Service (NSW) on the Register of Critical Habitat.

Conclusion:

The amount of suitable habitat that is likely to be removed represents a small part of the overall foraging habitat within the region. As such, the clearing of vegetation associated with all three route options for the North Nowra Link Road is not expected to have an adverse impact on the Square-tailed Kite.

Powerful Owl (*Ninox strenua*)

The Powerful Owl is listed as vulnerable under the TSC Act.

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

The Powerful Owl inhabits woodland and open sclerophyll forest, tall open wet forest and rainforest. This species requires large areas of forest or woodland habitat in which to breed and forage but is also known to hunt over fragmented landscapes (DECC 2010). The species roosts by day in dense vegetation and nests in large tree hollows, typically trees of 80 – 240cm DBH. Prey items include small to medium sized mammals and birds, many of which are themselves dependant on tree hollows for shelter and reproduce.

Given the abundance of suitable foraging and potential nesting habitat in the area, the small loss of suitable habitat due to the proposal and the ability for this species to traverse large distances, it is unlikely that the proposal will adversely affect the current disturbance regimes for this species.

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

This species requires a large area to forage and breed and is known to hunt over fragmented landscapes. It has been identified that all stands of forest and woodland in the area would form the foraging area for one pair of owls. Nesting if it occurs would only be in the very tall Spotted Gums in the gorge which would not be affected by the proposal.

A very small amount of suitable habitat will be lost due to the proposal. Given the large amount of available habitat in the study area and surrounding region, it is unlikely that this species will be adversely affected by the proposal.

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

The Powerful Owl is endemic to eastern and south-eastern Australia, mainly on the coastal side of the Great Dividing Range from Mackay to south-western Victoria. In NSW, it is widely distributed throughout

the eastern forests from the coast inland to tablelands, with scattered, mostly historical records on the western slopes and plains.

This proposal will not occur at the limit of known distribution for the Power Owl

How is the proposal likely to affect current disturbance regimes?

Fragmentation of suitable forest and woodland habitat has been classified as a disturbance regime for this species contribution to one of the major threats. Given the large amount of suitable habitat in the area and the relatively small loss of habitat from the construction of the road, it is unlikely that the proposal will have an adverse affect on the current disturbance regime for this species.

How is the proposal likely to affect habitat connectivity?

This species requires large areas of forest or woodland habitat in which to breed and forage but is also known to hunt over fragmented landscapes (DECC 2010). A permanent maintenance track already exists along the proposed alignment for the central route, thus already dividing the bushland habitat in the study area.

The proposed action will not further isolate or fragment potential habitat for the Powerful Owl, given that it is unlikely to isolate available foraging areas within the study area. This is primarily due to the high mobility of this species and the widespread distribution of potential habitat within local area and surrounding region.

How is the proposal likely to affect critical habitat

No critical habitat for the Powerful Owl has been identified by the Director-General of the National Parks & Wildlife Service (NSW) on the Register of Critical Habitat.

Conclusion:

The Powerful Owl would not be adversely affected by the proposed construction of the North Nowra Link Road.

Masked Owl (*Tyto novaehollandiae*)

The Masked Owl (*Tyto novaehollandiae*) is listed as vulnerable under the TSC Act. (DEC 2006).

The Masked Owl is threatened by a number of processes including habitat clearing and fragmentation, loss of mature hollow bearing trees, predation on fledglings, secondary poisoning from pesticides, disease, and being hit by vehicles (DECC 2005). A combination of grazing and regular burning is also a threat, affecting the quality of ground cover for mammal prey, particularly in open, grassy forests (DECC 2005).

The Masked Owl is known to occur throughout the region and has a large foraging territory. The Atlas of NSW Wildlife shows that the species has previously been recorded in the Bomaderry Creek region and recent surveys recorded the species within the study area. It is likely that the species is an infrequent visitor to the study area and surrounding bushland. Given that the species has a large foraging territory and home range and that only a small amount of habitat suitable for the species would be impacted by clearing for any of the three route options, adverse impacts on the species are not considered likely.

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

This species roosts are located in live or occasionally dead hollow eucalypts, dense foliage in gullies and caves and recesses in cliffs (DEC 2006). They require mature forest or woodland with large hollow trees and dense trees or shrubs for fledglings to shelter in. Given the abundance of suitable foraging and nesting habitat in the area, the small loss of suitable habitat due to the proposal and the

requirement for a large home range, it is unlikely that the proposal will adversely affect the lifecycle for this species.

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

The Masked Owl occurs in undulating wet-dry forests of the coast and dry eucalypt forests of the tablelands, with optimal habitat including a mosaic of sparse (grassy) and dense (shrubby) groundcover on gentle terrain. The Masked Owl is widespread throughout the region and a few records have come from the Bomaderry Creek bushland. It requires a large territory for foraging and home ranges are estimated to be 400-1000 ha, varying with habitat productivity. The species forages preferentially in ecotones within forests or along forest edges but also in open areas, and usually hunts from a perch at or near ground level, sometimes near the edges of roads. The addition of a road in the study area may increase the available preferential feeding habitat in the area.

Given the above, the abundance of suitable foraging and nesting habitat in the area, the small loss of suitable habitat due to the proposal and the requirement for a large home range, it is unlikely that the proposal will adversely affect the lifecycle for this species.

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

Extends from the coast where it is most abundant to the western plains. Overall records for this species fall within approximately 90% of NSW, excluding the most arid north-western corner.

This proposal will occur outside the known limit of its known distribution for this species.

How is the proposal likely to affect current disturbance regimes?

The Masked Owl is threatened by a number of processes including habitat clearing and fragmentation, loss of mature hollow bearing trees, predation on fledglings, secondary poisoning from pesticides, disease, and being hit by vehicles (DECC 2005). A combination of grazing and regular burning is also a threat, affecting the quality of ground cover for mammal prey, particularly in open, grassy forests (DECC 2005).

Given the abundance habitat in the area and the small loss of suitable habitat due to the proposal it is unlikely that the proposal will adversely affect the current disturbance regimes for this species.

How is the proposal likely to affect habitat connectivity?

This species requires large areas of forest or woodland habitat in which to breed and forage but is also known to hunt over fragmented landscapes (DECC 2010). A permanent maintenance track already exists along the proposed alignment for the central route, thus already dividing the bushland habitat in the study area.

It is regarded that the proposed action will not further isolate or fragment potential habitat for the Masked Owl, given that it is unlikely to isolate available foraging areas within the study area. This is primarily due to the high mobility of this species and the widespread distribution of potential habitat within local area and surrounding region.

How is the proposal likely to affect critical habitat

No critical habitat for the Masked Owl has been identified by the Director-General of the National Parks & Wildlife Service (NSW) on the Register of Critical Habitat.

Conclusion:

It is unlikely that the impacts from the proposal will adversely affect the Masked Owl.

Sooty Owl (*Tyto tenebricosa*)

The Sooty Owl (Tyto tenebricosa) is listed as vulnerable under the TSC Act. (DEC 2006).

The Sooty Owl is threatened by a number of processes including habitat clearing and fragmentation, loss of mature hollow bearing trees, predation on fledglings, secondary poisoning from pesticides, disease, and being hit by vehicles (DECC 2005). A combination of grazing and regular burning is also a threat, affecting the quality of ground cover for mammal prey, particularly in open, grassy forests (DECC 2005).

The Sooty Owl is known to occur throughout the region and has a large foraging territory. The Atlas of NSW Wildlife shows that the species has previously been recorded in the Bomaderry Creek region and recent surveys recorded the species within the study area. It is likely that the species is an infrequent visitor to the study area and surrounding bushland. Given that the species has a large foraging territory and home range and that only a small amount of habitat suitable for the species would be impacted by clearing for any of the three route options, adverse impacts on the species are not considered likely.

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

This species roosts are located in live or occasionally dead hollow eucalypts, dense foliage in gullies and caves and recesses in cliffs (DEC 2006). They require mature forest or woodland with large hollow trees and dense trees or shrubs for fledglings to shelter in. Given the abundance of suitable foraging and nesting habitat in the area, the small loss of suitable habitat due to the proposal and the requirement for a large home range, it is unlikely that the proposal will adversely affect the lifecycle for this species.

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

Sooty Owls are associated with tall wet old growth forest on fertile soil with a dense understorey and emergent tall Eucalyptus species. Pairs roost in the daytime amongst dense vegetation, in tree hollows and sometimes in caves. The Sooty Owl is typically associated with an abundant and diverse supply of prey items and a selection of large tree hollows. The Sooty Owl is widespread throughout the region and a few records have come from the Bomaderry Creek bushland. It requires a large territory for foraging, varying with habitat productivity. The addition of a road in the study area may increase the available preferential feeding habitat in the area.

Given the above, the abundance of suitable foraging and nesting habitat in the area, the small loss of suitable habitat due to the proposal and the requirement for a large home range, it is unlikely that the proposal will adversely affect the lifecycle for this species.

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

The species occupies the easternmost one-eighth of NSW, occurring on the coast, coastal escarpment and eastern tablelands. There is no seasonal variation in its distribution.

This proposal will occur outside the known limit of its known distribution for this species.

How is the proposal likely to affect current disturbance regimes?

The Sooty Owl is threatened by a number of processes including habitat clearing and fragmentation, loss of mature hollow bearing trees, predation on fledglings, secondary poisoning from pesticides, disease, and being hit by vehicles (DECC 2005). A combination of grazing and regular burning is also a

threat, affecting the quality of ground cover for mammal prey, particularly in open, grassy forests (DECC 2005).

Given the abundance habitat in the area and the small loss of suitable habitat due to the proposal it is unlikely that the proposal will adversely affect the current disturbance regimes for this species.

How is the proposal likely to affect habitat connectivity?

A permanent maintenance track already exists along the proposed alignment for the central route, thus already dividing the bushland habitat in the study area.

It is regarded that the proposed action will not further isolate or fragment potential habitat for the Sooty Owl, given that it is unlikely to isolate available foraging areas within the study area. This is primarily due to the high mobility of this species and the widespread distribution of potential habitat within local area and surrounding region.

How is the proposal likely to affect critical habitat

No critical habitat for the Sooty Owl has been identified by the Director-General of the National Parks & Wildlife Service (NSW) on the Register of Critical Habitat.

Conclusion:

It is unlikely that the impacts from the proposal will adversely affect the Sooty Owl.

Spotted-tailed Quoll (*Dasyurus maculatus*)

The Spotted-tailed Quoll (*Dasyurus maculatus*) is listed as vulnerable the TSC Act and as endangered under the EPBC Act

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

Nesting occurs in rock shelters, hollow logs, caves or tree hollows and they use numerous dens within the home range. Estimates of home ranges vary from 800 ha to 20 km^2 and individuals may move several kilometres in a night.

The species has not been recorded within the study area and most records are from the escarpment to the north of Nowra indicating that the study area is not likely to be used as breeding habitat. However, all stands of forest and woodland within the study site are considered potential habitat. Given that there will be a relatively small impact footprint from the proposed activities, and the size of other remnant vegetation stands in the area, the action is unlikely to adversely affect the life cycle of a viable local population to put it at risk of extinction.

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

This species is found in a variety of habitats, including sclerophyll forest and woodlands, coastal heathlands and rainforests (DECCW 2009). There are records of the species in the Atlas of NSW Wildlife within a 10 km radius of the study area. The species has not been recorded within the study area and most records are from the escarpment to the north of Nowra. All stands of forest and woodland within the study site are considered potential habitat. This suggests that there is potential for the species to utilise the study area. However, due to the species highly mobile nature and large home ranges, adverse impacts due to the clearing of a small amount of potential foraging habitat (for any of the three route options) are not considered likely

However, considering the above, the small loss from the proposal is unlikely to adversely affect the habitat of this species.

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

It occupies a range of environments with a disjunct distribution along the east coast of Australia, extending from south-eastern Queensland through NSW and Victoria to Tasmania. The impacts from the proposal will not occur at the limit of the known distribution for the Spotted-tailed Quoll.

How is the proposal likely to affect current disturbance regimes?

The building of a 1.8 km road is not considered a current disturbance regime nor is it considered likely to impact the current disturbance regimes for the Spotted-tailed Quoll.

How is the proposal likely to affect habitat connectivity?

The proposal is likely to further fragment a small amount of potential habitat within the study area that is already divided by a permanent utilities maintenance track. However, the Spotted-tailed Quoll is a highly mobile species with a home range up to 20km^2 for males. Considering the lack of records within the study area and ability to traverse large distances, the impacts from the proposal are not considered likely to affect habitat connectivity for the Spotted-tailed Quoll.

How is the proposal likely to affect critical habitat

No critical habitat of this species has been identified by the Director-General of the National Parks & Wildlife Service (NSW) on the Register of Critical Habitat.

Conclusion:

The Spotted-tailed Quoll would not be adversely affected by the proposed road upgrade

Large-footed Myotis (*Myotis macropus*)

Large-footed Myotis is listed as vulnerable under the TSC Act (DECC 2008). Roost sites in the vicinity of waterways are preferred, and include caves, anthropogenic features (such as bridges), tree hollows and clumps of vegetation.

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

Given that there will be a relatively small impact footprint from the proposed activities, and the size of other remnant vegetation stands in the area, the action is unlikely to adversely affect the life cycle of a viable local population to put it at risk of extinction.

Therefore, it is unlikely that the proposal will adversely affect the lifecycle for this species.

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

Roost sites in the vicinity of waterways are preferred, and include caves, anthropogenic features (such as bridges), tree hollows and clumps of vegetation. The species was previously recorded in the gorge at the southern end of the study area (Parnaby 1996) and may be a possible resident in this area, utilising habitat features such as the pools along Bomaderry Creek and possibly, caves where roosting could occur. The area of potential Large-footed Myotis habitat to be removed or modified under the current proposal is small with respect to the amount of similar habitat available throughout the region. A range of mitigation and management measures will alleviate indirect impacts on the habitat for this species.

Therefore, it is unlikely that the proposal will adversely affect the habitat for this species.

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

The Large-footed Myotis is found in the coastal band from the north-west of Australia, across the top-end and south to western Victoria.

This proposal is not at the limit of the known distribution for this species.

How is the proposal likely to affect current disturbance regimes?

The loss of hollow bearing trees is a major threat to the Large-footed Myotis. The proposed action within certain areas of the site may constitute a key threatening process for the loss of hollow bearing trees under the *Threatened Species Conservation Act 1995*.

However, the scale of these impacts within the study area is not considered to be significant in relation to Large-footed Myotis habitat requirements.

How is the proposal likely to affect habitat connectivity?

It is regarded that the proposed action will not further isolate or fragment potential habitat for the Large-footed Myotis, given that it is unlikely to isolate available foraging areas (water bodies) within the study area. This is primarily due to the high mobility of this species, and the widespread distribution of potential habitat within local area.

How is the proposal likely to affect critical habitat

No critical habitat of this species has been identified

Conclusion:

It is unlikely that the proposal will have an adverse impact to this species.

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

The Grey-headed Flying-fox is listed as vulnerable under both the EPBC Act and TSC Act.

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

Although the species has been recorded in the southern corner of the site, the majority of mature foraging eucalypts would be retained in the study area and thus the area of habitat lost is considered insignificant with regard to the Grey-headed Flying-fox.

Given that there will be a relatively small impact footprint from the proposed activities, and the size of other remnant vegetation stands in the area, the action is unlikely to adversely affect the life cycle of a viable local population to put it at risk of extinction

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

The species inhabits a wide range of habitats including rainforest, mangroves, paperbark forests, wet and dry sclerophyll forests and cultivated areas (Churchill 1998, Eby 1998).

The Grey-headed Flying-fox may visit the site to forage on flowering eucalypts although this would be infrequent. The area of potential Grey Headed Flying Fox habitat to be removed or modified under the current proposal is small with respect to the amount of similar habitat available throughout the region. The majority of mature foraging eucalypts would be retained in the study area and thus the area of habitat lost is considered insignificant with regard to the Grey-headed Flying-fox. The proposal is unlikely to impact on the habitat of this species.

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

The Grey-headed Flying-fox is highly mobile and known to occur along the east coast of Australia from Bundaberg in Queensland to Melbourne in Victoria. This proposal is not at the limit of the known distribution.

How is the proposal likely to affect current disturbance regimes?

The building of a 1.8 km road is not considered a current disturbance regime nor is it considered likely to impact the current disturbance regimes of the Grey-headed Flying fox.

How is the proposal likely to affect habitat connectivity?

It is regarded that the proposed action will not further isolate or fragment potential habitat for the Grey-headed Flying-fox, given that it is unlikely to isolate available foraging areas within the study area. This is primarily due to the high mobility of this species, and the widespread distribution of potential habitat within local area.

Therefore, the impacts from the proposal are not considered likely to affect habitat connectivity for the Grey-headed Flying-fox.

How is the proposal likely to affect critical habitat

No critical habitat of this species has been identified by the Director-General of the National Parks & Wildlife Service (NSW) on the Register of Critical Habitat.

Conclusion:

The Grey-headed Flying-fox would not be adversely affected by the proposed road upgrade.

Yellow-bellied Glider (*Petaurus australis*)

The Yellow-bellied Glider is listed as vulnerable under the TSC Act.

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

The species inhabits tall, mature moist eucalypt forests along the coast and ranges of eastern Australia. Its range extends from central Queensland to southern Victoria. The species diet is comprised of pollen, nectar, eucalypt sap and insects. Habitat suitable for the species is known to occur throughout the study area.

Given that there will be a relatively small impact footprint from the proposed activities, and the size of other remnant vegetation stands in the area, the action is unlikely to adversely affect the life cycle of a viable local population to put it at risk of extinction.

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

The Yellow-bellied Glider has a large home range, and occurs throughout the Shoalhaven region. The species has previously been recorded at various locations within the study area. Suitable habitat is known to occur throughout the study area. The northern route option has suitable habitat on the edge of the road corridor and the central and southern options have suitable habitat on both sides of the proposed road corridor.

The northern and central corridors are not likely to impact on feed trees. However, the southern option has potential to require the clearing of possible feed trees which may result in indirect impacts on the species. Although feed trees may be impacted by the construction of the southern route, it is unlikely that this will result in adverse impacts on the Yellow-bellied Glider as it only represent a small part of the species overall habitat in within the region. The northern and central route would not impact on any potential habitat for the species and impacts are not considered likely.

Therefore, it is unlikely that the proposal will adversely affect the habitat for this species.

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

The Yellow-bellied Glider is found along the eastern coast to the western slopes of the Great Dividing Range, from southern Queensland to Victoria.

The proposal will not occur at the limit of the known distribution for this species.

How is the proposal likely to affect current disturbance regimes?

The proposal will not affect the current disturbance regimes for this species.

How is the proposal likely to affect habitat connectivity?

It is regarded that the proposed action will not further isolate or fragment potential habitat for the Yellow-bellied Glider given that it is unlikely to isolate available foraging areas within the study area. This is primarily due to the high mobility of this species, and the widespread distribution of potential habitat within local area.

Therefore, the impacts from the proposal are not considered likely to affect habitat connectivity for the Yellow-bellied Glider.

How is the proposal likely to affect critical habitat

No critical habitat of this species has been identified by the Director-General of the National Parks & Wildlife Service (NSW) on the Register of Critical Habitat

Conclusion:

A minor indirect impact may occur to foraging habitat in the southern route option but not impacts on potential habitat are likely to arise from the central and northern routes. Given that there will be a relatively small impact footprint and the available habitat in the area, the proposal is unlikely to adversely affect the Yellow-bellied Glider.

Giant Burrowing Frog (*Heleioporus australiacus*)

The GBF is listed as a vulnerable species under both the TSC and EPBC Acts. Most records for this species occur in dry sclerophyll forests, although it has been reported to use wet habitats for breeding sites.

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

GBF was recorded on the site in 1992 but not since, despite several targeted surveys. While the habitat is suitable for the species, it is more limited in size and quality than other known habitat in the Shoalhaven Region (e.g. Vincentia and Booderee National Park). The potential breeding sites observed during the survey were also relatively small and would appear to be rarely inundated with water and thus providing sub-optimal breeding habitat.

The area of potential habitat is proposed for inclusion within the Bomaderry Creek Regional Park as part of a 50 hectare offset. This measure will ensure that if the species is found to be present an area of habitat will be afforded a high level of protection. Potential indirect impacts on this species habitat will be mitigated through a range of measures.

Therefore, it is unlikely that the proposal will adversely affect the lifecycle for this species.

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

A single possible call was heard (Garry Daly, DECC 2009c) from within the study area in 1992. The species has not been found in the study area since. However, the proposed route traverses an area containing potential suitable moist sandstone habitat. Direct impacts on this potential habitat will be limited to clearing a small area of habitat on the northern side of the central route corridor. There is also potential for indirect impacts including, road mortality, potential water quality and hydrologic changes in the area over which the species are likely to range. Many of these indirect factors can be avoided or mitigated.

Given that the area of potential habitat for this species is proposed for inclusion within the Bomaderry Creek Regional Park, indirect impacts on this species habitat will be mitigated through a range of measures, and that only a small area of suitable habitat may be cleared, it is unlikely that the proposal will adversely affect the habitat for this species.

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

The Giant Burrowing Frog is distributed in south eastern NSW and Victoria, and appears to exist as two distinct populations: a northern population largely confined to the sandstone geology of the Sydney Basin and extending as far south as Ulladulla, and a southern population occurring from north of Narooma through to Walhalla, Victoria.

The proposal will not occur at the limit of the known distribution for this species.

How is the proposal likely to affect current disturbance regimes?

Climate change is considered a threat and current disturbance regime for this species as is fragmentation and the species vulnerability to stochastic events as a result.

Considering the nature of the proposal and the range of mitigation and management measures that will be implemented, it is unlikely that the proposal will adversely affect the current disturbance regimes for this species.

How is the proposal likely to affect habitat connectivity?

The proposal is likely to provide protection to 50 ha of potential habitat through the inclusion of this habitat to the Bomaderry Regional Park. Direct impacts on this potential habitat will be limited to clearing a small area of habitat on the northern side of the central route corridor. It is regarded that the proposed action will not further isolate or fragment potential habitat for this species.

Given a permanent utility maintenance track already exists along the alignment of the proposed central route, the amount of available habitat in the area and the mitigation and management measures that will be implemented, it is unlikely that the proposal will adversely affect the habitat connectivity for this species.

How is the proposal likely to affect critical habitat

No critical habitat of this species has been identified by the Director-General of the National Parks & Wildlife Service (NSW) on the Register of Critical Habitat

Conclusion:

The Giant Burrowing Frog would not be adversely affected by the proposed construction of the North Nowra Link Road.

Appendix B – Kevin Mills, Supplementary Flora and Fauna Information

SUPPLEMENTARY FLORA AND FAUNA INFORMATION

NORTH NOWRA LINK ROAD
CITY OF SHOALHAVEN

prepared by

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Contents

1. Introduction

Shoalhaven City Council is planning for a new road at North Nowra, commonly known as the North Nowra Link Road. This has been the subject of numerous investigations over the past few years. Most recently flora and fauna reports have been prepared by KMA (2008) and EcoLogical (2010).

The purpose of this study is to provide supplementary information to the above two reports as part of Council's documentation for presentation to the Department of Planning under the Part 3A application process. In particular, the study covers the following matters:

- mapping the plant communities along each route option;
- mapping the distribution of potential habitat for selected threatened animal species in the area;
- mapping the occurrence of threatened plant species found in the vicinity of each route option; and
- identification, assessment and/or mapping of any other plants or communities that may be important.

Detailed descriptions and other information regarding the study areas is contained in previous reports and is not repeated here.

2. Supplementary Information

2.1 Plant Community Mapping

The plant communities occurring in the Bomaderry Creek area have been identified, described and at least partially mapped in previous studies. The relevant communities along the three route options are summarised in **Table 1**. The occurrence of these communities along the three route options is shown on the accompanying maps; see **Appendix 6**. The mapping shows the plant communities within 100 metres on both sides of the surveyed centre line of each option. Those areas that have been cleared of their original vegetation, including bare areas and residential land, are indicated on the maps as CL – cleared land.

Table 1
Plant Communities occurring in the Bomaderry Creek Area

Map Unit[1] **Plant Community**	**Key Species**	**Occurrence/Route Option(s)**
Map Unit GRG-COM **Gorge Complex**		
Coachwood Warm Temperate Rainforest	*Ceratopetalum apetalum* *Backhousia myrtifolia*	In the base of the gorge, along the banks of the creek. Only on the southern route.
Spotted Gum - Turpentine Tall Forest (MAC-SYN)	*Corymbia maculata* *Eucalyptus saligna/* *Eucalyptus botryoides* *Syncarpia glomulifera*	On the upper slopes of the gorge, just below the cliffline. Occurs on all three routes.
Riparian Association	*Tristaniopsis laurina* *Casuarina cunninghamiana*	Along immediate edge of Bomaderry Creek.
Map Unit PUN-AGG		
Grey Gum - Stringybark Forest/Woodland	*Eucalyptus punctata* *Eucalyptus agglomerata* *Corymbia gummifera* *Corymbia maculata* (occasional)	On gentle slopes above the gorge, usually on rocky ground. Occurs on all route options.
Map Unit SCL-GUM		
Scribbly Gum - Casuarina Forest/ Woodland	*Eucalyptus sclerophylla* *Allocasuarina littoralis* *Corymbia gummifera*	Scattered across the plateau on all route options, large area in northwest corner.

Table 1 cont...
Plant Communities occurring in the Bomaderry Creek Area

Map Unit[1] **Plant Community**	**Key Species**	**Occurrence/Route Option(s)**
Scribbly Gum - Bloodwood Woodland	*Eucalyptus sclerophylla* *Corymbia gummifera* *Eucalyptus consideniana*	Extensive across the plateau on all route options.
Map Unit KUN-SHR Kunzea Shrubland	*Kunzea ambigua* *Leptospermum sejunctum*	On broad rock outcrops above the gorge. On the Central route option.
Map Unit SST-SDG Sandstone Sedgeland	*Melaleuca thymifolia* *Viminaria juncea* *Leptospermum* spp.	Small areas on the plateau, on shallow, moist soils covering broad areas of bedrock.

1. Based on Mills (1998).

Based on the vegetation mapping, as digitised into Council's GIS, the following amount of clearing is calculated along each route option. The assumed width of clearing along each route is generally 16 metres. These figures should replace those previously given in the report by KMA (2008).

Table 2
Areas of each Plant Community that would be cleared on each Route Option

Plant Community	Southern	Central	Northern
Gorge Complex	2,368 m^2	1,042 m^2	670 m^2
Spotted Gum - Turpentine Tall Forest	nil	nil	4,294 m^2
Grey Gum - Stringybark Forest/Woodland	21,193 m^2	9,620 m^2	nil
Scribbly Gum - Casuarina Forest/Woodland and Scribbly Gum - Bloodwood Forest/Woodland	14,589 m^2	11,614 m^2	40,224 m^2
Kunzea Shrubland	1,210 m^2	813 m^2	nil
Sandstone Sedgeland	1,723 m^2	nil	nil
Total Clearing	**41,353 m^2**	**23,089 m^2**	**45,188 m^2**
Hectares	**4.14 ha**	**2.31 ha**	**4.52 ha**

2.2 Threatened Plant Species

The descriptions and distribution information in the reports by KMA (2008) and EcoLogical (2010) cover all of the following species except the undescribed *Hibbertia* species. Those reports should be read for that information. This report concentrates on the known records of the species in the vicinity of the route options. The *Hibbertia* species is dealt with in full, as it has not been addressed previously at North Nowra. New GPS points were recorded during the field surveys in May 2010 for all relevant plant species, except *Zieria baeuerleni* and *Genoplesium baueri*. Various maps have been prepared for each species as part of the study.

2.2.1 Genoplesium baueri

Local Records:
Recently discovered by NPWS near the central route option in February 2010. Council has these locations in its GIS.

Habitat:
At Bomaderry Creek, the orchid grows in woodland (SCL-GUM). The orchid apparently grows mainly in gaps in the dense shrubby understorey that forms in this woodland when it remains unburnt.

Local Habitat:
The area of potential habitat lost by each option is estimated to be: Southern - 14,589 m^2; Central - 11,614 m^2; and Northern - 40,224 m^2.

Map:
The map shows the GPS points for the species recorded by the NPWS in February 2010, and the area of potential habitat.

2.2.2 Zieria baeuerlenii

Local Records:
This shrub is endemic to the Bomaderry Creek area. The species has been surveyed on many occasions by various people; the location and number of plants in existence is quite well known.

Habitat:
The species grows in Grey Gum - Blue Stringybark Woodland (PUN-AGG), in a narrow band on the gentle and rocky slope above the gorge at Bomaderry Creek.

Local Habitat:
The area of potential habitat lost by each option is estimated to be: Southern – 21,193 m^2; Central – 9,620 m^2; and Northern - nil.

Map:
The map shows the GPS points for the species recorded by the NPWS and others, and the area of potential habitat as an envelope around those points. Although various workers have recorded the locations of this species over several years, there is consistency in the positioning that confirms the accuracy of the recordings.

2.2.3 Eucalyptus langleyi

Local Records:
This species is endemic to the Shoalhaven region, principally to the southwest of Nowra. The only known plants north of the Shoalhaven River occur in the Bomaderry Creek area. A comprehensive paper on this species is attached at **Appendix 8**.

Habitat:
This species grows in woodland, open woodland and shrubland, particularly where there is exposed sandstone bedrock. It is restricted to the Nowra Sandstone.

Local Habitat:
The species only occurs to the east of the gorge, where recent GPS points were recorded; see **Appendix 1**. Council has these locations in its GIS; see attached map.

Map:
The map shows the GPS points for the species recorded in May 2010, and the area of potential habitat as an envelope around those points.

Preliminary Listing as an Endangered Population
The NSW Scientific Committee made a Preliminary Determination to list the Bomaderry population of *Eucalyptus langleyi* as an endangered population on 11 June 2010. This is open for public comment until

6 August 2010. If this proposal reaches the Final Determination stage, the assessment required is the same as was undertaken for the species *Eucalyptus langleyi* in our previous report, with additional considerations to be made at steps 3, 4 and 5 in the Part 3A assessment. These are addressed below.

Step 3 – Evaluation of Impact

The impact of each route option on the population of *Eucalyptus langleyi* is summarised below. A recent survey for the plants at Bomaderry produced the following results (Mills 2010).

Stand No.	Location Land Tenure	Alt.	No. Plants (year[1])	Vegetation Type
23	S of Picnic area, Bomaderry Creek Regional Park. Berry 1:25,000 0279696 6141388 NPWS reserve.	35m	15 (2010)	Woodland
24	N of power line, E side of Bomaderry Creek. Berry 1:25,000 0279724 6141564 Shoalhaven City Council	35m	10 (2010)	Open woodland - shrubland

1. Year last counted by author.

Southern

No plants of *Eucalyptus langleyi* occur along this route.

Central

Two plants would probably be lost, as they are below the proposed bridge.

Northern

No plants of *Eucalyptus langleyi* occur along this route.

Step 4 – Avoid, mitigate and then offset

The southern and northern routes would avoid any impact upon this species. If the central route is chosen, then two plants would probably be lost. Council owns the land on which another nine (9) plants occur and that land could be dedicated as part of Bomaderry Creek Regional Park as an offset.

Step 5 – Key thresholds

The justifications in the *Guidelines* are addressed below. Note that the northern and southern routes need not be considered here.

whether or not the proposal, including actions to avoid or mitigate impacts or compensate to prevent unavoidable impacts, will maintain or improve biodiversity values.

Dedication of the land upon which the specimens of *E. langleyi* occur north of the central road route would lead to improved management of that area by including it within a conservation reserve. This would be an improvement over the current unmanaged situation. The death of two plants out of the 25 that represent the potential 'endangered population' would be a loss to biodiversity. In terms of the conservation of the species as a whole, it is a negligible loss (see **Appendix 8**).

whether or not the proposal is likely to reduce the long-term viability of a local population of the species, population or ecological community.

The 'local population' is the population in the Bomaderry Creek bushland, proposed as an 'endangered population'. The loss of two plants would not necessarily reduce the viability of the population this is more dependent upon management of the local area. This management would be improved if the Council land was dedicated as a part f eh NPWS reserve.

whether or not the proposal is likely to accelerate the extinction of the species, population or ecological community or place it at risk of extinction.

The loss of two plants would not have any impact upon the risk of extinction of the species, as it is so common elsewhere. In terms of the local population, it would not necessarily increase the risk to the population, this is more dependent upon management of the locality.

whether or not the proposal will adversely affect critical habitat.
There is no critical habitat declared for *Eucalyptus langleyi*.

2.2.4 Hibbertia sp. nov. 'Menai'

Local Records:
This taxon is known from Sutherland to the south of Sydney and to the southwest of Nowra (Mills 2009; see **Appendix 7**). The current study discovered plants at Bomaderry Creek that closely resemble this as yet undescribed taxon. The species is abundant (in the tens of thousands of plants) in the Colymea area west of Nowra (Mills 2009). The assessment of this species is provided in Section 2.6.

In all 45 pants were found at Bomaderry Creek. The suitable habitat there was not searched systematically, and it is considered that there are probably hundreds of plants in the area. Although the main populations are well to the southwest of Nowra, there are plants scattered throughout the sandstone country between North Nowra and the apparent centre of distribution of the taxon at Colymea, although a full survey has not been undertaken as the taxon has only recently been recognised.

Habitat:
The species grows in woodland, open woodland and heathland, particularly where shrubs are not too thick.

Local Habitat:
At Bomaderry Creek, the species grows in Grey Gum - Blue Stringybark Woodland (PUN-AGG) and Scribbly Gum - Bloodwood Woodland (SCL-GUM). The recent GPS points recorded are given in **Appendix 2**.

The area of potential habitat lost by each option is estimated to be: Southern – 35,782 m^2; Central – 21,234 m^2; and Northern - 40,894 m^2.

Map:
The map shows the GPS points for the species recorded in May 2010, and the area of potential habitat based on the known occurrence of the taxon in the area.

2.3 Other Significant Plant Species

2.3.1 Leptospermum sejunctum

Local Records:
This tall shrub is endemic to the Shoalhaven region, principally between North Nowra and Yalwal Creek, where it is often abundant.

Habitat:
This species grows on the Nowra Sandstone in woodland, open woodland and shrubland. It mostly grows where there is exposed sandstone bedrock.

Local Habitat:
At Bomaderry Creek, the species grows in Grey Gum - Blue Stringybark Woodland (PUN-AGG) and Kunzea Shrubland (KUN-SHR). The area of potential habitat lost by each option is estimated to be: Southern – 1,210 m^2; Central – 813 m^2; and Northern - nil.

Map:
The map shows the area of potential habitat based on the known occurrences of the species in the area.

2.3.2 Acacia subtilinervis

*Local Records*This species is found, often in abundance, throughout the sandstone country in the Shoalhaven.

Habitat:

The species grows in woodland, open woodland and, particularly, shrubland growing on sandstone bedrock surfaces.

Local Habitat:
The species is common in a few places around Bomaderry Creek. There, it is growing in Grey Gum - Blue Stringybark Woodland (PUN-AGG), Kunzea Shrubland (KUN-SHR) and Scribbly Gum – Bloodwood Woodland (SCL-GUM). The recent GPS points recorded are given in **Appendix 3.** The area of potential habitat lost by each option is estimated to be: Southern – 1,210 m^2; Central – 813 m^2; and Northern - nil.

Map:
The map shows the GPS points for the species recorded in May 2010, and the area of potential habitat based on the known occurrence of the species in the area.

2.4 Threatened Animal Species

The descriptions and distribution information in the reports by KMA (2008) and EcoLogical (2010) cover all of the following species. Those reports should be read for information on local records, etc. This report concentrates on the known and potential habitat of each species, particularly mapping of habitat for each species.

2.4.1 Grey-headed flying-fox

Local Records:
The species is a regular summer visitor to the Nowra area. Camps are known from the moist escarpment forests well to the north and south of Nowra.

Habitat:
The species camps in rainforest and similar dense forest. The bats forage very widely on a nightly basis, including forest, woodland, parks and gardens.

Local Habitat:
All treed areas are potential foraging habitat for this bat. The area of potential foraging habitat lost by each option is estimated to be: Southern – 38,420 m^2; Central – 22,276 m^2; and Northern – 67,464 m^2.

Map:
The map shows the potential foraging habitat; this is essentially all of the woodland and forest in the area.

2.4.2 Spotted-tailed Quoll

Local Records:
Most records are form the escarpment area to the north of Nowra, with scattered records elsewhere.

Habitat:
All stands of forest and woodland in the area are potential habitat.

Local Habitat:
All stands of forest and woodland in the area would be potential habitat, but the presence of this species at Bomaderry Creek has not been confirmed. The one local record is to the west among houses near Judith Drive. The area of potential foraging habitat lost by each option is estimated to be: Southern – 38,420 m^2; Central – 22,276 m^2; and Northern – 67,464 m^2.

Map:
The map shows the potential habitat; this is essentially all of the woodland and forest in the area.

2.4.3 Masked Owl

Local Records:

The species is widespread in the region. Locally, there are a few records from the Bomaderry Creek bushland.

Habitat:
The owl inhabits forests and woodlands, particularly foraging on the more open edges of forests. Nesting is in tree hollows.

Local Habitat:
All stands of forest and woodland in the area would form the foraging area for one pair of owls. The area of potential foraging habitat lost by each option is estimated to be: Southern – 38,420 m^2; Central – 22,276 m^2; and Northern – 67,464 m^2.

Map:
The map shows the potential foraging habitat; this is essentially all of the woodland and forest in the area. The map is combined with the Powerful Owl map, as the potential habitat is essentially the same.

2.4.4 Powerful Owl

Local Records:
There are numerous records of eh owl in the Shoalhaven where it is widespread throughout the region. Locally, there are a few records from the Bomaderry Creek bushland.

Habitat:
The owl lives mainly in tall forests and nearby forests and woodlands; populations of arboreal mammals are required. Nesting is in hollows very tall forest trees.

Local Habitat:
All stands of forest and woodland in the area would form the foraging area for one pair of owls; nesting, if it occurs would only be in the very tall Spotted Gum trees in the gorge. The area of potential foraging habitat lost by each option is estimated to be: Southern – 38,420 m^2; Central – 22,276 m^2; and Northern – 67,464 m^2.

Map:
The map shows the potential foraging habitat; this is essentially all of the woodland and forest in the area. The map is combined with the Masked Owl map, as the potential habitat is essentially the same.

2.4.5 Square-tailed kite

Local Records:
The species is a regular summer breeding visitor to the Shoalhaven, it is mostly observed between about Nowra and St Georges Basin.

Habitat:
The kite forages over a huge territory, including forest, woodland and open areas.

Local Habitat:
All stands of forest and woodland in h area would form the foraging area. nesting could occur, but this is probably more likely in more remote areas of forest. The area of potential foraging habitat lost by each option is estimated to be: Southern – 38,420 m^2; Central – 22,276 m^2; and Northern – 67,464 m^2.

Map:
The map shows the potential foraging habitat; this is essentially all of the woodland and forest in the area.

2.4.6 Yellow-belied Glider

Local Records:
The Yellow-bellied Glider has been known to occur in the Bomaderry Creek area for over 15 years. Surveys over that time have consistently found the species or the evidence of the glider in the form of feeding scars on Grey Gum trees.

Habitat:
The species inhabits forest and woodland where their preferred feed tree species occur. In the Shoalhaven region important trees are Spotted Gum, Grey Gum and Red Bloodwood.

Local Habitat:
The tall forest and Grey Gum Woodland around the gorge is the core area of habitat in this area. The species has been shown to feed on the Grey gums and use the hollows in the tall Spotted Gum for denning. The recent GPS points recorded for identified feed trees are given in **Appendix 4**.

Map:
The map shows the GPS points for the identified feed trees recorded in 2010, and the area of potential habitat based on the known occurrence of the species and these trees in the area. The area of potential foraging habitat lost by each option is estimated to be: Southern – 23,831 m^2; Central – 10,662 m^2; and Northern – 670 m^2.

2.4.7 Glossy Black-Cockatoo

Local Records:
The species occurs throughout Shoalhaven, many sites support a resident population that is regularly recorded. The species regularly visits the Bomaderry Creek area where the evidence of its feeding is found below Black She-oak trees.

Habitat:
Locally, the species forages primarily on Black She-oak seeds and nests in large tree hollows.

Local Habitat:
The main habitat utilised by this species are the stands of Black She-oak that are mainly associated with the disturbed area in the north-western part of the Bomaderry Creek bushland. There feed trees are regularly found; recent GPS points recorded for identified feed trees are given in **Appendix 5.**

Map:
The map shows the GPS points for the identified feed trees recorded in 2010, and the area of potential habitat based on the known occurrence of the species and stands of Black She-oak trees in the area. That map was prepared by marking the occurrence of stands of Black She-oak on a colour aerial photograph in the field. Stands were identified from previous and current field inspections and from aerial photographs. Black She-oak is a coloniser of disturbed land, so that the distribution pattern in the area is largely determined by past disturbance, hence the line of trees along West Cambewarra Road and the extensive stands on the old gravel pit near Pitt Street

2.4.8 Gang-gang Cockatoo

Local Records:
The cockatoo is regularly recorded in the Shoalhaven, including the North Nowra area. It is present in most months, perhaps being more obvious in winter when birds from the tablelands visit the coast and birds forage more widely.

Habitat:
The Gang-gang Cockatoo inhabits forests and woodlands, where it primarily feeds of eucalypt fruit and other dry fruit. The area of potential foraging habitat lost by each option is estimated to be: Southern – 38,420 m^2; Central – 22,276 m^2; and Northern – 67,464 m^2.

Local Habitat:
The foraging habitat includes all areas of woodland and forest; nesting could occur in the taller forest in the gorge.

Map:
The map shows the potential foraging habitat; this is essentially all of the woodland and forest in the area.

2.5 Plant Communities of Importance

The vegetation in the Bomaderry Creek area is in the main common and widespread in the locality and the region. The least common is the rainforest within the gorge. This rainforest is of particular interest as it is at a low altitude in an unusual location for rainforest dominated by Coachwood. None of the route options impact in any way on the rainforest.

2.6 Impact assessment Hibbertia sp. nov. 'Menai'

The taxon *Hibbertia* sp. nov. 'Menai' requires a full assessment under Part 3A, as its known occurrence at Bomaderry Creek is recent and it has not previously been assessed. This species is not included in the Director-General's requirements as it as only recently found in this area.

Guidelines for Threatened Species Assessment
Guidelines that identify matters relevant to the assessment of potential impact on threatened species, populations or ecological communities of proposed development under Part 3A of the *Environmental Planning and Assessment Act 1979* (NSW) have been prepared by the Department of Environment and Conservation (now Department of Environment and Climate Change) and the Department of Primary Industries (DEC July 2005).

The *Guidelines for Threatened Species Assessment* identify the following objectives in regard to conserving threatened species, etc.:

1 "Maintain or improve biodiversity values (i.e. there is no net impact on threatened species or native vegetation).
2 Conserve biological diversity and promote ecologically sustainable development.
3 Protect areas of high conservation value (including areas of critical habitat).
4 Prevent the extinction of threatened species.
5 Protect the long-term viability of local populations of a species, population nor ecological community.
6 Protect aspects of the environment that are matters of national environmental significance."

Note that matters of national environmental significance (NES) are those matters listed under the *Environment Protection & Biodiversity Conversation Act 1999* (Commonwealth); these matters are not listed under state legislation, although there is considerable overlap in the species and communities that area listed.

The *Guidelines* outline a broad five-step process for assessing impacts on threatened species. Note that 'threatened species' refers here to species, populations and communities listed as threatened under the *Threatened Species Conservation Act 1995* (NSW) or the *Fisheries Management Act 1994* (NSW).

As this project is being assessed under Part 3A of the *EP&A* Act, this investigation and report follow the *Guidelines* where relevant.

Step 1 – Preliminary Assessment
"The main purpose of a preliminary assessment is to determine the likelihood of the study area and subject site supporting threatened species" (*Guidelines*, page 2). As noted in the *Guidelines*, this step is primarily a 'desktop' study, using existing information, literature and data bases to identify relevant threatened species. The *Guidelines* state that the following matters should be included in the preliminary assessment:

- a description of the location and nature of the proposed development;
- a description of dominant vegetation types;'
- a description of habitat features;
- a list of threatened species that are known or likely to occur within the study area;
- an assessment of which of the threatened species that are known or likely to occur are likely to be directly or indirectly affected by the proposal provides a list of factors for consideration in identifying adverse impacts. This list is not necessarily exhaustive and is not development-specific." (*Guidelines*, page 3)

Step 2 – Field Survey and Assessment

As noted in the *Guidelines*, "the required intensity and extent of survey will vary greatly depending upon the species likely to be present, size of the development area, the level of biological and habitat diversity on the site, and the type and complexity of vegetation on the site." (*Guidelines*, page 3)

The *Guidelines* point out the need "to ensure that a reliable assessment of the presence or absence of threatened species can be made" (*Guidelines*, page 3). It is also noted that consideration needs to be given to the relevance of climatic or seasonal conditions for the target species.

Where relevant, the survey methods set out in the document titled *Threatened Species Survey & Assessment: Guidelines for Developments and Activities* (DECC 2004) should be followed. As noted above, the level of the survey will very much depend upon site conditions.

The outcome of Step 2 should be that adequate field surveys are undertaken for all target species identified in Step 1 such that confident statements can be made regarding the potential for the presence of the species on the subject site. In some instances, the precautionary principle should be adopted and the presence of a species assumed for the purposes of impact assessment.

Step 3 – Evaluation of Impact
This step involves identifying the potential magnitude and extent of the impact, if any, the development will have on each of the target species.

The *Guidelines* suggest that "impacts will be more significant if:

- areas of high conservation value are affected;
- individual animals and/or plants and/or subpopulations that are likely to be affected by the proposal play an important role in maintaining the long-term viability of the species, population or ecological community;
- habitat features that are likely to be affected by the proposal play an important role in maintaining the long-term viability of the species, population or ecological community;
- the duration of impacts are long-term;
- the impacts are permanent and irreversible." (*Guidelines* page 4)

Step 4 – Avoid, mitigate and then offset
Where there is a potential to impact on threatened species, this should be addressed through, firstly, avoiding the impact; this may mean making some changes to the proposed development. If avoidance is not possible, then some form of mitigation may be required. Finally, if neither avoidance nor mitigation are possible, then some form of offset or compensation will be required. This could entail the rehabilitation of similar habitat nearby.

Step 5 – Key thresholds
The *Guidelines* state that "the development application needs to contain a justification of the preferred option based on:

- whether or not the proposal, including actions to avoid or mitigate impacts or compensate to prevent unavoidable impacts will maintain or improve biodiversity values.
- whether or not the proposal is likely to reduce the long-term viability of a local population of the species, population or ecological community.
- whether or not the proposal is likely to accelerate the extinction of the species, population or ecological community or place it at risk of extinction.
- whether or not the proposal will adversely affect critical habitat." (*Guidelines* page 4)

Appendix 3 to the *Guidelines* contains more detail for identifying potential impacts on threatened species.

The assessment process under the *TSC Act 1995* commonly known as the 'seven part test' is not used for Part 3A matters. The matters to be considered in the assessment of a Part 3A development are determined by the Minister for Planning for each development. The following discussion addresses the five steps as set out above from the Part 3A *Guidelines*.

The Assessment
Step 1 – Preliminary Assessment

The *Guidelines* state that certain matters should be included in the preliminary assessment. These are primarily concerned with descriptions of the development, the vegetation types, habitats, the threatened species known and likely to occur in the area and those threatened species that may be impacted by the proposed development. Descriptions of the Project Site and its environment are provided in various reports as part of this application. Information on the vegetation, habitats and species within the study area are described in detail in these reports. A plant community map is attached to this report. A review of the taxon as at December 2010 (Mills 2009) is provided in **Appendix 7**.

Step 2 – Field Survey and Assessment

Field surveys were undertaken in the study area in May 2010. These surveys involved searching each route option for the taxon. When plants were found, the GPS location was recorded, along with the number of plants present and habitat information. A specimen was collected at one site for lodgement at the National Herbarium of NSW. No plants were found on the northern route; 9, plants on the central route and 23 plants on the southern route.

As noted above, maps were prepared on Council's GIS to show: (i) the GPS points where each population was observed, and (ii) the potential habitat of the taxon in the Bomaderry Creek area. The following conclusion are made from the results of this work:

- although the taxon is yet to be formally described, the plants at Bomaderry Creek appear to be consistent with the taxon *Hibbertia* sp. nov. 'Menai' at Sutherland and to the west of Nowra;
- the taxon is uncommon in the Bomaderry Creek area, occurring in small disparate populations;
- a few plants occur on the central and southern routes and plants would be lost is either of these route were to be constructed;
- the population at Bomaderry Creek is tiny compared to the abundance of the species to the west of Nowra, where there are probably tens of thousands of plants.

For assessment purposes, the precautionary approach is taken here in assuming that the plants at Bomaderry Creek are the taxon *Hibbertia* sp. nov. 'Menai'.

Step 3 – Evaluation of Impact

The impact of each route option on *Hibbertia* sp. nov. "Menai' is summarised below.

Southern

Some plants would be removed as they are within the construction corridor; other plants nearby would not be affected. The total area of potential habitat removed (woodland) is 35,782 m^2 (3.58 hectares).

Central

A few plants would be removed as they are within the construction corridor. Other plants nearby would not be affected. The total area of potential habitat removed (woodland) is 21,234 m^2 (2.12 hectares).

Northern

No plants were found along this route, although most of the habitat west of the creek is probably suitable. The total area of potential habitat removed (woodland) is 40,894 m^2 (4.09 hectares).

Step 4 – Avoid, mitigate and then offset

Construction of any route option will result in the removal of potential habitat for the taxon. This cannot be avoided. At this point in time, known plants would be lost on the southern and central routes.

Step 5 – Key thresholds

The justifications in the *Guidelines* are addressed below.

whether or not the proposal, including actions to avoid or mitigate impacts or compensate to prevent unavoidable impacts, will maintain or improve biodiversity values.

The road proposal, whichever route is chosen, will not impact significantly on the local population of the taxon; biodiversity values will largely be maintained, while dedication of the Council land will improve values by increasing the quality of the management of that bushland.

whether or not the proposal is likely to reduce the long-term viability of a local population of the species, population or ecological community.

The 'local population' is taken as the population in the Bomaderry Creek bushland. The long-term viability of the taxon in this area is dependent upon the management of the bushland as a whole. This would be strengthened through the dedication of the majority of the bushland to the existing Bomaderry Creek Regional Park. As part of the development of the link road, Council proposes that much of this bushland to be dedicated as a part of the Park.

The southern or central route options would remove some plants and some potential habitat; as known at the present time, the northern route would only remove some potential habitat.

whether or not the proposal is likely to accelerate the extinction of the species, population or ecological community or place it at risk of extinction.
The taxon *Hibbertia* sp. nov. 'Menai' is abundant in the Shoalhaven region, occurring across a large natural area to the west of Nowra (see **Appendix 7**), including thousands of plants within a dedicated protected area, namely Colymea State Conservation Area. The loss of a handful of plants and potential habitat at North Nowra on any of the three route options could not possibly accelerate the extinction of the species or place it at risk of extinction, as it is very secure at Colymea and also occurs in Bomaderry Creek Regional Park.

whether or not the proposal will adversely affect critical habitat.
There is no critical habitat declared for *Hibbertia* sp. nov. 'Menai'.

3. Conclusion

The information provided in this report supplements the extensive flora and fauna information provided in the previous reports prepared for the project. In particular, the recent work improves the mapping of the vegetation, habitats and threatened species occurrence in the area. The report deals in detail with *Hibbertia* sp. nov. 'Menai', a taxon that has not previously been identified as being present at Bomaderry Creek.

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Appendix 1
Location information for **Eucalyptus langleyi**

Stand 1
Location: GPS 56 0279713 6141562
Land Status: Shoalhaven City Council
No. of Plants: 2
Notes: Two plants 5 metres apart. Unburnt for over 20 years. Growing in dense *Kunzea ambigua* shrubland over 4 metres tall, with scattered eucalypts. No immediate threats.

Plants No.	**Live Stems**	**Height Est.**	**Dead Stems**	**Notes**
1.1	2	5m	1	Evidence of being burnt many years ago. Fresh shoots on stems.
1.2	6	10m	-	A large old plant.

Stand 2
Location: GPS 56 0279724 6141564
Land Status: Shoalhaven City Council
No. of Plants: 5
Notes: Plants along a row of about 8 metres. Unburnt for over 20 years. Growing in dense *Kunzea ambigua* shrubland over 4 metres tall, with scattered eucalypts. Some weeds upslope. No immediate threats.

Plants No.	**Live Stems**	**Height Est.**	**Dead Stems**	**Notes**
2.1	6	6m	8	Very large lignotuber. Fresh shoots on stems.
2.2	6	6m	-	Large lignotuber. Fresh shoots on stems.
2.3	2	8m	1	One stem with fresh shoots.
2.4	1	3m	-	Several small suckers from lignotuber.
2.5	7	1.5m	2	Dead stems 4m tall.

Stand 3
Location: GPS 56 0279659 6141546
Land Status: Shoalhaven City Council
No. of Plants: 1
Notes: A single plant on edge of cleared power line easement, growing in a small drainage line. Some threat from weeds, including shading by *Pittosporum undulatum*. No immediate threats.

Plants No.	**Live Stems**	**Height Est.**	**Dead Stems**	**Notes**
3.1	2	6m	-	-

Stand 4
Location: GPS 56 0279674 6141525
Land Status: Shoalhaven City Council
No. of Plants: 2
Notes: Two plants growing in crack in sandstone. One has previously been pruned as it overhangs the walking track. No immediate threats, but proposed road would be very close and is probably detrimental to plants.

Plants

No.	Live Stems	Height Est.	Dead Stems	Notes
4.1	3	5m	1	One stem cut off long ago.
4.2	3	6m	1	Also one very old stump.

Stand 5

Location: GPS 56 0279695 6141401 to 0279705 6141384

Land Status: National Parks and Wildlife Service (Bomaderry Creek Regional Park)

No. of Plants: 15

Notes: Plants are in a row for about 12 metres. A minor walking track traverses the stand. No immediate threats. Growing in a shrubland of *Leptospermum sejunctum* and *Kunzea ambigua*, with *Eucalyptus punctata* and *Eucalyptus agglomerata*.

Plants

No.	Live Stems	Height Est.	Dead Stems	Notes
5.1	2	5m	-	Fresh shoots on stems.
5.2	1	4m	-	-
5.3	3	4m	2	Also one small sucker stem.
5.4	1	2m	1	-
5.5	1	4m	-	Also one small sucker stem.
5.6	1	2m	1	Also one small sucker stem.
5.7	3	2,5m	1	-
5.8	2	2m	-	-
5.9	3	3m	-	Also one small sucker stem.
5.10	2	3.5m	-	-
5.11	3	4m	-	-
5.12	1	4m	-	-
5.13	1	4m	-	-
5.14	2	5m	2	Also a broken stump.
5.15	2	5.5m	4	Dead stems all spindly.

1. Grid system used – WGS84.

Appendix 2
Location information for **Hibbertia** *sp. nov.*

GPS location[1]	No. Plants	Notes
56 0279806 6140778	2	southern route option
56 0279888 6140578	8	southern route option
56 0279785 6140516	3	southern route option
56 0279809 6140532	10	southern route option
56 0279683 6141402	2	near picnic area
56 0279709 6141372	1	near picnic area
56 0279309 6141475	2	near central route option
56 0279178 6141356	2	on central route
56 0279188 6141370	1	on central route
56 0279334 6141442	5	on central route
56 0279339 6141441	1	on central route
56 0279680 6141401	2	near picnic area
56 0279684 6141403	3	near picnic area
56 0279693 6141401	1	near picnic area
56 0279668 6141429	1	near picnic area
56 0279681 6141464	1	near picnic area (flowers present)

1. Grid system used – WGS84.

Appendix 3
***Location information for* Acacia subtilinervis**

GPS location[1]	No. Plants	Notes
Central Route – north of trans. line easement		
56 0279497 6141491	3	
56 0279415 6141467	3	
56 0279384 6141470	3	
56 0279368 6141464	3	
56 0279369 6141456	3	
56 0279351 6141445	2	
56 0279347 6141446	1	
56 0279343 6141458	2	
56 0279341 6141438	1	
56 0279405 6141491	1	
56 0279403 6141482	2	
56 0279409 6141474	1	
56 0279392 6141471	3	
56 0279395 6141470	1	
56 0279335 6141434	2	on trans. line easement
56 0279344 6141436	1	on trans. line easement
56 0279354 6141429	1	on trans. line easement
56 0279419 6141468	2	on trans. line easement
Central Route – south of trans. line easement		
56 0279239 6141376	14	
56 0279386 6141440	20	
56 0279390 6141469	1	
56 0279408 6141427	1	
56 0279401 6141426	1	
56 0279399 6141426	1	
56 0279394 6141424	2	
56 0279385 6141436	1	
56 0279380 6141434	1	
56 0279380 6141437	1	
56 0279377 6141435	1	
56 0279375 6141436	1	
56 0279374 6141432	3	
56 0279373 6141431	8	
56 0279364 6141432	1	
Southern Route – east of gorge		
56 0280085 6140911	1	
56 0280080 6140912	1	
56 0280063 6140903	2	
56 0280110 6140919	1	

1. Grid system used – WGS84.

Appendix 4
Location information for Yellow-bellied Glider feed trees

GPS location	Notes
North of power line easement	
56 0279326 6141456	very old scars
56 0279318 6141478	recent scars
56 0279304 6141485	recent scars
South of power line easement	
56 0279702 6140485	recent scars
56 0279728 6140464	old scars
56 0279856 6140736	very old scars
56 0279795 6140762	recent and old scars
56 0279791 6140780	very old scars
56 0279791 6140802	old scars
56 0279788 6140803	old scars
56 0279779 6140782	very old scars
56 0279786 6140770	fairly recent scars
56 0279801 6140724	very recent scars
56 0279813 6140538	old scars (two trees)
56 0279363 6141392	very old scars, some recent ;'testing'
56 0279356 6141378	very old scars

Appendix 5
Location information for Glossy Black-Cockatoo feed trees

GPS location	Notes
56 0278841 6140963	Chewed cones below *Allocasuarina littoralis*
56 0278853 6141017	"
56 0278878 6141143	"
56 0278684 6140994	"
56 0278494 6141197	"
56 0278494 6141183	"
56 0278464 6141162	"
56 0278702 6141011	"
56 0278876 6141130	"
56 0278877 6141140	"
56 0278878 6141145	"
56 0278887 6141138	"
56 0278912 6141136	"
56 0279009 6141236	"
56 0279135 6141862	"
56 0279053 6141843	"
56 0278838 6141778	"
56 0278781 6141752	"
56 0278675 6141714	"
56 0278299 6141578	"

Appendix 6
Accompanying Maps

Species, etc.	**Attribute(s)** **(Source of information)**
Plant communities	plant communities identified along each route option. (map by KMA)
Plants	
Zieria baeuerlenii	Location points plus map of potential habitat. (NPWS report for location points, map of habitat by KMA)
Eucalyptus langleyi	Location points, envelope of known habitat. (location points and map of habitat by KMA)
Hibbertia sp. nov.	Location points plus map of potential habitat. (location points and map of habitat by KMA)
Genoplesium baueri	Location points plus map of potential habitat. (NPWS for location points, map of habitat by KMA)
Animals	
Grey-headed Flying-fox Spotted-tailed Quoll Masked Owl Powerful Owl Square-tailed Kite Gang-gang Cockatoo	Map of potential habitat (map by KMA); primarily species of forest and woodland.
Yellow-bellied Glider	Location points for feed trees (KMA and Ecological report) Map of core habitat (map by KMA)
Glossy Black-Cockatoo	Location points for feed trees (KMA and Ecological report) Map of core foraging habitat (map by KMA)

Appendix 7
Paper on* Hibbertia *sp. nov. 'Menai' by Kevin Mills

Appendix 8
Paper on* Eucalyptus langleyi *by Kevin Mills

Appendix C – Kevin Mills - Illawarra Vegetation Studies - Rare Plant Species in the Illawarra 4: *Eucalyptus langleyi* (Myrtaceae)

ILLAWARRA VEGETATION STUDIES

Rare Plant Species in the Illawarra 4: *Eucalyptus langleyi* (Myrtaceae)

KEVIN MILLS

PAPER NUMBER 20
JULY 2010

OCCASIONAL PAPERS ON THE VEGETATION OF THE ILLAWARRA REGION

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TITLES IN THIS SERIES - ILLAWARRA VEGETATION STUDIES

1 *Littoral Rainforest in Southern New South Wales: Inventory, Characteristics and Management*, by K. Mills (first published 1988; revised 1996).

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4 *Rainforest Plant Species in Southern New South Wales and their Southern Limits of Distribution. Part 2: List of Ferns and Revision and Additions to Part 1 (Conifers and Flowering Plants)*, K. Mills (1993; superseded in 1996 by paper no.6.

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20 *Rare Plant Species in the Illawarra 4:* Eucalyptus langleyi *(Myrtaceae),* by K. Mills (2010).

Rare Plant Species in the Illawarra 4:
***Eucalyptus langleyi* (Myrtaceae)**

CONTENTS

SPECIES PROFILE *Eucalyptus langleyi*

Family: Myrtaceae
Genus: *Eucalyptus* L'Heritier 1788
Species: *langleyi* L. Johnson & Blaxell 1991
Common Name: Nowra Mallee Ash

Habitat: *Eucalyptus langleyi* occurs on rather shallow and often poorly drained soils overlying sandstone bedrock. The sites support plant species preferring damp soils, including sedges and characteristic shrubs such as Thyme-leaved Paperbark *Melaleuca thymifolia,* or sites may be very dry supporting thickets of shrubs such as White Kunzea *Kunzea ambigua.* The main plant communities are open woodland, particularly with Grey Gum *Eucalyptus punctata,* and mallee-shrubland/heathland dominated by heathland plants characteristic of the sandstone soils. The large populations cover several hectares and are associated with broad areas of rock surface supporting few trees.
Distribution: *Eucalyptus langleyi* occurs in the Central Coast and South Coast botanical subdivisions of New South Wales. It has a very restricted range, from North Nowra, through the sandstone country to the southwest of Nowra, to near the junction of Tomerong and Braidwood Roads, where it is probably limited by increasing altitude. All occurrences are on the Nowra Sandstone; most stands occur within an area of about 17 km by 7 km. Almost all stands occur between the altitudes of 130 and 270 metres; the lowest sites at North Nowra are at 35 metres elevation.
Population: The species is known to occur in 37 stands, several of which contain thousands of plants. The total population is at least 7,600 plants.
Conservation Status: *Eucalyptus langleyi* has been given a conservation classification of 2V in the system of Briggs and Leigh (1996). The species is listed under the NSW *Threatened Species Conservation Act 1995* as a vulnerable species and under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* as a species that is vulnerable. The species occurs in several conservation reserves and almost all plants are on public land of one kind or another.
Main References: Hill & Johnson (1991); Mills (1985b); Kevin Mills & Associates (1996); Kevin Mills & Associates (2002); Kevin Mills & Associates (2008).

Buds and Flowers

Fruit

1 INTRODUCTION

This paper describes and assesses the status of the vulnerable plant species *Eucalyptus langleyi* (Myrtaceae), a mallee that is endemic to the Nowra district, on the boundary of the Central Coast and South Coast botanical subdivisions in southern New South Wales.

Eucalyptus langleyi was named by Hill and Johnson (1991). Prior to this, the taxon was treated as *Eucalyptus luehmanniana*, a similar looking mallee that occurs in the Sydney region, well to the north of Nowra.

This paper describes the results of field investigations undertaken by the author since 1985. The original studies of the distribution of this species was reported by Mills (1985a, 1985b). This current paper discusses the following aspects of the ecology and status of *Eucalyptus langleyi*: species description, distribution, habitat, threatening processes and conservation status. This paper provides a firm basis upon which to prepare a management strategy for this species.

2 SPECIES DESCRIPTION

Eucalyptus langleyi L. Johnson & Blaxell is a mallee described in 1991 by Hill and Johnson (1991), although its existence and its rarity was known for several years prior to this formal description being made (Mills 1985b).

Hill and Johnson(1991) provide the following taxonomic description of *Eucalyptus langleyi*:

> "Mallee to 5m high. *Bark* smooth, brown, shedding in long ribbons. *Young shoots* prominently 4-winged. *Juvenile leaves* glossy green, broad-lanceolate to ovate. *Adult leaves* disjunct, lanceolate, acuminate, sometimes oblique, coriaceous, glossy green, 8-18cm long, 1.8-4.0cm wide; petioles 8-18mm long, winged, wings decurrent with wings on twigs; lateral veins obscure, anastomosing, at 10-20^0 to midrib; intramarginal vein obscure, leaf margin prominently thickened. *Umbellasters* axillary, 7-flowered; peduncles broadly winged, 8-12mm long, to 7mm wide apically; pedicels 0-2mm long, angular. Mature buds irregularly pyriform, rugose, 11-14mm long, 4-6mm diam.; salyptra less than ¼ as long as hypanthium, hemispherical, very broadly obstuse. *Stamens* all fertile; filaments inflexed into hypanthium in bud; anthers 3- or 4-loculat, sometimes apically constricted, 8-10mm long, 8-10mm in diameter, sometimes with 1-3 vertical ridges; calyptra scar a narrow groove around hypanthium, stemonophore 0.5-1mm wide, flat, ultimately depressed to meet disc; disc enclosed, flat, 1-1.5mm wide; valves enclosed, tips often exserted. *Seeds* dull, grey-brown, angular, reniform, to 2.5mm long; chaff similar, smaller."

The type specimen was collected near Christmas Bush Fire Trail in what is now Colymea State Conservation Area by Blaxell and Benson in 1974 (Hill & Johnson 1991). This specimen came from stand number 13 as recognised in this study; **Plate 1** provides a photograph of the type specimen.

Eucalyptus langleyi consistently grows as a mallee, a multi-stemmed plant with few to many stems originating from a large underground or semi-exposed lignotuber. The lignotuber can be several metres in circumference and typically shows signs of fire damage. Closely spaced clumps of stems are probably the same individual plant, the lignotuber having burnt and subsequently developed into two or more plants, the intervening lignotuber having rotted away. Dead stems often remain standing for many years. The number of stems that shoot after a fire is high; these decrease in number over time. The number of stems on old plants typically range from 10 to 20.

The height of some specimens reach to more than six metres and the largest diameter trunks observed measured about six cm. Most stems are 2-4 cm in diameter at chest height. The large, thick blue leaves and angular yellow upper branchlets, in addition to its mallee habit, readily distinguish this species from all other eucalypts in the Nowra area. Seedlings are seldom observed (K. Mills, pers. obs.). A seedling photographed after the 2001/2002 bushfires (see **Plate 2**) had a small lignotuber at its base and was regrowing by suckering after the fire.

Eucalyptus langleyi is in the green-leaved ash group of eucalypts and is most closely related to *Eucalyptus burgessiana* (Hill & Johnson 1991), another mallee species that occurs on similar sandstone soils in a restricted area of the Blue Mountains.

Variation in the size and colour of the leaves and fruit and the colour of branchlets (reddish instead of yellow) of some specimens was noted by Mills (1985b) ; see **Table 1**. Mr Ken Hill suggested at the time that the observed variation is best explained by the crossing of *Eucalyptus langleyi* and *Eucalyptus dendromorpha*. The specimens exhibiting this variation only occur in stands at the highest elevations reached by *Eucalyptus langleyi*, these stands are 11, 12, 15, 16 and 17, and are close to the lower altitudinal limit of *Eucalyptus dendromorpha*.

Illustrations of *Eucalyptus langleyi* are provided in Hill and Johnson (1991), Harden (2002) and Mills and Jakeman (in press). Various colour images are provided in this paper.

3 DISTRIBUTION

Eucalyptus langleyi was first collected in March 1912 by L. G. Irby; it has been collected on numerous occasions since then, most often from two well known stands (i.e. stands 7 and 13). A list of the *E. langleyi* collections in the National Herbarium of NSW is provided in **Table 1**.

Eucalyptus langleyi was recorded in 22 stands by the author in 1985 (Mills 1985a) and has subsequently been found at another 15 sites, including two sites at Bomaderry Creek to the north of the Shoalhaven River, up to July 2010.

Plate 1. Type specimen of *Eucalyptus langleyi*.

Plate 2. Seedling of *Eucalyptus langleyi* (photographed in 2002).

Table 1
Herbarium Collections of *Eucalyptus langleyi*

Location	Date	Collector	Stand No.[1]
Central Coast			
1. Bomaderry Creek Walking Track	7 Apr. 1985	K. Mills	23
2. Bomaderry Creek	3 Dec. 1995	T. Barratt	23
South Coast			
3. Nowra	Mar. 1912	L. G. Irby	-
4. Christmas Bush Fire Trail	16 Mar. 1978	J. D. Briggs	13
5. Christmas Bush Fire Trail (c.1 km along)	6 Feb. 1974	D. F. Blaxell & D.H. Benson	13
6. Christmas Bush Fire Trail (c.1 km along)	8 Dec. 1970	D. F. Blaxell & L.A.S Johnson	13
7. 1.7 km W of Nowra Airport Terminal	7 Feb. 1985	K. Mills	2
8. 16 km from Nowra, Sassafras Road	-	M.I.H. Brooker	7
9. 6 km from HMAS Albatross on Braidwood Road	12 Mar. 1986	Hill, K., L.A.S. Johnson & K. Wilson	7 7
10. c. 3 miles SW of HMAS Albatross	7 Dec. 1968	L.A.S. Johnson & D.F. Blaxell	7
11. 8.1km NE from Tomerong-Nerriga Road on road to Nowra	27 Aug. 1991	R. Johnstone	7
12. 8.5km N of the Nerriga-Tomerong Road on the Nowra Road	21 Sept. 1977	J.D. Briggs	7
13. 7 miles S of Nowra on Sassafras Road, near gravel pit on RHS of road going S	Oct. 1968	L.J. Langley	7
14. 8.5km from Nerriga-Tomerong Road on the Nowra Road to Nowra	27 Nov. 1989	M.I.H. Brooker	7
15. 9.4 miles (15.1km) SW of Nowra on the road to Nerriga	13 Mar. 1973	R. Coveny & R. Bisby	7
16. 10.1 miles from Princes Highway at Nowra on the direct road to Braidwood	4 Aug. 1971	N. Hall	7
17. 16.5km SW from Nowra on Braidwood Road	7 Feb. 1985	K. Mills	7
18. 1.1km along Parma Fire Road off Braidwood Road	7 Feb. 1985	K. Mills	8
19. 1.2km towards Nowra from the Nerriga to Tomerong Road (about 40m E of road)	21 Sept. 1977	J.D. Briggs	11
20. Near Turpentine to Braidwood Road	30 May 1934	F.A. Rodway	7?
Possible Hybrids			
1. 0.4km along fire track opposite Yerriyong Trig, on Braidwood Road	7 Feb. 1985	K. Mills	12
2. S side of Yarran Road, Yerriyong SF 4km E of Turpentine Road	9 Feb. 1985	K. Mills	15
3. 200m E of Stand 16, 200m off Yarran Rd (N), 4.6km E of Turpentine Road	9 Feb. 1985	K. Mills	17
4. 200m off Yarran Road, 4.6km E of Turpentine Road	9 Feb. 1985	K. Mills	16

1. Stand number as used here.

Most stands occur between altitudes of 130 metres and 270 metres, although the stands at Bomaderry Creek are at about 35 metres elevation. A summary of all known stands of *Eucalyptus langleyi* appears in **Table 2**. The distribution of the known stands of *Eucalyptus langleyi* is shown on **Figure 1**. The stands are numbered as they were located; stands 1 to 22 are consistent with the 1985 surveys (Mills 1985b). This species is endemic to the Nowra Sandstone soils and almost all of the stands occur within an area of about 17 kilometres by seven kilometres, with three outlying stands eight and 13 kilometres to the northeast; see **Figure 1**.

Table 2
Summary of known Populations of *Eucalyptus langleyi*

Stand	Location	Alt.	No. Plants (year[1])	Vegetation Type	Associated Trees	Land Tenure[2]
1	1.3km NW of Nowra Airport Terminal. Nowra 1;25,000 0273100 6131000	130m	10+(1985)	Open woodland - heath-sedgeland	*E. eximia, E. punctata E. beyeri*	VCL
2	1.7km W of Nowra Airport Terminal. Nowra 1;25,000 0272650 6130000	130m	100 (1985)	Open woodland - heath-sedgeland	*E. punctata, E. sclerophylla C. gummifera*	VCL
3	0.8km S of Portion 20, Parish Tomerong. Nowra 1:25,000 0272050 6126000	155m	20 (1985)	Open woodland - heathland	*E. sclerophylla, C. gummifera E. consideniana, E. agglomerata*	Parma Creek Nature Reserve
4	1.3km S of Portion 20, Parish Tomerong. Nowra 1:25,000 0271900 6125500	155m	50 (1985)	Open woodland - shrubland	*E. punctata, C. gummifera*	Parma Creek Nature Reserve
5	2.4km S of Portion 20, Parish Tomerong. Yalwal 1:25,000 02715667 6124472	160m	1,000+ (2002)	Shrubland - open woodland	*E. punctata, C. gummifera E. sclerophylla*	Parma Creek Nature Reserve
6	2.4km NE of Yerriyong Trig Station Sassafras 1:25,000 02717888 6124105	155m	2,000+ (2002)	Open woodland - shrub/heathland	*E. punctata, C. gummifera*	Parma Creek Nature Reserve
7	16.5km from Nowra on Braidwood Road. Yalwal 1:25,000 0271336 6127032	200m	840+ (2002)	Open woodland - shrubland	*C. gummifera, E. consideniana E. sclerophylla*	Parma Creek Nature Reserve; RTA
8	1.1km along Parma Fire Track off Braidwood Road. Yalwal 1:25,000 0270562 6124942	200m	62+ (2002)	Open woodland - heathland	*E. sclerophylla, E. consideniana E. agglomerata, C. gummifera*	Parma Creek Nature Reserve
9	1.3km along Parma Fire Track off Braidwood Road. Yalwal 1:25,000 0270855 6124876	200m	10 (2002)	Open woodland - heathland	*E. sclerophylla, C. gummifera E. consideniana*	Parma Creek Nature Reserve
10	0.6km N of Yerriyong Trig Station. Sassafras 1:25,000 0269629 6123573	225m	200+ (2010)	Open woodland - shrubland	*E. consideniana, E. punctata C. gummifera, E. sclerophylla*	VCL

Stand	Location	Alt.	No. Plants (year[1])	Vegetation Type	Associated Trees	Land Tenure[2]
11	1.1km N of Turpentine Road, E side Nowra Road. Sassafras 1:25,000 0268539 612871	255m	22 (2010)	Open woodland - shrubland	*E. punctata, C. gummifera*	Parma Creek Nature Reserve
12	0.4km along Hell Hole Track, off Nowra Rd, E side. Sassafras 1:25,000 0269976 6123159	220m	100s (2010)	Open woodland - heathland	*E. punctata, C. gummifera E. consideniana, E. sclerophylla*	VCL
13	1.2km S of Yalwal Road on Christmas Bush Track. Yalwal 1:25,000 0269026 6131723	210m	>500 (2008)	Open woodland	*E. punctata, E. capitellata*	Colymea SCA
14	0.4km S of gravel pit E of Flat Rock Creek on Turpentine Road. Map: Sassafras 1:25,000 0270800 6119000	210m	40 (1985)	Open woodland - shrubland	*E. sclerophylla, E. consideniana C. gummifera*	Jerrawangala National Park
15	S side of Yarran Fire Track 4km E of Turpentine Road. Sassafras 1:25,000 0269993 6118223	245m	100+ (2002)	Open woodland	*E. sclerophylla, C. gummifera*	Jerrawangala National Park
16	0.2km N of Yarran Fire Track 4.6km E of Turpentine Road. Sassafras 1:25,000 0270763 6118029	215m	138+ (2002)	Open woodland	*E. gummifera, E. consideniana*	Jerrawangala National Park
17	200m E of Stand 16 Sassafras 1:25,000 0270923 6118011	215m	121+ (2002)	Open woodland	*E. sclerophylla, C. gummifera E. consideniana*	Jerrawangala National Park
18	5.1km N along Blackbutt Ridge and Parma Fire Tracks. Huskisson 1:25,000 0274333 6122346	170m	3 (2010)	Woodland	*E. sieberi, E. consideniana C. gummifera, E. sclerophylla*	Parma Creek Nature Reserve
19	1.3km along Saltwater Road, Yalwal 1:25,000 0269114 6131071	210m	<50 (2008)	Open woodland - heathland	*E. punctata, C. gummifera E. capitellata, E. sclerophylla*	Colymea SCA
20	1.5km along Saltwater Road, 30m S of track. Yalwal: 1:25,000 0269200 6130898	210m	<50 (2008)	Open woodland	*E. punctata, E. ligustrina E. capitellata, E. sclerophylla E. consideniana*	Colymea SCA
21	1.6km along Saltwater Road, 300 E of track. Yalwal 1:25,000 0269472 6130843	200m	>100 (2008)	Open woodland	*E. punctata, E. capitellata C. gummifera, E. ligustrina*	Colymea SCA

Stand	Location	Alt.	No. Plants (year[1])	Vegetation Type	Associated Trees	Land Tenure[2]
22	0.8km along Hell Hole Track, off Nowra Rd. N side. Sassafras 1:25,000 0270090 6122865	220m	100 (2010)	Open woodland	*C. gummifera, E. sclerophylla E. consideniana*	VCL
23	S of Picnic area, Bomaderry Creek Regional Park. Berry 1:25,000 0279696 6141388	35m	15 (2010)	Woodland	*E. punctata, E. agglomerata*	Bomaderry Creek Regional Park
24	N of power line, E side of Bomaderry Creek. Berry 1:25,000 0279724 6141564	35m	10 (2010)	Open woodland - shrubland	*E. punctata, E. agglomerata*	Shoalhaven City Council
25	Just SE of wall, Flat Rock Dam west Nowra. Nowra 1:25,000 0278562 6136690	55m	27 (2010)	Open woodland - heathland	*E. punctata, E. agglomerata C. gummifera*	VCL
26	Near Parma Creek Fire Trail Huskisson 1:25,000 0274030 6123354	140m	100+ (2010) 26 (2010)	Open woodland - shrubland	*E. punctata, E. sclerophylla C. gummifera*	VCL Private
27	Christmas Bush Fire Trail Yalwal 1:25,000 0268586 6131681	210m	200+ (2010)	Open woodland - heathland	*E. punctata, E.capitellata C. gummifera*	Colymea SCA
28	Christmas Bush Fire Trail Yalwal 1:25,000 0269459 6131734	195m	<50 (2008)	Open woodland - heathland	*E. punctata, E. capitellata C. gummifera*	Colymea SCA
29	Bottlebrush Fire Trail Yalwal 1:25,000 0269088 6132538	200m	200+ (2008)	Open woodland - heathland	*E. punctata, E. capitellata C. gummifera, E. consideniana*	Colymea SCA
30	Off end of Wax flower Fire Trail Yalwal 1:25,000 0268952 6132346	200m	<20 (2008)	Open woodland - heathland	*E. punctata, E. capitellata C. gummifera, E. consideniana*	Colymea SCA
31	North arm, Wattle Fire Trail Yalwal 1:25,000 0268845 6130498	210m	20 (2010)	Open woodland - heathland	*E. punctata, E. agglomerata C. gummifera*	Colymea SCA
32	Link Fire Trail Yalwal 1:25,000 0270490 6131890	165m	200+ (2008)	Open woodland - heathland	*E. punctata, E. sclerophylla C. gummifera*	Colymea SCA

Stand	Location	Alt.	No. Plants (year[1])	Vegetation Type	Associated Trees	Land Tenure[2]
33	Escarpment north of Yalwal Road Yalwal 1:25,000 0268404 61326861	210m	<10 (2008)	Open woodland - heathland	*E. punctata, E. sclerophylla C. gummifera*	VCL
34	Escarpment north of Yalwal Road Yalwal 1:25,000 0267783 6132182	220m	>1,000 (2008)	Open woodland - heathland	*E. punctata, C. gummifera*	VCL
35	North of Yalwal Road Yalwal 1:25,000 0266538 6134611	270m	<10 (2008)	Woodland – Open Woodland	*E. consideniana, E. sclerophylla C. gummifera, C. eximia*	VCL
36	Plateau to south of Wattle Fire Trail. Yalwal 1:25,000 0268530 6129265	200m	50+ (2009)	Woodland – Open Woodland	*E. consideniana, C. gummifera*	Colymea SCA
37	3.9 km N of Turpentine Rd, E side of Braidwood Rd, opp. gas booster station. Sassafras 1:25,000 0269753 6123176	235m	9 (2010)	Woodland	*E. consideniana, C. gummifera E. sclerophylla*	VCL

1. The year in which the latest count was undertaken (all counts by the author).
2. VCL – vacant Crown land.

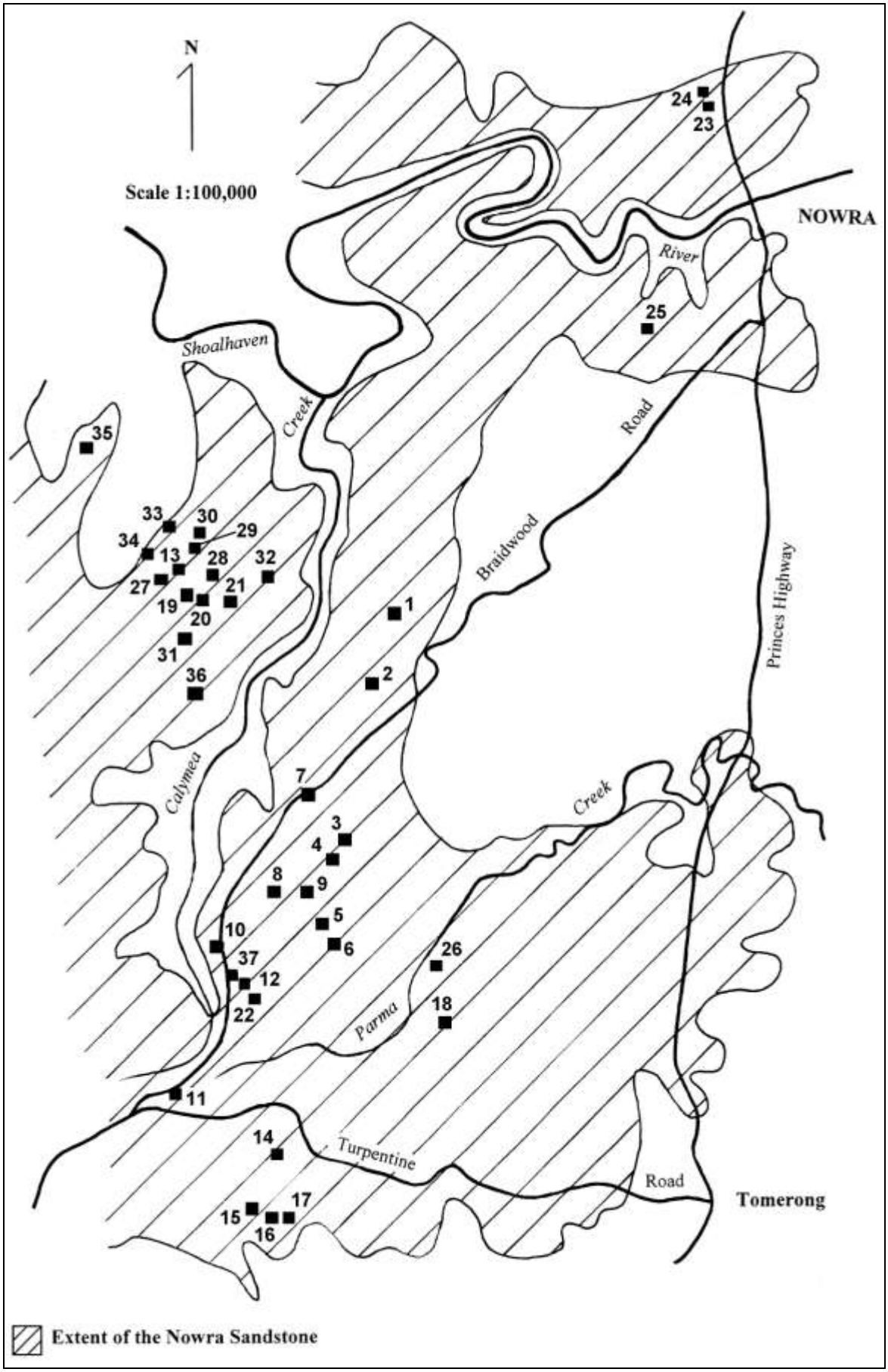

Figure 1.
Distribution of *Eucalyptus langleyi*.

Most of the populations of this species occur on the southern side of the Shoalhaven River, on the South Coast. *Eucalyptus langleyi* occurs at only one known location on the Central Coast, i.e. to the north of the Shoalhaven River, on the eastern side of Bomaderry Creek (stands 23 and 24). Seventeen stands, 46% of the known number of stands, have more than 100 plants, at least three stands contain several thousand plants. Three stands have 10 or less than 10 plants.

The total population of *Eucalyptus langleyi* is at least 7,600 plants, with many stands containing hundreds of plants. **Table 2** indicates the number of plants in each stand, although the estimates for the largest stands are probably much too low. A graph showing the distribution of the 37 known stands in population size classes is provided in **Figure 2**.

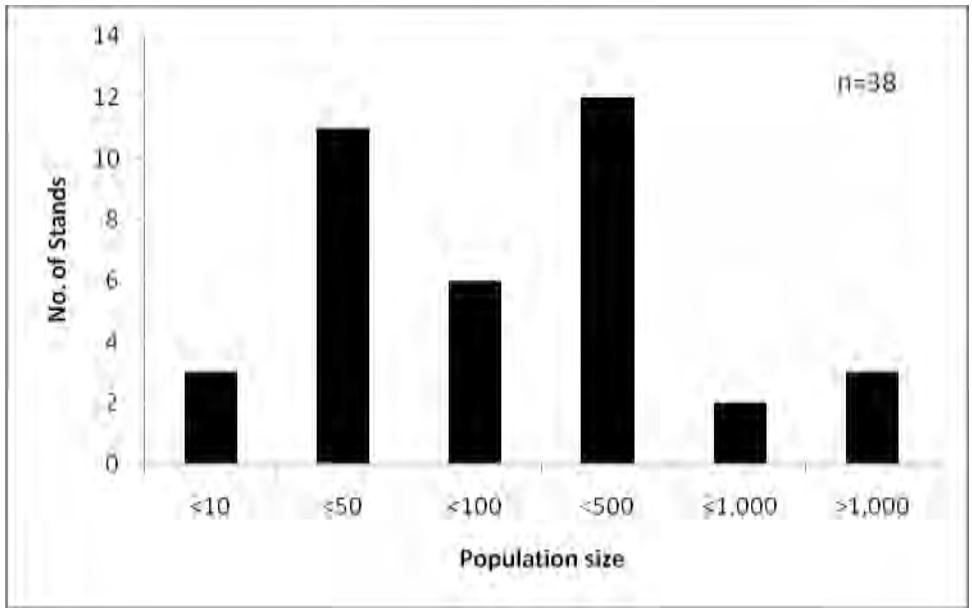

Figure 2.
Number of Stands in Population Size Classes.
(Note that one stand crosses two land tenures.)

The stands have changed little over the intervening 25 years. For example, even after major fires in 2002 the stands grew back in the same locations and in similar numbers of plants (Kevin Mills & Associates 2002). For example, the same three plants still exist at stand 18 as observed 25 years ago. One plant is known to have been lost at Bomaderry Creek and stand 1 could not be found in 2010.

4 HABITAT

Eucalyptus langleyi is only found on the Nowra Sandstone, a Permian sedimentary rock towards the southern edge of the Sydney Basin geological province. Rock outcrops and low nutrient sandy soils are characteristic of this rock, consistent with other coarse-grained sandstone rocks in the Sydney Basin. The Nowra Sandstone is dominated by

woodlands, open woodlands and heathlands, also a characteristic shared with the other sandstone regions in the Sydney Basin.

The tree species commonly associated with *Eucalyptus langleyi* include typical woodland species; the species of trees growing at each stand are listed in **Table 2**. The most common trees are Yertchuk *Eucalyptus consideniana,* Grey Gum *E. punctata,* Hard-leaved Scribbly Gum *Eucalyptus sclerophylla* and Red Bloodwood *Corymbia gummifera*.

Other typical species include those associated with rock outcrops and those usually found growing on moist sites. The species include *Leptospermum trinervium*, *Banksia ericifolia*, *B. spinulosa, Melaleuca thymifolia, Persoonia mollis, Hakea teretifolia, Epacris microphylla, Kunzea ambigua, Lepyrodia scariosa, Dillwynia ramosissima* and *Mirbelia rubiifolia*.

A survey of this species after the wildfire of 2001/2002 by Kevin Mills & Associates (2002) found that *Eucalyptus langleyi* responded very well following the bushfires, no doubt partly due to the recent rains at the time. Profuse growth of suckers from lignotubers was observed on all plants. This new growth was up to 1.5 metres in height, and had occurred in the previous five months. Fruit capsules were observed on many of the larger plants, and their seed had been released, but no recent seedlings were found. One seedling only was found in February 2002, but this was at least a couple of years old; see **Plate 2**.

The species tends to occur in fairly discrete stands, rather than being spread throughout the woodland. This is probably because its preferred habitat is usually the edges of broad rock surfaces. *Eucalyptus langleyi* nearly always occurs where there is sandstone close to the surface. Rock surfaces occur within most stands; the larger stands tending to grow in linear fashion, following the contours and the edges of sandstone outcrops.

Most stands occur with other rare plant species, particularly *Leptospermum epacridoideum*, *Acacia subtilinervis* and *Hibbertia sp. nov.* 'Menai'.

5 CONSERVATION STATUS

Under the ROTAP system, the species has a conservation classification of 2V (Briggs & Leigh 1988, 1996). This means that it has a very restricted distribution in Australia (<100 km) and that it is vulnerable, or at risk of disappearing from the wild state over a period of 20 to 50 years. *Eucalyptus langleyi* is listed on Schedule 2 of the NSW *Threatened Species Conservation Act 1995* as a "vulnerable" species. The species is also listed as vulnerable under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999.*

The number of stands and estimated number of plants under all land tenures is shown in **Table 3**; this information is illustrated graphically in **Figures 3 and 4**. Almost all of the stands are on public land of one kind or another. The species occurs in several protected areas managed by the NSW National Parks and Wildlife Service, namely Bomaderry Creek Regional Park, Colymea State Conservation Area, Jerrawangala

National Park and Parma Creek Nature Reserve. The number of known stands within NPWS reserves is 25, or 68% of the total, while the number of plants within these reserves is over 5,862, or 78% of the total.

Table 3
Land Tenure and Distribution of *Eucalyptus langleyi*

Tenure	No. Stands	No. Plants
National Parks and Wildlife Service		
Bomaderry Creek Regional Park	1	15
Colymea State Conservation Area	11	1,440+
Parma Creek Nature Reserve	9	4,006+
Jerrawangala National Park	4	400+
Total NPWS	25	5,862+
Vacant Crown land[1]	11	1,666+
Shoalhaven City Council	1	10
Private[1]	1	26
Totals	37	7,554+

1. One stand extends across both land tenures.

The major change in conservation status was the dedication in 2001 of several protected areas, namely Bomaderry Creek Regional Park, Colymea State Conservation Area, Parma Creek Nature Reserve and Jerrawangala National Park. As shown above, these reserves contain the majority of known stands and the majority of the known plants.

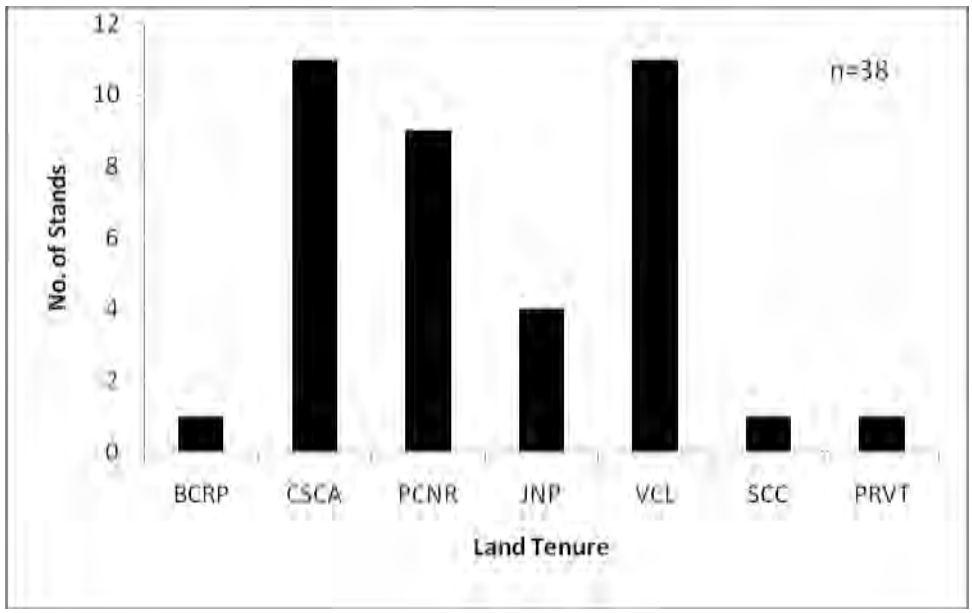

Figure 3.
Number of Stands by Land Tenure.
(BCRP – Bomaderry Creek Regional Park; CSCA Colymea State Conservation Area; PCNR Parma Creek Nature Reserve; JNP Jerrawangala National Park; VCL – vacant Crown land; PRVT – private land.) Note that one stand crosses two land tenures.

The author has visited most of the stands in the last few years, indicating that the distribution and abundance of the species has changed very little over the past 25 years. Because the majority of the known stands and plants occur within conservation reserves, the species is considered secure. It faces little threat to its survival in the foreseeable future.

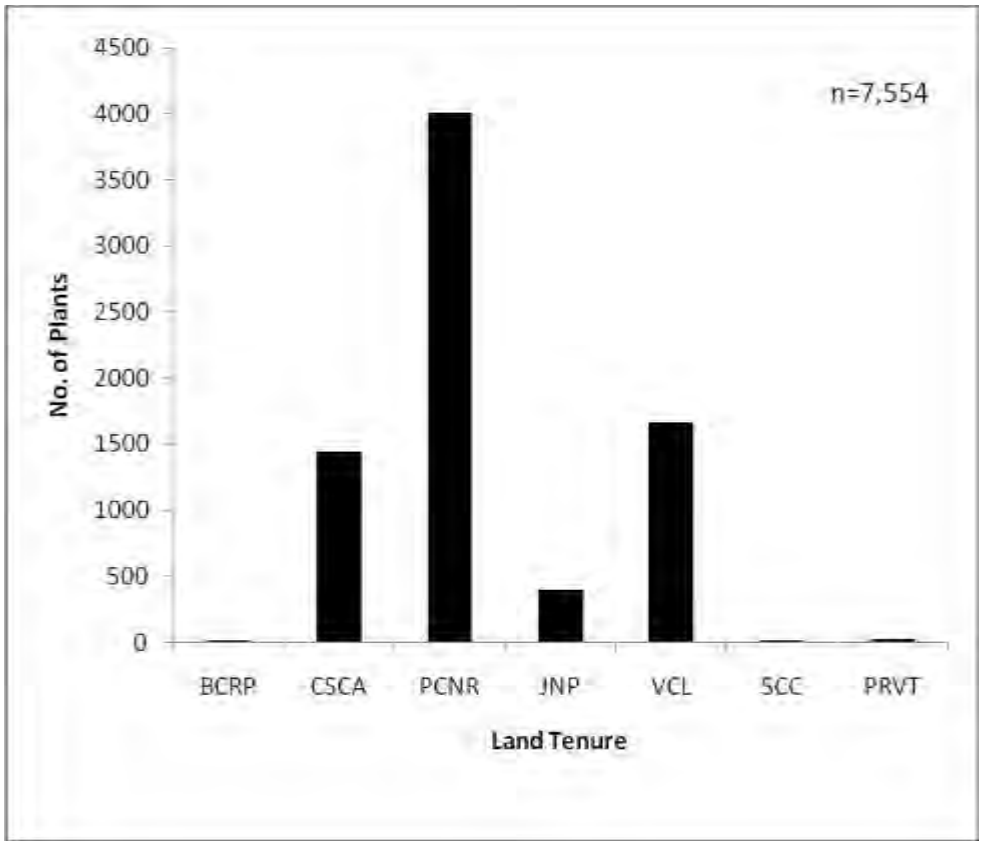

Figure 4.
Number of Plants by Land Tenure.
(See Figure 3 for key to land tenure.)

6 THREATENING PROCESSES

Since the extensive dedications of the conservation reserves in 2001, *Eucalyptus langleyi* faces little threat from human activities. As noted elsewhere, there have been few losses or major changes in the location and number of stands and plants in the past 25 years.

Threats to the species come from inappropriate use of Crown land, installation and maintenance of utility corridors (roads, power lines and water pipelines), and, potentially, unsympathetic bushfire regimes.

Plate 3. Typical clump of stems of *Eucalyptus langleyi*.
Note large number of slender stems and dead stems.

Plate 4. *Eucalyptus langleyi* growing on a cliff edge in stand 34.
This is the only stand growing in such a habitat.

Improved management of vacant Crown land, land that contains 29% of the stands and 22% of the estimated population, would benefit *Eucalyptus langleyi* and the several other rare or threatened plants that occur widely on this public land. Off-road vehicle use, in particular, is a major problem, as tracks are created and widened, erosion and sedimentation occur and plants are physically impacted.

Inappropriate bushfire regimes, that are either too frequent or too infrequent, potentially may affect the species. Fires that are too frequent may eventually destroy stands, particularly as seedlings are apparently seldom produced. Lack of fire for decades may result in the death of mature plants without recruitment. This is more likely to be a long-term impact and one that we have little information about. Certainly, the species and indeed individual plants survive wildlife very well. The long-term impact of the current fire regimes in those areas supporting this species is unknown.

Minor threats include road maintenance works (e.g. stand 7), weed invasion (stands 23 and 24) and maintenance of utility easements (e.g. stand 25).

7 CONCLUSION

This study has defined the geographic limits of the species *Eucalyptus langleyi*, estimated the minimum population of the species and provided some ecological information on the species. The paper also provides seldom-published photographs of the species. This information provides a firm basis upon which to manage and conserve the species.

The study found that the distribution and abundance of the species has changed very little over the past 25 years. The species is secure and faces little to no threat from human or other agents. A majority of the known stands (68%) and a majority of the known plants (78%) occur within protected areas managed by the NSW National Parks and Wildlife Service. The total population is easily well over 8,000 plants, with most contained within four conservation reserves. The view here is that the minimum criteria are met for adequate conservation of the species.

Threats to the species come from inappropriate use of vacant Crown land, installation and maintenance of utility corridors (roads, power and water), and, in the long term, unsympathetic bushfire regimes, where fires are either too frequent or too infrequent. Improved management of the vacant Crown land, containing a substantial proportion of the stands and population, would benefit *Eucalyptus langleyi*. Off-road vehicle use, in particular, is a major problem.

Plate 5. *Eucalyptus langleyi* at stand 16, photographed in 2002. Note the extensive new growth at the base of the old stems. These older stems, with their thin bark, are killed by the fire. Regeneration is by suckering from extensive underground lignotuber.

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Appendix D – Kevin Mills, Investigation of the undescribed taxon *Hibbertia* sp. Nov. 'Menai' (Dilleniaceae)

Investigation of the undescribed taxon *Hibbertia* sp. nov. 'Menai' (Dilleniaceae)

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Photograph 1 (Cover): *Hibbertia* sp. nov. 'Menai' photographed at site B(1) at North Menai. Photographed 4 November 2009.

Contents

Appendices

Tables

Figures

1 Introduction

An undescribed species of *Hibbertia* (Dilleniaceae) from south of Sydney is listed as an endangered species under the NSW *Threatened Species Conservation Act 1995*; see **Appendix 1**. As noted in the Final Determination, *Hibbertia* sp. nov. 'Menai' occurs in two widely separated localities. These localities are the Menai district in Sutherland Shire on the southern outskirts of Sydney and the country to the west of Nowra, on the South Coast of New South Wales. Both areas are on sandstone; the Hawkesbury Sandstone at Sutherland and the Nowra Sandstone on the South Coast. The South Coast population is about 110 kilometres to the south of Sutherland. Other plant species mirror this disjunct distribution pattern, such as another rare plant *Melaleuca deanei* (Myrtaceae). This distribution pattern may be explained by the fact that the intervening sandstone country, i.e. the Woronora Plateau, is at a relatively high elevation and the rainfall is quite high (greater than 1200 mm per year); these two environmental attributes are not shared by the Menai or Nowra areas.

This paper provides an overview of the current knowledge of the distribution and conservation status of *Hibbertia* sp. nov. 'Menai', based on recent surveys of both populations by the author.

2 Methods

The bushland growing on selected sites on sandstone in the western part of Sutherland Shire were surveyed for *Hibbertia* sp. nov 'Menai' in November and December 2009. Likely habitat was searched and the numbers of plants observed were recorded, along with a GPS location (WGS84) and habitat notes. Various photographs were taken, and several specimens were gathered. Locations known to contain the taxon were obtained from various sources, including the Final Determination, the Internet and enquiries at the National Herbarium of NSW. The surveys initially searched known locations, which turned out to be very few, and then worked outwards from those sites where the taxon was found.

The author also carried out a survey of the sandstone country to the west and southwest of Nowra. That area is much larger than the rather fragmented natural areas in Sutherland where the taxon is reported to occur. The south coast area where the population is known to occur is primarily the Toorooroo Plateau. The country is little disturbed and mostly in public ownership, either vacant Crown land or part of Colymea State Conservation Area. A similar survey procedure was followed in that area as at Sutherland.

3 Hibbertia *sp. nov. 'Menai'*

Although not formally described and named, the NSW Flora Online site of the National Herbarium of NSW provides the following detailed description of the taxon. This description is repeated in the Final Determination made by the NSW Scientific Committee in August 2007; see **Appendix 1**.

> "Small shrub 0.8-1.3 m high, up to 70 cm wide, usually upright, branchlets, sepals and carpels densely hairy, leaves densely hairy, hairs lacking a basal tubercle, reduced-stellate, with two or three stiff strongly ascending to erect arms (or hairs rarely simple), hairs and arms sometimes directed antrorsely. Branchlets pale orange-brown, angular distally, with ridges produced downwards from base of each leaf."

"Leaves alternate, unevenly spaced, often appearing almost whorled; each leaf sits on a cupped protuberance from branchlet, linear, 7-15 mm long, 0.5–0.8 mm wide; margin entire and recurved; adaxial (upper) surface slightly sunken along midrib, venation indistinct or not visible; abaxial (lower) surface with midvein up to 1.5 times as broad as 'rolled' margin, somewhat sunken, with a deep distinct groove along either side."

"Flower solitary, mostly on short lateral branchlets and terminal (but sometimes appearing axillary), sessile or very shortly pedicellate (pedicel up to 0.5 mm long). Sepals narrowly ovate, 4.5–7 mm long, 1.5–2.5 mm wide, the two 'outer' sepals slightly narrower than other three; margin entire; apex with a short to long point; outer surface hairy, except near margin, sometimes slightly ridged along midline, paper, green to margin on two 'outer' sepals, or with a distinct pale margin 0.5 mm wide on other three sepals; inner surface glabrous. Petals obovate, 4-6.5 mm long, c. 3 mm wide, yellow; midvein pale orange-coloured. Stamens 6–8, inserted to one side of carpels; filaments 0.5–0.7 mm long; anthers 2–3 mm long. Carpels 2, 0.8–1 mm long, densely hair; styles laterally inserted, c. 3 mm long."

The above NSW Flora site states that the taxon is:

"known to occur in two metapopulations, one in the southern outskirts of Sydney (Woronora River gorge area), and one near Nowra on the mid-South Coast of NSW. The Southern Sydney metapopulation occurs on both sides of the Woronora River gorge."

The taxon was listed as an endangered species in New South Wales under the *Threatened Species Conservation Act 1995* in August 2007. The Final Determination summarises the knowledge of the taxon at that time; see **Appendix 1.**

4 Results of Investigations

4.1 General Distribution

As noted above, the taxon occurs in two regions separated by over 100 kilometres. The South Coast population occurs across the Toorooroo Plateau and nearby to the west of Nowra. The northern population occurs in the western part of Sutherland Shire, particularly around Menai. Both areas are located on coarse-grained sandstones within the Sydney Basin geological province. The typical woodland and heathland vegetation growing in each region where the *Hibbertia* occurs is very similar and share most plant species.

4.2 Sutherland Regional Population

Distribution in the Menai-Woronora District

The results of the field surveys in the Sutherland area by the author in November-December 2009 are summarised in **Table 1**. The areas referred to in that table are shown on **Figures 1 and 2**; the location of the outlying Dalkara Circuit site is not shown on the maps. The unsuccessful surveys in the Sutherland region, i.e. those locations where no *Hibbertia* sp. nov. 'Menai' were found, are summarised in **Appendix 2**. The table and the appendix both indicate in the 'notes' column any other rare or threatened plant that was located, along with other relevant observations, including other species of *Hibbertia*.