

Appendix D Technical Working Paper: Ecology



Glenugie Upgrade Upgrading the Pacific Highway

APPENDIX D TECHNICAL WORKING PAPER
ECOLOGY

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- David Redman and Damien Hofmeyer (DECC)
- Kevin Roberts and John O'Donnell (RTA)

Glossary of terms and abbreviations

AusRivAS	Australian Rivers Assessment System
CAMBA	China Australia Migratory Bird Agreement
DECC	NSW Department of Environment and Climate Change
DEWHA	Commonwealth Department of Environment Water Heritage and the Arts
DPI	NSW Department of Primary Industries
EEC	Endangered ecological community
EP&A Act	NSW <i>Environmental Planning and Assessment Act 1979</i>
EPBC Act	Commonwealth <i>Environment Protection and Biodiversity Conservation Act 1999</i>
FM Act	<i>Fisheries Management Act 1994</i>
GIS	Geographic Information System
GPS	Geographic Positioning System
JAMBA	Japan Australia Migratory Bird Agreement
MNES	Matters of National Environmental Significance
NPWS	NSW National Parks and Wildlife Service
ROTAP	Rare or Threatened Australian Plant
RTA	NSW Roads and Traffic Authority
SEPP	State Environmental Planning Policy
sp.	Species (singular)
spp.	Species (plural)
subsp.	Subspecies
TSC Act	NSW <i>Threatened Species Conservation Act 1995</i>
var.	Variety

Executive summary

This working paper is a technical report on the ecological issues associated with the upgrade of the Pacific Highway at Glenugie. The working paper forms part of the environmental assessment and addresses one of the key issues in the Director-General's requirements. The working paper reports on the methods and results of an investigation into the terrestrial and aquatic flora and fauna associated with the study area, the prediction of impacts, their magnitude and significance and an outline of measures to minimise impacts on biota.

Investigations into the biodiversity values of the study area, including the landscape characteristics, background reviews and baseline field surveys was used to identify the flora and fauna diversity and the distribution of vegetation and habitat associated with the study area with a focus on acknowledging the key issues identified in the Director-Generals requirements. Direct impacts on identified vegetation and species habitat were calculated from the project corridor (for the full motorway style upgrade proposal). Including a 10 m buffer surrounding the proposed road design, there is a total of 85 ha of vegetation/habitat within the project footprint that will be impacted. This includes 5.3 ha of endangered ecological communities present along watercourses in the project footprint.

A population of the Square-fruited Ironbark (*Eucalyptus tetrapleura*) was identified in and surrounding the project footprint. This species is listed as vulnerable under both the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the NSW *Threatened Species Conservation Act 1995* (TSC Act). The significance of impacts on this species was informed by regional surveys conducted for the project. The 'Glenugie population' of *Eucalyptus tetrapleura* is estimated to comprise about 147,000 trees. Of this total, an estimated 6,156 trees (4.2 per cent) would be removed by the project. The current known extant of *Eucalyptus tetrapleura* occupies a 5000 km² area entirely centred on the north coast of NSW. This population is considered to comprise at least 50 different sub-areas and between 170,000 and 250,000 trees. In this context, the project would remove between 2.5 per cent and 3.6 per cent of the total population. In addition to *Eucalyptus tetrapleura*, the project would directly and indirectly impact a small population of the threatened plant species *Melaleuca irbyana* (between 5-10 trees), and a portion of the habitat available for up to 30 threatened fauna species recorded and expected to occur in the study area will be impacted.

Project specific impact mitigation measures and long-term management and monitoring strategies for biodiversity are identified in this report. These would be incorporated into a flora and fauna management plan (FFMP) that would be part of the construction environmental management plan and operational environmental management plan for the project. The FFMP would identify the areas of ecological conservation significance to be protected, advise appropriate methods for vegetation and habitat protection and management during construction, and outline species monitoring protocols.

1. Introduction

1.1. Preface

This working paper is a technical report on the biodiversity impacts associated with the upgrade of the Pacific Highway between Franklins Road and Eight Mile Lane south of Grafton (the project). The paper identifies the terrestrial and aquatic flora and fauna impacted by the project, presents an assessment of the magnitude and importance of impacts and outlines monitoring and management measures.

1.2. Overview

The NSW Roads and Traffic Authority (RTA) is upgrading a section of the Pacific Highway, about seven kilometres in length, between Franklins Road and Eight Mile Lane south of Grafton on the mid north coast of NSW as part of the Pacific Highway Upgrade Program. The RTA has prepared an environmental assessment for the upgrade. The upgrade is referred to as ‘the project’ throughout this document and is illustrated in **Figure 1-1**.

This working paper documents the methods and results of an investigation of the terrestrial and aquatic flora and fauna along the proposed road, the prediction of impacts and their significance, and impact mitigation measures. Data from targeted surveys along the route have been used to assess the ecological impacts of the project, together with previous flora and fauna surveys prepared for the route selection phase of the larger Wells Crossing to Iluka Road upgrade, which includes the Glenugie section.

1.3. Ecological assessment requirements

Key issues for the environmental assessment are identified in the Director-General’s requirements that were developed in consultation with the Department of Primary Industries (DPI) and the Department of Environment and Climate Change (DECC). Potential impacts on ecology were identified as a key issue. The specific requirements to be addressed are described in **Table 1-1**, which also shows where these issues are addressed throughout the report.

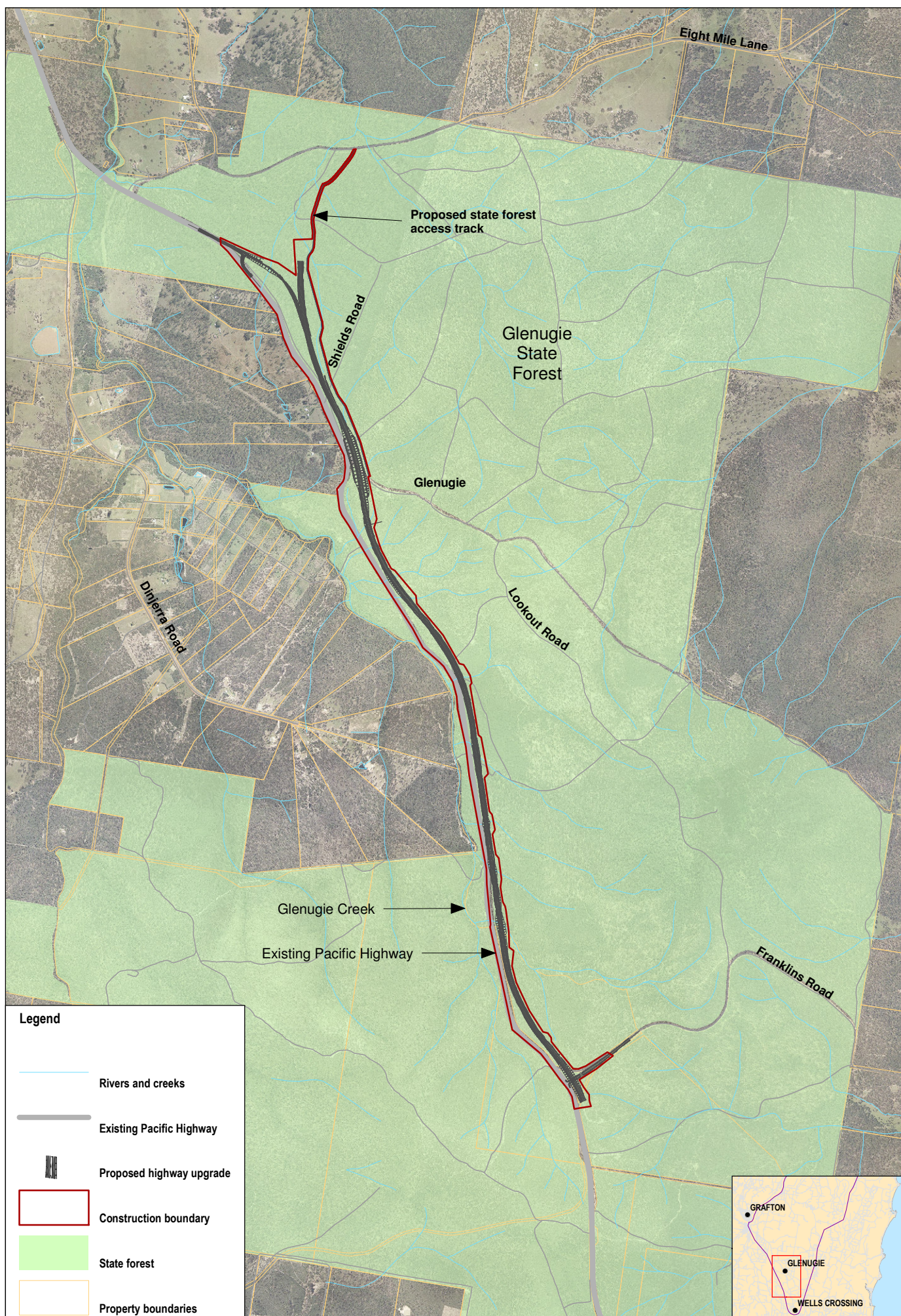


Figure 1-1: The proposal



■ **Table 1-1 Environmental assessment requirements for biodiversity**

Environmental assessment requirement	Sections where addressed
Director Generals Requirements	
Potential ecological impacts with specific reference to vegetation and habitat clearing and connectivity implications for the species present	5,6
Threatened terrestrial species, populations, ecological communities and/or critical habitat	4
Targeted surveys of threatened flora and fauna species including Square-fruited Ironbark (<i>Eucalyptus tetrapleura</i>) and Weeping Paperbark (<i>Melaleuca irbyana</i>).	4.3.1, 4.3.2
Specific impacts to the flora and fauna of Glenugie State Forest	3,4,5
Minimisation of impacts to riparian vegetation, fish passage and water quality in the watercourse resulting from construction at watercourse crossings	6

1.4. Legislative context

The project will be assessed under Part 3A of the *Environmental Planning and Assessment Act 1979* (EP&A Act). The requirements of the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) have also been considered in the assessment of the project. Additional legislation of relevance to the protection of biodiversity for the project includes the *Threatened Species Conservation Act 1995* (TSC Act) and the *Fisheries Management Act 1994* (FM Act).

1.4.1. Environment Protection and Biodiversity Conservation Act 1999

The EPBC Act protects the environment, particularly matters of national environmental significance. It streamlines the national environmental assessment and approvals process, protects Australian biodiversity and integrates management of important natural and cultural places. The EPBC Act identifies seven matters of national environmental significance:

- World Heritage properties.
- National heritage places.
- Wetlands of international importance (Ramsar wetlands).
- Threatened species and ecological communities.
- Migratory species.
- Commonwealth marine areas.
- Nuclear actions (including uranium mining).

1.4.2. Environmental Planning and Assessment Act 1979

The EP&A Act details the development assessment system in NSW and this project has been declared a Part 3A project and critical infrastructure under the EP&A Act. The consent and/or

determining authority must consider the effects of a proposed development or activity on threatened species, populations and ecological communities as listed under Schedules 1, 1A and 2 of the TSC Act and determine if there is likely to be a significant impact. This document identifies matters which are relevant to the assessment of impacts to threatened species, populations, or ecological communities, or their habitats arising from the project under the *Guidelines for Threatened Species Assessment* (Part 3A) (DECC and DPI 2005).

1.4.3. Threatened Species Conservation Act 1995

The TSC Act identifies threatened species, populations and ecological communities, as listed under Schedules 1, 1A and 2, that are to be addressed in assessing the significance of impacts arising from a project assessed under the EP&A Act.

1.4.4. Fisheries Management Act 1994

The objectives of the NSW FM Act are to conserve, develop and share the fishery resources of the State for the benefit of present and future generations. Objectives of the Act also include the conservation of fish stocks, key fish habitats, threatened species, populations and ecological communities of fish and marine vegetation. Any action that has an impact on threatened species, populations and ecological communities of fish and marine vegetation must be properly assessed to ensure conservation through the implementation of co-operative management.

1.5. Assessment approach

The principal aim of the biodiversity assessment was to identify, describe and map the biodiversity and ecological characteristics of the proposed road corridor. This process provided baseline data which was used to predict impacts and determine monitoring and management actions for features of conservation value. The specific objectives of the assessment were devised in accordance with the biodiversity assessment requirements referred to in **Table 1-1** and included:

- Identification and description of the flora and fauna species, communities and populations of local, regional, state and national conservation significance (as defined under the EPBC Act, FM Act and TSC Act) and their habitats, that are known or considered likely to occur in the study area.
- Provide baseline biodiversity data to a standard that can be used to predict and assess the significance of impacts of the project on terrestrial and aquatic flora and fauna of conservation significance as provided by the statutory requirements of the EPBC Act, TSC Act, FM Act and EP&A Act.

- Conduct targeted surveys for threatened biota known or considered to potentially occur in the study area to identify the size and extent of local populations and assess the significance of impacts on these resulting from the project.
- Investigation and description of the vegetation and habitats and an inventory of species occurring in the study area including their conservation status.
- Identifying direct and indirect impacts on biodiversity by describing the extent of native vegetation and habitat loss and the impacts on the biodiversity landscape features such as habitat connectivity and impacts specific to the ecology of Glenugie State Forest.
- Development of appropriate biodiversity mitigation and monitoring measures to be incorporated into the construction and operational phases of the project to minimise and monitor impacts.

2. Methodology

2.1. Definitions

The following definitions are used in the working paper to describe the specifications of the project:

- Footprint – the footprint of the project has been calculated as the limits of the design footprint plus a 10 m buffer to account for edge effects and other disturbances.
- Study area – the design footprint and any proximal areas that could potentially be affected by the project.
- Locality – the area within 10 km of the design centreline.
- Landscape – the area within 20 km of the design centreline.
- Region – a bioregion defined in a national system of bio-regionalisation. For this study this is the NSW North Coast bioregion as defined in the Interim Biogeographic Regionalisation for Australia (Thackway & Cresswell 1995).

2.2. Assessment team

The team associated with the completion of this working paper is listed in **Table 2-1**, together with details of their qualifications and role. All work was carried out under the appropriate scientific investigation licences as required under Clause 22 of the *National Parks and Wildlife Regulations* 2002, Section 132C of the *National Parks and Wildlife Act* 1974 and Section 37 of the FM Act, in addition to animal research authority under the DPI.

■ Table 2-1 Assessment team

Name	Qualification	Role
Chris Thomson	BappSc	Ecologist - Team Leader, fauna survey and assessment
Andrew Carty	BenvSc	Botanist – field surveys, targeted threatened flora surveys, reporting, GIS
Dr. Julie-Anne Harty	BAppSc; PhD	Zoologist – field surveys
Martin Sullivan	BSc	Botanist – field surveys, reporting, condition assessment
Sarah Foy	BSc; MEnvStud	Aquatic Ecologist – field surveys, reporting
Mirella Verhoeven	BSc	Aquatic Ecologist – field surveys, reporting
David Fleming	BappSc	Ecologist – field surveys

2.3. Literature and database review

As a preliminary phase of the assessment a review of relevant biodiversity literature, consultation with key stakeholders and government maintained databases pertaining to the study area and locality was undertaken. From the review a list of threatened biota relevant to the locality was compiled and assessed to determine their potential presence in the study area and

provide a focus for the investigation. The data sources used in this review included but were not limited to the following:

- Atlas of NSW Wildlife Database (DECC 2009).
- NPWS (2002a and 2002b) Threatened Species of the Upper North Coast of New South Wales: (i) Fauna; and (ii) Flora.
- Records published in scientific journals, reports and general flora and fauna distribution texts.
- Results of local environmental studies, including studies prepared by consultants, local government authorities, biological organisations, universities and other sources (e.g. Steenbeeke 1998; 1999).
- Discussions with personnel from the DECC and DPI (NSW State Forests) and Clarence Valley Council.
- Anecdotal reports from authorities and local ecologists / naturalists.
- Records provided by Clarence Valley WIRES.
- Threatened Species, Population and Ecological Communities of NSW (<http://www.threatenedspecies.environment.nsw.gov.au/index.aspx>).
- Protected Matters Search Tool. (<http://www.environment.gov.au/erin/ert/epbc/index.html>).

2.4. Landscape assessment

The potential impacts of the project on the landscape were assessed using a strategic assessment of ecosystem functions and values, focusing on lands covering the study area and up to 20 km from the project. The assessment involved a review and analysis of the following datasets:

- Aerial photographs of the study area to examine the vegetation patch network and habitat connectivity in the landscape.
- NSW Landscapes (Mitchell 2003). The NSW Landscapes coverage is a state-wide map of landscapes, mapped at a scale of 1: 250 000, describing land attributes considered to drive ecosystem processes. Definition of the landscapes emphasises geologic, geomorphic and pedologic factors.
- Key habitats and corridors (DEC 2003). The key habitats map layer is a regional representation displaying the likelihood of occurrence of key fauna habitats consolidated at the regional scale. This is combined with a layer of regional and subregional linking corridors for fauna of the Upper North East and Lower North East NSW RFA regions.
- Climate Change Wildlife Corridors for North-east NSW (DEC 2007) was a project was conducted on behalf of the Northern Rivers Catchment Management Authority (NRCMA) to help identify land areas for strategic conservation efforts to aid adaptation to the potential adverse effects of climate change for wildlife.

- Lower North East Forest Ecosystems (NPWS 1998).
- Comprehensive Regional Assessment Aerial Photographic Interpretation (CRAFTI) (Resource and Conservation Division 2001).

2.5. Field investigations

2.5.1. Overview

Investigation into the biodiversity values of the study area, including the landscape features and baseline field data (aquatic and terrestrial) were gathered during the period 2005 to 2009, commencing with studies for the Wells Crossing to Iluka Road Pacific Highway upgrade route options development and concept design, and culminating in specific survey associated with the Glenugie upgrade project as described in **Table 2-2**.

■ Table 2-2 Details of field surveys conducted for the proposed road alignment

Dates	Survey detail	Personnel
TERRESTRIAL FAUNA		
2-7 July 2007 (Route option studies)	<ul style="list-style-type: none"> ■ <i>Mammal survey</i> (arboreal and ground based trapping, spotlighting, bat call recording and bat trapping). ■ <i>Bird census</i> (diurnal and nocturnal). ■ <i>Reptile and amphibian census</i>. 	Chris Thomson
27 April to 1 May 2009 (Glenugie upgrade EA)	<ul style="list-style-type: none"> ■ <i>Mammal survey</i> (arboreal and ground based trapping, spotlighting, bat call recording and bat trapping). ■ <i>Bird census</i> (diurnal and nocturnal). ■ <i>Reptile and amphibian census</i>. ■ <i>Targeted surveys</i> for Bush Stone-curlew, searches for evidence (Glossy Black-Cockatoo, Yellow-bellied Glider and Koala). ■ <i>Tree hollow counts</i>. 	Chris Thomson Julie-Anne Harty
11-15 May 2009 (Glenugie upgrade EA)	<ul style="list-style-type: none"> ■ <i>Mammal survey</i> (targeted spotlighting for Yellow-bellied Glider, Rufous Bettong and Brush-tailed Phascogale). ■ <i>Bird census</i> (diurnal and nocturnal, targeted Swift Parrot and Regent Honeyeater). ■ <i>Reptile and amphibian census</i>. ■ <i>Targeted surveys</i> for Bush Stone-curlew, searches for evidence (Glossy Black-cockatoo, Yellow-bellied Glider and Koala). ■ <i>Hollow tree counts, habitat assessments</i>. 	Chris Thomson
TERRESTRIAL FLORA		
2-7 July 2007 (Route options studies)	<ul style="list-style-type: none"> ■ <i>Vegetation communities</i>: delineation and mapping of vegetation communities. ■ <i>Flora survey</i>: limited quadrat and transect based flora survey to provide a list of species present in each vegetation community. ■ <i>Targeted flora survey</i>: Targeted searches for threatened flora along the proposed route, including mapping of the distribution and population estimate of <i>Eucalyptus tetrapleura</i> within the footprint area. 	Andrew Carty
27 April to 1 May (Glenugie upgrade EA)	<ul style="list-style-type: none"> ■ <i>Targeted flora survey</i>: Targeted survey for <i>Melaleuca irbyana</i> and other potential threatened species in the proposed footprint. ■ <i>Targeted flora survey</i>: Targeted survey and mapping of <i>Eucalyptus tetrapleura</i> in the regional area. 	Andrew Carty

Dates	Survey detail	Personnel
11-15 May 2009 (Glenugie upgrade EA)	<ul style="list-style-type: none"> ■ <i>Comprehensive flora survey</i>: Completed a detailed quadrat and transect based flora survey in the alignment to update the species list and vegetation community mapping for the project and provide a vegetation and habitat condition assessment. ■ <i>Targeted flora survey</i>: Continued survey to identify the extent and size of <i>Eucalyptus tetrapleura</i> population in the region. 	Martin Sullivan Andrew Carty David Fleming
AQUATIC FAUNA		
2-7 July 2007 (Route options studies)	<ul style="list-style-type: none"> ■ <i>Overview surveys</i>: rapid habitat assessment of Glenugie Creek. 	SKM
11-15 May 2009 (Glenugie upgrade EA)	<ul style="list-style-type: none"> ■ <i>Comprehensive fish and macroinvertebrate survey</i>: concentrated on Glenugie Creek and associated tributaries directly impacted by the project. 	Sarah Foy Mirella Verhoeven

The field surveys reported in the Wells Crossing to Iluka Road Concept Design Report (RTA 2006) broadly covered the project area. That investigation identified the vegetation communities and species diversity associated with the project study area, including the type and distribution of endangered ecological communities (EECs) and threatened flora and fauna, and provided a basis for the targeted survey along the Glenugie alignment. The survey effort and techniques used for comprehensive survey of the Glenugie study area were conducted with reference to *Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities - working draft* (DEC 2004).

2.5.2. Terrestrial flora

Aerial photographs, previous vegetation mapping from the concept design investigations and topographic maps (1: 25,000) were used to stratify vegetation and habitats into individual units and identify appropriate sampling sites according to the extent of each unit. The stratification units are based on broad groupings of vegetation map units such as dry open forest, riparian forest and woodland and specific vegetation communities associated with the dominant flora.

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

- A thorough review of available literature and scientific databases to gain an appreciation of the diversity of flora species that potentially occur in the locality.
- General replicate sampling to define vegetation communities, threatened species habitat and develop an inventory of flora species specific to each vegetation association.
- Targeted searches for threatened flora species in areas of suitable habitat.

Vegetation community mapping

Transect sampling was used to identify vegetation community boundaries. The number of transects sampled was proportional to the size of the stratification units identified with up to two 100 m transects sampled per 2-50 ha of each stratification unit and three 100 m transects

sampled per 51-250 ha of stratification unit (DEC 2004). A GPS unit was used to record vegetation community boundaries.

Digital mapping of vegetation communities was conducted using ArcGIS® software. A combination of field data, aerial photograph interpretation and biophysical data such as elevation and soil type were used to delineate community boundaries. Description of the vegetation communities was based on their structure and dominant canopy species (Specht 1981) and correlated with Keith (2004) and CRAFTI (Resource and Conservation Division 2001) for comparison with final determination advice on EECs.

Plot-based surveys

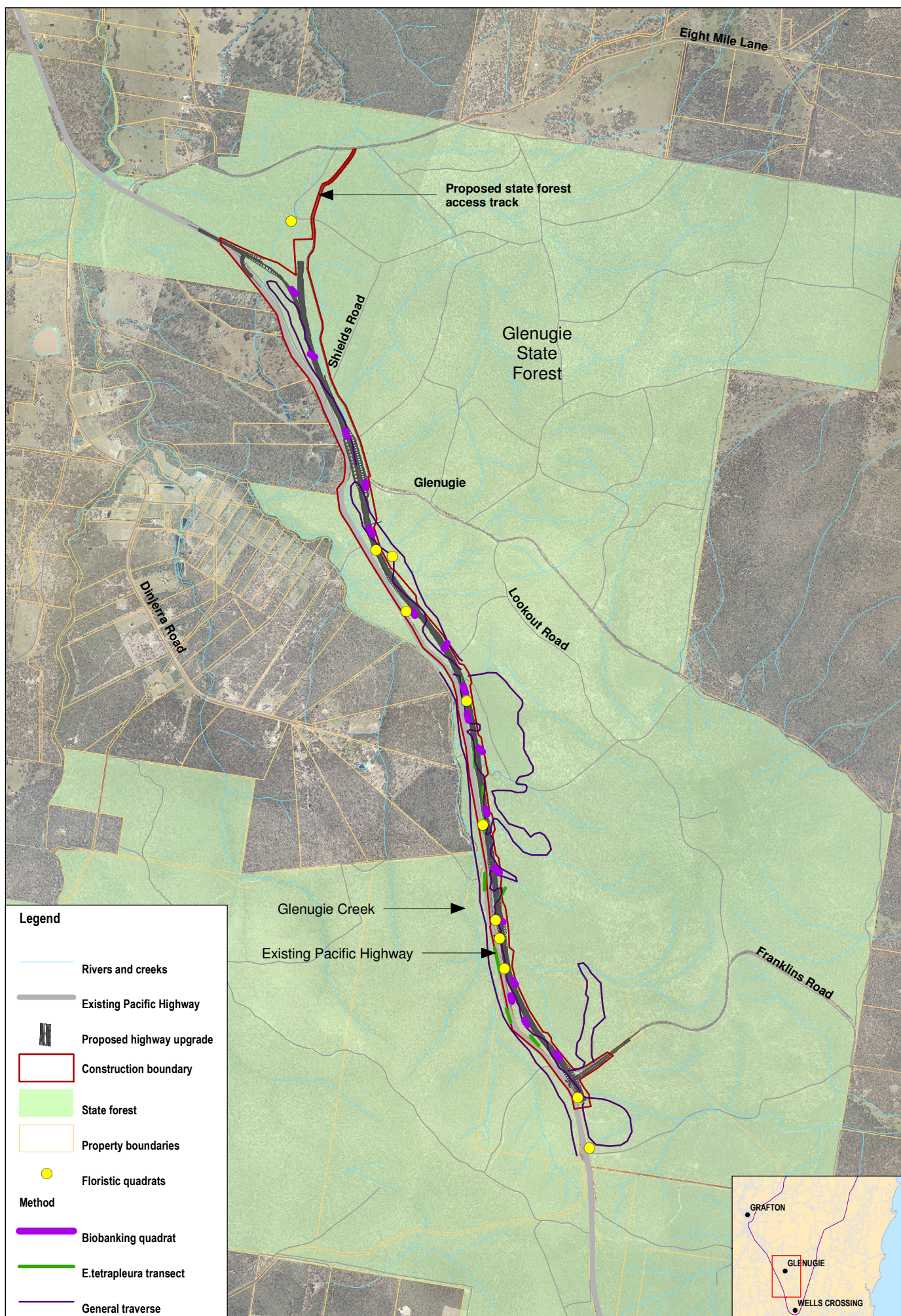
Standard quadrat based sampling was used in conjunction with general traverses of the study area in particular associated with the design footprint. Quantitative data on plant species richness were collected from a series of sample plots (400 m²) sampled within each vegetation association. The dominant species within each plot were given a cover abundance score using a modified Braun-Blanquet cover scale (Braun-Blanquet 1965). Data collected within each sample plot included:

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

Transects and traverses

General traverses were used in combination with the plot sampling. These comprised random searches throughout targeted areas to develop a flora inventory and to complete searches for threatened species, as well as opportunistically record the distribution of vegetation communities, significant habitat attributes and any other factors that may be of interest. The location of all threatened species, vegetation community boundaries and any other ecological factors were recorded with a GPS.

The locations of flora surveys are shown in **Figure 2-1**. Specific details of survey effort with respect to the number of quadrats and transects sampled are discussed below and summarised in **Table 2-3**.



Data Sources
 Topodata: Streetworks, LPI 2008
 Aerial: 2007

Figure 2-1: Location of flora surveys



0 1
 A4 1:40,000 Kilometres

■ **Table 2-3 Flora survey effort per habitat stratification unit**

Habitat	Area (ha)	Number of survey sites		
		Quadrat	Traverse	Total
Open Forest	825	6	14	20
Riparian forest	104	2	6	8
Moist shrubby woodland	36	2	4	6
TOTAL	965	10	24	34

Targeted surveys

Threatened flora species were targeted in areas of suitable habitat and concentrated specifically on the presence and abundance of the listed threatened species *Eucalyptus tetrapleura* (EPBC Act and TSC Act) and *Melaleuca irbyana* (TSC Act) both of which have been recorded previously in Glenugie State Forest (DECC 2009; RTA 2006).

Eucalyptus tetrapleura

Regional distribution

The location of known populations in the region were identified from the DECC Atlas of NSW Wildlife (DECC 2009) and DPI threatened species database (DPI 2008). These locations provide point data or individual records only and there were no data available on the size and extent of the population. The locations identified as occurring within state forest and conservation reserves were therefore surveyed in more detail to gather data on the regional distribution and abundance of the species. The approximate extent of each population was mapped using a hand-held GPS and ArcGIS software and the approximate density of trees at each site was determined.

A detailed survey of the Glenugie population was conducted, which included the study area and surrounding habitats in Glenugie State Forest, Wells Crossing Flora Reserve and Yuraygir State Conservation Area. Data on distribution in surrounding private lands were extrapolated from roadside inspections and knowledge of the species habitat preferences in the locality.

Mapping and density estimates

At each locality standardised transects were traversed recording details on the number of trees 10 m either side of the centreline, with the start and finish of the transect recorded with GPS so the exact length of the transect could be calculated. Trees were characterised into size classes based on the Diameter at Breast Height (DBH). The density of trees per hectare was calculated based on the average density from all transects undertaken within that population and extrapolated across the entire distribution of the population cluster.

In some circumstances the approximate distribution of *Eucalyptus tetrapleura* was extrapolated based on the particular distribution within that population. For example in some populations the species was restricted to ridge and upper slope areas and faded out below a certain elevation, and so the approximate area of its distribution could be mapped based on contour heights. In other circumstances it was restricted to areas below a certain contour height or was closely associated with a thick shrubby understorey which could be mapped through aerial photography interpretation. However several areas appeared to have complex soil, topography, geology and hydrological interactions making the mapping of *Eucalyptus tetrapleura* more problematic, requiring a larger degree of ground-truthing to determine the limits of the population. Where state forests and conservation reserves adjoin areas of private property, the approximate distribution of *E. tetrapleura* on private property was extrapolated from data collected and identified as a predicted occurrence.

Melaleuca irbyana

Targeted surveys comprised random meanders through areas of suitable habitat. Where *Melaleuca irbyana* was identified data were recorded for habitat condition, population size and range, reproductive status, existing threatening processes and habitat disturbances, age structure and land use.

Vegetation condition assessment

A vegetation and habitat condition assessment was conducted for the project area. The assessment was based upon past experience and available tools to provide an indicative measure of habitat condition for each of the vegetation types impacted by the project. Features examined included the type and distribution of plant communities, floristic diversity, vegetation structure, and density of fauna habitat features.

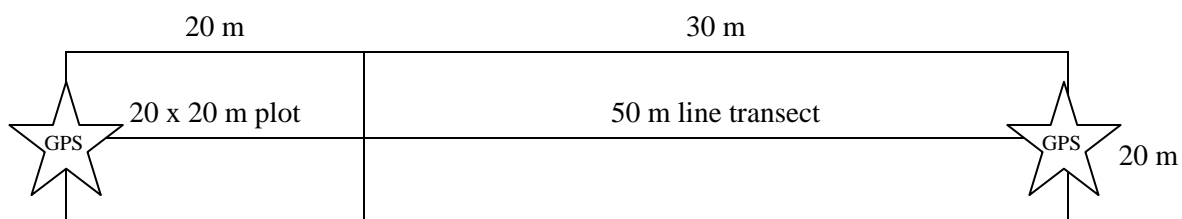
The vegetation communities of the study area were classified in the context of regional vegetation types identified in the DECC Vegetation Types Database (DECC 2008a). The vegetation types present in the study area closely resemble those identified in **Table 2-4** and were used for the purposes of the investigation.

■ **Table 2-4 Vegetation types (DECC 2008a)**

Associated vegetation classification	Dominant species	Other associated species	Landscape position	% cleared since European settlement
Narrow-leaved Red Gum woodlands of the lowlands of the North Coast	Narrow-leaved Red Gum (<i>Eucalyptus seeana</i>)	Large-leaved Spotted Gum (<i>Corymbia henryi</i>) Pink Bloodwood (<i>Corymbia intermedia</i>), Grey Ironbark (<i>Eucalyptus siderophloia</i>), Swamp Box (<i>Lophostemon suaveolens</i>), Cabbage Gum (<i>Eucalyptus amplifolia</i> subsp. <i>sessiliflora</i>), Swamp Oak (<i>Casuarina glauca</i>), Broad-leaved Apple (<i>Angophora subvelutina</i>)	On low poorly drained sites near coastal streams and swamps.	40 %
Spotted Gum - Grey Box - Grey Ironbark dry open forest of the Clarence Valley lowlands of the North Coast	Large-leaved Spotted Gum (<i>Corymbia henryi</i>), Grey Box (<i>Eucalyptus moluccana</i>), Grey Ironbark (<i>Eucalyptus siderophloia</i>)	Red Ironbark (<i>Eucalyptus fibrosa</i>), Swamp Box (<i>Lophostemon suaveolens</i>), Forest Red Gum (<i>Eucalyptus tereticornis</i>), Rough-barked Apple (<i>Angophora floribunda</i>) Thin-leaved Stringybark (<i>Eucalyptus eugenioides</i>)	Mainly confined slopes and hills on low quartz sediments in the Clarence lowlands.	45 %
Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast	Large-leaved Spotted Gum (<i>Corymbia henryi</i>), Spotted Gum (<i>Corymbia variegata</i>), Grey Ironbark (<i>Eucalyptus siderophloia</i>)	Small-fruited Grey Gum (<i>Eucalyptus propinqua</i>), Pink Bloodwood (<i>Corymbia intermedia</i>)	On slopes and ridges in undulating terrain of the Clarence lowlands	50 %

The characteristics of the vegetation were recorded from sample plots (20 x 20 m) and a 50 m line transect adjoining the plot as shown in **Figure 2-2**.

■ **Figure 2-2 Survey plot layout**



The number of plots and transect sampling effort for each vegetation type was determined in consideration of established sampling methodologies and the degree of variation within each of the identified vegetation communities in the study area. The number of plots sampled for each vegetation community is shown in **Table 2-5**.

■ **Table 2-5 Plots and transects required**

Vegetation type	Area (ha)	Number of plots surveyed
Narrow-leaved Red Gum woodlands of the lowlands of the North Coast	15.4	6
Spotted Gum - Grey Box - Grey Ironbark dry open forest of the Clarence Valley lowlands of the North Coast	30.8	4
Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast	70.5	7

Quantitative data were collected from each plot for native species richness; and native versus exotic species cover; hollow bearing trees; over-storey regeneration; and length of fallen logs. Native canopy and mid-storey cover were visually estimated at 10 points along the 50 m line transect and divided by 10 to provide an estimated project foliage cover for the plot. The projected foliage cover (per cent) of ground covers (native grasses, shrubs, other and exotic species), was calculated by recording their presence/absence at 50 points along the 50 m line transect and dividing the total number of hits by 50.

The plot data for each vegetation type was compared against the Vegetation Type Benchmarks (DECC 2008b) to assess the condition of the vegetation in each plot and the vegetation type overall.

2.5.3. Terrestrial vertebrate fauna

The assessment of impacts on terrestrial fauna has utilised quantitative and qualitative data collected on the type and distribution of fauna habitats and features, fauna species richness, distribution and abundance with a particular focus on threatened species listed under the TSC Act and EPBC Act. This included all threatened fauna species identified previously in the regional area from the search of the DECC Atlas of NSW Wildlife and discussion with the DECC (Hofmeyer 2009, *pers.comm*).

Data provided on the fauna of the study area are presented from the two separate survey periods associated with the initial concept design assessment (July 2007) and investigations for the environmental assessment (April-May 2009).

Site selection

Three broad fauna habitat types are represented in the study area predominantly associated with dry sclerophyll forest dominated by Large-leaved Spotted Gum (*Corymbia henryi*) with different sub-dominants depending on locality, including Square-fruited Ironbark (*Eucalyptus tetrapleura*), Broad-leaved Ironbark (*E. fibrosa*), Grey Box (*E. moluccana*), Forest Red Gum (*E. tereticornis*), and Narrow-leaved Red Gum (*E. seeana*).

Riparian areas associated with Glenugie Creek and smaller tributaries exhibit a habitat distinct from the surrounding dry open forest and comprising predominantly Swamp Turpentine

(*Lophostemon saueolens*) and *Melaleuca* spp. A third smaller habitat type exists comprising moist shrubby woodland dominated by Narrow-leaved Red Gum (refer **Figure 3-7**).

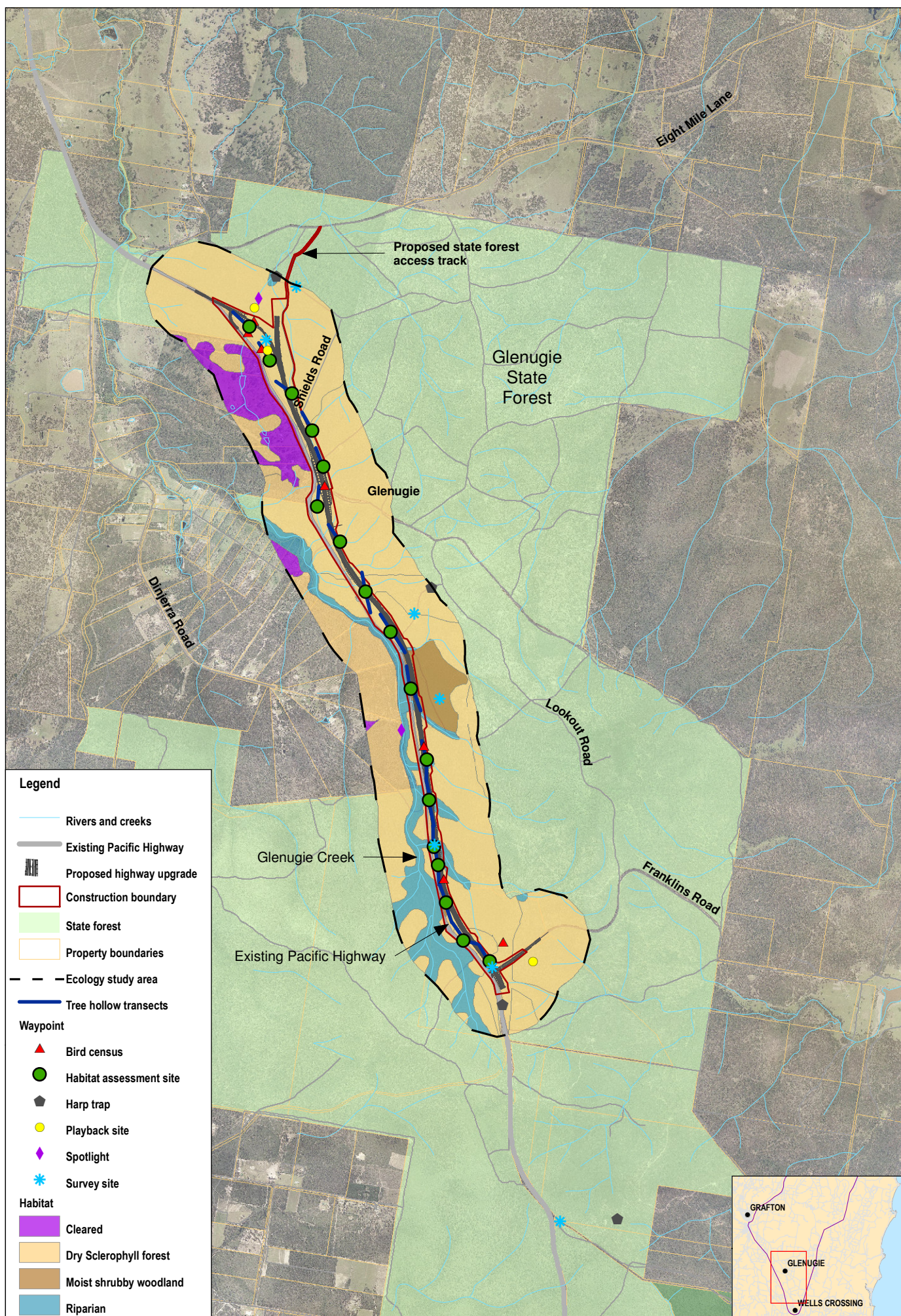
The fauna survey sites were selected to sample the range of habitat types identified by the initial stratification. Where possible surveys were conducted across the different range of floristic types associated with these units. Aquatic habitats (creeks and small wetlands) provided additional incidental data when encountered. This regime resulted in sampling 61 sites in total (refer **Table 2-6** and **Figure 2-3**).

Baseline fauna data were collected at seven primary survey sites sampled during July 2007 (sites 1-4) and then April-May 2009 (sites 5-7). A combination of sampling techniques was employed at each site in general accordance with the *Draft Threatened Biodiversity Survey and Assessment Guidelines* (DEC 2004) which included diurnal and nocturnal census and opportunistic observations. Details of survey techniques, effort and localities are provided below. Habitat assessment sites and tree hollow transects were sampled during April-May 2009 and aimed to provide a landscape assessment of the habitats in the study area. The location of fauna survey sites are presented in **Figure 2-3**.

■ **Table 2-6 Fauna survey effort per habitat stratification unit**

Habitat	Area (ha)*	Survey sites				Total
		Primary sites	Supplementary sites	Habitat assessment	Tree hollow transects	
Dry sclerophyll forest	74.7	5	11	13	18	47
Riparian forest	5.3	1	1	3	3	8
Moist shrubby forest	5.1	1	0	1	4	6
TOTAL	85 ha	7	12	17	25	61

* Based on the habitat to be impacted by the project, including a 10 m wide buffer.



Data Sources
 Topodata: Streetworks, LPI 2008
 Aerial: 2007

Figure 2-3: Location of fauna surveys



0 1
 A4 1:50,000 Kilometres

Survey conditions

Details of temperature and rainfall conditions during field surveys for the project are provided in **Table 2-7**. Conditions were generally dry and mild during the 2007 detailed field surveys, although periodic rainfall occurred in the study area over the months of June (82 mm) (immediately prior to the survey), August (193 mm), September (31 mm) and October (125 mm). Surveys in April and May 2009 were dry and mild and following heavy rainfall over March (154 mm) and February (169 mm).

The survey conditions were considered suitable for detection of the large majority of fauna groups and species expected in the study area particularly threatened birds and mammals. However, the cooler temperatures and season would have affected the activities of reptiles and amphibians. The predicted presence of additional species from these fauna groups has been inferred from the data collected for the Wells Crossing to Iluka Road project and regional data.

■ **Table 2-7 Survey weather conditions**

Dates	Mean temp (°C)		Rainfall (mm)	Conditions
	Min	Max		
2-7 July 2007	8.5	22.5	None (30mm the week preceding)	Cool to mild, light winds predominantly from the northwest
27 April – 1 May 2009	10.1	24.9	None	Cool nights and mild days, calm winds predominantly from the southeast
11-15 May 2009	11.5	23.5	6.8 mm	Mild to warm, calm to light winds predominantly from the north and northeast

Terrestrial mammals

Live-trapping of small to medium sized mammals was conducted in July 2007 (sites 1-4) and April 2009 (sites 5-7) in all habitat types. A standardised transect arrangement (200 m) was used delineated by 20 Elliott traps (type A, 33 x 10 x 9 cm, aluminium folding traps) placed 10 m apart and one cage trap (30 x 30 x 60 cm) placed at each end. All Elliott traps were baited with peanut butter, rolled oats and honey and cage traps were baited with tinned sardines. Traps and cages were placed in or under cover wherever possible. Traps were opened for a three-night period (96 hours) at each site and were checked each morning. Captured animals were measured, weighed, identified and released.

Total ground trapping effort equated to 420 Elliot trap nights and 42 cage trap nights. The species and location of mammal scats, scratches and other evidence of fauna presence when encountered were noted to provide locality records for native and exotic species.

Arboreal mammals

Live-trapping of arboreal mammals was conducted in July 2007 (sites 1-4) and April 2009 (sites 5-7). At each survey site an arboreal trapping grid of 10 traps was established. The

configuration of each grid was two parallel lines of five traps, with each trap spaced 50 metres apart (200 m in length). At each trap point, one Elliott trap (type B, 15 x 16 x 45 cm aluminium folding trap) was mounted on a platform attached to a tree trunk at a height of 3.5 metres. Each trap was baited with a mixture of peanut butter, rolled oats and honey and the trunk of the tree adjacent to the trap sprayed with a mixture of water and honey to act as an attractant. Traps were inspected each morning and the tree re-sprayed with the honey-water mixture. Any animals captured were measured, weighed, identified and released at the capture site the following night. The effective trap area of this grid configuration is 200 x 100 metres (two hectares). Each trap grid was active for three consecutive nights (96 hours). Total arboreal trapping effort equated to 210 arboreal trap nights.

Spotlighting and dusk census for arboreal mammals was conducted at all seven primary sites during the trapping periods. Spotlighting was foot-based and comprised a general traverse across the two hectare trapping grid, utilising hand-held spotlights. Two observers conducted the survey for a minimum period of one hour per site following dusk (approx 1800-1900 hours). All fauna heard or observed were recorded to species level. Observations of fauna were aided by the use of binoculars. Counts were taken on the number of fauna heard and observed.

Spotlighting was also conducted at two supplementary locations not associated with the primary sites, along Nine Mile Creek and Glenugie Creek (refer **Figure 2-3**). Total survey effort by spotlight was 16 hours.

Bats

Standard two-bank 4.2m² harp traps were used to sample for microchiropteran bats. A total of seven harp trap locations were sampled in July 2007 and April 2009. The location of each harp trap was chosen to sample the range of different habitat types and consisted of a single trap placed in proximity to each of the primary survey sites (**Figure 2-3**). Harp traps were predominantly placed in forested areas along narrow gaps such as vehicle and walking tracks as close to the primary site as possible. Such locations are generally associated with natural flyways for microchiropteran bats. Harp traps were placed at each location for two nights resulting in a total trapping effort of 14 trap nights. Captured bats were collected early the following morning, identified and measured. Captured individuals were held that day and released at the capture point that night.

A stationary ultrasonic bat call detector (Anabat II, Titley Electronics) was used with a storage ZCAIM unit to record bat calls at three sites in April 2009. Calls were recorded continuously between 1800 and 0500 hours on each occasion for two nights. Calls were identified to genus or species level where possible using computer frequency analysis software (Analook v.4.0).

Spotlighting and listening for calls of megachiropteran bats (*Pteropus* spp.) was conducted during all spotlighting activities.

Birds

Surveys were conducted at each primary survey site in July 2007 (sites 1-4) and April-May 2009 (sites 5-7) (refer **Figure 2-3**). Seven supplementary bird survey sites were sampled additional to the primary sites in April 2009 targeting threatened birds, including Brown Treecreeper (*Climacteris picumnus*) and Black-chinned Honeyeater (*Melithreptus gularis*). Line transects were undertaken by a single observer moving along a fixed route and recording the birds seen and heard on either side of the route. Each transect was a fixed 200 m long and 100 m wide, generating a two hectare search area. The survey aimed to record all birds seen or heard within 50 m either side of the transect over a minimum period of 20 minutes. This survey effort was applied to each site. Birds were also recorded opportunistically during all other site visits and field survey. Binoculars were carried in the field at all times to assist in identification.

Call playback of the threatened species Powerful Owl (*Ninox strenua*), Barking Owl (*Ninox connivens*), Masked Owl (*Tyto novaehollandiae*) and Bush Stone Curlew (*Burhinus grallarius*) was conducted during spotlighting surveys at each of the primary survey sites and three additional supplementary sites, as shown on **Figure 2-3**. Pre-recorded calls were broadcast via a portable MP3 player and megaphone for a period of five minutes for each species, followed by a five minute listening period. Spotlighting was conducted briefly between calls and then following completion of the call playback series for a period of 10 minutes. Quiet listening for dusk calls of species was also undertaken whilst conducting other field activities such as spotlight searches.

Reptiles and amphibians

Both nocturnal and diurnal herpetological surveys were conducted at each primary site in July 2007 (sites 1-4) and April 2009 (sites 5-7). Refer to **Figure 2-3** for location of primary survey sites. Nocturnal herpetofauna was opportunistically identified during spotlighting surveys and included the survey of the margins of wet areas for active frogs and reptiles. Systematic frog searches were also carried out at Glenugie Creek (site 5) and Nine Mile Creek (supplementary site). Nocturnal surveys for frogs were conducted by two persons using spotlights and battery powered head torches to survey along drainage lines and soaks.

Frogs were identified by call, and / or visual characteristics. All active frogs were captured, where possible, identified and immediately released. At potentially suitable locations throughout the study area, a period of listening for the calls of frog species was undertaken, especially at dusk on moist and warm nights. The diurnal component of the reptile surveys consisted of hand searches for active and resting individuals under rocks, logs, bark, leaves and timber and artificial debris when encountered. Specific reptile census was conducted for 30 minutes at each primary survey site (1-7). Opportunistic observations were also recorded during the carrying out of other survey activities.

Summary of fauna survey effort

The total fauna survey effort per technique and habitat unit is summarised in **Table 2-8**. The survey effort is applicable to all surveys conducted along the alignment including the route options studies (2007) and EA studies (2009).

■ **Table 2-8 Summary of fauna survey effort employed within each habitat unit**

Technique	Fauna group	Survey effort*			
		Dry open forest	Riparian	Woodland	Total effort
Tree-traps	Arboreal mammals	150 ¹	30 ¹	30 ¹	210 trap nights
Ground traps (Elliott's)	Small terrestrial mammals	300 ¹	60 ¹	60 ¹	420 trap nights
Ground traps (cages)	Medium terrestrial mammals	30 ¹	6 ¹	6 ¹	42 trap nights
Harp-traps	Microchiropteran bats	10 ¹	2 ¹	2 ¹	14 trap nights
Bat call recording	Microchiropteran bats	1 site	1 site	1 site	3 sites (36 hrs)
Spotlighting	All groups	10 ²	4 ²	2 ²	16 person hrs
Diurnal birds	Diurnal birds	12 sessions ³	1 sessions ³	1 session ³	14 sites
Call playback	Nocturnal birds	8 ³	1 ³	1 ³	10 sites
Herpetofauna	Frogs and Reptiles	5 ²	1 ²	1 ²	7 person hrs

* 1= trap nights; 2 = person hours; 3 = each session is minimum 20 minutes

Tree hollow counts

Transects (200 m x 50 m) were used to quantify the density of tree hollows for comparison between the different habitat types. Surveys were conducted along the length of the route alignment resulting in a total of 25 transects. Details were recorded on the number, size and species of hollow-bearing tree and the number of tree hollows recorded in size classes of small (0-4 cm), medium (4-15 cm) and large (>15 cm). The location of hollow trees was recorded using a hand-held GPS.

Habitat assessment and mapping

Habitat assessment data were collected from 17 sites along the length of the alignment to gather information on the type and condition of fauna habitat present. Each site was selected to correspond with a tree hollow transect (refer **Figure 2-3**) to compare data on hollow abundance with habitat type. At each survey site 50 x 50 m quadrats were used to investigate and document fauna habitat features, by assessing the condition and abundance of a set of habitat criteria which included the:

- Type and structure of the vegetation, including an assessment of the 'naturalness' in terms of the presence of remnant vegetation or planted and regrowth areas and the extent of logging.
- Presence and frequency of large mature trees, tree hollows and their size classes, standing dead trees (stags) and logs or boulders.
- Dominant flora species and a subjective assessment of floristic diversity at different structural layers, flowering and fruiting resources.

- Presence of significant keystone species and critical habitat elements for threatened fauna.
- Representation of the habitat type on a local and regional scale.
- Disturbance regimes, both past and ongoing including fire regime and weed abundance.
- Density of each vegetation strata (structural diversity).
- Presence and quality of wet areas or waterbodies, significant aquatic habitats where present.
- Size of remnant patches and extent of connectivity, movement corridors and refuge value.

The habitat assessment and tree hollow data were used in combination with field survey results to identify important habitats for threatened species. The surveys identified and mapped the distribution of broad habitat types in relation to the predicted presence of threatened fauna species. This included firstly identifying important habitat characteristics required for each species (i.e. keystone food plants, locations with abundant tree hollows or logs, or preferences for a particular habitat type and structure). Secondly the survey and mapping of these features was conducted in proximity to the alignment. This information in conjunction with targeted fauna surveys and a review of regional records was used to accurately assess the extent and magnitude of impacts on threatened species habitat.

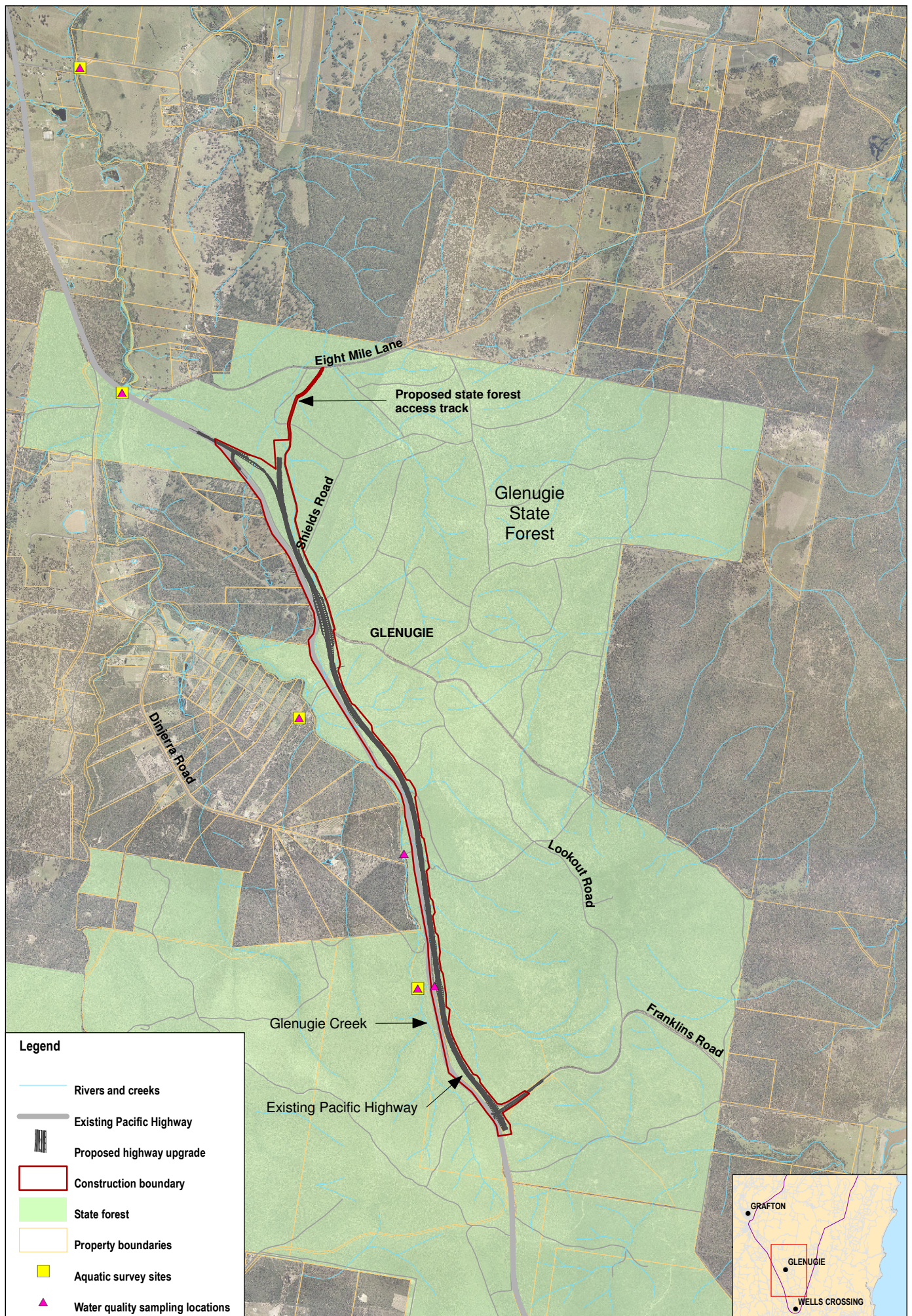
Opportunistic searches

Opportunistic surveys were conducted to search for evidence of the Koala (*Phascolarctos cinereus*) and Glossy Black-Cockatoo (*Calyptrorhynchus lathami*). Searches for evidence of Koalas were conducted opportunistically where Forest Red Gum (*Eucalyptus tereticornis*) was encountered during the tree hollow transects. At each site a grid of 50 x 50 m was established and searches for koala droppings (scats) were conducted around the base of trees greater than 20 centimetre diameter at breast height, until a total of 20 trees were searched.

Searches for evidence of Glossy Black-Cockatoo were also conducted opportunistically where Black She-oak (*Allocasuarina littoralis*) was encountered during tree hollow transects. This involved searching for ‘chewed cones’ beneath larger trees.

2.5.4. Aquatic fauna

The route alignment crosses one named creek, Glenugie Creek. There is a lack of baseline data for this aquatic ecosystem and a survey was required to collate information on fish and macro-invertebrates in order to assess the significance of impacts from the project. This information also provides a basis for managing and monitoring impacts on the waterway during construction. Aquatic ecology fieldwork was conducted from the 12-14 May 2009. The following section details the sampling methodology and survey locations are provided in **Figure 2-4**.



Data Sources
 Topodata: Streetworks, LPI 2008
 Aerial: 2007

Figure 2-4: Location of aquatic survey sites and water quality sampling



0 1
 A4 1:50,000 Kilometres

Site selection

Glenugie Creek is situated within the Clarence River Catchment, NSW and includes minor unnamed tributaries located within the study area. Preliminary site inspections were conducted to select suitable sampling sites, near locations suggested by DPI (*Gordos 2009, pers comm*). Four water quality and aquatic ecology sites were selected, with an additional two water quality only locations. Effort was made to position two sites upstream of the proposed road alignment, however all tributaries inspected upstream of Glenugie Creek were dry at the time of sampling. Aquatic ecology and water quality fieldwork was conducted during dry conditions to provide dry weather water quality data in addition to macroinvertebrate, fish and aquatic habitat data. **Table 2-9** lists the location and field survey techniques applied at each of the six sites sampled.

■ **Table 2-9 Summary of aquatic survey effort**

Glenugie Creek	Site code	Water quality	Bait trapping	Fyke nets	Macro-invertebrates
Downstream	1	√	√	√	√
Downstream	2	√	√	√	√
Downstream	3	√	√	√	√
Downstream	3.5	√			
Downstream	4	√	√	√	√
Upstream	4.5	√			

Water quality

Water quality was measured in situ at each of the freshwater sites using a Yeokal-611 multi-parameter water quality probe. A range of parameters were measured from a single reading in slack water including dissolved oxygen (DO), pH, conductivity ($\mu\text{S}/\text{cm}$ – mS/cm), turbidity (NTU) and temperature ($^{\circ}\text{C}$).

Fish sampling

Freshwater fish communities were sampled at each site using a combination of bait traps and fyke nets. The feasibility of deploying each type of net depended upon the channel and habitat characteristics at each site, and the appropriate fish sampling gear was deployed accordingly.

Bait traps

A total of 10 bait traps ($45 \times 25 \times 25$ cm) were set overnight in shallow habitats at each site. Where possible, traps were set in stands of emergent vegetation, areas with submerged vegetation, or snag piles, as these areas are likely to support a greater diversity and abundance of small bodied fish.

Fyke nets

Two large fyke nets with a six metre leader were set overnight in freshwater littoral habitats (>0.4 m deep), at each site. The fyke nets were used to trap mobile, large bodied fish. The nets were set with a float in the cod end to provide an air pocket for any turtles or diving birds and mammals, which may have been trapped.

Fish species measurements

All fish captured were identified to species and information recorded on abundance, the size of fish (total length in mm); and sampling technique.

Macroinvertebrate sampling

AusRivAS samples were collected at each of the four major sites by AusRivAS accredited personnel during the autumn sampling period (11- 15 May) using NSW AusRivAS protocols summarised below (Turak *et al.* 2004).

AusRivAS sampling methodology

The sampling area at each site was determined as a length of 100 m or 10x the mode width (whichever is larger). At each sample site macroinvertebrate samples were collected from edge habitats (creek bank in areas of little or no flow, including alcoves and backwaters, with abundant leaf litter, fine sediment deposits, macrophyte beds and overhanging bank vegetation) (Turak *et al.* 2004). Riffle habitats, consisting of areas of broken water with rapid current (Turak *et al.* 2004) were not present and therefore not sampled. Samples were collected from 10 m of representative edge sub-habitats using a kicknet (0.25 mm mesh size) to dislodge macroinvertebrates. Care was taken to ensure all sub-habitats within the site were represented within the sample.

Water quality was assessed at each AusRivAS sampling location. Temperature, conductivity, turbidity, dissolved oxygen, salinity and pH were measured using a YeoKal 611 water quality probe. Alkalinity (CaCO_3) was determined using Total Alkalinity titration kits. In addition to providing habitat predictor variables used in the AusRivAS model, water chemistry can be compared to the ecological health SIGNAL scores and macroinvertebrate taxa presence to determine variables impacting upon macroinvertebrate communities. The assessment of water quality in this report is made in accordance with default trigger values in slightly disturbed estuarine and lowland river ecosystems in south-east Australia as outlined in the National Water Quality Management Strategy (ANZECC/ARMCANZ 2000).

Chemical and physical habitat variables (environmental data) were recorded using AusRivAS datasheets at each site and used as predictor variables in the AusRivAS modelling program.

Samples were live sorted by trained staff shortly after collection and placed into separate, labelled jars containing 70 per cent ethanol. A minimum sorting time of 40 minutes applied after which sorting time depended upon whether a new taxon had been recently collected. The

maximum sorting time allowed was 60 minutes. Debris remaining after sorting was returned to the creek where it was collected.

Macroinvertebrate identification

The live picked macroinvertebrate samples were identified to family level of taxonomic resolution, except for Chironomidae which was identified to subfamily as required by the AusRivAS model. If large crustaceans were found they were identified to species level due to the high level of endemism.

Data analyses - AusRivAS modelling

Macroinvertebrate data were entered into the AusRivAS modelling program. The program uses mathematical models to predict the aquatic macroinvertebrate fauna expected to occur at modelled locations with similar habitat which have minimal or no impact from most human activity (reference condition) and compares these results with fauna actually collected, providing a measure of biological impairment. Predictor variables (including physical habitat variables, latitude, longitude, altitude, slope and distance from source) are used to determine the modelled reference condition of similar type against which to compare macroinvertebrate assemblages.

The AusRivAS model software outputs specify the Observed (macroinvertebrates collected during sampling) to Expected Ratios (macroinvertebrates which are predicted to occur in reference conditions). The 'Observed' (O) macroinvertebrates are calculated for all macroinvertebrates which were observed with a predicted probability of occurrence greater than 50 per cent. The 'Expected' (E) variable is calculated as the sum of all modelled probabilities greater than 50 per cent. An O/E value close to 1 indicates that the macroinvertebrate fauna found are similar to those of the predicted reference streams, and a value close to zero indicates severe impairment compared to reference condition. Based upon these ratios, a 'band ranking' indicating the ecological health of the river is assigned as follows:

- Band X: Macroinvertebrate assemblage is more biologically diverse than reference sites.
- Band A: Site is in reference condition with most/all of the expected families found.
- Band B: Site is significantly impaired, indicating a potential impact either on water quality and/or habitat quality which has resulted in a loss of taxa.
- Band C: Site is severely impaired; indicating a loss of biodiversity due to substantial impacts on water and/or habitat quality.
- Band D: Site is extremely impaired; few expected taxa remain, indicating extremely poor water and/or habitat quality resulting in a highly degraded waterway.

The model also calculates the expected and actual SIGNAL score for each site. SIGNAL is a biotic index that allocates a value to each macroinvertebrate family based largely upon their

sensitivity to pollution (a value of 10 indicates high sensitivity, one represents high tolerance) (Chessman, 1995). The SIGNAL classification is:

- Signal Score > 6: Healthy Habitat
- Signal Score 5-6: Mild Pollution
- Signal Score 4-5: Moderate Pollution
- Signal Score <4: Severe Pollution.

Waterway classification

Photographs taken upstream and downstream of each sampling site combined with the physical characteristic data taken as part of the AusRivAS sampling were used to characterise each site according to Fairfull and Witheridge (2003) *Fish Passage Requirements for Waterway Crossings* (Table 2-10).

■ Table 2-10 Fish passage requirements for waterway crossings

Classification ¹	Characteristics of waterway type	Minimum [2] recommended crossing type
Class 1 Major fish habitat	Major permanently or intermittently flowing waterway (e.g. river or major creek), habitat of a threatened fish species.	Bridge, arch structure, culvert [3] or tunnel
Class 2 Moderate fish habitat	Named permanent or intermittent stream, creek or waterway with clearly defined bed and banks with semi -permanent to permanent waters in pools or in connected wetland areas. Marine or freshwater aquatic vegetation is present. Known fish habitat and/or fish observed inhabiting the area.	Bridge, arch structure, culvert [3] or ford.
Class 3 Minimal fish habitat	Named or unnamed waterway with intermittent flow and potential refuge, breeding or feeding areas for some aquatic fauna (e.g. fish, yabbies). Semi - permanent pools form within the waterway or adjacent wetlands after a rain event. Otherwise, any minor waterway that interconnects with wetlands or recognised aquatic habitats.	Culvert [4] or ford.
Class 4 Unlikely fish habitat	Named or unnamed waterway with intermittent flow following rain events only, little or no defined drainage channel, little or no flow or free standing water or pools after rain events (e.g. dry gullies or shallow floodplain depressions with no permanent aquatic flora present).	Culvert [5], causeway or ford.

[1] Fairfull and Witheridge, 2003.

[2] In all cases bridges are preferred to arch structures, culverts, fords and causeways (in that order).

[3] High priority given to the "High Flow Design" procedures presented for the design of these culverts - refer to Design Considerations section of this document, or engineering guidelines (Witheridge, 2002).

[4] Minimum culvert design using the "Low Flow Design" procedures; however, "High Flow Design" and "Medium Flow Design" should be given priority where affordable (refer to Witheridge (2002)).

[5] Fish friendly waterway crossing designs possibly unwarranted. Fish passage requirements should be confirmed with the local fisheries department/authority.

2.6. Limitations

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

Due to the timing of the project spring and summer surveys were not conducted and this factor may have a bearing on the results of the flora and fauna surveys particularly in the identification of cryptic species or species with seasonal preferences. As a precautionary measure, threatened species not recorded during the surveys but considered to potentially occur have been considered in the assessment of impacts of the project.

3. Results

3.1. Landscape context

The study area lies within the NSW North Coast Bioregion which encompasses an area of 5,694,360 ha along the coast and eastern slopes from Port Macquarie to the Queensland border (Thackway and Creswell 1995). Two hundred and two flora species found in the North Coast Bioregion are listed in the schedules of the TSC Act (NPWS 2001b). Of these, 108 are endangered, 89 are vulnerable and five are considered extinct in the bioregion (NPWS 2001). One hundred and fifty-seven fauna species recorded in the North Coast Bioregion are listed in the schedules of the TSC Act (NPWS 2001a). Of these, 36 are listed as endangered and 121 are listed as vulnerable.

A major factor which contributes to this high species diversity is the location within the MacPherson-Macleay Overlap Zone. This zone is defined as that area of eastern Australia where the Tropical and Temperate Zones overlap (Burbridge 1960). It includes part of south-east Queensland and part of north-east NSW. In this area tropical elements predominate in the wetter habitats of the eastern slopes of the ranges and temperate elements in the drier or cooler and more open sites. Bassian (or south-eastern Australian) and Torresian (or northern Australian) species overlap with the former being at the northern extent of their range, the latter being at the southern extent of their range.

The NSW North Coast Bioregion has the second highest proportion of lands under conservation reserves of the NSW bioregions. In total 1,061,709.6 ha or 18.7 per cent of the bioregion is conserved. The following nine conservation reserves are located within 20 km of the project:

- Tallawudjah Nature Reserve.
- Koukandowie Nature Reserve.
- Sherwood Nature Reserve.
- Susan Island Nature Reserve.
- North Rock Nature Reserve.
- Yuraygir State Conservation Area.
- Yuraygir National Park.
- Chambigne Nature Reserve.
- Flaggy Creek Nature Reserve.

A review of threatened flora and fauna species present in conservation reserves of the region is presented in **Table 3-1** and the location of threatened flora and fauna records within 10 km of the project is shown in **Figure 3-1** and **Figure 3-2**.

■ **Table 3-1 Threatened species present in regional conservation reserves**

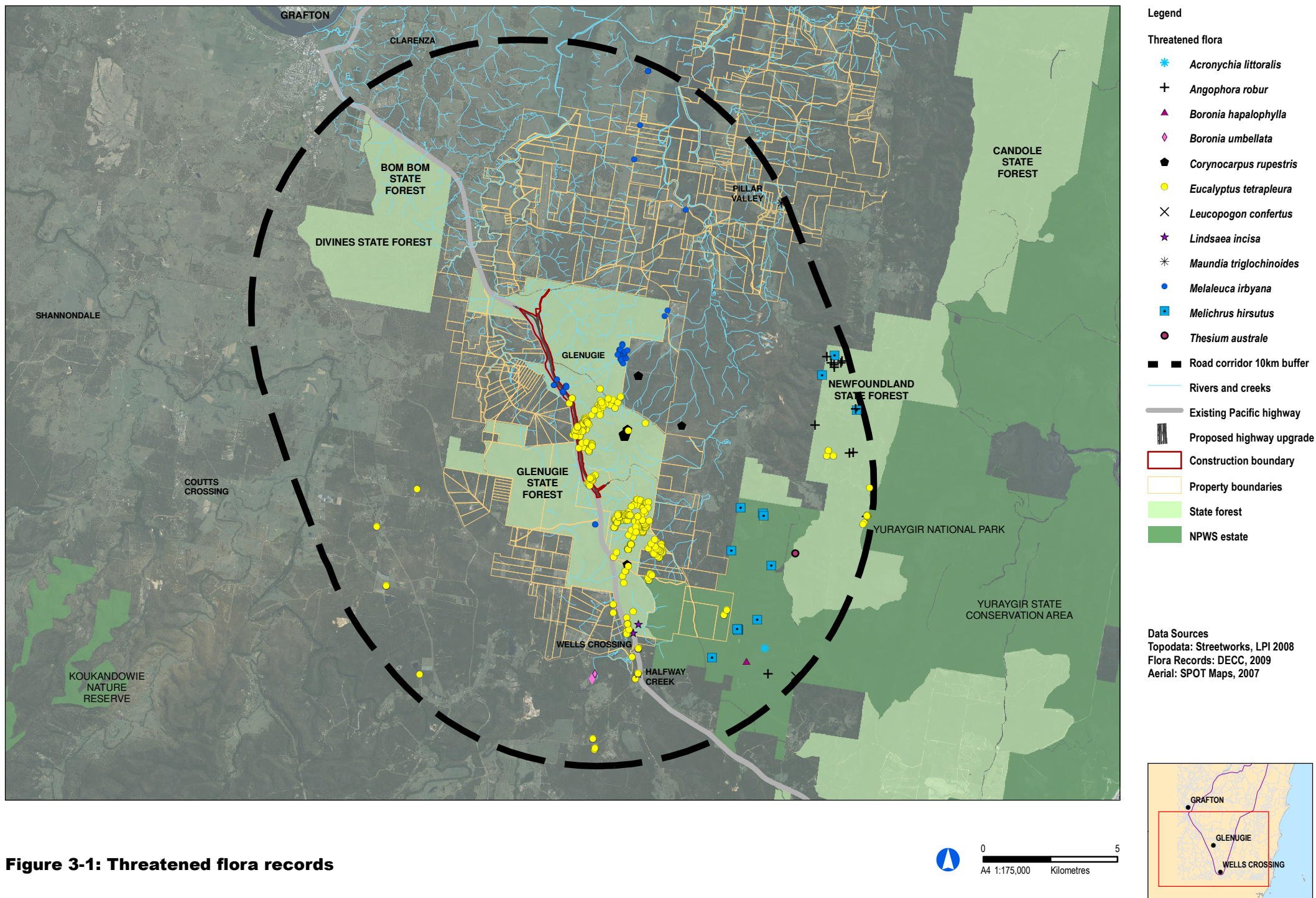
Common name	Species	Status (TSC Act)	Status (EPBC Act)	Tallawudjah NR	Koukandowie NR	Sherwood NR	Yuraygir SCA	Yuraygir NP	Chambigne NR	Flaggy Creek NR	Susan Island NR	North Rock NR
Threatened Fauna												
Barking Owl	<i>Ninox connivens</i>	V						•				
Barred Cuckoo-Shrike	<i>Coracina lineata</i>	V				•						
Beach Stone-Curlew	<i>Esacus neglectus</i>	E1						•				
Black Bittern	<i>Ixobrychus flavicollis</i>	V						•				
Black-Chinned Honeyeater	<i>Melithreptus gularis gularis</i>	V					•					
Black-Necked Stork	<i>Ephippiorhynchus asiaticus</i>	E1		•				•				
Brolga	<i>Grus rubicunda</i>	V						•				
Brown Treecreeper	<i>Climacteris picumnus</i>	V					•					
Brush-Tailed Phascogale	<i>Phascogale tapoatafa</i>	V						•				
Brush-Tailed Rock Wallaby	<i>Petrogale penicillata</i>	E1	V		•	•			•			
Bush-Stone Curlew	<i>Burhinus grallarius</i>	E1				•						
Comb-Crested Jacana	<i>Irediparra gallinacea</i>	V						•				
Common Blossom-Bat	<i>Syconycteris australis</i>	V				•		•				
Common Planigale	<i>Planigale maculata</i>	V					•					
Eastern Bentwing-Bat	<i>Miniopterus schreibersii oceanensis</i>	V				•						
Eastern Cave Bat	<i>Vespadelus troughtoni</i>	V				•			•			
Eastern Chestnut Mouse	<i>Pseudomys gracillicaudatus</i>	V						•				
Eastern False Pipistrelle	<i>Falsistrellus tasmaniensis</i>	V				•						
Eastern Ground Parrot	<i>Pezoporus wallicus wallicus</i>	V						•				
Emu Population	<i>Dromaius novaehollandiae</i>	E2						•				
Giant Barred Frog	<i>Mixophyes iteratus</i>	E1				•		•				
Giant Dragonfly	<i>Petalura gigantea</i>	E1				•						

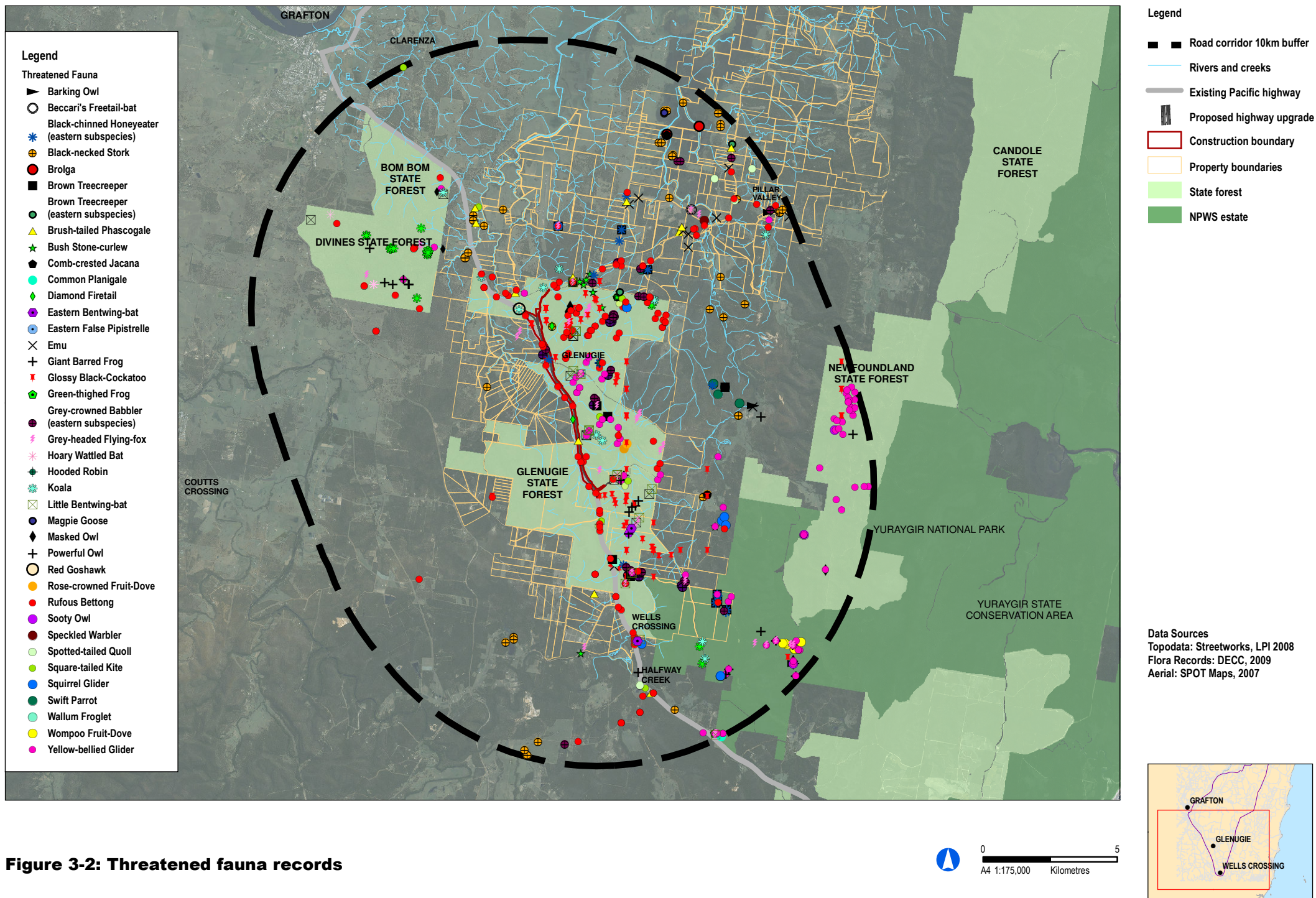
Common name	Species	Status (TSC Act)	Status (EPBC Act)	Tallawudjah NR	Koukandowie NR	Sherwood NR	Yuraygir SCA	Yuraygir NP	Chambigne NR	Flaggy Creek NR	Susan Island NR	North Rock NR
Glossy Black-Cockatoo	<i>Calyptrorhynchus lathamii</i>	V			•	•	•	•	•			
Golden-Tipped Bat	<i>Kerivoula papuensis</i>	V				•						
Grass Owl	<i>Tyto capensis</i>	V						•				
Greater Broad-Nosed Bat	<i>Scoteanax rueppellii</i>	V				•						
Green And Golden Bell Frog	<i>Litoria aurea</i>	E1						•				
Green-Thighed Frog	<i>Litoria brevipalmata</i>	V					•					
Grey-Crowned Babbler	<i>Pomatostomus temporalis temporalis</i>	V			•		•	•				
Grey-Headed Flying-Fox	<i>Pteropus poliocephalus</i>	V	V		•	•	•	•			•	
Hoary Wattled Bat	<i>Chalinolobus nigrogriseus</i>	V			•			•	•			
Koala	<i>Phascolarctos cinereus</i>	V			•	•	•	•				
Large-Eared Pied Bat	<i>Chalinolobus dwyeri</i>	V	V			•			•			
Little Bentwing-Bat	<i>Miniopterus australis</i>	V			•	•	•	•	•			
Little Tern	<i>Sterna albifrons</i>	E1						•				
Long-Nosed Potoroo	<i>Potorous tridactylus</i>	V				•						
Masked Owl	<i>Tyto novaehollandiae</i>	V			•	•		•				
Olongburra Frog	<i>Litoria olongburiensis</i>	V						•				
Osprey	<i>Pandion haliaetus</i>	V						•				
Pied Oystercatcher	<i>Haematopus longirostris</i>	V						•				
Powerful Owl	<i>Ninox strenua</i>	V				•	•	•				
Red-Backed Button-Quail	<i>Turnix maculosa</i>	V						•				
Regent Honeyeater	<i>Xanthomyza phrygia</i>	V	E			•		•				
Rose-Crowned Fruit-Dove	<i>Ptilinopus regina</i>	V				•		•				
Rufous Bettong	<i>Aepyprymus rufescens</i>	V			•	•	•	•	•			
Sooty Owl	<i>Tyto tenebricosa</i>	V				•		•				
Sooty Oystercatcher	<i>Haematopus fuliginosus</i>	V						•				•

Common name	Species	Status (TSC Act)	Status (EPBC Act)	Tallawudjah NR	Koukandowie NR	Sherwood NR	Yuraygir SCA	Yuraygir NP	Chambigne NR	Flaggy Creek NR	Susan Island NR	North Rock NR
Spotted-Tailed Quoll	<i>Dasyurus maculatus</i>	V	V					•	•			
Square-Tailed Kite	<i>Lophoictinia isura</i>	V						•				
Squirrel Glider	<i>Petaurus norfolcensis</i>	V			•	•	•	•				
Superb Fruit-Dove	<i>Ptilinopus superbus</i>	V				•						
Swift Parrot	<i>Lathamus discolor</i>	E1	E					•				
Turquoise Parrot	<i>Neophema pulchella</i>	V						•				
Wallum Froglet	<i>Crinia tinnula</i>	V						•				
White-Crowned Snake	<i>Cacophis harriettae</i>	V						•				
Wompoo Fruit-Dove	<i>Ptilinopus magnificus</i>	V				•	•	•				
Yellow-Bellied Glider	<i>Petaurus australis</i>	V				•	•	•	•			
Yellow-Bellied Sheath-tail-Bat	<i>Saccolaimus flaviventris</i>	V						•	•			
Threatened Flora												
Austral Toadflax	<i>Thesium australe</i>	V	V					•				
Bordered Guinea Flower	<i>Hibbertia marginata</i>	V						•				
Dwarf Heath Casuarina	<i>Allocasuarina defungens</i>	E1	E					•				
Hairy Melichrus	<i>Melichrus hirsutus</i>	E1	E	•			•	•	•	•		
Heath Wrinklewort	<i>Rutidosis heterogama</i>	V	V					•				
Lemon-Scented Grass	<i>Elymus citreus</i>	E1						•				
Maundia	<i>Maundia triglochoides</i>	V						•				
Moonee Quassia	<i>Quassia</i> sp. Moonee Creek	E1	E			•						
Orara Boronia	<i>Boronia umbellata</i>	V	V			•						
Rusty Plum	<i>Amorpospermum whitei</i>	V				•						
Sand Spurge	<i>Chamaesyce psammogeton</i>	E1						•				
Sandstone Rough-Barked Apple	<i>Angophora robur</i>	V	V	•	•	•	•		•	•		

Common name	Species	Status (TSC Act)	Status (EPBC Act)	Tallawudjah NR	Koukandowie NR	Sherwood NR	Yuraygir SCA	Yuraygir NP	Chambigne NR	Flaggy Creek NR	Susan Island NR	North Rock NR
Scented Acronychia	<i>Acronychia littoralis</i>	E1	E				•					
Shannon Creek Boronia	<i>Boronia haplophylla</i>	E1				•	•		•	•		
Short-Footed Screw Fern	<i>Linsaea brachypoda</i>	E1						•				
Silverbush	<i>Sophora tomentosa</i>	E1						•				
Slender Marsdenia	<i>Marsdenia longiloba</i>	E1	V					•				
Slender Screw Fern	<i>Lindsaea incisa</i>	E1				•						
Small Pale Grass-Lily	<i>Caesia parviflora</i> var. <i>minor</i>	E1						•				
Square-Fruited Ironbark	<i>Eucalyptus tetrapleura</i>	V	V				•	•	•			
Square-Stemmed Olax	<i>Olax angulata</i>	V	V					•				
Torrington Beard-Heath	<i>Leucopogon confertus</i>	E1						•				

- Status – E1 = Endangered Species; E2 = Endangered Population; V = Vulnerable Species (TSC Act)





A number of state forests are located within the landscape, Glenugie, Bom Bom, New Foundland, Candole, Divines and Pine Brush. These state forests are managed primarily for forestry activities although are also of conservation value. There are numerous records of the threatened flora and fauna species in these state forests highlighting their conservation value and as indicated by their inclusion in the DEC (2003) key habitats database.

The project is located entirely within Glenugie State Forest which supports habitat for a diversity of native flora and fauna species, including threatened and rare species and endangered and unique vegetation communities. In particular Glenugie State Forest supports a large population of the threatened flora species Square-fruited Ironbark (*Eucalyptus tetrapleura*) which has been a large focus of the ecological surveys for this project to date. Additionally, this area supports populations of several threatened fauna species.

3.2. Mitchell landscapes

The Landscapes of NSW were mapped at a broad scale (1: 250,000) using land systems, geology, geomorphology and elevation data (Mitchell 2003). The study area lies in extensive low undulating hills referred to as the Grafton – Whiporie Basin (Mitchell 2003). These data identify one landscape type present across the study area (refer **Figure 3-3**) and an additional four in the regional area, these include:

- Grafton – Whipore Basin: present throughout the project footprint and study area.
- Flat Top Basalts: present on Glenugie Peak to the east of study area.
- Clarence – Richmond Alluvial Plains: present along Glenugie Creek to the west of the study area.
- Somervale Range: to the east of the study area.
- Clarence – Manning Basin Margin: to the east of the study area.

Grafton - Whiporie basin

Extensive low undulating hills and large drainage basins on sub-horizontal upper Jurassic interbedded quartz sandstone, lithic sandstone, clayey siltstone and coal measures. Often exhibits ironstone concretions in the weathering profile. General elevation 50 to 150m, local relief 50 m. Yellow and brown texture-contrast soils on slopes and dark grey clays along valley floor streamlines.

Flat top basalts

Peaks and flat-topped hills of Tertiary trachytic and basaltic volcanic plugs and flow remnants, general elevation 150 to 470 m, local relief 180 m. Thin stony structured red-brown loam and clay loam, friable, well drained and moderately fertile.

Clarence - Richmond alluvial plains

Wide valleys, channels, floodplains, terraces and estuaries of the Clarence and Richmond Rivers and other coastal streams on Quaternary alluvium, general elevation 0 to 50m, local relief 15 m. Deep brown earths and structured brown clay on floodplains. Terrace with yellow texture-contrast soil containing ironstone concretions.

Somervale range

Higher inland coastal range adjacent to Ballina Coastal Ramp on prominent line of middle Jurassic quartz sandstone and conglomerate, with prominent water gaps where streams have cut across the structure. Strong structural control with north-south folds. General elevation 50 to 325 m, local relief 150 m. Shallow stony red-brown structured loams, and red, yellow or brown texture-contrast soils in different slope positions, the colour differing with drainage conditions.

Clarence – Manning basin margin

Low ranges and foothills on the western margin of the Clarence-Manning basin margin below the Great Escarpment on gently folded middle Jurassic felspathic and lithic clayey sandstones, general elevation 100 to 400 m, local relief 150 m. Yellow and brown texture-contrast soils on slopes, sandy alluvium and dark uniform clay or clay loams along valley floors. Moist hardwood forest of; Blackbutt (*Eucalyptus pilularis*), Grey Gum (*Eucalyptus punctata*), White Mahogany (*Eucalyptus acmenoides*), Red Mahogany (*Eucalyptus resinifera*) and some New England Blackbutt (*Eucalyptus andrewsii* subsp. *campanulata*).

Based on the *BioMetric Assessment Tool* (D Gibbons et. al. 2005) about 39 per cent of the historical vegetation has been cleared across this landscape.

3.3. Habitat connectivity

The DECC key habitats and corridors project (DEC, 2003) and Climate Change Corridors project (DECC 2007) were reviewed for relevance to the study area. These projects adopted a systematic approach to landscape conservation in north-east NSW by identifying regional fauna key habitats and linking habitat corridors, including current corridor locations and corridors likely to become important in the face of future climate change. The review also included an assessment of local fauna movement corridors specific to the study area to determine the most appropriate location of fauna movement passageways in the study area.

A summary of the information and data used in the assessment included:

- The location of large parcels of habitat associated with forestry land and conservation reserves, including forestry special protection zones (flora reserves).
- Flora and fauna records from the DECC Atlas of NSW Wildlife database (2009) and State Forests (DPI 2008) threatened species database and data recorded from the field survey of the study area.

- Key fauna habitats and corridors identified in DEC (2003) and DECC (2007).
- The results of the habitat assessments conducted within the study area and in particular the predicted distribution of threatened species habitat.

The entire highway alignment is located within a portion of Glenugie State Forest. This forestry land extends further to the east and west totalling over 3400 ha in area. Glenugie State Forest has been identified as a 'key habitat' and is positioned at a strategic location in the landscape being a connecting link from the coast via Newfoundland State Forest and Yuraygir National Park through to the west into Bom Bom State Forest and dry open forest habitats on freehold land in the Coutts Crossing and Shannondale areas (refer **Figure 3-4**). At the north-eastern end of the forest there are fragmented links to Sandy crossing and eventually the Pillar Valley range.

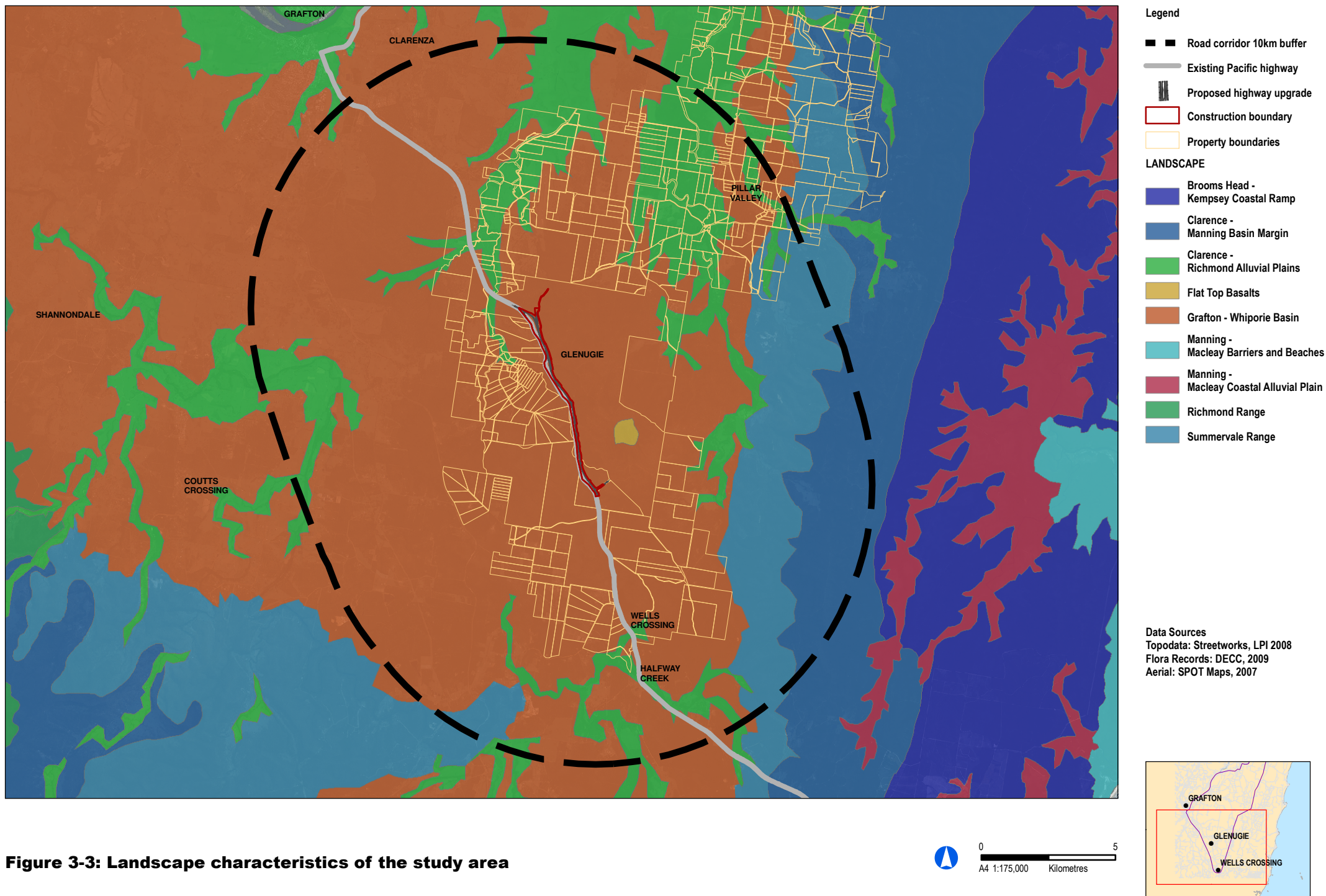
The network of key habitats and habitat fragments in the region south and east of Grafton indicate that the Glenugie study area is well connected. This fact combined with the high diversity of flora and fauna in the region illustrates the importance of maintaining connectivity and minimising the potential barrier effect of the project through appropriate mitigation. The review of key habitats, corridors and habitat patch network was used to develop appropriate specifications for the type and location of proposed fauna crossing structures within the final road design. Further detail on the fauna crossing strategy is provided in Section 4.1.

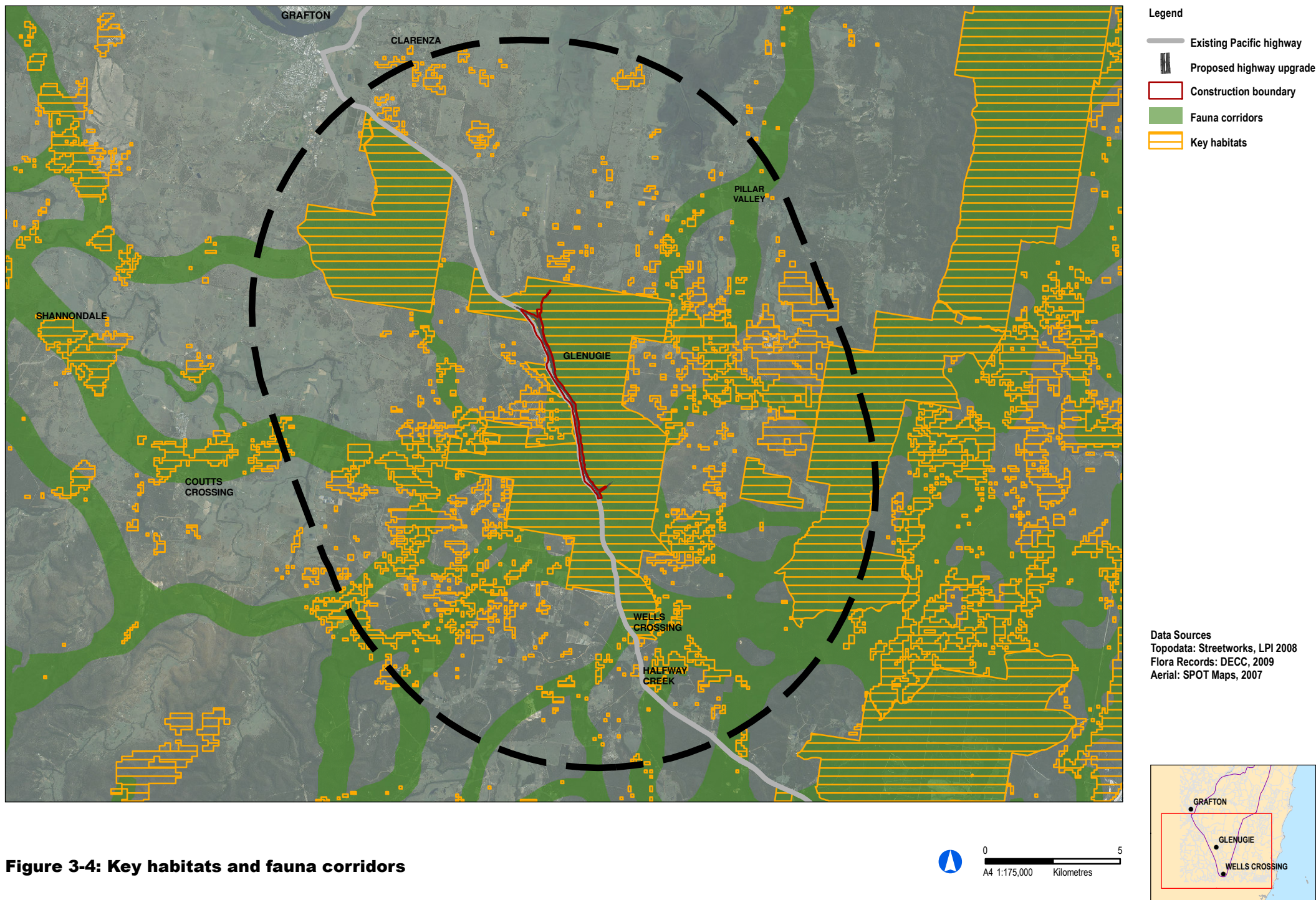
Climate change corridors are those landscapes that represent large scale corridors of optimum habitat significant for the movement of wildlife that may be vulnerable to the adverse effects of climate change and other threatening processes. The entire study area has been identified as being within a dry corridor (**Figure 3-5**).

3.4. Special management zones

The entire highway alignment is located within a portion of Glenugie State Forest, of which areas have been identified as Special Management Zone. These areas have been identified as "High Conservation Value Old Growth". Special Management Zones are for the management and protection of native forests containing significant natural and cultural conservation values. The special management zones mapped in the study area were not identified in the field surveys as being significantly different from surrounding areas in terms of old growth forest. However these areas do support some larger trees within riparian corridors and some larger hollow-bearing trees have been retained as habitat in areas.

Construction of new roads is permitted in this zone provided the development adheres to special conditions.







3.5. Literature and database review

The conservation significance of flora and fauna species and endangered ecological communities (EECs) is discussed in the national context with reference to Briggs & Leigh (1996) (Rare or Threatened Australian Plants – RoTAP) and the Commonwealth EPBC Act, and in the State context with reference to Schedules 1 and 2 of the TSC Act. The result of the background investigation into listed biodiversity relevant to the study locality is discussed in the following section.

3.5.1. Endangered ecological communities

The study area is not part of any major coastal floodplain area and therefore does not support extensive areas of floodplain associated EECs. However, the main watercourses in the project area, namely Glenugie Creek and its tributaries, support suitable habitat (including soils and hydrological regimes) for Subtropical Coastal Floodplain Forest on Coastal Floodplains, a locally occurring EEC. Vegetation along some of these creeks has strong floristic affinities to this EEC.

3.5.2. Threatened species

The potential presence of all rare and threatened flora and fauna species has been previously recorded for the upper north coast region. The possible presence of these species was considered by assessing the preferred habitat attributes of each species with the habitat attributes within the study area. Appendix A lists all species and endangered populations previously recorded within 10 km of the preferred route (DECC 2009 and EPBC Act Protected Matters Search Tool: accessed April 2009) and their broad habitat preferences in addition to assessment of their potential presence in proximity to the preferred route on the basis of the habitats identified.

3.5.3. Aquatic fauna

A Bionet search for species of fish protected under NSW legislation was conducted by the Ecology Lab (2007) for the Wells Crossing to Iluka Road Aquatic Ecology Assessment. No listed species have been recorded in Glenugie Creek or its tributaries. Three listed species of freshwater fish are known to occur in the region, including the Oxleyan Pygmy Perch (*Nannoperca oxleya*), the Eastern Freshwater Cod (*Maccullochella ikei*) and Purple-spotted Gudgeon (*Morgurnda adspersa*). Other species likely to occur in the region which are not listed under NSW legislation but should still be considered as ecologically significant are the eastern population of the Olive Perchlet (*Ambassis agassizii*) and the Freshwater Catfish (*Tandanus tandanus*). No endangered populations or endangered ecological fish communities as listed under schedule 4 of the FM Act 1994 are known to occur within the study area.

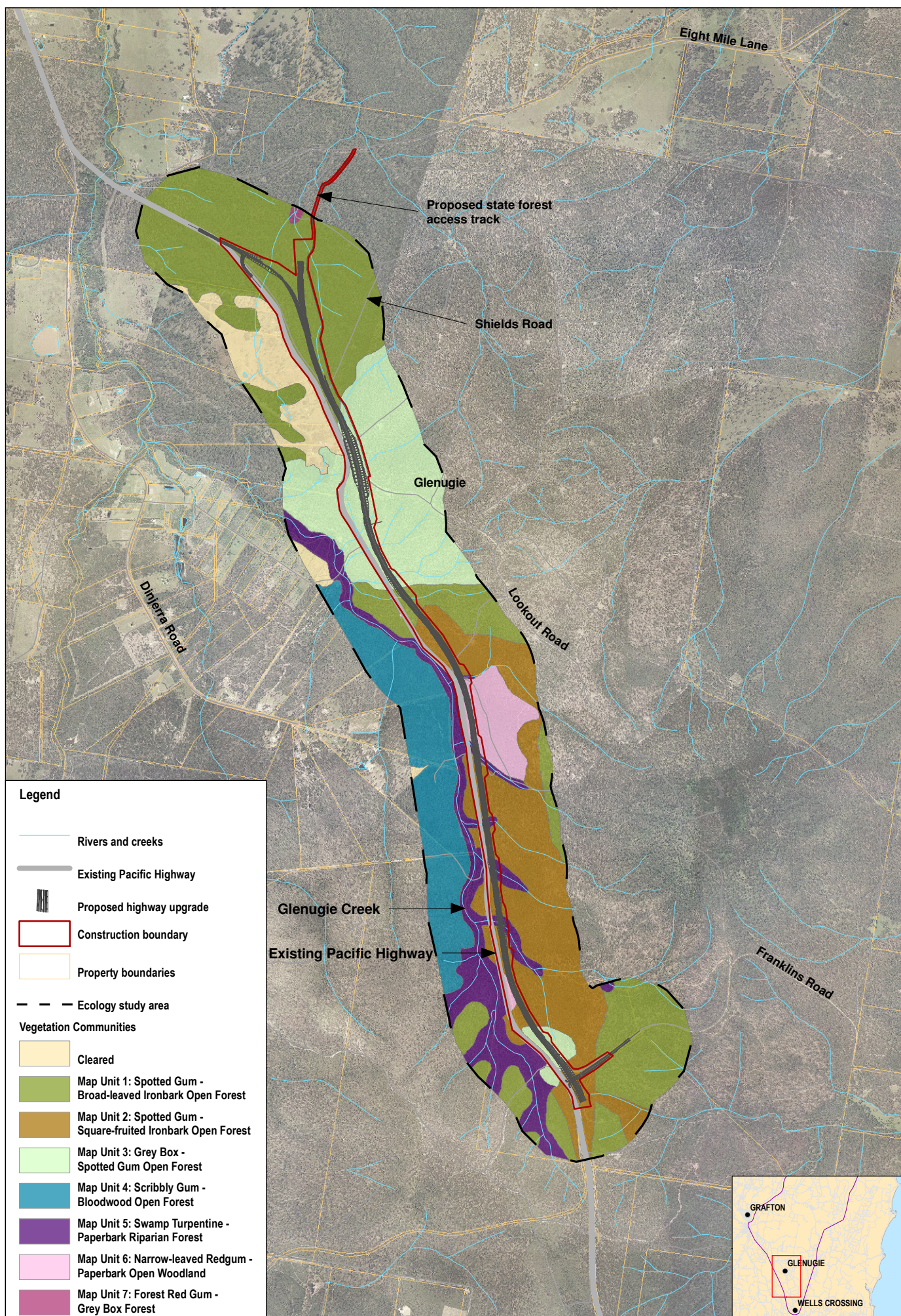
3.6. Terrestrial flora

3.6.1. Vegetation communities

The following descriptions of vegetation communities are derived from the results of the flora survey and describe the vegetation located within proximity to the proposed footprint. Seven vegetation structural types are described according to the classification system of Specht (1970). These comprise dry sclerophyll open forests and moist sclerophyll forests, including the following associations:

- Map Unit 1: Spotted Gum – Ironbark Forest.
- Map Unit 2: Spotted Gum – Square-fruited Ironbark Forest.
- Map Unit 3: Grey Box – Spotted Gum Forest.
- Map Unit 4: Scribbly Gum – Bloodwood Forest.
- Map Unit 5: Swamp Turpentine - Paperbark Riparian Forest.
- Map Unit 6: Narrow-leaved Red Gum - Paperbark Woodland.
- Map Unit 7: Forest Red Gum - Grey Box Forest.

These structural communities include a number of vegetation ‘associations’ classified on the basis of the dominant canopy species. A description of the structure and floristics and distribution of each vegetation association is provided below. The locations of vegetation communities within the preferred route corridor are shown in **Figure 3-6**.



Data Sources
 Topodata: Streetworks, LPI 2008
 Aerial: 2007

Figure 3-6: Vegetation communities



0 1
 A4 1:40,000 Kilometres

Dry sclerophyll forests

Dry sclerophyll forests dominate the study area and include four distinctive associations. The understorey vegetation appears to have been modified in these areas from past disturbances including over-frequent fires and forestry management practices. When compared with other areas of this community in the local area, the study area supports a sporadic distribution of medium-sized shrub species from the Fabaceae, Ericaceae and Proteaceae families and a high abundance and diversity of grass species possibly indicating high frequency fire events in the past. The canopy in areas of dry sclerophyll forests ranges from 15-20 m, with many areas supporting a varied age structure including saplings, juveniles, medium and large trees. Little weed invasion is present within these forest areas, with exotic species being restricted to the edge of the existing highway and localised occurrences of several pasture weed species which have been spread into forested areas by Brumbies.

Map Unit 1: Spotted Gum – Ironbark Forest

This community occupies drier elevated areas generally with clay soils and is dominated almost exclusively by Large-leaved Spotted Gum (*Corymbia henryi*) and Broad-leaved Ironbark (*Eucalyptus fibrosa*), although other species occasionally occur including Small-fruited Grey Gum (*E. propinqua*) and Grey Box (*E. moluccana*). This community occurs throughout the study area and is widespread throughout Glenugie State Forest.

The understorey includes open grassy areas with patches of shrub thickets dominated by Ball Honey-myrtle (*Melaleuca nodosa*), with some areas also including Black She-oak (*Allocasuarina littoralis*) and Curracabah (*Acacia concurrens*). Dominant understorey species mainly include grass species such as Three-awned Speargrass (*Aristida vagans*), Wiry Panic (*Entolasia stricta*), Kangaroo Grass (*Themeda australis*), Barbed-wire Grass (*Cymbopogon refractus*) and Blady Grass (*Imperata cylindrica*). Forb species present include Kidney Weed (*Dichondra repens*), White Root (*Pratia purpurascens*), Wattle Mat-rush (*Lomandra filiformis subsp. coriacea*) and Variable Glycine (*Glycine tabacina*). The threatened flora species Square-fruited Ironbark (*Eucalyptus tetrapleura*) may occur as isolated occurrences in this community, particularly where it adjoins map unit 2. The threatened species Weeping Paperbark (*Melaleuca irbyana*) also occurs in this community mainly in more protected areas surrounding drainage lines and depressions.

Map Unit 2: Spotted Gum – Square-fruited Ironbark Forest

This association typically occurs on sandy clay soils with a slightly higher soil-moisture content or water table in the central and southern areas of the study area. This forest type is dominated almost exclusively by Large-leaved Spotted Gum and Square-fruited Ironbark. Other species which occasionally occur include Small-fruited Grey Gum, Grey Box and Orange Gum (*E. bancroftii*).

The understorey is often dominated by a highly to moderately dense sub-canopy of Ball Honey-myrtle, Black She-oak and Curracabah occurs throughout much of this community. The groundcover includes a similar suite of species as present in map unit 1, however some sedge species are present in higher abundance including Sword Sedge (*Lepidosperma laterale*) and Rough-leaved Saw-sedge (*Gahnia aspera*). The threatened flora species Square-fruited Ironbark (*Eucalyptus tetrapleura*) is a dominant component of this community occurring in relatively high abundance. The threatened species Weeping Paperbark (*Melaleuca irbyana*) also occurs on the northern edge of this community.

Map Unit 3: Grey Box – Spotted Gum Forest

This community occurs within lower elevated areas of Glenugie State Forest on clay soils mainly towards the northern end of the study area, however there is also a small occurrence at the southern end of the study area. Dominant species comprise Grey Box and Large-leaved Spotted Gum with several other species occurring as subdominants, particularly along drainage lines including Small-fruited Grey Gum, Northern Grey Ironbark (*Eucalyptus siderophloia*) and Forest Red Gum (*E. tereticornis*).

The understorey comprises a mix of shrub patches including Black She-oak and Curracabah and grassy areas supporting a diversity of grass and forb species. It contains a moderate diversity of groundcover species similar to those in map units 1 and 2, including Small-flower Finger Grass (*Digitaria parviflora*), Weeping Grass (*Microlaena stipoides*), *Lagenophora gracilis*, *Vernonia cinerea* and Wombat Berry (*Eustrephus latifolius*). The threatened species Weeping Paperbark (*Melaleuca irbyana*) occurs on the southern edge of the main patch of this community.

Map Unit 4: Scribbly Gum – Bloodwood Forest

This community occurs outside the project footprint west of Glenugie Creek on the other side of the existing highway and is confined to areas with sandy soils. Dominant species comprise Scribbly Gum (*Eucalyptus signata*), Pink Bloodwood (*Corymbia intermedia*) and Red Bloodwood (*C. gummifera*). This forest contains a high-moderate diversity of shrub and groundcover species and was not subject to detailed surveys due its location outside of the project footprint.

Moist sclerophyll forests

These communities are associated with drainage lines and lower elevated areas subject to intermittent flooding with moist soils. The canopy in these areas ranges from 15-20 m high along with a sub-canopy 5-8 m high. Many of these areas support a high abundance of Blady Grass possibly indicating the area has been subject to high frequency fire events. The three moist sclerophyll forest associations have strong affinities to the state-listed EEC Subtropical Coastal Floodplain Forest.

Map Unit 5: Swamp Turpentine - Paperbark Riparian Forest

This community occupies areas where flooding is intermittent with sandy alluvial soils including some of the tributaries of Glenugie Creek which extend into the project footprint and areas on the western side of the existing highway surrounding Glenugie Creek. A mixed canopy generally dominated by Swamp Turpentine (*Lophostemon suaveolens*), Red Mahogany (*Eucalyptus resinifera*) and Narrow-leaved Red Gum (*E. seeana*). Several other canopy species are present in areas of this community including those from surrounding dry sclerophyll forest map units, such as Square-fruited Ironbark, Forest Red Gum, Grey Box, Scribbly Gum, Pink Bloodwood and *Angophora woodsiana*.

An open shrub cover or sub-canopy is present in some areas including *Melaleuca alternifolia*, Yellow Tea-tree (*Leptospermum polygalifolium*), Red Ash (*Alphitonia excelsa*), Cheese Tree (*Glochidion ferdinandi*), Curracabah and Ball Honey-myrtle. Other understorey species includes a mix of shrubs grasses and forbs similar to other map units. However several mesic flora species are also present within and surrounding drainage lines including Coffee Bush (*Breynia oblongifolia*), Maidenhair Fern (*Adiantum spp.*), *Baumea juncea*, Basket Grass (*Oplismenus spp.*), Headache Vine (*Clematis glycinoides*), Common Silkpod (*Parsonsia straminea*) and Wombat Berry. A low abundance of *Lantana camara* is present in this map unit along with several other minor weed species.

Map Unit 6: Narrow-leaved Red Gum - Paperbark Woodland

This association is generally positioned on the lower elevated areas of Glenugie State Forest on sandy clay soils in the central area of the study area. This community supports an open to very open canopy with a dense sub-canopy of shrub species. Dominant canopy species comprise Narrow-leaved Red Gum and Square-fruited Ironbark with Large-leaved Spotted Gum and Pink Bloodwood also occurring in low abundance.

A dense sub-canopy of Curracabah, Ball Honey-myrtle, *Hakea florulenta*, *Melaleuca sieberi* and juvenile canopy species is present. The groundcover is relatively low in diversity with a sparse cover due to the dense sub-canopy limiting light penetration, with dominant species including Rock Fern (*Cheilanthes sieberi subsp. sieberi*), Sword Sedge and Rough-leaved Saw-sedge. The threatened flora species Square-fruited Ironbark (*Eucalyptus tetrapleura*) is a dominant component of this community occurring in relatively high abundance.

Map Unit 7: Forest Red Gum - Grey Box Forest

This community occurs on alluvial soils associated with Pheasants Creek at the northern end of the study area outside of the project footprint. Dominant species include Forest Red Gum, Grey Box, Northern Grey Ironbark, Broad-leaved Apple (*Angophora subvelutina*) and Pink Bloodwood. This association exhibits disturbance from logging activities and inappropriate fire regimes as well as agricultural activities, resulting in a simplified understorey containing several weed species.

3.6.2. Flora diversity

A total of 242 plant taxa from 64 families were identified in the study area. This total comprises 90 species of monocotyledons, 145 species of dicotyledons, six ferns and one conifer. It also includes two threatened species, namely *Eucalyptus tetrapleura* and *Melaleuca irbyana*. Exotic species are dominant along roadsides, trails and areas of disturbed vegetation. Of the 242 flora species recorded, 32 (13 per cent) are introduced species. The complete list of flora recorded within the study area is provided in Appendix D.

3.6.3. Introduced flora

Introduced flora species were mainly located along existing highway, with only minor occurrences recorded within areas of intact remnant vegetation. The study area generally supports a low diversity and abundance of exotic species. A low abundance of the noxious weed species *Lantana camara* and Camphor Laurel (*Cinnamomum camphora*) is present within some areas of intact bushland, particularly areas with higher soil fertility such as drainage lines. An area south of Franklins Road appears to be formerly inhabited or utilised with several exotic trees planted in the area and other minor weeds present. Introduced species were generally absent within intact areas of dry sclerophyll forest, apart from a sporadic occurrence of minor pasture weeds such as *Richardia* spp. and Cudweed (*Gamochaeta spicata*) spread by wild horses. Of the 32 introduced flora species recorded within the study area, two of these are declared noxious weeds within the control area of Clarence Valley Council; these are listed in Table 3-2.

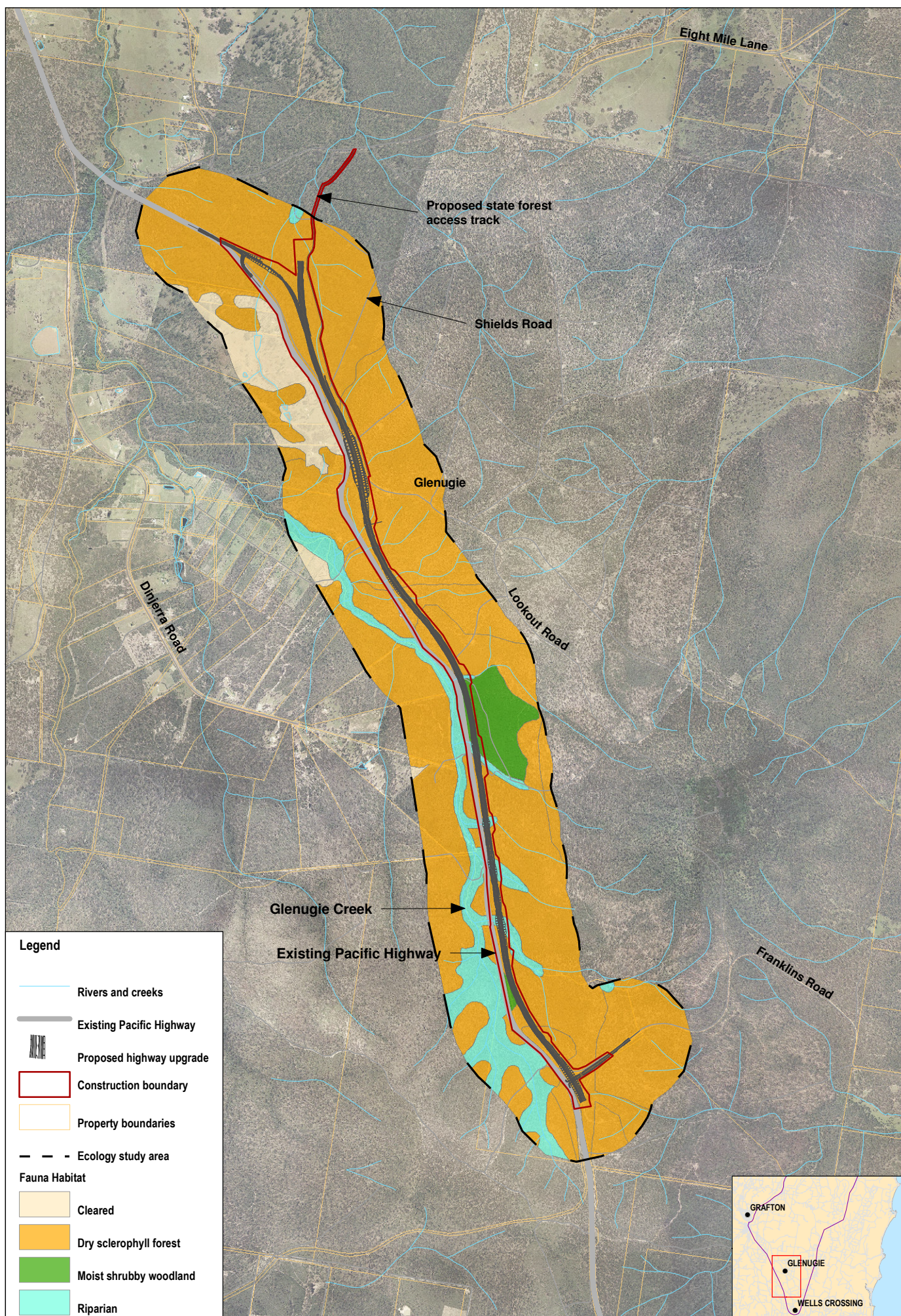
■ Table 3-2 Declared noxious flora species recorded in study area

Noxious species	Noxious class and legal requirements
<i>Cinnamomum camphora</i> (Camphor Laurel)	Class 4 -The growth and spread of the plant must be controlled according to the measures specified in a management plan published by the local control authority
<i>Lantana camara</i> (Lantana)	

3.7. Vertebrate fauna

3.7.1. Fauna habitats

The following descriptions of fauna habitat types in the study area are derived from the results of the habitat assessment. These comprise dry sclerophyll forests, shrubby woodland, riparian habitats and aquatic habitats. The locations of fauna habitats are shown in Figure 3-7.



Data Sources
 Topodata: Streetworks, LPI 2008
 Aerial: 2007

Figure 3-7: Fauna habitats



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The dominant habitat type in the study area is associated with the dry open sclerophyll forests on alluvial clay soils. Characteristic tree species are dominated by Large-leaved Spotted Gum (*Corymbia henryi*), in association with several Ironbarks (*Eucalyptus fibrosa*, *E. tetrapleura* and *E. siderophloia*), Grey Box (*E. moluccana*) and Small-fruited Grey Gum (*E. propinqua*). Tree cover is generally open and large mature trees, hollow-bearing trees or stags are generally scarce as a result of logging, clearing and fire management. The structure and floristics of this habitat vary considerably along the alignment with some areas exhibiting a simple structure comprising canopy and groundcover with no obvious small tree or shrub layers. Conversely large areas of low regrowth following disturbance have resulted in a very dense middle strata dominated by Wattles (*Acacia* spp.) and Paperbarks (*Melaleuca nodosa*). The latter areas are common through the central and southern parts of the study area, while the open structure is more common in the northern end.

The degree of successional change in the forest structure which occurs across the study area provides a diversity of microhabitats suited to a wide diversity of species. This includes habitat for species which prefer a predominantly open diverse grassy understorey and lightly timbered forest to more cover dependent species occupying dense forest structure with lower diversity. Other important features associated with the dry open forests include a general patchiness of open and dense structure, rather than continuous structure, a high floristic diversity particularly in the groundcover layers, scattered larger trees and trees with hollows, a variety of food resources for nectarivores, granivores and insectivores and hollow logs and leaf litter.

The dry open forests of the study area occupy large portions of land within Glenugie State Forest where they are contiguous and comparable in quality with the larger forests to the east continuing into Yuraygir National Park and Newfoundland State Forest extending to the coast. A moderately high diversity of species from all fauna groups would be expected to occupy these habitat types including several threatened forest fauna species.

Narrow bands of riparian habitat occur in restricted locations along Glenugie Creek and associated tributaries, which while small and linear in nature, are distinctly different than the surrounding dry open forests and indicative of a more natural habitat that has had limited disturbance from logging. This habitat comprises a moderately dense and diverse tree canopy comprising Swamp Turpentine (*Lophostemon suaveolens*), Red Mahogany (*Eucalyptus resinifera*) and Orange Gum (*E. bancroftii*), with Paperbarks (*Melaleuca* spp.). The riparian habitats are generally characterised by a higher structural diversity than the surrounding open forests including shrubs and a small tree layer with diverse groundcover. The riparian areas provide dense cover for fauna and important refuge. Other important habitat micro-features present include a higher proportion of large trees, tree hollows and logs, than the surrounding open forests and an aquatic habitat. Riparian habitats can comprise important fauna movement corridors, particularly in heavily logged areas, and provide refuge during fire and drought.

Aquatic habitats are represented by a number of ephemeral creeks, in particular Glenugie Creek and Nine Mile Creek, which retain water for long periods following rainfall as well as a small number of natural depressions in the landscape along ephemeral drainage lines which have retained shallow water for long periods and have consequently been colonised by aquatic plant species, including sedges and rushes. The aquatic habitats in the study area are considered too small to be frequented by waterfowl and other wetland birds but may provide some refuge for these species. These habitats provide high value habitat for frogs, some reptiles and mammals and can exhibit a comparatively species-rich habitat in combination with the riparian vegetation.

3.7.2. Species richness and abundance

The field surveys of the study area recorded a total of 114 fauna species, comprising 65 birds, 25 mammal, 16 reptiles and eight amphibians. The list of species identified is provided in Appendix E. Additional species expected to occur in the study area based on knowledge of the habitats present and a review of records from the DECC Atlas of NSW Wildlife are included in Appendix E.

3.7.3. Mammals

Terrestrial mammals

A total of nine terrestrial mammal species (six native and three introduced) were recorded through trapping, visual observation and secondary indications (e.g. scats, tracks and diggings). The ground mammal trapping effort yielded a total of 26 captures identifying one small mammal species, the Yellow-footed Antechinus (*Antechinus flavipes*). Trapping success was closely correlated to ground cover, in particular sites comprising a density of fallen trees, leaf litter, shrubs and / or rocks. This was evident at sites 2 and 3, which recorded the highest capture rates. Sites with apparent longer intervals between fires were favoured by the Yellow-footed Antechinus.

Small mammals were captured at only three of the seven traps sites (42 per cent) which may be a reflection of the lack of ground cover in the form of vegetation and logs resulting from inappropriate fire regimes, physical removal of understorey and grazing which is particularly evident in Glenugie State Forest.

Macropods were the most common terrestrial mammals recorded from the survey, dominated by the Red-necked Wallaby (*Macropus rufogriseus*), Swamp Wallaby (*Wallabia bicolor*) and Eastern Grey Kangaroo (*Macropus giganteus*) the latter was frequently observed in open grassland on the western side of the existing highway. Two observations of the Rufous Bettong (*Aepyprymnus rufescens*) were recorded at the northern end of the study area associated with riparian habitats along Nine Mile Creek and Pheasants Creek, both to the east of the route.

Both the Northern Brown Bandicoot (*Isodon macrourus*) and Long-nosed Bandicoot (*Perameles nasuta*) were recorded, with the latter identified at most sites where some ground cover was present. Diggings and scats attributed to the Echidna (*Tachyglossus aculeatus*) were observed at several dry sclerophyll forest sites.

Arboreal mammals

The tree-trapping and spotlighting program recorded a total of five arboreal mammal species and one scansorial species. The abundance of arboreal mammals was highest near riparian habitats associated with a greater density of mature trees and tree hollows. The richness of arboreal mammal species is probably a reflection of the diversity of Eucalypt species found to occur in the landscape, which provide an abundance of seasonal nectar, foliage and insect resources for mammals.

A total of five captures were reported of two species, the Sugar Glider (*Petaurus breviceps*) and the Brush-tailed Phascogale (*Phascogale tapoatafa*). Sugar Gliders were also commonly observed from spotlighting and the species is widespread throughout all habitat types represented in the study area, particularly in riparian areas and associated with Orange Gum (*Eucalyptus bancroftii*), Pink Bloodwood (*Corymbia intermedia*) and Small-fruited Grey Gum (*Eucalyptus propinqua*). Conversely the Brush-tailed Phascogale was only reported from one capture in Spotted Gum / Ironbark open forest east of the alignment. The species is expected to be more widespread particularly where rough-barked Eucalypts are present.

Additional species recorded from the spotlighting surveys included the Yellow-bellied Glider (*Petaurus australis*), Common Brush-tailed Possum (*Trichosurus vulpecula*) and Feathertail Glider (*Acrobates pygmaeus*). The Common Ringtail Possum (*Pseudocheirus peregrinus*) was identified from scats collected in dry open forest habitat, this species occurs in very low densities. Yellow-bellied Gliders were frequently heard calling and observed in proximity to riparian areas associated with a higher density of tree hollows. Sap feeding scars were noted in Orange Gum and Grey Box (*Eucalyptus moluccana*).

Bats

The total number of microchiropteran bat species recorded during this study using a combination of both techniques is eight. A total of 10 captures identified four species of microchiropteran bats (**Table 3-3**). All species captured were members of the family Vespertilionidae, the most common capture being the Little Bent-wing Bat (60 per cent of captures). This small bat has been predominantly recorded roosting in caves and tunnels (Churchill, 1998) although has also been recorded roosting in tree hollows (Schulz, 1997).

■ **Table 3-3 Results of bat trapping survey (2007)**

Species	Common name	Total captures	Per cent of total captures	Capture rate / 100 trap nights	Site
<i>Chalinolobus morio</i>	Chocolate Wattled Bat	1	10	3.1	2
<i>Miniopterus australis</i>	Little Bent-wing Bat	6	60	9.4	2, 5
<i>Nyctophilus gouldii</i>	Gould's Long-eared Bat	1	10	3.1	2
<i>Vespadelus pumilus</i>	Eastern Forest Bat	2	20	21.9	5
TOTAL	4 species	10	100	37.5	

The distribution of bat captures is primarily a function of the quality of trap sites and does not accurately reflect the distribution of roosting and foraging habitat for bats. Sites 2 and 5 consist of narrow tracks through woodland with a denser mid-storey and canopy. The use of bat call detectors indicated that activity is more evenly distributed across the study area with bats recorded at all sites particularly near water and open areas adjoining forest.

Analysis of 200 call recordings identified seven microchiropteran bat species. This included positive identification of five species and an additional two probable species (refer **Table 3-4**) including calls of a Long-eared Bat (*Nyctophilus* spp.). Calls of the species *N. geoffroyi* and *N. gouldii* cannot be separated on the basis of call frequency alone. However, *N. gouldii* was captured using harp traps and its presence is confirmed.

■ **Table 3-4 Bat species recorded by ultrasonic call recording**

Family/ species	Common name	Confidence of identification	Habitat
MOLLOSSIDAE			
<i>Mormopterus species 2.</i>	Eastern Freetail-bat	D	DOF
<i>Nyctinomus australis</i>	White-striped Freetail Bat	D	DOF, SW
VESPERTILIONIDAE			
<i>Miniopterus australis</i>	Little Bent-wing Bat	D	DOF
<i>Nyctophilus spp.</i>	A Long-eared Bat	D	DOF, Riparian
<i>Chalinolobus gouldii</i>	Gould's Wattled Bat	Pr	DOF
<i>Scotorepens orion</i>	Eastern broad-nosed Bat	D	DOF
<i>Vespadelus vulturnus</i>	Little Forest Bat	Pr	DOF

Key: D – Definite identification, Pr – Probable identification, Po – Possible identification

As mentioned previously, the bat assemblage comprises both tree-roosting and cave-roosting species, the latter including the Little Bent-wing Bat (*Miniopterus australis*). The cave roosting species inhabit a wide variety of caves and mines (Churchill 1998), which may include abandoned shafts and buildings or sandstone caves and crevices in escarpment areas. No potential cave roosting habitats were identified within the study area and the roost site for the local population is unknown.

One megachiropteran species, the Grey-headed Flying-fox *Pteropus poliocephalus* was recorded during spotlighting surveys in dry open forest habitat. Foraging habitat for this species is widespread and no roosting colonies have been identified within the study area.

3.7.4. Birds

A total of 65 bird species were recorded, representing moderate species richness which can be attributed to the size of the study area and connectivity to large fragments of habitat, the diversity of habitats available, topographic variation and floristic diversity. The diversity of habitats present provides sufficient shelter, foraging and breeding resources to support several bird groups and provides significant refuge given the extent of clearing which has occurred throughout the Clarence Valley.

The dominant bird groups noted included nectarivores and foliage insectivores, also present were granivores, diurnal and nocturnal raptors, and aerial foragers. Lorikeets (Psitticidae) and honeyeaters (Meliphagidae) were particularly abundant, corresponding with the proliferation of flowering Large-leaved Spotted Gum and Grey Box during the surveys. Common species included the Little Lorikeet (*Glossopsitta pusilla*), Scaly-breasted Lorikeet (*Trichoglossus chlorolepidotus*) and Rainbow Lorikeet (*T. haematodus*), Scarlet Honeyeater (*Myzomela erthrocephala*), Yellow-faced Honeyeater (*Lichenostomus chrysops*), White-plumed Honeyeater (*L. penicillatus*) and Fuscous Honeyeater (*L. fuscus*). The vulnerable species Black-chinned Honeyeater (*Melithreptus gularis*) and Brown Treecreeper (*Climacteris picumnus*) were present in low abundance and appeared to be restricted to more open forest habitats.

Several common birds were recorded as widespread and abundant within all forest habitats and could be considered generalists; this included the Torresian Crow (*Corvus orru*), Grey Fantail (*Rhipidura fuliginosa*), Leaden Flycatcher (*Myiagra rubecula*), Striated Pardalote (*Pardalotus striatus*), Golden Whistler (*Pachycephala pectoralis*) and Noisy Miner (*Manorina melanocephala*).

A number of nocturnal bird species were recorded from the dry open forests including the Australian Owlet Nightjar (*Aegotheles cristatus*), Tawny Frogmouth (*Podargus strigoides*), Southern Boobook (*Ninox novaeseelandiae*) and White-throated Nightjar (*Eurostopodus mystacalis*). These nocturnal species roost predominantly in tree hollows, although may also roost in dense foliage.

3.7.5. Reptiles and amphibians

The reptile diversity is dominated by skinks (Family Scincidae) representing 47 per cent of the total reptile species richness. Of these, a number of species are generalists found in a variety of forest and woodland habitats where there is generally an adequate cover of trees, leaf litter and

logs. This includes *Cryptoblepharus virgatus*, *Carlia vivax*, *Lygisaurus foliorum*, *Ctenotus robustus*, and *Lampropholis delicata*. Lace Monitors (*Varanus varius*) were widespread throughout all forested habitats and Eastern Water Dragons (*Physignathus lesuerii*) were restricted to the creek habitats.

A total of eight frog species was recorded. The most widespread and abundant species were associated with the Family Myobatrachidae and included the Brown Toadlet (*Pseudophryne bibroni*) and Common Eastern Froglet (*Crinia signifera*). These species were found occupying a greater diversity of habitats than all other species ranging from flowing creeks to soaked depressions and riparian vegetation.

3.7.6. Introduced fauna

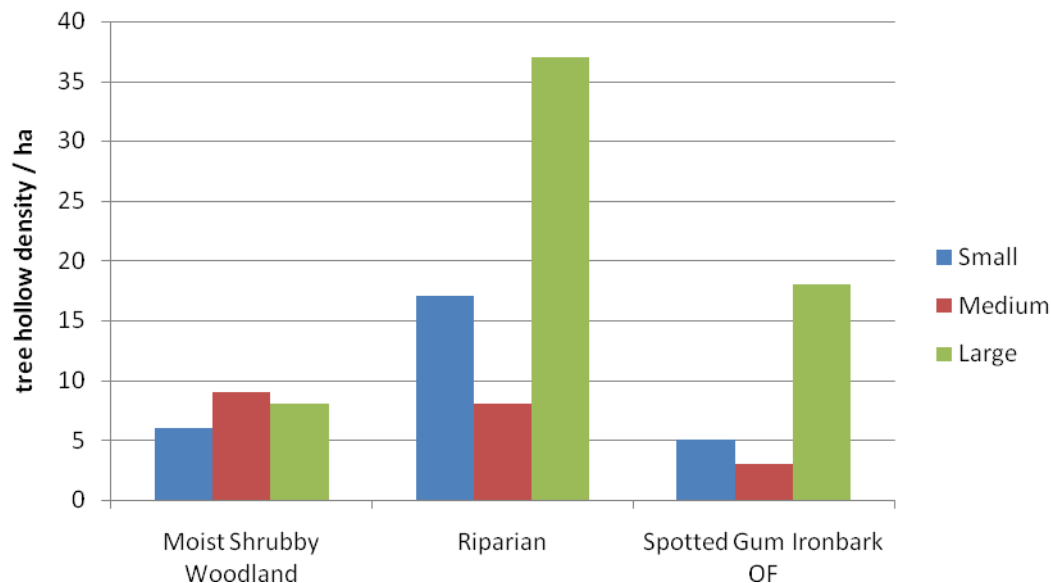
Six introduced vertebrate fauna species, all mammals, were identified during the surveys. Surveys were not conducted with urban areas, however, and several species could be expected in modified habitats. Three feral predators were found to occur in low abundance which included the Red Fox (*Vulpes vulpes*), Dog (*Canis familiaris*) and Cat (*Felis catus*).

A breeding population of wild horses (*Equus caballus*) is present in Glenugie State Forest from which they appear to be restricted by fencing around the perimeters of the Forest. There are no current data on the population size, although juvenile and adult horses were observed.

3.7.7. Tree hollows

The abundance of tree hollows varies across the landscape, with a higher density occurring in the riparian habitats and lowest density in the moist shrubby woodland (**Figure 3-8**). The presence of tree hollows reflected recent forestry management practices. Riparian areas, supporting the Narrow-leaved Red Gum (*Eucalyptus seeana*) and Orange Gum (*E. bancroftii*) had a greater density of hollows than Spotted Gum / Ironbark dominated habitats where logging has been more intense.

The abundance of hollows in the riparian habitats suggests that sheltering and breeding opportunities for hollow-dependent species, particularly Sugar Gliders and Yellow-bellied Gliders are well represented. Indeed all observations of Yellow-bellied Gliders reported from this study were associated with riparian habitat, although foraging areas occur more widely. The proximity of foraging areas to riparian habitat is considered important for this species.



■ **Figure 3-8 Tree hollow density for identified fauna habitat types**

3.8. Aquatic fauna

3.8.1. Glenugie Creek

Glenugie Creek is situated south of Grafton, with the headwaters in Glenugie State Forest. Downstream, Glenugie Creek flows into the Clarence River. For the majority of the project study area, Glenugie Creek runs in parallel with the existing Pacific Highway. Frequent unnamed tributaries cross the existing highway and drain directly into Glenugie Creek. Many of these tributaries are ephemeral, flowing only after periods of high rainfall, and causing temporary high velocity flows into Glenugie Creek. At the time of sampling, all sites had very little flow and were turbid, although the sampling period followed several high rainfall events.

The Glenugie Creek upstream reaches consist primarily of disconnected pools providing Class 2 and 3 moderate to minimal fish habitat. A Class 2 waterway provides moderate habitat for fish, it is typically a permanent or intermittent stream, creek or waterway with clearly defined banks, semi-permanent to permanent waters in pools and the provision of suitable known habitat for fish. A Class 3 waterway is a minor waterway which typically has intermittent flow, providing limited potential refuge, breeding or feeding areas for some aquatic fauna. A description of the sites is provided in **Table 3-5**. Sample sites are shown in **Figure 2-4**.

■ **Table 3-5 Characteristics of the aquatic habitat at the sample sites**

Site	Description	Characteristics
1	Glenugie Creek at Six Mile Lane Crossing (Outside of study area)	Site 1 was situated in Glenugie Creek under the Six Mile Lane Bridge crossing, east of Grafton. The surrounding land use was predominantly grazing. The limited riparian vegetation and free cattle access to the stream have resulted in bank erosion. Average creek width was 3 to 7 m. Local impacts to the site include the existing 6 Mile Creek Bridge Crossing and cattle grazing. Submerged logs and aquatic macrophytes including Milfoil (<i>Myriophyllum sp.</i>) and Pondweed (<i>Potamogeton sp.</i>) occur throughout the site. Site 1 was classified as Class 2 moderate fish habitat (Fairfull and Witheridge 2003).
2	Glenugie Creek at the northern end of the existing Pacific Highway crossing	Site 2 Glenugie Creek is situated beneath the most northern crossing of the existing Pacific Highway in the study area. Aside from the existing Pacific Highway the surrounding land use includes Glenugie State Forest and cattle grazing. The riparian zone is densely vegetated and contiguous with upstream and downstream riparian areas. Minimal erosion of the clay and sand banks was evident. The width of the creek ranges from 7 to 15 m with a vegetated sand bar occurring mid channel upstream. Macroinvertebrate and fish habitat is present throughout the site including the aquatic macrophytes (<i>Eleocharis sp.</i>) and submerged woody debris. Site 2 was classified as Class 2 moderate fish habitat (Fairfull and Witheridge 2003).
3	Glenugie Creek 1 km south of Shields Road	Site 3 Glenugie Creek is situated downstream of the existing Pacific Highway, about 1 km south of Shields Road within Glenugie State Forest. In this area, Glenugie Creek flows parallel to the existing Pacific Highway and the project. Both banks are clay and densely vegetated with overhanging <i>Lomandra longifolia</i> . The creek width ranges from 1 to 7 m. Channel depth is greater than 2 m. Minimal submerged logs were observed at the site and no aquatic macrophytes were present when the site was surveyed. Site 3 was classified as Class 2 moderate fish habitat (Fairfull and Witheridge 2003).
4	Glenugie Creek 2 km north of Franklins Road	Site 4 Glenugie Creek is the most southern site, situated within Glenugie State Forest about 2 km north of Franklins Road. At this location, Glenugie Creek is situated downstream of and parallel to the existing Pacific Highway. The site is densely vegetated, with <i>Lomandra longifolia</i> overhanging the stream channel. The stream width ranges from 1.5 to 3 m. The channel is less than 1 m deep. The banks are predominantly sand and clay with a bedrock channel. Minimal aquatic macrophytes and submerged logs were present at the site. Site 4 was classified as Class 2 moderate fish habitat (Fairfull and Witheridge 2003).

3.8.2. Fish assemblage

A total of seven fish species were recorded at the sites using the three complementary sampling techniques (**Table 3-6**). Relatively small numbers of fish were recorded at Site 2. Site 1 (the most northern site) was the richest site in terms of fish diversity with five species detected. A single Olive Perchlet (*Ambassis agassizii*) was recorded at Site 2. Although not protected under the NSW legislation, this species is considered ecologically important by the Australian Society for Fish Biology. No listed threatened fish species were recorded. Freshwater Yabbies (*Cherax destructor*), an Eastern Water Dragon (*Physignathus lesueurii*) and a Short-neck Turtle (*Emydura macquarii*) were also detected during the fish sampling.

■ **Table 3-6 Aquatic species detected during Glenugie Creek fish survey (May 2009)**

Common Name	Species Name	Site 1	Site 2	Site 3	Site 4	Total
Freshwater Yabbie	<i>Cherax destructor</i>	1	0	6	16	23
Flathead Gudgeon	<i>Phlypnodon grandiceps</i>	3	2	0	3	8
Firetail Gudgeon	<i>Hypseleotris galii</i>	12	5	33	12	62
Plague Minnow*	<i>Gambusia holbrooki</i>	25	1	10	21	57

Common Name	Species Name	Site 1	Site 2	Site 3	Site 4	Total
Striped Gudgeon	<i>Gobiomorphus australis</i>	2	0	0	0	2
Short Finned Eel	<i>Anguilla australis</i>	0	0	1	0	1
Long Finned Eel	<i>Anguilla reinhardtii</i>	0	1	0	0	1
Short Neck Turtle	<i>Emydura macquarii</i>	2	0	0	0	2
Olive Perchlet	<i>Ambassis agassizii</i>	1	0	0	0	1
Total		47	9	50	51	157

* Exotic species.

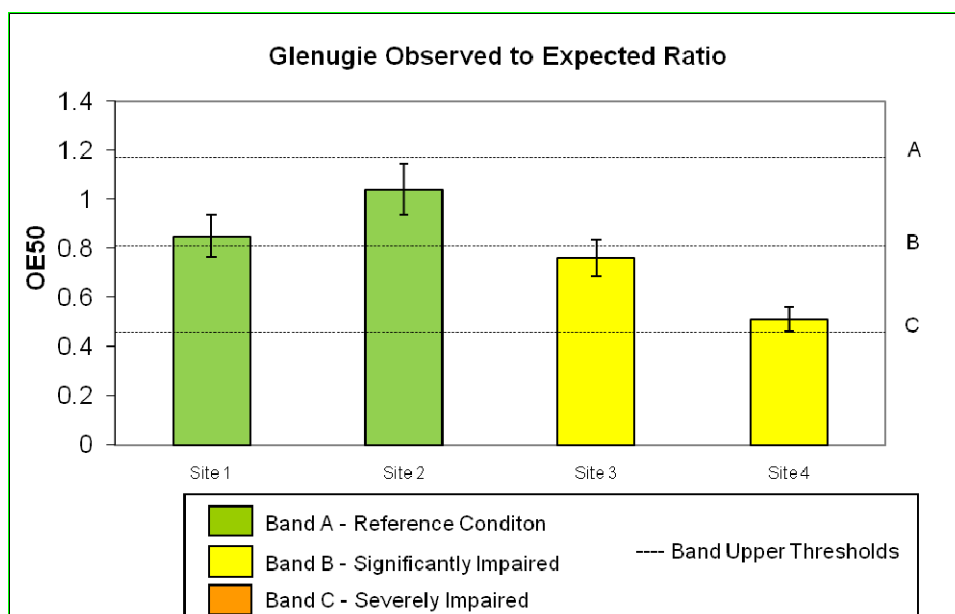
3.8.3. Macroinvertebrates

Fourty one macroinvertebrate taxa were recorded (Appendix F). The most commonly occurring taxa were freshwater shrimp (*Atyidae* spp.) followed by small water striders (*Veliidae* spp.).

The sensitivity of macroinvertebrate families to environmental disturbances is indicated by assessing the SIGNAL2 scores (Chessman 1995, 2004). SIGNAL scores for each family are scaled from one to ten with the most sensitive macroinvertebrate families receiving a score of 10. Sensitive macroinvertebrates would be expected to occur only where water quality is high. No highly sensitive macroinvertebrate taxa with SIGNAL scores of 9 and 10 were observed at any location, potentially indicating environmental disturbance. The overall SIGNAL scores for each site (E0Signal, Appendix F) ranged from 3.64 to 4.04 indicating all sites are considered 'severely polluted'.

The Observed to Expected ratio (OE50 score) calculated for each site (see **Figure 3-9**) indicates that sites 3 and 4 were impaired compared to reference condition with AusRivAS band rankings of B – Severely Impaired. Band B indicates fewer macroinvertebrate families have been collected than were expected to occur in the modelled reference condition. This suggests the sites support impaired water and/or habitat quality. Site 2, Glenugie Creek at the northern crossing of the existing Pacific Highway had the highest OE50 score (1.04), and a Band A ranking indicating the site is in modelled Reference condition. Site 2 also supported the greatest macroinvertebrate species richness with 26 taxa collected.

Site 4 (the most southern Glenugie Creek site) had the lowest OE50 score (0.51), just above the Band C threshold, which indicates the site is severely impaired. Site 4 supported the lowest species richness with 12 taxa and the lowest number of pollution sensitive taxa (indicated by pollution sensitivity SIGNAL scores 7 and 8; Appendix F). Site 4 had minimal macroinvertebrate habitat accessible for AusRivAS sampling, with the habitats sampled consisting primarily of clay banks and overhanging *Lomandra longifolia* which may have contributed to the lower species richness and AusRivAS Band ranking. Typically AusRivAS macroinvertebrate sampling habitats should include other habitat types including submerged logs, aquatic macrophytes and detritus.



■ **Figure 3-9 Observed to expected ratios for macroinvertebrate communities**

3.9. Condition assessment

All of the vegetation types in the study area are considered to be of high conservation value in the region due to their moderate to high species richness, structural diversity and important fauna habitat features (including shelter and foraging resources). The other factor contributing to the high conservation value of the vegetation is the large size of the habitats represented and degree of connectivity in the landscape, including links with conservations reserves.

Vegetation condition rankings varied across the vegetation types with the highest values being represented in the riparian communities where large mature trees and tree hollows are abundant. The Spotted Gum / Ironbark and Grey Box communities had comparatively lower vegetation condition rankings, reflecting timber harvesting activities, reduced tree hollow abundance and simplification of the habitat structure. Overall, despite the logging operations in Glenugie State Forest, the vegetation in the study area is relatively diverse and is considered to be of high conservation value.

4. Conservation significance

4.1. Biodiversity

The results of the background review and detailed field surveys for the project contribute to the knowledge of the area's biodiversity, and in particular highlight the high diversity of species known and considered to potentially occur in the locality. A major factor which contributes to this high species diversity is the location within the MacPherson-Macleay Overlap Zone. This zone is defined as that area of eastern Australia where the Tropical and Temperate Zones overlap (Burbridge 1960). It includes part of south-east Queensland and part of north-east New South Wales. Within this area tropical elements predominate in the wetter habitats of the eastern slopes of the ranges and temperate elements in the drier or cooler and more open sites. Bassian (or south-eastern Australian) and Torresian (or northern Australian) species overlap; with the former being at the northern extent of their range, the latter being at the southern extent of their range. The native flora and fauna of the NSW Upper North Coast are among the most diverse in Australia (NPWS 2002a; 2002b) and include a considerable number of threatened species, populations and ecological communities (NPWS 2002a). The high biodiversity of the region highlights the importance of any remnant natural habitats in the study area and their subsequent conservation value.

The road construction for the highway upgrade will be developed with consideration for these values by minimising removal and disturbance of native vegetation, particularly areas identified in this report as having high conservation significance for threatened species.

The following section outlines the findings of the review and survey with regard to the presence of the species, populations and communities known or likely to occur along the alignment that are listed under the schedules of the TSC Act and EPBC Act.

4.2. Endangered ecological communities

There are no nationally listed endangered ecological communities (EECs), as listed under the Commonwealth EPBC Act, located within the study area.

Riparian forest in the study area is consistent with the TSC Act listed Subtropical Coastal Floodplain Forest EEC (**Table 4-1**). Locations of riparian communities that are consistent with the Subtropical Coastal Floodplain Forest EEC are shown on **Figure 4-1**.

■ **Table 4-1 EECs identified in the project area**

Map Unit	Vegetation Community	EEC type	Habitat	Dominant species
5	Swamp Turpentine – Paperbark Forest	Subtropical Coastal Floodplain Forest of the NSW North Coast Bioregion	Tributaries of Glenugie Creek	<i>Lophostemon suaveolens</i> , <i>Eucalyptus resinifera</i> , <i>Eucalyptus tereticornis</i> , <i>Corymbia intermedia</i> , <i>Eucalyptus seeana</i> , <i>Melaleuca alternifolia</i>
7	Forest Red Gum – Grey Box Forest	Subtropical Coastal Floodplain Forest of the NSW North Coast Bioregion	Floodplain areas on sandy alluvial soils	<i>Eucalyptus tereticornis</i> , <i>Eucalyptus siderophloia</i> , <i>Eucalyptus moluccana</i> , <i>Corymbia intermedia</i>

Subtropical Coastal Floodplain Forest includes vegetation associations derived on soils with clay and sandy loams, on periodically inundated alluvial flats, drainage lines and river terraces on coastal floodplains generally below 50 m elevation. Structurally, this community varies from the open forests and woodlands of the adjoining elevated lands, with the composition primarily determined by flooding regimes and the texture, nutrient and moisture content of the soil, in addition to latitude and history of disturbance. The combinations of features that distinguish this community in the study area include:

- A dominant mixed eucalypt canopy including Swamp Turpentine, Red Mahogany, Pink Bloodwood, and Forest Red Gum.
- Presence along major watercourses.
- The occasional presence of rainforest elements as scattered trees or understorey plants.
- The prominent groundcover of soft-leaved forbs and grasses.

In the study area, this EEC is highly restricted to major watercourses with sandy clay soils. There is evidence of flooding surrounding these major watercourses and the creek banks are deeply incised.