ANNEX R

Species Impact Statement

Addendum

The approved Master Plan MP 20-4-2005 for Fern Bay Seaside Village was signed by the Minister on 8 August 2006. A number of technical assessments supported the Master Plan, including the attached Species Impact Statement.

As the Species Impact Statement report is a supporting document to the approved Master Plan, it has not been updated. The EA report in support of the Project Plan has however been prepared in accordance with the approved Master Plan (as detailed in Section 2.4 of the EA). The Project Plan application is essentially consistent with the items listed in Schedule 2 of the Master Plan, with minor amendments to the project plan to account of the requirements of government agencies and site constraints, including lot layout and configuration changes. These changes do not impact the assessment and outcomes of the attached Species Impact Statement. The updated project plan is detailed in the EA.

FERNBAY
seaside village

Fern Bay Estate

Master Plan Study

WINTEN PROPERTY GROUP

CVC Limited

Fern Bay Estate

Species Impact Statement

Winten Property Group & Continental Venture Capital Limited

April 2005

0017825 - FINAL

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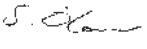
Delivering sustainable solutions in a more competitive world

Project Manager:	*Sally Crews*
	
Date:	*20 April 2005*
Partner/ Project Director:	*Steve O'Connor*
Signed:	

Environmental Resources Management Australia Pty Ltd Quality System

Fern Bay Estate

Species Impact Statement

Prepared by: Dr Andrew Hamer

Winten Property Group & Continental Venture Capital Limited

April 2005

0017825 FINAL

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EXECUTIVE SUMMARY

This Species Impact Statement (SIS) has been prepared to assess the likely impacts of a proposed residential estate at Fern Bay (referred to as Fern Bay Estate) on a number of threatened species known or considered likely to occur in the Fern Bay area. The subject site, which is identified as Lot 16, DP 258848, No. 85 Nelson Bay Road, Fern Bay, has an area of 205.5 hectares.

The subject site contains swamp forest, dry sclerophyll open forest and wet heath that supports habitat for a range of threatened species and ecological communities listed in the *Threatened Species Conservation Act 1995*. It forms part of a larger fragment of coastal woodland in the Fern Bay area and adjoins the floodplain of the Fullerton Cove wetlands, which are mapped as SEPP 14 and conserved within the Kooragang Nature Reserve. The subject site is a component of a regional corridor in the Lower Hunter region and the fragment contains key habitats for threatened species in the region.

A total of 37 threatened species and one endangered ecological community have the potential to be impacted by the proposed development. Seven of these species (the masked owl, powerful owl, hoary wattled bat, eastern freetail-bat, yellow-bellied sheathtail-bat, greater broad-nosed bat and squirrel glider) are considered most likely to be impacted by the proposal, as local populations are present and depend on habitats in the subject site for their long-term viability. The endangered ecological community known as 'swamp sclerophyll forest on coastal floodplains of the NSW North Coast, Sydney Basin and south east corner bioregions' occurs within the subject site.

The proposed residential estate will involve the direct loss of approximately 70.2 hectares of vegetation (comprising 9.7 hectares of swamp forest, 15 hectares of wet heath and 45.5 hectares of dry sclerophyll open forest) as well as habitat resources such as hollow-bearing trees and winter-flowering trees. However, the concept plan for Fern Bay Estate strategically conserves 107 hectares of habitat within a minimum 200 metre wide ecological corridor along the northern boundary of the subject site and in areas that will maintain the present level of local and regional connectivity.

This means that although development consent has been granted for residential development over part of the subject site, those approved lots and roads within the minimum 200 metre wide ecological corridor, will not be constructed. Furthermore, it is proposed to protect this and other corridors on the subject site by seeking the rezoning of those parts of the subject site that do not form part of the proposed development footprint to 7(a) Environment Protection.

The habitat retention strategy aims to conserve and manage affected species and communities habitat in the long-term, and maintain local and regional connectivity. The retention of approximately 54 percent of the estimated number of habitat trees and retention of movement corridors on the subject site will ensure the long-term viability of the squirrel glider population, which

is a flagship species for the conservation of threatened species in the Fern Bay area and wider locality.

Management of native vegetation on the subject site is proposed to involve the rehabilitation of disturbed areas and management of the bushfire regime in order to increase floristic diversity in the area. Hydrology and water quality, fire, pest animals and weeds are proposed to be managed to reduce any deleterious impacts to affected species and communities. These measures address seven key threatening processes currently operating at the subject site. The risk of traffic strike to fauna will be reduced by appropriately designed and sign posted urban roads, including fauna underpasses on the northern ingress road.

The subdivision of the Fern Bay Estate will be carried out under Community Title. This means that a Community Association will be established to manage the open space areas of the subject site and ensure that rehabilitation works, weed management, pest animal control, bushfire protection and other management measures are carried out. The Community Association will also be responsible for ensuring that ongoing monitoring is undertaken to determine the effectiveness of these management measures.

1 INTRODUCTION

Winten Property Group (WPG) and Continental Venture Capital Pty Ltd (CVC) propose to jointly develop a residential estate at Lot 16, DP 258848, No. 85 Nelson Bay Road, Fern Bay (the 'study area', see *Figure 1.1*). Environmental Resources Management Australia Pty Ltd (ERM) was commissioned by WPG and CVC to prepare a Species Impact Statement (SIS) for the proposed development. This SIS has been prepared to address the requirements of the Director-General of Department of Environment and Conservation (DEC) for the proposed development. These requirements are hereafter referred to as the 'DGRs' and are provided within *Annex A*.

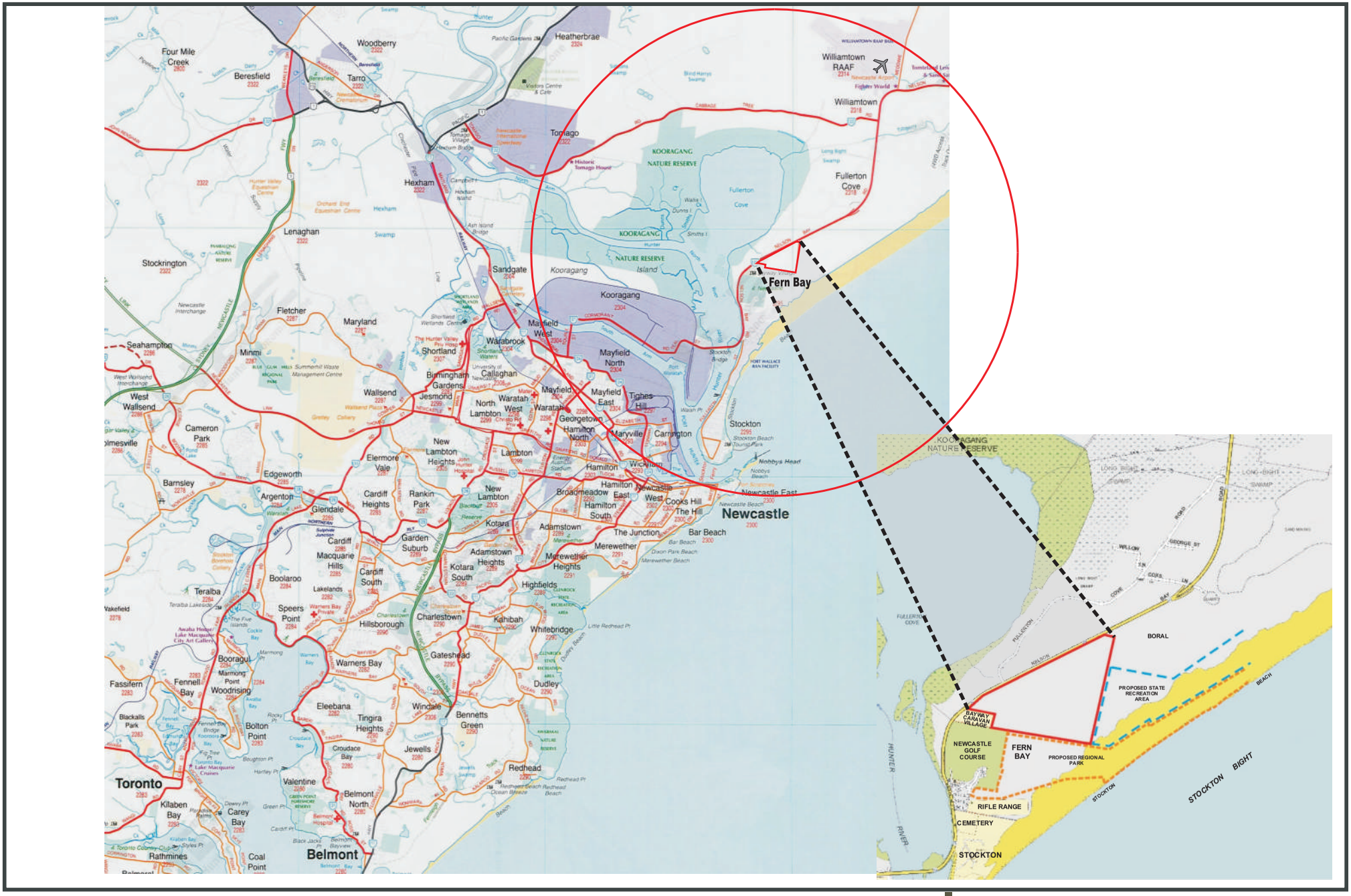
1.1 PURPOSE AND OBJECTIVES

This SIS has been prepared to assess the likely impacts on a number of threatened species that could occur as a result of the proposed residential development at Fern Bay (see *Figure 1.1*). This SIS has been prepared to comply with the requirements of Part 5 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) and the *Threatened Species Conservation Act 1995* (TSC Act). Threatened species are those specified in Schedule 1 or Schedule 2 of the TSC Act.

The list of threatened species known or considered likely to occur in the study area was derived in consultation with DEC and by reviewing flora and fauna surveys conducted in the study area and locality. The DGRs listed 40 species and two endangered ecological communities for consideration in the SIS. These species are termed *subject species* and *subject communities*. An additional species was considered as a subject species. Of the revised list of 41 subject species and two endangered ecological communities, the likelihood of four species and one community occurring in the study area is low due to the lack of suitable habitat. The remaining 37 species and one ecological community have a moderate to high likelihood of occurring in the study area, and therefore have the potential to be impacted by the proposed development at Fern Bay. These species are referred to as *affected species*.

Key objectives of the investigation were to:

- describe and map vegetation communities and habitats that may be directly or indirectly affected by the proposal;
- assess the significance of flora and fauna in the study area in a local, regional and State context, including the significance of habitat corridors and linkages in the study area;
- assess the potential direct and indirect impact on flora and fauna;
- identify and describe the threatened species and communities known or likely to be present in the study area, and assess which species or communities may be affected by the proposal;



ERM

Figure 1.1 **Locality Plan**

Winten Property Group - CVC Limited - Fern Bay Estate - SIS

- describe the type, location, size and condition of habitat of affected species and/or communities, and provide details of the distribution and condition of similar habitats in the locality and region;

- assess the potential impact of the proposal on subject species and subject communities, focusing on any affected species and including the qualitative effect on local populations and the cumulative effect in the region; and

- describe and assess measures to minimise the impact of the proposal on flora and fauna, especially affected species, and to enhance their survival in the study area.

Eight *affected species* are considered the most likely to be impacted by the proposal, as local populations are present and depend on habitats in the study area for their long-term viability. They are:

- masked owl (*Tyto novaehollandiae*);

- powerful owl (*Ninox strenua*);

- hoary wattled bat (*Chalinolobus nigrogriseus*);

- eastern freetail-bat (*Mormopterus norfolkensis*);

- yellow-bellied sheathtail-bat (*Saccolaimus flaviventris*);

- greater broad-nosed bat (*Scoteanax rueppellii*);

- squirrel glider (*Petaurus norfolcensis*); and

- swamp sclerophyll forest on coastal floodplains of the NSW north coast, Sydney basin and south east corner bioregions.

The remaining 32 species are less likely to be affected by the proposal as they are likely to make less use of the study area. However, the proposal still has the potential to have a significant impact on some of these species.

In assessing the potential impacts of the proposed development on threatened species and ecological communities, the precautionary principle was adopted when there was a lack of full scientific certainty.

1.2 BACKGROUND

There have been several ecological studies conducted in the study area:

- Clements, A.M., Rodd, A.N., Lim, I., Clulow, J. and Hoye, G. (1992) *Flora and Fauna Report: part of the Environment Assessment of Fern Bay, New South Wales*. Prepared for Port Stephens Shire Council. Anne Clements & Associates Pty Ltd, North Sydney;

- SWC Wetlands and Ecological Management Consultancy (Shortland Wetlands Centre) (1993) *Fern Bay Rezoning Proposal Assessment of Impact on Endangered Fauna*;

- Ecological Management Consultancy (Shortland Wetlands Centre) (1994) *Fern Bay Rezoning Proposal Assessment of Impact on Migratory Birds*;

- Gunninah Consultants (1996 and revised in 1997) *Fauna and Flora Assessment, Proposed Residential Development, Nelson Bay Road, Fern Bay (including Section 5A and SEPP 44 Assessments)*;

- ERM Mitchell McCotter (1998) *Fern Bay Rezoning Application* prepared for Howship Holdings Pty Ltd;

- Gunninah Consultants (2002) *Preliminary Draft Flora and Fauna Assessment, Lot 16 DP 258848, No. 85 Nelson Bay Road, Fern Bay*;

- ERM (2005a) *Fern Bay Estate. Response to the Port Stephens Comprehensive Koala Plan of Management*. Prepared for WPG and CVC.

- ERM (2005b) *Fern Bay Estate. Bushfire Assessment Report*. Prepared for WPG and CVC.

- ERM (2005c) *Fern Bay Estate. Vegetation Management Plan*. Prepared for WPG and CVC.

Additional ecological studies conducted adjacent to the study area include:

- Fanning, F.D. and Clark, S.S. (1993) *Flora and Fauna Assessment for a proposed Sewage Treatment Plant at Fern Bay, Port Stephens Shire*. Prepared for Hunter Water Corporation by Gunninah Consultants;

- ERM Resource Planning (1994) *Sand Extraction operations on Boral Resources freehold property at Fern Bay, Newcastle Bight. Fauna Impact Statement*. Prepared for Boral Resources Pty Ltd;

- Ecotone Ecological Consultants (1994) *Bat Survey of Land proposed for Sand Extraction by Boral Resources Pty Ltd at Fern Bay*. Prepared for ERM Resource Planning Pty Ltd;

- Ecotone Ecological Consultants (2001) *Flora and Fauna Survey and Threatened Species Assessment. Proposed Subtransmission Line Upgrade to Tomaree Peninsula. Southern Section Lavis Lane to Nelson Bay Road, Salt Ash*. Prepared for Enerserve; and

- ERM (1997 - 2003) *Boral Stockton Sandpit. Flora and Fauna Monitoring Program*. Prepared for Boral Resources Pty Ltd.

1.2.1 Subject Species

A total of eight threatened flora species, 33 threatened fauna species and two endangered ecological communities have been recorded in the region or have the potential to occur in the study area based on habitat suitability.

1.2.2 Legislative Requirements

This SIS has been prepared in accordance with Sections 109 and 110 of the TSC Act, which describe the form and content of a SIS. The DGRs were sought for this SIS pursuant to Section 111 of the TSC Act. These requirements, and where they are dealt with in the SIS, are listed in *Annex A* (*Table A.1*).

Pursuant to the EP&A Act, a development application (DA) in respect of development on land that is, or is part of, critical habitat or is likely to significantly affect threatened species, populations or ecological communities, or their habitats, must be accompanied by a SIS. Given the proposed development is likely to have a significant impact on threatened species, this SIS has been prepared.

Affected species and communities must be identified within the SIS. The methodology for identifying affected species is provided in *Section 4*. The full list of subject species and subject communities is provided in *Section 5*.

1.2.3 Other Approvals

A range of other approvals may be required for the proposed development to proceed (see *Table 1.1*). Section 110(2)(j) of the TSC Act states that the SIS must provide a list of other approvals.

Table 1.1 Table of Approvals

Approval Authority	Environmental Planning Instrument / Act	Provision	Approval	Approval Date or Expected Approval Date
Approved Subdivision				
NSW Land and Environment Court	*Port Stephens Local Environmental Plan 1987* *Environmental Planning and Assessment Act 1979*	Clause 9 Section 76A	Development consent for 208 lot subdivision.	Approved September 1997.
NSW Land and Environment Court	*Environmental Planning and Assessment Act 1979*	Section 96	Modification of approved 208 lot subdivision.	Approved March 1999.
Port Stephens Council	*Environmental Planning and Assessment Act 1979*	Section 96	Modification of approved 208 lot subdivision.	Section 96 submitted to Council in December 2004. Awaiting approval.
Department of Environment and Conservation	*National Parks and Wildlife Act 1974*	Section 90	Consent to knowingly destroy, deface or damage or knowingly cause or permit the destruction or defacement of or damage to, a relic or Aboriginal place within the area of the approved subdivision.	Approved on 1 October 2004.
NSW Rural Fire Service	*Rural Fires Act 1997*	Section 100B	Authorisation under section 100B in respect of bush fire safety of subdivision of land that could lawfully be used for residential purposes.	In March 2005 provided written support of the approval of the Section 96 application to modify the subdivision subject to conditions in relation to bushfire protection.
NSW Roads and Traffic Authority	*Roads Act 1993*	Section 138	Consent to: (e) connect a road (whether public or private) to a classified road.	Approved in February 2005 the commencement of construction of the roundabout at the intersection of Fullerton Cove Road and Nelson Bay Road.

Approval Authority	Environmental Planning Instrument / Act	Provision	Approval	Approval Date or Expected Approval Date
Proposed Subdivision				
Minister for Infrastructure, Planning and Natural Resources	*Port Stephens Local Environmental Plan 2000* *Environmental Planning and Assessment Act 1979* *State Environmental Planning Policy No. 71 - Coastal Protection*	Clauses 16, 32 and 62 Section 76A Clause 10	Development consent	Approval yet to be sought. Development consent cannot be granted until a Master Plan has been approved for the estate by the Minister for Infrastructure, Planning and Natural Resources. A draft Master Plan has been prepared for the Estate. The Master Plan is expected to be submitted in March 2005.
Department of Environment and Conservation	*National Parks and Wildlife Act 1974*	Section 90	Consent to knowingly destroy, deface or damage or knowingly cause or permit the destruction or defacement of or damage to, a relic or Aboriginal place within the area of the approved subdivision.	Approval yet to be sought.
NSW Rural Fire Service	*Rural Fires Act 1997*	Section 100B	Authorisation under section 100B in respect of bush fire safety of subdivision of land that could lawfully be used for residential purposes.	Approval yet to be sought.
NSW Roads and Traffic Authority	*Roads Act 1993*	Section 138	Consent to: (e) connect a road (whether public or private) to a classified road.	Approval yet to be sought.
Minister for Infrastructure, Planning and Natural Resources	*Native Vegetation Conservation Act 1997*	Section 21	Development consent for clearing of native vegetation within parts of the site zoned 7(a) Environment Protection	Approval yet to be sought.

1.3 DEFINITIONS OF KEY WORDS

Definitions provided by the Director-General of DEC (see *Annex A*) are used in the SIS as follows:

- *abundance* means a quantification of the population of the species or community.
- *affected subject species* means subject species likely to be affected by the proposal.
- *consent authority* has the same meaning as in the EP&A Act.
- *conservation status* is considered to be the degree of representation of a species or community in formal conservation reserves; it also takes into account the degree and type of threatening process affecting the species or community, and its range and abundance both within and outside reserves. The provision of information on "conservation status" is **not** satisfied by reference to the schedule category that the species or community is listed in under the TSC Act.
- *DEC* means the NSW Department of Environment and Conservation.
- *development* has the same meaning as in the EP&A Act.
- *Director-General* means the Director-General of DEC.
- *locality* means the area within a 10 kilometre radius of the study area.
- *native plant* has the same meaning as in the *National Parks and Wildlife Act 1974* (NP&W Act).
- *proposal* means the proposed development or action.
- *protected fauna* has the same meaning as in the NP&W Act.
- *study area* is the subject site and any additional areas that are likely to be affected by the proposal, either directly or indirectly.
- *subject site* means the cadastral area that is proposed for development.
- *subject species* means those threatened species, populations and ecological communities that are known or considered likely to occur in the study area.
- *threatening process* has the same meaning as in the TSC Act; the definition is not limited to key threatening processes.

For the purposes of this SIS, *study area* and *subject site* are considered to have the same meaning.

1.4 STRUCTURE OF THE REPORT

The remainder of this SIS is organised as follows:

- *Section 2* provides a description of the proposal;
- *Section 3* presents information on the study area within a regional context;
- *Section 4* outlines the methodology used in conducting targeted surveys for subject species and communities;
- *Section 5* provides information on the flora and fauna and subject species and communities recorded during the field surveys;
- *Section 6* identifies the potential impacts that may occur as a result of the proposal and assesses each impact on the affected species and communities;
- *Section 7* details the measures designed to mitigate those impacts on affected species and communities;
- *Section 8* draws conclusions based on the discussion in the preceding sections;
- *Annex A* provides Compliance Tables for the SIS. This includes compliance with Sections 109 and 110 of the TSC Act and with the DGRs for this SIS;
- *Annex B* provides the flora species list for the study area from surveys conducted by ERM;
- *Annex C* presents the survey effort for bird surveys conducted in the study area;
- *Annex D* includes a description of the vegetation communities in which flora surveys were conducted;
- *Annex E* provides the fauna species list for the study area from surveys conducted by ERM;
- *Annex F* provides the Curricula Vitae of the persons who prepared this SIS and were involved in the fieldwork effort; and
- *Annex G* includes a list of the Australian Map Grid (AMG) co-ordinates of habitat trees assessed in the study area.

2 DESCRIPTION OF THE PROPOSAL

2.1 CONCEPT PLAN

Winten Property Group and Continental Venture Capital Pty Ltd propose to develop a residential estate within the study area. The estate is proposed to comprise:

- approximately 950 residential lots in total (some of which have development approval);
- open space lots, which will include formal parks and an Aboriginal heritage reserve within 2(a) zoned land and conservation reserves within 1(a), 2(a) and 7(a) zoned land. These areas of open space are designed to provide opportunities for passive and active recreation, stormwater management and the protection of sites of Aboriginal heritage significance and ecological corridors;
- a community nursery which will be used for the propagation of plants for use in the landscape areas of the estate;
- community, recreational and commercial facilities;
- new public roads, fire trails and pedestrian trails; and
- bushfire buffers (asset protection zones).

The concept plan for development of the estate is illustrated in *Figure 2.1*. A description of feasible alternatives to the proposal, having regard to the biophysical, economic and social considerations and the principles of ecologically sustainable development are presented in the draft Master Plan prepared for the proposed estate (see ERM 2005d).

There is already an approval to subdivide part of the study area into 208 residential lots and a school site (refer to *Figure 2.2* for the approved subdivision). Clearing and earthworks have already commenced for part of this subdivision. The approved lots form part of the proposed Fern Bay Estate, however, those approved lots and roads within 200 metres of the northern boundary of the site will not be constructed. Instead this area is proposed to form part of a minimum 200 metre wide ecological corridor that will connect the site with the vegetated areas to the north and south. The school site is also now proposed to be developed for residential purposes given the Department of Education and Training has confirmed that it is no longer required for educational purposes.

LEGEND

- Residential Integrated Housing
- Residential Villas 340m² to 399m²
- Residential Premium Villas 400m² to 449m²
- Residential Courtyard 450m² to 589m²
- Residential Conventional lots 590m² +
- Residential Duplex 750m² +
- Existing DA
- Part of Approved Development Footprint
- Recreational Facilities/Community Centre
- Active Recreational Facility
- Open Space - conservation areas
- Open Space - Landscaped areas, playground
- Community Nursery
- Aboriginal Heritage Reserve
- Fern Bay Study Area
- Fire Trail
- Major Walking trail
- Asset Protection Zone
- 1(a) Rural 1(a) Zone
- 2(a) Residential 2(a) Zone
- 7(a) Environment Protection 7(a) Zone
- 7(c) Environment Protection 7(c) Zone

ALLOTMENT TYPES AND NUMBERS

Residential Integrated Housing 3.78ha x 25/ha	94 units
Residential Villas	123 lots
Residential Premium Villas	120 lots
Residential Courtyard	255 lots
Residential Conventional Lots	186 lots
Residential Duplex	20 units
Existing DA	149 lots
Total	**947**

Source: Robertsday, Town Planning Design

ERM

0 100m
Approximate only

Figure 2.1 **Concept Plan of Proposed Subdivision**

Winten Property Group - CVC Limited - Fern Bay Estate - SIS

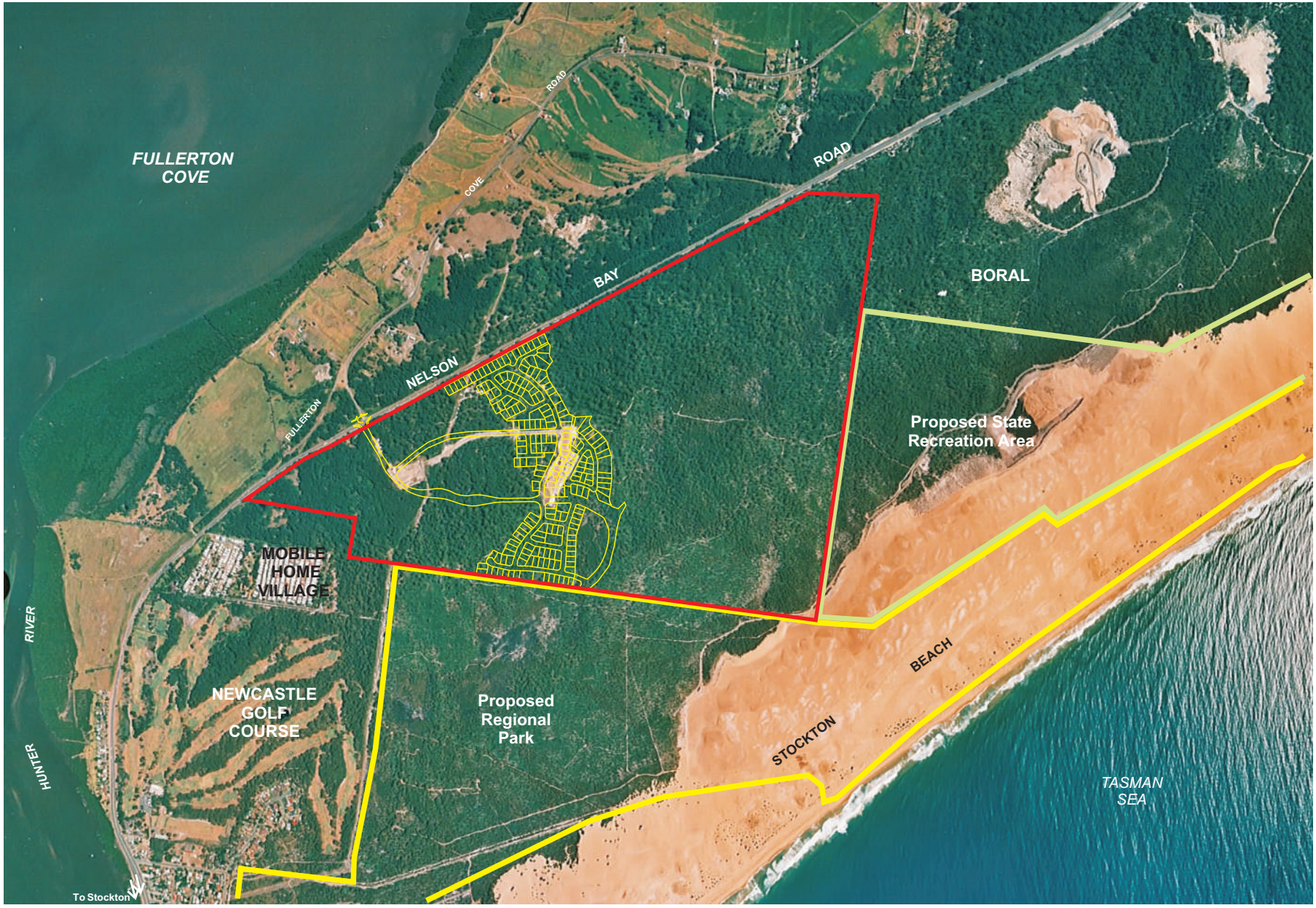


Figure 2.2 **Approved Subdivision**

Winten Property Group - CVC Limited - Fern Bay Estate

2.2 *VEGETATION LOSS*

The proposed residential estate (including the asset protection zone) will involve the direct loss of approximately 70.2 hectares of vegetation comprising swamp forest, wet heath and dry sclerophyll open forest. A total of 30 hectares of vegetation has already been approved to be cleared under the existing development consent that applies over part of the study area. However, 7.2 hectares is not now proposed to be cleared and will be retained in a vegetated fauna movement corridor. Therefore the net area of vegetation to be cleared as a result of this proposed estate (i.e. excluding the approved 22.8 hectares that can be cleared) is 70.2 hectares (see *Table 2.1*). There is also five hectares of existing cleared land in the study area.

Table 2.1 Clearance of Vegetation in the Study Area (approximate hectares)

Vegetation community	Total hectares of native vegetation in study area	Hectares to be removed by approved subdivision	Hectares removed by this subdivision proposal	Hectares conserved in study area
swamp forest	43.5	3.3	9.7	30.5
wet heath	26.0	4.0	15.0	7.0
dry sclerophyll open forest	130.5	15.5	45.5	69.5
TOTAL	**200.0**	**22.8**	**70.2**	**107.0**

A conservative approach has been adopted in calculating the extent of vegetation clearance required for the proposed estate. In reality the amount of clearing will be less than the estimate provided as some vegetation will be retained in the open space and residential areas of the estate as well as within the asset protection zone. No vegetation will be disturbed with the Aboriginal heritage reserve.

2.3 *VEGETATION RETENTION*

The proposed subdivision concept plan includes several conservation-oriented measures, including:

- a minimum 200 metre wide ecological corridor will be retained between Nelson Bay Road and the proposal. This corridor will be bisected by two roads (approximately 20 metres wide) to provide ingress to the proposed subdivision. The corridor is also currently traversed by a powerline easement. Although the approved subdivision plan for the study area originally showed development within this corridor, it is considered that if this was to proceed, it would significantly compromise the ecological function of this corridor. Therefore those approved lots and roads within this corridor will not be constructed. This will prevent the disturbance of approximately 7.2 hectares of vegetation;

- areas of native vegetation, including swamp forest, will generally be retained in areas currently zoned 7(a) Environment Protection;

- an open space corridor will be provided through the centre of the site. This corridor will be bisected by a road that will link the eastern and western parts of the proposed subdivision;

- vegetation will be retained within that part of the site currently zoned 1(a) Rural Agriculture, with the exception of approximately 0.5 hectares along the western boundary of this zone; and

- that part of the 33kV powerline that traverses the site within the proposed development footprint will be placed underground and the easement revegetated. All electricity supplied throughout the estate will be via underground cables (as opposed to overhead lines) to minimise vegetation clearance and maximise visual amenity.

2.4 BUSHFIRE HAZARD MANAGEMENT

ERM (2005b) conducted an assessment of the bushfire hazard to the proposed residential estate based on the concept plan. The minimum asset protection zone (APZ) requirement for the proposal, given the vegetation of the study area, is 20 metres. The APZ will only require clearance along the boundary of proposed open space areas and residential integrated housing areas as the remaining APZs can be accommodated in the roads and active recreation areas. Perimeter roads will form part of the inner protection area of APZs and provide a minimum road reserve width of 20 metres. Public roads will be at least eight metres wide with shoulders on either side. Roads do not traverse low-lying areas that are subject to periodic inundation. Where perimeter roads are not provided perimeter fire trails will be constructed in the inner protection area of the APZ. In general, fire trails will be located within a reserve minimum of six metres wide.

3 LOCALITY, STUDY AREA AND SUBJECT SITE

This section provides a description of the environmental context in which the proposal will occur. *Section 3.1* describes the study area that has been defined for the SIS. It includes specific information about the locality and regional context, landscape, soils, climate, vegetation and land use history, land tenure and zonings, and relevant State Environmental Planning Policies (SEPPs).

3.1 STUDY AREA

The study area is defined as the subject site and any additional areas that are likely to be either directly or indirectly affected by the proposal (see *Figure 2.1*).

3.1.1 Locality

The locality is defined as a 10 kilometre radius around the study area (approximately 30,000 hectares) and is shown in *Figure 1.1*. It is situated within the Sydney bioregion (Thackway and Cresswell 1995).

3.1.2 Regional Context

The locality is comprised of three physiographic regions as defined in Matthei (1995) and described in NPWS (2002):

- Lower Hunter plain – swampy estuarine backplains on the Hunter delta, tidal flats and creeks;
- Tomago coastal plain – marine and aeolian sand deposits and silt/clay deposits of the interbarrier depression; and
- Awaba hills – rolling low hills on Permian Newcastle Coal Measures.

The study area is situated on the Tomago coastal plain, which is also referred to as Stockton Bight. Stockton Bight incorporates a dual barrier of sand dunes, referred to as the Inner and Outer Barrier. The Outer Barrier comprises the sand dunes that are closest to the shoreline, which includes dunes in the study area. The Inner Barrier occurs further inland around Raymond Terrace. The area between the two barriers is generally referred to as the interbarrier depression, and has similar characteristics to the Lower Hunter plain (generally flat, low relief, swampy).

3.1.3 Local Landscape

Broad vegetation communities in the locality have been mapped in the Lower Hunter and Central Coast Regional Environmental Management Strategy

(LHCCREMS) (House 2003). A range of vegetation communities occur in the locality, from mangrove-estuarine complex to swamp mahogany – paperbark forest, heath and extensive areas of coastal sand apple – blackbutt forest. The study area is within one kilometre of estuarine wetlands of Fullerton Cove, which include internationally important habitat for migratory shorebirds listed under the Japan-Australia Migratory Birds Agreement (JAMBA) and China-Australia Migratory Birds Agreement (CAMBA). These significant wetlands are Ramsar listed and occur within Kooragang Nature Reserve. Stockton Bight occurs east of the study area and forms the largest coastal sand dune system in New South Wales. The city of Newcastle and the suburb of Stockton are situated some five kilometres south of the study area.

The study area forms part of a remnant (ie fragment) of coastal woodland that stretches from the old rifle range to the south and through Boral's freehold property, where sandmining has been undertaken over the last ten years, to the north. This remnant is fragmented from a larger remnant that includes Tomaree National Park by a sand blowout east of Williamtown. This blowout is the result of the landward transgressive movement of the sand sheet of Stockton Bight. The distance between the two remnants is approximately 500 metres. The nearest other remnants of woodland are in the Tomago sandbeds south of Newcastle airport. The non-forested areas surrounding the study area include areas of pasture used for broad-acre farming around Fullerton Cove, urban developments such as the mobile home village and non-vegetated sand dunes.

3.1.4 Soils and Soil Landscapes

The study area comprises four soil landscapes as mapped and defined by Matthei (1995).

Lower Pindimar

This swamp landscape occurs as a small area in the south west corner of the study area. It is characterised by poorly-drained Holocene sandsheets, small isolated permanently wet areas, with cleared to uncleared closed forest swamp with small areas of open forest. Soils are deep (> 300 centimetres) imperfectly drained humus podzols on sandy rises with poorly drained siliceous sands on low-lying, poorly drained areas.

Blind Harry's Swamp

This swamp landscape occurs in a small area in the centre southern portion of the study area, which corresponds to the area mapped as swamp mahogany – paperbark forest by House (2003). It is characterised by waterlogged swales and deflation areas on sands of the Tomago coastal plain, with uncleared swamp forest. Soils are deep (> 150 centimetres) poorly-drained acid peats – siliceous sands.

Boyce's Track

This aeolian landscape is widely distributed over the study area. It is characterised by steep Quaternary Holocene sand dunes on the Tomago coastal plain, with uncleared tall open forest. Soils are deep (>300 centimetres) well-drained, weakly developed podzols.

Hawks Nest

This aeolian landscape is widely distributed over the study area. It is characterised by low Holocene sandsheets and low transgressive dunes on the Tomago coastal plain, with dry scrubland, woodland and tall open forest. Soils are deep (> 300 centimetres) well-drained podzols and siliceous sands and podzols on dunes.

3.1.5 Climate

The locality is dominated by a temperate maritime climate. Daily temperatures in the locality range from –3.9 to 44.4°C. Mean daily maximum and minimum temperatures are presented in *Table 3.1*.

Table 3.1 Mean Daily Temperatures

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean daily maximum (°C)	27.8	27.4	26.1	23.6	20.2	17.6	16.9	18.5	21.1	23.5	25.3	27.2	23.0
Mean daily minimum (°C)	18.0	18.0	16.3	13.2	10.1	7.8	6.4	6.9	9.0	11.9	14.2	16.5	12.4

1. Source: Bureau of Meteorology, Williamtown RAAF weather station

Rainfall data for the locality was obtained from Williamtown RAAF weather station, located within 10 kilometres of the study area to the north west. The wettest months are January to June, with the lowest rainfall recorded in July to September. The highest monthly rainfall is 599.6 mm in February, and lowest is 0.0 mm in July and August. Mean monthly rainfall is presented in *Table 3.2*.

Table 3.2 Mean Monthly Rainfall

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean rainfall (mm)	101.6	120.7	121.5	100.5	115.0	116.7	72.6	78.4	57.4	74.4	80.1	81.5	1120.4

1. Source: Bureau of Meteorology, Williamtown RAAF weather station

3.1.6 Vegetation Communities

Vegetation Communities Mapped in Lower Hunter and Central Coast Regional Environmental Management Strategy (LHCCREMS)

The study area includes three vegetation communities mapped for LHCCREMS by House (2003): namely coastal sand apple – blackbutt forest, swamp oak rushland forest and swamp mahogany – paperbark forest (see *Figure 5.3a*).

The eastern half of the study area has been mapped as coastal sand apple – blackbutt forest, which occurs principally on Holocene sands. The canopy within this community is typically dominated by smooth-barked apple (*Angophora costata*) and blackbutt (*Eucalyptus pilularis*) with occasional red bloodwood (*Corymbia gummifera*), scribbly gums (*E. haemastoma* or *E. signata*), Sydney peppermint (*E. piperita*) and mahogany (*E. umbra*). Structurally it is an open forest with a moderately open shrubby understorey of *Banksia serrata*, *Acacia ulicifolia* and *Dillwynia retorta* with a ground layer composed of grasses, herbs and bracken (*Pteridium esculentum*) (CRA Unit NPWS 2000).

The western half of the study area has been mapped as swamp oak - rushland forest. This community occurs in low-lying areas and along coastal lagoon fringes where brackish-saline groundwater or periodic inundation by saline tidal waters exerts a strong influence on the range of species present (CRA Unit NPWS 2000). The low forest canopy ranges from moderate to open depending on the relative abundances of swamp oak (*Casuarina glauca*) and broad-leaved paperbark (*Melaleuca quinquenervia*). In areas where the saline influence is less pronounced, canopy species might include swamp mahogany (*Eucalyptus robusta*) and forest red gum (*E. tereticornis*). The mid-storey vegetation is sparse and often absent, although when present it is usually characterised by tall reeds and rushes (two to three metres) such as common reed (*Phragmites australis*).

Swamp mahogany – paperbark forest occupies a small isolated pocket of land toward the west of the study area. This community occurs in areas of impeded drainage near coastal swamps, lagoons and along drainage lines on alluvial flats of Quaternary sands and sediments. Structurally, this community ranges from open forest to forest with swamp mahogany and broad-leaved paperbark forming the key diagnostic species either in combination or as monospecific stands. There are four main variations within this group. It is not uncommon for swamp oak and cabbage tree palm (*Livistona australis*) to be included in the canopy especially in areas close to estuarine fringes.

Vegetation Communities Identified by Ecological Consultants

Clements *et al* (1992) delineated five distinct vegetation communities in the study area:

- swamp forest with broad-leaved paperbark (*Melaleuca quinquenervia*), swamp oak (*Casuarina glauca*) and cabbage tree palm (*Livistona australis*) as dominant canopy species;
- foredune vegetation with sparse *Spinifex sericeus* cover;
- lemon-scented tea-tree (*Leptospermum laevigatum*) thicket heavily infested with bitou bush (*Chrysanthemoides monilifera*);
- wet heath separated into two transgression ages, formed 2000 and 4000 years ago, dominated by red bloodwood (*Corymbia gummifera*) on the 2000 year transgression and swamp mahogany (*Eucalyptus robusta*) on the 4000 year transgression; and
- dry sclerophyll forest that can be separated into groups dependent on height above the watertable.

Clements *et al* (1992) identified remnant trees from a presumed belt of littoral rainforest that existed along the western edge of the present caravan park, golf course, and motel sites, which represents the leeward side of the main dune system. Within the study area, these trees are situated in the triangle between Nelson Bay Road, the northern boundary of the caravan park, and the power-line access track. Rainforest species that form a narrow fringe to the swamp forest in this triangle include common acronychia (*Acronychia oblongifolia*), lilly-pilly (*Acmena smithii*) and ribbonwood (*Euroschinus falcata*).

Gunninah Consultants (1996 revised 1997, 2002) identified three distinct vegetation communities in the study area, reflecting the landform and groundwater characteristics, based on Clements *et al* (1992) (see *Figure 5.1*):

- dry sclerophyll open forest;
- swamp forest; and
- coastal scrub.

Dry Sclerophyll Open Forest

The dry sclerophyll open forest community occupies the greatest area and is dominated by smooth-barked apple (*Angophora costata*), blackbutt (*Eucalyptus pilularis*) and old man banksia (*Banksia serrata*), with occasional red bloodwood (*Corymbia gummifera*) and black she-oak (*Allocasuarina littoralis*). The canopy density ranges from 30 to 70 percent and the mid-storey is sparse, reflecting the likely fire history of the study area. There is a well-developed understorey, mainly of shrubs, although some herbaceous species are also

present. Some bitou bush occurs in this community. This community corresponds to the LHCCREMS mapping unit of coastal sand apple – blackbutt forest.

Swamp Forest

The swamp forest is dominated by broad-leaved paperbark, swamp mahogany (*Eucalyptus robusta*), swamp oak (*Casuarina glauca)* and cabbage tree palm (*Livistona australis*). The community mainly occurs along the Nelson Bay Road boundary of the study area, with an extensive patch in the western corner of the study area. The canopy density is 70 percent or greater and there is a sparse mid-storey of occasional broad-leaved paperbark. The ground cover is sparse and is dominated by swamp water fern (*Blechnum indicum*), jointed twigrush (*Baumea articulata*) and saw sedge (*Gahnia clarkei*). Weeds such as pennywort (*Hydrocotyle bonariensis*) are present, due to the favourable moisture conditions.

This community corresponds to the LHCCREMS mapping unit swamp mahogany – paperbark forest. Although the western half of the study area has been mapped by LHCCREMS as swamp oak - rushland forest, swamp forest in the study area is more characteristic of swamp mahogany – paperbark forest due to the dominant plant species present in the canopy, mid- and ground strata.

Coastal Scrub (Wet Heath)

The coastal scrub community is dominated by swamp mahogany, red bloodwood and old man banksia as occasional emergent trees, although the community is generally less than three metres in height. This community corresponds to the wet heath community identified by Clements *et al* (1992), and can be delineated into heath occurring on a 2000 year BP sand transgression, dominated by red bloodwood, and a 4000 year BP sand mass dominated by swamp mahogany that occurs further inland. Wet heath species such as *Melaleuca nodosa* and *Restio tetraphyllus* dominate the community. This community corresponds to the LHCCREMS mapping unit of Tomago sand swamp woodland on the 4000 year BP sand transgression.

Classification of vegetation communities in the study area within this SIS are consistent with the above three communities mapped and described by Clements *et al* (1992), and refined by Gunninah Consultants (1996 revised 1997, 2002). The area of each community is presented in *Table 2.1*.

3.1.7 Landscape and Vegetation History

Vegetation in the study area has been subjected to several human disturbances including illicit dumping of cars and rubbish, including garden refuse, and off-road vehicle recreation. As a result of human activity in the study area, the stability of the transgressive sand dune system has been affected, leading to a reduction in vegetation cover in some areas. Fire frequency has also increased as a result of human activity (see *Section 3.1.8*). Garden and non–compostable

household rubbish dumping is currently occurring in the study area. This has primarily occurred along tracks with easy access from Nelson Bay Road.

Sandmining has been conducted on Boral's holdings to the north east of the study area and has altered the fragment of coastal woodland in Stockton Bight. Hawkins and Sons commenced sand extraction originally on this site in 1976 and disturbed approximately 10.5 hectares up until 1984 (ERM Resource Planning 1994). Boral Resources (NSW) Pty Ltd purchased the property in 1986. Between 1986 and 1992 approximately 5.0 hectares was disturbed within the current extraction boundary (ERM Resource Planning 1994). The current extraction operation commenced in 1996 with approval for 44.5 hectares. Rehabilitation of mined areas has been undertaken although maturity of vegetation has yet to be achieved.

An area to the north of Coxs Lane (ie north of Boral's holdings) was mined for titanium minerals by Mineral Deposits Limited in the late 1970s/early 1980s. TollbulkSands Pty Ltd to the north covers approximately 200 hectares. This operation commenced in the 1940s, however, it is largely within active sand dunes and has only required minimal clearance of trees. Quality Sand and Ceramics Pty Ltd, which operate further north of TollbulkSands operation, commenced in the mid 1970s although it did not clear vegetated sand dunes.

3.1.8 Fire History

Fire frequency in the study area is currently higher than in pre-European settlement times and is likely related to illicit dumping and human activity (Clements *et al* 1992). Three fires have occurred in the study area over the last ten years (Port Stephens Rural Fire Service pers. comm. 10.2.2005). A small fire occurred in August 1997 that started south of Boral's property but did not encroach into the study area. A larger fire in October 1998 burnt from Boral's property to the powerline easement in the study area, although the ignition point is unknown. A large fire in 2000 (month not reported) swept through the study area that ignited from Boral's property and travelled south to Newcastle Golf Club. All fires were deliberately lit.

Clements *et al* (1992) noted that the vegetation diversity in the study area is poor in comparison with topographically similar areas elsewhere in the region and the likely reason for this may be a prolonged excessive fire frequency over the last 20 years.

3.1.9 Land Tenure and Zoning

The legal description of the land known as Fern Bay Estate, 85 Nelson Bay Road, Fern Bay, is Lot 16 of Deposited Plan 258848. This land is owned by Winten (No. 20) Pty Limited and is within the Port Stephens local government area (LGA).

The study area is 205 hectares in area and is triangular in shape, with its longest boundary running along Nelson Bay Road. It comprises 16.4 hectares zoned 1(a) Rural Agriculture, 136.4 hectares zoned 2(a) Residential and 52.2 hectares zoned 7(a) Environment Protection under Port Stephens Local Environmental Plan 2000 (LEP 2000).

3.1.10 Adjoining Land Uses and Zoning

Nelson Bay Road forms the north west boundary of the study area, with the vegetated land on the opposite side of the road zoned 1(a) Rural Agriculture under LEP 2000. Land to the north east of the study area is also zoned 1(a) Rural Agriculture. This land is owned by Boral Resources (NSW) Pty Ltd and part of this land is used for sand extraction purposes. The area used for sand extraction is not in close proximity to the north eastern boundary of the study area.

Land adjacent to the eastern boundary of the study area is zoned 7(c) Environment Protection (Water Catchment) and is proposed to become part of a future State Recreation Area, approximately 1,475 hectares in area. The land to the south east of the study area is zoned 7(a) Environment Protection and is managed by the Department of Environment and Conservation. This land is proposed to become part of an 818 hectare Regional Park. These environment protection areas form part of a vegetated corridor that adjoins the study area and runs along Stockton Bight to Fern Bay, approximately one kilometre to the south of the study area.

A mobile home park is located adjacent to the south west corner of the study area and is zoned 1(a) Rural Agriculture. Adjoining land ownership is shown on *Figure 2.2*.

3.1.11 State Environmental Planning Policies

SEPP 14 - Coastal Wetlands

State Environmental Planning Policy 14 – Coastal Wetlands (SEPP 14) was gazetted on 12 December, 1985 with the aim of ensuring that coastal wetlands are preserved and protected in the environmental and economic interests of the State. The policy was designed to protect wetlands in coastal areas in New South Wales. If a proposed development is in the proximity of a wetland, the flora and fauna assessment should assess the impact of the development on the wetland, and recommend measures to minimise impacts of the proposed development.

There are low-lying areas within swamp forest that have open water on a semi-permanent basis and contain emergent vegetation typically found in wetlands (eg *Typha* spp., *Eleocharis* spp.). As these areas are not classified under SEPP 14, the provisions of the policy do not apply to the proposed subdivision. SEPP 14 wetland number 821 is situated west of the study area

and encompasses the estuarine wetlands of Fullerton Cove. Development within the study area has the potential to impact on this wetland due to the movement of groundwater.

SEPP 44 - Koala Habitat Assessment and Port Stephens Comprehensive Koala Plan of Management 2001

State Environmental Planning Policy 44 - Koala Habitat Protection (SEPP 44) aims to:

> '*...encourage the proper conservation and management of areas of natural vegetation that provide habitat for koalas, to ensure permanent free-living populations over their present range and to reverse the current trend of population decline...*'

The practical effect of SEPP 44 is that in consideration of a development application (DA), the consent authority must ensure that approval is not issued without prior investigation of *potential* and *core* koala habitat. The policy applies to land in relation to which a DA has been made when the site has an area of more than one hectare. This policy applies to all local government areas within the known Statewide distribution of the koala, including the Port Stephens Local Government Area (LGA).

Swamp mahogany (*Eucalyptus robusta*) is listed in Schedule 2 of SEPP 44 and a key diagnostic species within the swamp mahogany – paperbark swamp forest vegetation community (NPWS 2003). An assessment of the potential of the study area to support a population of koala (*Phascolarctos cinereus*) was undertaken by ERM, with the aim to determine if *potential* and/or *core* koala habitat is present in the study area (see *Section 4.7.4*).

Port Stephens Council has prepared a Comprehensive Koala Plan of Management 2001 (CKPoM) for the Port Stephens local government area (LGA), which operates under the provision of SEPP 44 (PSC 2001). The CKPoM seeks to conserve koalas over their existing range by identifying and protecting koala habitat and incorporating koala conservation into local government planning processes. The principal aim of the CKPoM is identical to that of SEPP 44.

The CKPoM identifies areas of preferred, supplementary and marginal koala habitat based on community consultation, historical records, vegetation mapping, field based surveys and identification of movement corridors between habitat areas. The study area contains supplementary koala habitat, preferred koala habitat, a 50 metre buffer over supplementary koala habitat and a link over supplementary koala habitat (PSC 2001). Development standards and assessment criteria are outlined in the CKPoM for proposals either overlapping or adjacent to areas of preferred or supplementary koala habitat, habitat buffers or habitat linking areas. Further consideration of koala habitat in the study area is presented in *Section 5.5*.

4 ASSESSMENT METHODOLOGY

4.1 INTRODUCTION

This section summarises the methods used for flora and fauna surveys, mapping and data interpretation in providing information for the assessment of impacts on subject species.

Field surveys were undertaken within the study area by ERM in 2002, 2004 and 2005. These were designed to map and describe the vegetation communities and habitat, and target threatened flora and fauna that may be directly or indirectly affected by the proposal, so that potential impacts on flora and fauna could be assessed. Several other environmental consultants have conducted surveys throughout the study area since 1992. Details of all surveys undertaken in the study area, including survey methods and survey effort, are included in this section. Environmental conditions during the surveys are also described where available. The effects of environmental conditions on the adequacy of surveys is presented. Database searches, mapping and data interpretation for the assessment of impacts on the affected species are also described. This is in compliance with requirement 4.4 of the DGRs (see *Table A.1*, *Annex A*).

4.2 LITERATURE REVIEW AND DATABASE SEARCHES

A literature review was undertaken of relevant studies and published information for the study area. Previous studies undertaken in the study area are listed in *Section 1.2*. Vegetation mapped for the LHCCREMS (House 2003) for the study area and locality was reviewed. Koala habitat mapping in the Port Stephens CKPoM was reviewed and further assessed during field investigations.

A search of the DEC Wildlife Atlas database, including Rare or Threatened Australian Plants (ROTAP), was conducted for all recent records of threatened flora and fauna within the locality. This search revealed the presence of several threatened species within a 10 kilometre radius of the site. A search of the on-line database maintained by the Commonwealth Department of the Environment and Heritage (DEH) was completed for a 10 kilometre radius of the study area, to identify the presence of nationally listed threatened and migratory species in the locality. A search was also conducted of the Birds Australia New Atlas database (2004) for records of threatened and migratory birds in the locality.

All flora and fauna database records within the locality were plotted using a geographic information system and were analysed to determine the likelihood that threatened flora and fauna could occur within habitats in the study area. The analysis entailed assessment of dates, source reliability and numbers of

records to assess the accuracy and current relevance to the study area. It should be noted that the DEH search is based on habitat requirements rather than actual records, and the assessment is based on those listed species considered likely to be in the study area.

4.3 *FLORA SURVEYS CONDUCTED IN THE STUDY AREA BY OTHER CONSULTANTS*

Initial information on the flora of the study area was obtained from Clements *et al* (1992) and Gunninah Consultants (1996 revised 1997, 2002). Other ecological studies conducted in the study area include Croft and Associates (1980) and Corkery and Co. (1988), the results of which were summarised by Clements *et al* and Gunninah Consultants. The methodology of these previous studies is summarised in *Table 4.1*. Vegetation communities in the study area were identified from these sources to verify vegetation mapping by LHCCREMS (House 2003, CRA Unit NPWS 2000), and to provide a consistent and transferable mapping approach.

Table 4.1 Compilation of Previous Flora Survey Effort and Methodology in the Study Area

Source	Survey Dates	Survey Aims	Survey Methodology	Data Analysis
Clements *et al* (1992)	March – April 1992	Description of floristics and vegetation communities	Quadrat-based transects	TWINSPAN ordination
Fanning and Clark (1993)	June, July 1993	Description of floristics and vegetation communities	Transects	Subjective description
Gunninah Consultants (1996 revised 1997)	25 and 26 September 1996	Description of floristics and vegetation communities; threatened species searches, impact assessment	No details	Subjective description
Gunninah Consultants (2002)	31 January and 1 February 2001	Description of floristics and vegetation communities; threatened species searches, impact assessment	York *et al* (1991) and random meander technique (Cropper 1993), aerial photography	Subjective description

4.3.1 *Clements et al.*

Clements *et al* (1992) assessed the vegetation communities in the study area from 31 transects in March to April 1992 (see *Figure 4.1*). Transects were 10 metres wide and consisted of 10 contiguous quadrats of 10 by 10 metres in area, in which the height and number of individuals of all tree species was recorded. The presence/absence of shrub and herb species in five by five metre sub-quadrats were recorded. Herbarium specimens of most species were collected, and in all cases of doubt, specimens were identified at the

Legend

- Spotlight Transect - Anne Clements & Associates (1992)
- Vegetation Transect - Anne Clements & Associates (1992)
- Trap Lines - Gunninah Environmental Consultants (1996)
- Spotlight Transect - Gunninah Environmental Consultants (1996)
- H Harp Trap - Gunninah Environmental Consultants (1996)
- P Pitfall Trap - Gunninah Environmental Consultants (1996)
- T Hair Tubes - Gunninah Environmental Consultants (1996)
- M Mist Nets - Gunninah Environmental Consultants (1996)
- A Anabat Recorders - Gunninah Environmental Consultants (1996)

Nelson Bay Road

Fullerton Cove Road

Nelson Bay Road

Tomaree Escarpment

Tomaree Escarpment

Figure 4.1 **Survey Effort - Previous Studies**

NSW National Herbarium and lodged as a full herbarium collection at the Royal Botanic Gardens, Sydney.

The data was objectively analysed using TWINSPAN, which examines the clustering of the 31 transects sampled. The clustering procedure was based on the relative abundance of plant species within each transect.

4.3.2 Gunninah Consultants

Fanning and Clark (1993) conducted a flora survey in the study area in June and July 1993, which was transect-based but did not involve the use of quadrat as used by Clements *et al* (1992). This survey provided a detailed description of the vegetation communities present in the study area.

Gunninah Consultants (1996 revised 1997) conducted a flora survey on 25 and 26 September 1996, which provided a general description of the vegetation communities present in the study area, with particular attention paid to the possible presence of threatened flora species, as listed in the TSC Act and in Briggs and Leigh (1996) (see *Figure 4.1*). Searches for threatened species concentrated on dry sclerophyll open forest and swamp forest.

Gunninah Consultants (2002) conducted a flora survey on 31 January and 1 February 2001, using the survey method outlined by York *et al* (1991) to establish an inventory of most plant species occurring in the study area and to determine the location and extent of vegetation types. Vegetation mapping was aided by aerial photography and previous vegetation mapping conducted by Clements *et al* (1992) and Gunninah Consultants (1996 revised 1997). Specific searches for plant species of conservation significance were conducted in potential habitat using the random meander technique (Cropper 1993), including searches for *Eucalyptus parramattensis* subsp. *decadens* and dwarf kerrawang (*Rulingia prostrata*) in low-lying areas.

4.4 FAUNA SURVEYS CONDUCTED IN THE STUDY AREA BY OTHER CONSULTANTS

Several fauna studies have been conducted in the study area and wider Fern Bay area (Croft and Associates 1980; Corkery and Co. 1988; Clements *et al* 1992; Fanning and Clark 1993; ERM Resource Planning 1994; Ecotone Ecological Consultants 1994; Gunninah Consultants 1995, 1996 revised 1997, 2002). The methodology of each is discussed below and/or is summarised in *Table 4.2*.

Table 4.2 Compilation of Previous Fauna Survey Effort and Methodology

Source	Survey Dates	Survey Aims	Survey Method	Survey Effort
Croft and Associates (1980)	No formal surveys	General species list	Observations from local residents, literature review	No details provided
Corkery and Co. (1988)	July 1987	General species list	Observations from local residents, literature review, opportunistic observations, bird census	3 days
Clements *et al* (1992)	13 – 17 March, 3 – 7 April 1992	General species list	Elliott A type traps, cage traps, harp traps, mistnets, Anabat detection, spotlighting, bird census, pitfall traps, opportunistic observations	1,284 Elliott A trap nights, 15 hours spotlighting, no other details
Fanning and Clark (1993)	June 1993	General species list	Harp traps, Anabat detection, Elliott A traps, hair tubes, spotlighting, owl call playback, habitat searches	4 days
ERM Resource Planning (1994)*	May and September 1994	General species list	Anabat detection, Elliott A and B traps, spotlighting, owl call playback, habitat searches	8 days
Ecotone Ecological Consultants (1994)*	March 1993, October 1994	Microchiropteran bat survey	Harp traps, Anabat detection	5 nights
Gunninah Consultants (1995)*	unknown	General species list	Spotlighting, pitfall traps, hair tubes, Elliott A and B type traps, bird and reptile census, searches for indirect evidence of fauna, targeted search for the little tern and sooty tern on sand dunes	6 days
Gunninah Consultants (1996 revised 1997)	25 September – 3 October 1996	General species list, description of fauna habitats, impact assessment including SEPP 44 koala habitat	Elliott A type traps, cage traps, harp traps, mistnets, Anabat detection, spotlighting, pitfall traps, bird and reptile census, opportunistic observations and searches for indirect evidence of fauna	No details provided

Source	Survey Dates	Survey Aims	Survey Method	Survey Effort
Gunninah Consultants (2002)	29 January – 1 February 2001	General species list, description of fauna habitats, impact assessment including koala habitat	Diurnal herpetofauna census (all reptiles and amphibians)	16 person hours
			Nocturnal call playback (owls, arboreal mammals, amphibians)	3 hours
			Anabat detection	72 hours
			Diurnal bird census	15 person hours
			Spotlighting (owls, arboreal mammals, amphibians)	20 person hours
			Elliott trapping (small mammals)	240 trap nights
			Cage trapping (medium-sized mammals)	60 trap nights
			Harp trapping (microchiropteran bats)	8 trap nights
			Pitfall trapping (small and medium-sized mammals)	12 trap nights
			Hair tubes (small and medium-sized mammals)	128 tube nights

1. * surveys conducted outside the study area

4.4.1 *Clements et al.*

Clements *et al* (1992) sampled fauna in the study area between 13 and 17 March 1992, and 3 and 7 April 1992, including mammals, birds, reptiles and amphibians (see *Table 4.2, Figure 4.1*). Special attention was paid to species listed on the revised (interim) Schedule 12 of the *National Parks and Wildlife Act 1973*, such as the koala and glossy black cockatoo. Particular attention was also afforded to migratory birds as part of the wetland avifauna of Kooragang Nature Reserve.

A variety of methods were used to survey fauna, including Elliott traps, cage traps, harp traps, mistnets, Anabat detection, spotlighting, bird census and pitfall traps with drift fences.

4.4.2 *Gunninah Consultants*

Gunninah Consultants (1996 revised 1997, 2002) conducted fauna surveys in the study area 25 September to 3 October 1996, and 29 January to 1 February 2001 (see *Figure 4.1*). In addition to general survey techniques (see *Table 4.2*), particular attention was paid to the potential for threatened species to occur in the study area, and to features or resources that could be of potential significance for threatened fauna such as the squirrel glider, koala and powerful owl.

4.5 *IDENTIFICATION OF SUBJECT SPECIES AND AFFECTED SPECIES*

Forty-one species and two vegetation communities have the potential to occur in the locality but only 37 species and one community are likely to be impacted by the proposal. The DGRs listed species and communities to be considered for inclusion as subject species or subject communities (see *Annex A*). This list was then considered and screened to produce a list of species that were likely to be affected by the proposal (ie affected species). The screening process was based on the results of database searches, vegetation maps, habitat assessment, flora and fauna surveys, and known habitat requirements of threatened species and communities.

Several affected species have the potential to occur within vegetation communities and habitats identified in the study area but were not recorded during targeted surveys. This may be because such species are cryptic and unlikely to be detected unless extensive surveys are undertaken over several years and in excellent weather conditions. A list of subject species and affected species and communities is provided in *Table 5.7*.

4.6 MAPPING AND INTERPRETATION OF DATA

The objective of the flora and fauna habitat mapping was to:

- map and describe vegetation communities occurring within the study area using the classification scheme of the LHCCREMS as a basis, and refined by the mapping of Clements *et al* (1992) and the descriptions provided by Gunninah Consultants (1996 revised 1997);
- identify fauna habitats; and
- identify the level and type of disturbance in the study area (ie fire, clearing, under-scrubbing, rubbish development, and recreational use).

Fauna habitat mapping was based on vegetation communities identified and described by Clements *et al* and Gunninah Consultants, and field verification of the following attributes:

- dominant vegetation types;
- structural vegetation characteristics;
- presence of standing or flowing water;
- presence of rock outcropping;
- presence of foraging resources for threatened species such as feed tree species;
- presence of hollow-bearing trees;
- cover abundance of dominant canopy species, and the presence of fire scars and dead tops on these trees;
- connectivity to adjacent areas of habitat;
- presence of other potential threatened flora and fauna habitat;
- level and type of disturbance, particularly fire; and
- density and type of ground cover.

Identification of potential habitat for threatened flora and fauna occurred during field assessments conducted by ERM and from previous studies in the study area.

The geographic information system *MapInfo* (Version 5) was used to map and interpret data in the SIS. Vegetation communities and records of subject species were plotted on maps. The boundaries of vegetation communities mapped by Clements *et al* (1992) were ground-truthed. Scale plans of the proposal were then overlaid to provide an indication of the vegetation

communities and habitats to be directly and indirectly impacted by the proposal. MapInfo was used to calculate areas of the vegetation communities and the areas of each that will be impacted by the proposal.

The estimates used to derive the areas occupied by the vegetation communities in the study area are constrained by the accuracy with which the boundaries have been defined. This is because the boundaries of vegetation communities are often difficult to define as they form ecotones, rather than precise boundaries. Therefore, measurements of vegetation community areas should be regarded as approximate rather than precise.

4.7 FLORA AND FAUNA SURVEYS CONDUCTED BY ERM

4.7.1 General Flora

A general flora survey was conducted by ERM in January 2005 (see *Table 4.7*). Four sites were sampled within the swamp forest, three within the dry sclerophyll open forest and two within the wet heath (see *Figure 4.2*). The three sites in the dry sclerophyll open forest were stratified by topography (ie dune crest, mid-dune slope and dune swale). A randomly chosen 20 metre by 20 metre quadrat was sampled at each site, including a replicate 20 by 20 metre quadrat adjacent. All vascular plant species within the quadrats were identified and recorded, as well as the height and percentage cover (using the modified Braun Blanquet scale) of the dominant species within each structural layer. Plant species names follow Harden (1992, 1993, 2000, and 2002). Where plants could not be confidently identified in the field, specimens were collected and sent to the NSW National Herbarium for identification. The disturbance history at each site was noted to determine the severity and timing of fire, grazing, logging/clearing, dumping and weeds. Flora species were also recorded while undertaking targeted flora searches along random meander transects in January 2005 (see *Section 4.7.2*).

4.7.2 Threatened Flora

The likelihood of threatened or significant flora occurring in the study area was determined by considering the type and condition of vegetation and habitats, and analysis of database records. The results of previous searches dedicated to surveying for threatened species were used in determining the likelihood of their occurrence in the study area (eg Gunninah Consultants 2002).

A targeted search for the leafless tongue orchid (*Cryptostylis hunteriana*) was conducted along the ecotone of the dry sclerophyll open forest and swamp forest on 19 November 2002 using the random meander technique (Cropper 1993). This species was targeted due to the presence of records in Port Stephens and was conducted during the species' flowering period to assist in

Legend

- Orchid Survey Location (ERM 2002)
- Orchid Survey Location (ERM 2004)
- Threatened Flora Transect (ERM 2005)
- Flora Survey Quadrats
- Cleared Vegetation
- Swamp Mahogany - Paperbark Forest
- Coastal Sand Apple Blackbutt Forest
- Wet Heath - Tomago Sand Swamp Woodland
- Swamp Sclerophyll Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South-east Corner Bioregion

Nelson Bay Road

Fullerton Cove Road

Nelson Bay Road

Transmission Easement

1 2 3 4 5 6 7 8 9

Figure 4.2 **Flora Survey Effort in the Study Area**

detection. A known population at Lemon Tree Passage was inspected prior to the survey to verify that the species was in flower.

A targeted search for rough doubletail (*Diuris praecox*) was conducted in July 2002 using the random meander technique along tracks and cleared easements in the dry sclerophyll open forest. An additional survey for *Diuris praecox* was conducted on 25 August 2004 by two ecologists using the random meander technique. The latter survey was conducted when the species was flowering at two reference sites in the locality (electricity easement at Bob's Farm, and Boral's holdings immediately north of the study area).

A targeted search for sand doubletail (*Diuris arenaria*) was conducted on 10 September 2004 by two ecologists targeting the areas randomly traversed while searching for *Diuris praecox*. This survey was undertaken when the species was flowering at a reference site within a cleared electricity easement at Salt Ash.

Targeted searches for *Eucalyptus parramattensis* subsp. *decadens*, netted bottlebrush (*Callistemon linearifolius*) and heath wrinklewort (*Rutidosis heterogama*) were conducted in wet heath and dry sclerophyll open forest on 18 January 2005 by two ecologists walking random meander transects. Searches for *Eucalyptus parramattensis* subsp. *decadens* also occurred during koala habitat assessments, as the species is a preferred koala feed tree in the Port Stephens local government area (see *Section 2.7.4*).

Targeted searches for dwarf kerrawang (*Rulingia prostrata*) were undertaken in swamp forest at the time of the quadrat surveys, on 13 and 14 January 2005.

The location of random meander transects is shown in *Figure 4.2*.

4.7.3 Endangered Ecological Communities

The likelihood of endangered ecological communities ('EECs', Schedule 1, Part 3 of the TSC Act) occurring in the study area was determined by considering the dominant plant species that comprise the vegetation communities, and the dominant soils present. This assessment was based on vegetation mapping by LHCCREMS, ground-truthing and the results of previous flora surveys (Clements *et al* 1992; Gunninah Consultants 2002).

Based on this approach, it was determined that the EEC 'swamp sclerophyll forest on coastal floodplains of the NSW North Coast, Sydney Basin and south east corner bioregions' is present in the swamp forest where it adjoins Nelson Bay Road. Accordingly, 20 by 20 metre quadrats and replicates were sampled at four sites in the swamp forest (see *Section 4.7.1, Figure 4.2*). A list of all native and introduced plant species recorded was compiled, including estimates of cover abundance. From this information, an age class and condition assessment was derived for the EEC in the study area.

4.7.4 Koala Habitat Assessment

An assessment of the potential of the study area to support a population of koala (*Phascolarctos cinereus*) was undertaken by ERM in 2004, with the aim to determine if *potential* and/or *core* koala habitat is present in the study area. The assessment involved determining the presence of koala feed tree species in the study area. If more than 15 percent of the upper and lower strata tree species are koala feed species, the area is designated as *potential* koala habitat, as defined by SEPP 44. This assessment was undertaken to also verify the habitat mapping in the CKPoM. Three 20 by 20 metre quadrats were sampled in the swamp forest, and three quadrats in the wet heath, on 28 May 2004 (see *Figure 4.3*). The results of the habitat assessment were considered within the framework of determining whether areas qualified as *preferred* or *supplementary* koala habitat in the Port Stephens CKPoM. This was accomplished by referring to the vegetation associations of Lunney *et al* (1998).

The CKPoM identified the study area as predominantly supplementary habitat, with an area of preferred koala habitat corresponding with the swamp mahogany – paperbark forest mapped by LHCCREMS. The CKPoM mapping of the study area also includes a 50 metre buffer over supplementary around this preferred habitat, and a link over supplementary that connects the preferred habitat in the study area to preferred koala habitat at Newcastle Golf Course to the south west of the study area. Accordingly, a koala spot assessment was conducted in the study area to assess the level of current koala activity.

A koala spot assessment was conducted on 21 May 2004. A total of 80 swamp mahogany (*Eucalyptus robusta*) trees were surveyed, each with a diameter at breast height (dbh) of greater than 10 centimetres, in the swamp oak – rushland forest and swamp mahogany – paperbark forest vegetation communities at four sites in the study area (see *Figure 4.3*). Swamp mahogany is a primary koala feed tree species in the Port Stephens local government area. Twenty-one trees were inspected at site 1, 24 trees at site 2, 18 trees at site 3 and 17 trees at site 4. A faecal pellet search was undertaken beneath each tree for two to three minutes by one ecologist. Trees were also searched for koalas and trunks inspected for the presence of the characteristic 'pock mark' scratches made by koalas. The assessment of koala activity levels was based on the spot assessment technique used by the Australian Koala Foundation (Phillips and Callaghan 1995). Swamp mahogany trees encountered while undertaking a koala habitat assessment in wet heath on 28 May 2004 were also inspected for evidence of koala usage.

The koala activity level for each plot sampled in the study area was determined by dividing the number of trees containing one or more koala faecal pellets recorded beneath them, by the total number of trees assessed in the plot (Phillips and Callaghan 1995). The resulting value was then expressed as a percentage (ie multiplied by 100) to indicate the proportion of trees in each plot recently used by koalas.

Legend

- 6 ● Koala Habitat Assessment and Faecal Pellet Search
- 2 ● Nocturnal Call Playback
- T1 Spotlighting and Anabat Detection Transects
- Wallum Froglet Survey Site
- Swift Parrot/Regent Honeyeater Survey Site
- 3 ✖ Frog Survey Site (ERM 2005)
- Owl Call Playback Location (ERM 2005)
- Cage Trap Location (ERM 2005)
- Powerful Owl Observed (ERM 2005)
- Hairfunnel and Elliot Trapping Transect (ERM 2005)
- Fauna Survey Locations (ERM 2005)
- Harp3 Harp Trap Survey Location (Forest Fauna Surveys 2005)
- Ana3 Anabat Survey Location (Forest Fauna Surveys 2005)
- Site 5 Squirrel Glider Survey Location (Forest Fauna Surveys 2005)
- FB3 Bird Survey Site (Ekerlogic 2005)
- Approved Subdivision

- Cleared Vegetation
- Swamp Mahogany - Paperbark Forest
- Coastal Sand Apple Blackbutt Forest
- Wet Heath - Tomago Sand Swamp Woodland
- Swamp Sclerophyll Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South-east Corner Bioregion

Nelson Bay Road
Fullerton Cove Road
Nelson Bay Road
Powerline Easement
Harp 1
Site 3
Ana 1
FB7G
FB6B
FB7F
Site 2
T3
1
FB7E
3
T1
Site 5
4
2
Harp 4
Ana 3
FB6A
Ana 4
6
5
Site 4
Harp 5
FB7A
FB7D
2
T2
FB3
2
1
4
FB3B
FB3A
FD2
FB6
FB7B
3
Harp 2
FB7C
1
7
Harp 3
Site 1
Ana 2
FB8

Figure 4.3 **Fauna Survey Effort in the Study Area**

Plots that return activity levels of approximately 30 percent or greater are considered likely to be within areas containing home range trees and/or areas of major activity currently being utilised by koalas with well defined home range areas (Phillips and Callaghan 1995). Conversely, plots that return activity levels below 30 percent are generally indicative of areas of either unsuitable habitat, little used parts of an individual koala's home range, or areas of otherwise suitable habitat that are not presently supporting a socially stable koala population (Phillips and Callaghan 1995).

4.7.5 Squirrel Glider Habitat Assessment

An assessment of the habitat types occurring within the study area was undertaken based on selected criteria to indicate the habitat attributes essential for the squirrel glider. Such attributes include:

- the dominant vegetation type(s) within the study area;
- the density of mature trees with hollows;
- degree of disturbance to habitats from impacts including clearings for vehicular tracks and infestations of introduced plant species;
- frequency of fire regime to canopy, understorey and ground layer vegetation; and
- density of preferred food resources for the squirrel glider, including *Acacia*, *Banksia*, red bloodwood and winter flowering eucalypts.

The habitat attributes was determined by sampling within a one hectare plot of each vegetation community at five sites where squirrel gliders were surveyed (see *Figure 4.3*). Attributes are scored along a 100 metre line intercept transect, recording all plant species (canopy, understorey, ground layer vegetation). All species were identified where possible and all canopy species were rated into size categories. Abundance of all species is recorded within a 100 by 50 metre quadrat and scores are doubled to determine density per hectare.

4.7.6 Mapping of Habitat Trees

Initially, the scope of the habitat assessment for the squirrel glider was to locate, describe and map the locations of all habitat trees within the study area. However, due to the size of the study area (205 hectares) and very high abundance of habitat trees, mapping of habitat trees was restricted to most of the 7(a) land that would be conserved. The objective of this approach was to determine whether sufficient habitat trees would be retained in conservation areas in comparison to the loss of habitat trees within the proposed development footprint (land zoned 1(a) or 2(a)).

Habitat trees were identified to species and positioned by GPS. The location data collated was analysed by GIS to ascertain the distribution of habitat trees within the proposed development area versus environmental protection areas (zoned 7(a)). Outcomes from this analysis indicated the distribution and abundance of potential (or actual) den trees conserved versus those removed by the proposed development. This analysis also assists in any management strategies required (ie installation of nest boxes) within areas to be conserved that presently support low densities of habitat trees.

4.7.7 Squirrel Glider Fragmentation Analysis

The study area is presently continuous with about 1,000 hectares of remnant bushland (hereafter referred to as the Fern Bay fragment). This fragment is isolated from adjoining fragments by cleared agricultural land to the west and north west, the township of Fern Bay to the south, Holocene sand dunes to the east and a large sand drift to the north, which has severed connectivity to fragments further north.

The potential size of the local squirrel glider population was derived from analysis of trapping data for this and previous local studies, and extrapolated to the extent of suitable habitat within the larger Fern Bay fragment. Fragmentation analysis also included the extent of suitable habitat for the squirrel glider based on local vegetation mapping such as LHCCREMS (House 2003) and location of barriers to movement and dispersal.

Habitat within land use zones (Port Stephens Council Local Environment Plan 2000) was overlayed on regional vegetation mapping of the Fern Bay fragment to quantify the extent of habitat in each land tenure. Additionally, the tenure of corridors linking the Fern Bay Estate site to the larger fragment was assessed.

4.7.8 Threatened Fauna

Arboreal Fauna

A targeted search for the squirrel glider (*Petaurus norfolcensis*) was conducted by ERM between 11 and 15 February 2002, and 3 and 5 September 2002, to identify the presence of any squirrel gliders in the study area, and to quantify the number and size of the population. This search was undertaken due to previous records of squirrel gliders in the study area (Gunninah Consultants 1996 revised 1997). This investigation involved arboreal mammal trapping using 25 size B Elliott traps over 375 trap nights. The traps were baited with a peanut butter/honey/rolled oats mix and placed in trees along three separate transect lines, at approximately 50 metre intervals over five nights in February 2002 (see *Figure 4.3*). In September 2002, 20 traps were placed along Transect 3 near the eastern boundary of the study area, at approximately 50 metre intervals for 60 trap nights (see *Figure 4.3*).

A targeted search for the squirrel glider was conducted by Forest Fauna Surveys Pty Ltd, 14 to 18 February 2005. Five arboreal trapping grids were established within the study area (see *Figure 4.3*). The configuration of each trapping grid was two lines of five traps, with each trap spaced 50 to 100 metres apart. At each trap point, one Elliott Type B (15 by 16 by 45 cm) folding aluminium trap was mounted on a platform attached to the tree trunk at a height of 4.5 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 sprayed with the honey/water mixture.

The effective trap area of this grid configuration (4.0 hectares), plus a boundary strip of 45 metres wide is 9.3 hectares. A trapping grid of this area was considered likely to sample at least two separate sub-populations (Smith and Murray 2003). Each trap grid was active for three consecutive nights, resulting in 150 arboreal trap nights for this survey.

Data collated from the arboreal trapping include the age composition (presence of juvenile and/or adults), sex and reproductive performance of the population (presence of breeding females, pouch young). Recaptured individuals also enable an estimate of population size. Individuals captured were released at the point of capture and followed to locate den trees.

Survey effort is provided in *Table 4.7.*

Nocturnal Fauna Call Playback

Nocturnal call playback was undertaken by ERM on 3, 4 and 5 September 2002 at two sites, and at three sites on 24 and 31 January and 15 February 2005 (see *Figure 4.3*). Call playback techniques and spotlighting were used, with pre-recorded owl call playback tapes broadcast through a 10W directional megaphone designed to project the sound for at least one kilometre under calm evening conditions.

Surveys commenced within one hour after dusk. Ten minutes of quiet listening initiated the surveys, followed by several minutes of powerful owl (*Ninox strenua*) call playback, followed by five minutes of quiet listening. Following this, several minutes of barking owl (*Ninox connivens*) playback was broadcast followed by several minutes of quiet listening. This process was repeated for calls of the masked owl (*Tyto novaehollandiae*), koala (*Phascolarctos cinereus*) and squirrel glider, and finalised with a further ten minutes of quiet listening. On completion of the listening time, 10 minutes of spotlighting was undertaken within 50 metres of the call playback site. Survey weather conditions and effort are provided in *Table 4.3* and *Table 4.7*, respectively.

Table 4.3 Weather Conditions during Call Playback and Spotlighting, 2002 and 2005

Date	Site	Start time	Stop time	Temperature °C	Weather	Survey Effort
*Nocturnal call playback**						
3 September 2002	Site 1	1810	1905	19.0	0/8 cloud, 0 wind, new moon, no rain	25 minutes call playback, 28 minutes listening
4 September 2002	Site 2	1835	1930	-	0/8 cloud, moderate NW wind, new moon, no rain	25 minutes call playback, 28 minutes listening
5 September 2002	Site 3	1800	1835	18.0	0/8 cloud, light NW wind, new moon, no rain	10 minutes call playback, 24 minutes listening
31 January 2005		2015	2100	25.0	0/8 cloud, calm, 2/4 moon, dry	25 minutes call playback, 28 minutes listening
15 February 2005		2010	2055	26.0	6/8 cloud, light NW wind, 2/4 moon	25 minutes call playback, 28 minutes listening
*Spotlighting**						
3 September 2002	Transect 1	1905	2005	19.0	0/8 cloud, 0 wind, new moon, no rain	2.0 person hours
3 September 2002	Transect 2	2015	2055	-	0/8 cloud, 0 wind, new moon, no rain	1.5 person hours
4 September 2002	Transect 3	1930	2015	19.0	0/8 cloud, 0 wind, new moon, no rain	1.5 person hours
4 September 2002	Transect 2	2020	2105	-	0/8 cloud, light NW wind, new moon, no rain	1.5 person hours
5 September 2002	Transect 1	1835	1935	18.0	0/8 cloud, light NW wind, new moon, no rain	2.0 person hours
5 September 2002	Transect 4	2020	2120	18.0	0/8 cloud, light NW wind, new moon, no rain	2.0 person hours
24 January 2005		2010	2300	22.0	6/8 cloud, moderate NW wind, full moon, light drizzle	3.6 person hours
31 January 2005		2100	2300	25.0	0/8 cloud, calm, 2/4 moon, dry	4.0 person hours

Date	Site	Start time	Stop time	Temperature °C	Weather	Survey Effort
14 February 2005#		-	-	-	2/8 cloud, light east wind, ¼ moon	2.6 person hours
15 February 2005		2055	2230	26.0	6/8 cloud, light NW wind, 2/4 moon	3.2 person hours
16 February 2005		-	-	-	6/8 cloud, moderate NE wind, ¼ moon	2.0 person hours
17 February 2005		-	-	-	5/8 cloud, light east wind, ¼ moon	no spotlighting conducted
18 February 2005		-	-	-	1/8 cloud, light NE wind, ¼ moon	no spotlighting conducted

* Anabat sampling was conducted during call playback and spotlighting
# harp trapping was conducted 14 – 17 February 2005

Spotlighting

Spotlighting was conducted by ERM on 3, 4 and 5 September 2002 along two transects in the study area, and on 24 and 31 January and 15 February 2005 along two transects (see *Figure 4.3*). Spotlighting involved two ecologists walking along each transect. The vegetation canopy and understorey was illuminated with 55W hand-held spotlights to search for foraging arboreal fauna and nocturnal birds. All spotlighting was undertaken within the first two hours after dusk. Survey weather conditions and effort are provided in *Table 4.3* and *Table 4.7*, respectively.

Spotlight searches were undertaken by Forest Fauna Surveys Pty Ltd on foot within and adjacent to each trapping grid with a 55 watt spotlight for approximately 60 minutes, intervened by periods of quiet listening in darkness to detect any animal movements or vocalisations. Particular attention was paid to blackbutt (*Eucalyptus pilularis*) and red bloodwood (*Corymbia gummifera*) as these two tree species were in flower during the survey period and provide a source of blossom and nectar for gliders.

Microchiropteran and Megachiropteran Bat Surveys

The use of handheld Anabat ultrasonic detection was conducted at three sites in the study area by ERM on 3, 4 and 5 September 2002, and 24 January 2005 to survey threatened microchiropteran bats (see *Figure 4.3*). A further five sites were sampled in February 2005 with the use of Anabat delay-switch units.

Surveys conducted by Forest Fauna Surveys Pty Ltd for megachiropteran (flying foxes) and microchiropteran (insectivorous) bat species consisted of:

- harp trapping undertaken at five sites for two consecutive nights to determine the presence of subcanopy species (see *Figure 4.3*);
- detection of echolocation calls via Anabat II detector recorded onto digital storage card (Zcaim – Titley Electronics) for computer analysis; and
- spotlighting for flying foxes and large microchiropteran bats.

Sampling for microchiropteran bats by Anabat echolocation calls and harp trapping was conducted 14 to 17 February 2005.

Harp traps were placed across suitable flyways to capture low flying microchiropteran bats. Five sites were sampled by harp traps, which were active for two consecutive nights each, resulting in a total of 10 harp trap nights for the study area. Each trap was checked daily for captured bats, which were identified and measured prior to being released.

Echolocation calls of microchiropteran bats were recorded at four of the five bat trapping survey sites. Calls were recorded via an Anabat II detector and

stored onto digital storage card via Zcaim recorder. The Zcaim unit was programmed to sample from dusk to dawn each evening, resulting in the equivalent of eight entire nights. Bat calls were analysed by Glenn Hoye (Fly by Night Bat Surveys Pty Ltd, Belmont).

Flying-foxes were surveyed by spotlighting of potential food trees and by identification of their characteristic social calls. The presence of flying bats was also monitored by activity at dusk each day by visually watching the skyline for bats.

Survey weather conditions and effort are provided in *Table 4.3* and *Table 4.7*, respectively.

Stag Watching

Stag watching of potential squirrel glider den trees was undertaken on 14 and 16 February 2005 (see *Table 4.7*). This involved direct counts of nocturnal animals emerging from tree hollows at dusk. The technique involves an observer stationed beneath hollow bearing dead or living trees in the study area and recording the identity and number of emergent animals following dusk for a period of about 40 minutes. This technique is useful as it provides an accurate measure of absolute abundance providing all individuals emerge following dusk, and all individuals in a population or group den in tree hollows (Smith *et al* 1989).

Wallum Froglet

Targeted surveys for the wallum froglet (*Crinia tinnula*) were conducted by two ecologists on 22 and 29 June, and 1 July 2004 at four sites in the study area (see *Figure 4.3*). This period corresponds with the winter breeding season of this species (Ehmann 1996). All sites were within the swamp forest (swamp mahogany – paperbark forest), which is considered to be wallum froglet habitat (Murray *et al* 2002). Surveys at each site were conducted for 15 minutes, comprising an initial five minutes of quiet listening, followed by five minutes of call playback, and concluded with five minutes of quiet listening. Surveys commenced following dusk. Weather conditions were noted at each site. Survey effort is summarised in *Table 4.4*. Surveys were not conducted during optimal conditions (winter rain), due to the exceptionally dry weather in winter 2004. Spotlight searches for individuals were not conducted as this species is cryptic and therefore difficult to locate in ground vegetation, even when calling.

Table 4.4 Survey Effort for Wallum Froglet

Date	Site	Time (hours Eastern Standard Time)	Temperature (°C)		Weather Conditions
			Dry Bulb	Wet Bulb	
22 June 2004	1	1900	12.5	11.5	¼ moon, 0/8 cloud, calm
	2	1923	5.0	5.0	
	3	1949	9.0	8.0	
	4	2025	7.5	6.5	
29 June 2004	1	1850	11.0	9.0	¾ moon, 0/8 cloud, light west wind
	4	1907	8.0	6.5	
	2	1926	8.5	5.0	
	3	1950	10.0	9.5	
1 July 2004	1	1843	6.0	5.5	Full moon, 0/8 cloud, calm
	4	1900	5.0	4.5	
	2	1917	3.0	3.0	
	3	1944	9.0	8.5	
Total survey effort = 3.0 hours					

Green-thighed Frog and Green and Golden Bell Frog

Targeted surveys for the tadpoles of the green-thighed frog and the green and golden bell frog were conducted on 21 February 2005 at four sites (ie ephemeral wetlands) in the swamp forest (see *Figure 4.3*). Surveys consisted of diurnal habitat searches for the green and golden bell frog, as this species basks on emergent vegetation around waterbodies. Dip-netting was conducted to sample tadpoles in waterbodies that contained areas of open water and a suitable depth. The time engaged in surveys was proportional to the waterbody or wetland area and habitat complexity (see *Table 4.5*). For example, large wetlands with complex vegetation structure take longer to survey than areas of open water in small waterbodies. Tadpoles were identified using Anstis (2002).

Table 4.5 Survey Effort for Green-thighed Frog and Green and Golden Bell Frog

Date	Site	Time (Daylight Savings Time)	Temperature (°C)		Weather Conditions
			Dry Bulb	Wet Bulb	
21 February 2005	1	0830 - 0900	23.0	22.5	0/8 cloud, light west wind
	2	0930 - 1000	24.0	22.0	0/8 cloud, light west wind
	3	1100 - 1145	24.0	22.0	0/8 cloud, light west wind
	4	1230 - 1300	25.0	24.5	0/8 cloud, light west wind
Total survey effort = 2.2 hours					

Swift Parrot and Regent Honeyeater

Targeted surveys for the swift parrot (*Lathamus discolor*) and regent honeyeater (*Xanthomyza phrygia*) were conducted on 9, 10 and 23 June 2004 at five sites in the study area (see *Figure 4.3*). Sites 1, 2, 3 and 5 are located within the swamp forest, while site 4 is located in the wet heath associated with the 4000 year before-present sand transgression. The swamp forest in sites 1, 2, 3 and 5 corresponds with the LHCCREMS vegetation mapping unit 'swamp mahogany – paperbark forest', while the wet heath at site 4 corresponds to the mapping unit 'Tomago sands swamp woodland' (CRA Unit NPWS 2000). These habitats were targeted as they contain a significant proportion of swamp mahogany, and the flowers of this eucalypt are a favoured food source of the swift parrot and regent honeyeater.

Surveys were conducted in the morning during the period of highest bird activity. Surveys comprised point call censuses of 20 minutes duration at each site, and were conducted by ornithologist Mr. Peter Ekert (Ekerlogic Consulting Services). All birds observed and heard calling were recorded during each survey. Survey effort is presented in *Table 4.6*.

Table 4.6 Survey Effort for Swift Parrot and Regent Honeyeater

Date	Site Number	Start - Stop Time (hours Eastern Standard Time)
9 June 2004	1	0820 – 0840
10 June 2004	1	0820 - 0840
23 June 2004	1	0800 – 0820
9 June 2004	2	0854 – 0941
10 June 2004	2	0852 – 0812
23 June 2004	2	0826 – 0846
9 June 2004	3	0923 – 0943
10 June 2004	3	0917 – 0937
23 June 2004	3	0851 – 0911
9 June 2004	4	1002 – 1022
10 June 2004	4	0950 – 1010
23 June 2004	4	0920 – 0940
9 June 2004	5	1044 – 1104
10 June 2004	5	1020 – 1040
23 June 2004	5	0950 – 1010
Total survey effort = 5.0 hours		

Woodland Birds, Rainforest Birds, Raptors

Targeted surveys for the following species were conducted on the morning of 1, 2 and 3 February 2005, afternoon on the 5 February 2005 and the morning of 6 and 7 February 2005:

- glossy black-cockatoo (*Calyptorhynchus lathamii*);
- brown treecreeper (eastern subspecies) (*Climacteris picumnus victoriae*);

- grey-crowned babbler (eastern subspecies) (*Pomatostomus temporalis temporalis*);
- rose-crowned fruit-dove (*Ptilinopus regina*);
- wompoo fruit-dove (*Ptilinopus magnificus*);
- superb fruit-dove (*Ptilinopus superbus*);
- osprey (*Pandion haliaetus*); and
- square-tailed kite (*Lophoictinia isura*).

Surveys for the brown treecreeper and grey-crowned babbler occurred at 34 sites in dry open forest and wet heath (see *Figure 4.3*). The surveys consisted of searching each of the two to three hectare survey sites for 20 minutes and opportunistic surveys were conducted while walking between survey sites. Birds were identified visually with binoculars or by call interpretation. Surveys for the fruit-doves occurred in swamp forest at four sites in the south and west of the study area. The surveys comprised of active searches and call playback, with similar methodology to brown treecreeper and grey-crowned babbler. The glossy black-cockatoo was targeted at a low number of sites due to the paucity of *Allocasuarina* in the study area. Where mature *Allocasuarina* were present, searches of fruit (cones) on the ground were conducted to assess use by glossy black-cockatoo. Surveys for the osprey and square-tailed kite were conducted concurrent with surveys for other bird species. During a survey period (20 minutes), large trees at least 20 metres in height were inspected for the presence of individuals and nests. Nest searches were also conducted by ERM while undertaking other field activities during the day (eg flora surveys and transects). Survey effort is summarised in *Table 4.7* and detailed in *Table B.1, Annex B*. Survey effort for each bird species was proportional to the area of each habitat type. A total of 4.2 hours was dedicated to survey of fruit-doves (swamp forest), 12.0 hours for glossy black-cockatoo, osprey and square-tailed kite (all habitats), and 10.0 hours for brown treecreeper and grey-crowned babbler (dry open forest and wet heath).

Ground Mammal Trapping

Eighty A-sized Elliott traps were baited with peanut butter, honey and rolled oats and placed in the field along four transects (lines of traps) at four different sites to trap small-sized ground mammals (see *Figure 4.3*). Transects 1 and 4 were positioned in dry sclerophyll open forest, Transect 2 was positioned in swamp forest and Transect 3 in wet heath. Each transect was 200 metres in length. Traps were placed at approximately 10 metre intervals, depending on the nature of the ground cover. For example, traps were placed in potential runways in undergrowth, and near logs and rock outcropping. The traps were set on 24 January 2005 and recovered on 28 January 2005 (four nights total). The total number of A-sized Elliott trap nights was 320. The

traps were checked within two hours of dawn each morning and the bait re-applied if required. One cage trap was set in dry sclerophyll open forest and baited with sardines to target spotted-tailed quoll (see *Figure 4.3*).

Forty hair funnels (*Faunatech*) were placed on the ground and left in the field for 10 nights (24 January to 4 February 2005). Ten hair funnels with a spacing of 20 metres were placed adjacent to the Elliott A type traps along the four transects. The total number of funnel nights was 400. Half of the terrestrial hair funnels were baited with peanut butter, honey and rolled oats, and half with sardines. The sardine mix targeted the spotted-tailed quoll, while the peanut butter mix targeted the brush-tailed phascogale and ground-dwelling mammals. Hairs collected from the funnels were sent to Barbara Triggs (Dead Finish, Genoa) for identification.

Survey effort for ground mammal trapping is presented in *Table 4.7*.

Scats, Tracks and Diggings

Searches for scats, tracks and diggings were conducted while undertaking other field activities, particularly during vegetation quadrat and transect surveys, and while spotlighting.

Table 4.7 Survey Effort, ERM 2002-2005

Survey Type (fauna targeted)	Vegetation Community	Survey Effort	Date
Flora survey	swamp forest	4 quadrats (replicated)	13 and 14 January 2005
	dry sclerophyll open forest	3 quadrats (replicated)	13 and 14 January 2005
	wet heath	2 quadrats (replicated)	13 and 14 January 2005
Targeted flora surveys:			
• leafless tongue orchid	swamp forest/dry sclerophyll open forest	random meander transect	19 November 2002
• rough doubletail	dry sclerophyll open forest	random meander transect	July 2002, 25 August 2004
• sand doubletail	dry sclerophyll open forest	random meander transect	10 September 2004
• *Eucalyptus parramattensis* subsp. *decadens* / netted bottlebrush	dry sclerophyll open forest/wet heath	random meander transect	18 January 2005
• Heath wrinklewort	dry sclerophyll open forest	random meander transect	18 January 2005
• dwarf kerrawang	swamp forest	4 quadrats (replicated)	13 and 14 January 2005
• swamp sclerophyll forest[1]	swamp forest	4 quadrats (replicated)	13 and 14 January 2005
Koala habitat assessment	swamp forest/wet heath	6 quadrats	28 May 2004
Koala spot assessment	swamp forest	4 sites (80 swamp mahogany searched)	21 May 2004
Squirrel glider habitat assessment	swamp forest/dry sclerophyll open forest/wet heath	5 sites/5 by 1 ha quadrats	14 and 15 February 2005
Elliott B type trapping (squirrel glider, brush-tailed phascogale)	dry sclerophyll open forest/swamp forest	375 trap nights	11 – 15 February 2002
	dry sclerophyll open forest	60 trap nights	3 – 5 September 2002
	swamp forest/dry sclerophyll open forest/wet heath	150 trap nights	14 – 18 February 2005
Call playback (owls, squirrel glider, koala)	dry sclerophyll open forest/swamp forest	2 sites/2.3 hours	3 – 5 September 2002
Call playback (owls)	dry sclerophyll open forest/swamp forest	3 sites/2.5 hours	24 and 31 January, 15 February 2005
Spotlighting (all nocturnal fauna)[2]	dry sclerophyll open forest/swamp forest/wet heath	2 transects/10.5 hours	3 – 5 September 2002
	dry sclerophyll open forest/swamp forest/wet heath	2 transects/9.2 hours	24 and 31 January, 15 February 2005

Survey Type (fauna targeted)	Vegetation Community	Survey Effort	Date
	dry sclerophyll open forest/swamp forest/wet heath	4 sites/4.6 hours	14 and 16 February 2005
Stagwatching (arboreal fauna)	dry sclerophyll open forest/swamp forest	2 sites/2.0 hours	14 and 16 February 2005
Anabat detection (microchiropteran bats) hand-held unit	dry sclerophyll open forest/swamp forest	3 sites/12.8 hours	3 – 5 September 2002
	dry sclerophyll open forest/swamp forest/wet heath	1 site, 1 transect/2.8 hours	24 January 2005
Anabat detection (microchiropteran bats) delay-switch unit	dry sclerophyll open forest/swamp forest/wet heath	4 sites/8 Anabat nights	14 – 17 February 2005
Harp trapping (microchiropteran bats)	dry sclerophyll open forest/swamp forest/wet heath	5 sites/10 harp nights	14 – 17 February 2005
Call playback (wallum froglet)	swamp forest	4 sites/3.0 hours	22 and 29 June, 1 July 2004
Tadpole searches (green-thighed frog)	swamp forest	4 sites/2.2 hours	21 February 2005
Habitat and tadpole searches (green and golden bell frog)	swamp forest	4 sites/2.2 hours	21 February 2005
Point call census (nectivorous birds)	swamp forest/wet heath	5 sites/5.0 hours	9, 10 and 23 June 2004
Point call census/chewed *Allocasuarina* cone search (woodland birds)	dry sclerophyll open forest/wet heath	30 sites/10.0 hours	1, 2, 3, 5, 6 and 7 February 2005
Call playback/point call census (frugivorous birds)	swamp forest	4 sites/4.2 hours	1, 2, 3 and 5 February 2005
Point call census/nest search (raptors)	dry sclerophyll open forest/swamp forest/wet heath	34 sites/14.2 hours	1, 2, 3, 5, 6 and 7 February 2005
Elliott A type trapping (small ground mammals)	dry sclerophyll open forest/swamp forest/wet heath	4 transects/320 trap nights	24 – 28 January 2005
Hair tubes (spotted-tailed quoll, brush-tailed phascogale, small ground mammals)	dry sclerophyll open forest/swamp forest/wet heath	4 transects/400 funnel nights	24 – 28 January 2005

1. endangered ecological community
2. spotlighting and stagwatching hours are person hours

5 RESULTS

5.1 INTRODUCTION

This section provides information on the flora, vegetation communities, fauna habitats and subject species that were recorded during the field surveys. Information is provided on the habitat requirements of each affected species, and the extent and condition of habitat for these species in the study area.

5.2 GENERAL FLORA

A total of 113 vascular plant species were recorded from the nine sites and transects in the study area (see *Table B.1, Annex B*). Four weed species were recorded, including the noxious bitou bush (*Chysanthemoides monilifera* subsp. *rotundata*), which was present in all three vegetation communities. A description of the dominant composition and structure within each community is provided in *Annex D*. Plant diversity was highest in the swamp forest with 25 species being the mean number recorded in the quadrats, 23 species in the dry sclerophyll open forest and 20 species in the wet heath.

The threatened rough doubletail (*Diuris praecox*) was recorded in the north east corner of the study area in July 2002. Two individuals were recorded. Four individual *Eucalyptus parramattensis* subsp. *decadens* X *Eucalyptus robusta* hybrid trees were recorded in February 2005 from wet heath and dry sclerophyll open forest. No other threatened flora species were recorded in the study area during targeted surveys.

5.3 WEEDS

The distribution and abundance of weeds in the study area have been mapped (ERM 2005c). Information on the particular species and broad distribution weed species was obtained from ERM (2005c) in addition to Clements *et al* (1992) and Gunninah (1996 revised 1997 and 2002). The low local occurrence of exotic weed species in the undisturbed areas of the study area (as opposed to the cleared areas) is indicative of soil nutrient levels unfavourable to their growth. Off road vehicles and garbage dumping is likely to have transported weeds to the study area. The main weed infestations generally occur where rubbish has been dumped in cleared areas of the study area and along four-wheel drive tracks**.** *Table 5.1* lists the significant weed species identified in the study area and provides a general description of their abundance and distribution. Significant weed species are those with the highest densities and which pose the most significant threat to the conservation values of the study area. The highest weed density was recorded in the swamp forest (ERM 2005c).

Table 5.1 Dominant Weed Species in the Study Area

Common Name	Species Name	Description of Weeds from Previous Surveys
whisky grass	*Andropogon virginicus*	On the sides of the tracks a higher abundance and number than within the natural vegetation. The most widespread with a habitat preference for open areas in low nutrient soils. It does not occur in natural vegetation unless the vegetation has been cleared or disturbed.[1] Invaded some disturbed areas mostly confined to vegetation edges.[2]
guinea grass	*Panicum maximum*	Sides of the tracks and in disturbed areas.[1]
African love grass	*Eragrostis curvula*	Sides of the tracks and in disturbed areas.[1] Invaded some disturbed areas although mostly confined to vegetation edges.[2]
bitou bush	*Chysanthemoides monilifera subsp. rotundata* W3, N	Forms clumps on the foredune and is dominant in small patches of the hind dune vegetation and seedlings were widespread throughout the dry sclerophyll forest. Bitou bush appears to require open sand and perhaps continuous nutrient enrichment for establishment. Occurs on the boundaries between the swamp forest and dry sclerophyll forest. [1] Occurs extensively through the study area especially along edges of disturbed swamp forests. Common along edges of dune vegetation.[2] One of the main weed species present in the dry sclerophyll open forest[3]
lantana	*Lantana camara* W3, N	Occurs on the boundaries between the swamp forest and dry sclerophyll forest. [2]
blackberry	*Rubus fruticosu*s ssp. *aggregate* W2, N	Not common and is generally confined to large cleared areas where dumping has occurred. [2]
wild tobacco plant	*Solanum mauritianum*	Not common and is generally confined to large cleared areas where dumping has occurred. [2]
ink weed	*Phytolacca octandra*	Not common and is generally confined to large cleared areas where dumping has occurred. [2]
mile- a minute	*Ipomoea cairica*	Common along Nelson Bay Road. Particularly noticeable growing over the canopies of a number of swamp forest stands.[2]
pennywort	*Hydrocotyle bonariensis*	Has become naturalised on the NSW coast including the study area.[1] Most commonly occurring species beneath the swamp forest canopy.[2] Found in swamp forest due to favourable moisture conditions.[3]
cyperus	*Cyperus dubius* and *C. flavus*	Localised to the Newcastle region. Appears to be naturalised in the dry sclerophyll forest.[1]
fleabanes	(*Conzya albida, C.canadensis* and *C parva)*	These wind and tyre carried species were relatively widespread in the dry sclerophyll forest.[1]
fire weed	*Senecio madagascariensis*	This wind and tyre carried species was relatively widespread in the dry sclerophyll forest.[1]
variable groundsel	*Senecio lautus*	Few weeds are present, but one of the main weed species in the dry sclerophyll open forest. [3]

Common Name	Species Name	Description of Weeds from Previous Surveys
toothed hebenstretia	*Hebenstretia dentata*	Weeds of disturbed sandy places, localised to the Hunter Region.[1]
turkey rhubarb	*Acetosa sagittata*	Common along Nelson Bay Road.[2]
paddy's lucerne	*Sida rhombifolia*	Common along Nelson Bay Road.[2]

References

[1] Clements, 1992

[2] Gunninah, 2002

[3] Gunninah 1996 revised 1997

Noxious Weeds in Port Stephens LGA

W1- weed category- notifiable, must be fully and continuously suppressed and destroyed

W2- weed category- must be fully and continuously suppressed and destroyed

W3- weed category- prevent spread, reduce distribution and numbers

Weeds of National Significance

[N]- nationally significant

5.4 VEGETATION COMMUNITIES

Surveys were conducted in swamp forest, dry sclerophyll open forest and wet heath to determine the composition and structure of these communities. The purpose of these surveys was to update existing information (see Gunninah Consultants 2002). A summary description of these communities is included in *Annex D*. Mapping of vegetation communities in the study area is shown in *Figure 5.1*.

5.5 KOALA HABITAT ASSESSMENT

The koala habitat assessment identified the areas mapped as swamp forest and wet heath in the study area as *potential* koala habitat as defined by SEPP 44. This was due to the presence of greater than 15 percent of swamp mahogany in the upper and lower canopy strata of these vegetation communities (see *Table 5.2*).

Table 5.2 Koala Habitat Assessment

Tree Species	Upper strata		Lower strata		Total	
	No.	%	No.	%	No.	%
Swamp forest						
Angophora costata	2	3	0	0	2	**3**
*Eucalyptus robusta**	23	41	0	0	23	**34***
Livistona australis	9	16	7	63	16	**24**
Melaleuca quinquenervia	17	30	0	0	17	**25**
Melaleuca styphelioides	4	7	4	36	8	**12**
Wet heath						
Angophora costata	1	6	2	9	3	**8**
Banksia serrata	9	60	11	50	20	**54**
*Eucalyptus robusta**	5	33	9	40	14	**37***

1. * preferred koala feed tree species in Port Stephens LGA.
2. swamp forest and wet heath are *potential* koala habitat (ie *Eucalyptus robusta* is greater than 15% of the total species.

Subsequent searches for koala faecal pellets within one metre of the base of swamp mahogany trees, however, did not find any evidence of koala usage in these areas. Therefore, although the swamp forest and wet heath support *potential* koala habitat, the two vegetation communities do not support *core* koala habitat as defined by SEPP 44. This conclusion is also supported by the lack of recent (post-1992) records of koalas in the study area and the fact that Gunninah Consultants (1996 revised 1997, 2002) and ERM did not find any evidence of koala usage in the study area.

According to the vegetation associations of Lunney *et al* (1998), swamp forest and wet heath in the study area qualify as *preferred* koala habitat, as defined by the CKPoM. The areas should therefore be mapped as *preferred* koala

Legend

Powerful Owl Roost Tree

Threatened Species

	Easting	Northing
Powerful Owl	388115	6363629
	388236	6363826
Masked Owl	388330	6363740
Squirrel Glider	389070	6364160
	389550	6364330
	389790	6364200
	389720	6363880
	388330	6363740
	389288	6363352
	389262	6363316
	389265	6363221
Grey-headed Flying-fox	389000	6364110
	389820	6364300
	388300	6363570
Diuris praecox	389765	6364485
	389800	6364430
Greater Broad-nosed Bat	389107	6364193
	389019	6363782
	389019	6363782
Eastern Bentwing-bat	389107	6364193
	389019	6363782
Little Bentwing-bat	389107	6364193
Hoary Wattled Bat	389019	6363782
Wallum Froglet	388582	6363697

1(a) 1(a) Rural Agriculture Zone

2(a) 2(a) Residential Zone

7(a) 7(a) Environment Protection Zone

Approved Subdivision

Cleared VegetationCleared Vegetation

Swamp Mahogany - Paperbark Forest

Coastal Sand Apple Blackbutt Forest

Wet Heath - Tomago Sand Swamp Woodland

Swamp Sclerophyll Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South-east Corner Bioregion

Nelson Bay Road

Fullerton Cove Road

Nelson Bay Road

Powerline Easement

7a

2a

1a

Figure 5.1 **Vegetation Communities and Threatened Species in the Study Area**

habitat in the CKPoM Koala Habitat Mapping. Remaining areas are mapped as 50 metre habitat buffer over supplementary koala habitat, supplementary koala habitat and habitat linking area over supplementary koala habitat (see *Figure 5.2*). Preferred koala habitat in the study area is contiguous with preferred habitat (ie swamp mahogany – paperbark forest) at Newcastle Golf Course to the south west of the study area.

5.6 FAUNA HABITAT

The dry sclerophyll open forest community provides fauna habitat in the form of tree hollows, logs and ground cover such as grasses and bracken. Logs and ground cover provide shelter and foraging habitat for reptiles and small ground-dwelling mammals. The sandy substrate enables small to medium-sized mammals to create burrows for shelter. It is likely that tree hollows of this community provide suitable roosting habitat for the squirrel glider, powerful owl, masked owl and microchiropteran bats. No habitat in the form of bush rock or rock platform was identified in the study area. The presence of *Banksia* in the mid-strata provides foraging resources for nectivorous birds and the squirrel glider.

The wet heath community has little to no habitat in the form of tree hollows, however, the dense grass cover and presence of *Acacia*, *Banksia* and *Leptospermum* provides extensive foraging habitat for granivorous and nectivorous birds, and some sheltering habitat for reptiles and small ground-dwelling mammals. The sandy substrate provides potential burrow habitat for reptiles and small ground-dwelling mammals. The presence of a sparse canopy strata composed of swamp mahogany provides sub-optimal foraging habitat for the squirrel glider, koala and winter migratory birds such as the swift parrot and regent honeyeater. There are no permanent or ephemeral wetlands suitable for frogs in this habitat type.

The swamp forest community provides potential foraging habitat to koalas, squirrel gliders, powerful owl, grey-headed flying-fox and a number of nectivorous birds such as the swift parrot. Swamp mahogany comprises the primary winter foraging resource in this community, although *Melaleuca* also provides a flowering resource. Cabbage tree palms provide a food resource for grey-headed flying-fox. Rainforest plant species such as blueberry ash and lilly pilly provide a foraging resource for frugivorous birds. Some hollow-bearing trees are also present in this community, providing potential roost sites for the squirrel glider and microchiropteran bats. This vegetation community also supports ephemeral wetlands that provide suitable habitat for frog species such as the threatened wallum froglet. There are no permanent wetlands in this habitat type. Swamp forest acts as a biological filter for the movement of water between the study area and wetlands in Fullerton Cove.

Legend

- Cleared vegetation
- Preferred Koala Habitat
- Supplementary Koala Habitat
- 50m Habitat Buffer over Supplementary
- Habitat Linking Area over Supplementary
- Approved Subdivision

Nelson Bay Road

200m Ecological Corridor

Fullerton Cove Road

Nelson Bay Road

Powerline Easement

100 year Hind Dune Hazard Line

Figure 5.2 **Koala Habitat in the Study Area**

5.6.1 *Squirrel Glider Habitat Assessment*

There are essentially two microhabitat components necessary for an area to maintain a population of squirrel gliders: tree hollows and food plants. The most important food plants are considered to be regular winter flowering *Banksia* and *Eucalyptus,* which provide pollen for protein and nectar for energy during winter when other food resources are scarce. Other important food resources include sap and exudate producing trees and shrubs (red bloodwood, *Xanthorrhoea* species and some *Acacia*), spring and summer flowering eucalypt, *Angophora* and *Banksia* species (Smith 2000).

Within the study area, key food plants for the squirrel glider and their relative density per hectare is presented in *Table 5.3*.

Table 5.3 Key Food Plants and Relative Densities (plants per hectare)

Species	**Dry Open Forest**		**Swamp / Dry Open Forest**	**Wet Heath**	**Swamp Forest**
Food Plant	**Site 1**	**Site 2**	**Site 3**	**Site 4**	**Site 5**
Corymbia gummifera	3.4%	-	-	-	-
Eucalyptus pilularis	60.7%	54.6%	52.2%	-	-
Angophora costata	33.7%	19.8%	-	65.1%	-
Eucalyptus robusta	-	-	2.2%	-	57.9%
Melaleuca quinquenervia	-	-	-	-	21.6%
Banksia serrata	2.2%	25.6%	6.6%	35.8%	-
Shrub Layer (density per ha)					
Acacia longifolia	>40.0 plants ha^{-1}	-	>40.0 plants ha^{-1}	-	20 plants ha^{-1}
Acacia irrorata		-	25 plants ha^{-1}	-	35 plants ha^{-1}
Banksia serrata	>40.0 plants ha^{-1}	-	-	>40.0 plants ha^{-1}	
Leptospermum laevigatum	-	-	-	>40.0 plants ha^{-1}	-

Observations of feeding of the squirrel glider in north east NSW indicates that nectar and pollen account for the majority of diet intake (Sharpe and Goldingay 1998). Key food plants in the study area and locality would include sap of red bloodwood (*Corymbia gummifera*) (although in low density within the study area), bipinnate leaved *Acacia* spp. which provide gum, and swamp mahogany (*Eucalyptus robusta*), broad-leaved paperbark (*Melaleuca quinquenervia*) and *Banksia serrata* providing a winter source of nectar and pollen. Blackbutt (*Eucalyptus pilularis*) and smooth-barked apple (*Angophora costata*) are likely to provide nectar and pollen over summer.

5.6.2 *Mapping of Habitat Trees*

An assessment of the distribution and abundance of habitat trees for tree hollow dependent fauna was undertaken in parts of the study area. Initially, the scope of the mapping was to identify and map all habitat trees in the study

area, but it became apparent very early in the field mapping that the site supports a very high abundance of habitat trees. Hence, mapping of habitat trees was reduced to areas of 7(a) land within the study area in an attempt to quantify the abundance of this resource conserved versus cleared for development.

A total of 379 habitat trees were mapped (see *Annex G*). It must be noted that not all of the 7(a) land was mapped, including areas in proximity to Nelson Bay Road, and a small area in the southern boundary of the study area. A large area of 7(a) land on the western boundary of the study site supports tall *Melaleuca quinquenervia* and swamp oak (*Casuarina glauca*) forest with very sparse habitat trees. No mapping of habitat trees was undertaken in this area.

Average habitat tree density is very high at 9.38 ± 5.54 habitat trees per hectare. Similar density of habitat trees was mapped for the immediately adjoining 2(a) land, indicating that habitat trees are relatively evenly distributed in open forest and woodland across the study area. Areas of lower density or absence of habitat trees within the study area include the swamp forest (average of 3.6 habitat trees per hectare) and wet heath (2.2 habitat trees per hectare).

The extent of habitat trees cleared versus conserved within the study area can be extrapolated from the habitat tree mapping. The extent of habitat to be cleared by the approved development is 22.8 hectares, comprising 9.7 hectares of swamp forest, 4.0 hectares of wet heath and 15.5 hectares of dry sclerophyll forest. Based on the average habitat tree density per vegetation type, approximately 166 habitat trees would be cleared under current approved development.

Additional habitat that would be cleared by this development proposal is 9.7 hectares of swamp forest, 15.0 hectares of wet heath and 45.5 hectares of dry open forest, a total of 70.2 hectares. This would equate to an estimated 495 habitat trees to be cleared by this development proposal.

An estimate of the number of habitat trees within each vegetation type is presented in *Table 5.4*. The estimate of habitat trees conserved in the study area is approximately 777 habitat trees. The conservation zoned land in the study area would support sufficient numbers of habitat trees to not warrant management options such as nest boxes as mitigation measures.

Table 5.4 Average Habitat Tree Density Estimates

Vegetation Community	Total Area Native Vegetation	Av. Habitat Tree Density / ha	Habitat Tree Estimate	Estimate of Habitat Trees Cleared		Estimate of Habitat Trees Conserved
				Approved Development	Proposed Development	
Swamp forest	43.5	3.60	156.6	12.0	34.9	109.8
Wet heath	26.0	2.25	58.5	8.8	33.0	15.4
Dry sclerophyll open forest	130.5	9.38	1,219.4	145.4	426.8	651.9
Total	**200.0**		**1,434.5**	**166.2**	**494.7**	**777.1**

5.7 GENERAL FAUNA

A list of fauna species recorded in the study area during surveys by ERM is included in *Table F.1, Annex F*. A total of 74 species were recorded throughout habitats in the study area.

Mammals trapped in ground traps included swamp rat (*Rattus lutreolus*) in swamp forest and wet heath, and brown antechinus (*Antechinus stuartii*) in all three habitats (see *Table 5.5*). The bush rat (*Rattus fuscipes*) was recorded in habitats with ground cover such as the dry sclerophyll open forest and swamp forest. The hair funnel analysis detected the same species recorded from the traps. The squirrel glider was captured during the trapping in February 2005 (see *Section 5.12.9*).

Table 5.5 Elliott A Type Trapping Results, ERM 2005

Date	Transect	Species	No. of individuals
25 January 2005	1	bush rat	1
25 January 2005	1	brown antechinus	1
25 January 2005	2	black rat*	1
26 January 2005	1	brown antechinus	2
26 January 2005	1	bush rat	1
26 January 2005	2	brown antechinus	1
26 January 2005	2	bush rat	1
26 January 2005	2	black rat	1
26 January 2005	4	brown antechinus	1
26 January 2005	4	bush rat	1
27 January 2005	1	brown antechinus	1
27 January 2005	1	bush rat	1
27 January 2005	1	black rat	1
27 January 2005	2	bush rat	1
27 January 2005	2	brown antechinus	1
27 January 2005	2	black rat	1
27 January 2005	3	brown antechinus	1
27 January 2005	4	brown antechinus	1
27 January 2005	4	bush rat	1
28 January 2005	1	brown antechinus	4
28 January 2005	1	swamp rat	3
28 January 2005	1	black rat	1
28 January 2005	2	swamp rat	6

Date	Transect	Species	No. of individuals
28 January 2005	2	black rat	2
28 January 2005	2	brown antechinus	1
28 January 2005	3	swamp rat	3
28 January 2005	3	brown antechinus	2
28 January 2005	4	brown antechinus	4

* introduced species

A total of 20 microchiropteran bat species were recorded from the study area (see *Table 5.6*). They were the most abundant and diverse mammal group recorded. The small forest bat (*Vespadelus vulturnus*) was the most abundant species captured, and is widespread in the study area. In contrast, the lesser long-eared bat (*Nyctophilus geoffreyi*) was captured in taller forest with a relatively dense understorey, being absent in captures in the more open blackbutt/*Angophora costata* woodland in the southern parts of the study area. One greater broad-nosed bat (*Scoteanax rueppellii*) was captured in tall blackbutt/*Angophora costata* forest in the centre of the study area. This capture site is close to a previous capture of the species in 1992 (Clements *et al* 1992). Habitat associated with this site is blackbutt (*Eucalyptus pilularis*) and smooth-barked apple (*Angophora costata*) to 20 metres in height, and numerous habitat trees with abundant hollows. Tall understorey includes *Banksia serrata* and *Acacia* spp. to five metres in height. One eastern broad-nosed bat (*Scotorepens orion*) was captured in the wet heath in the centre of the study area.

A total of 664 passes of microchiropteran bats were recorded during surveys in February 2005. The high activity recorded is attributed to the forest age and structure, and warm nights with high insect activity experienced. A total of 10 species were recorded by echolocation call recordings (see *Table 5.6*). Five species were also captured by harp trapping.

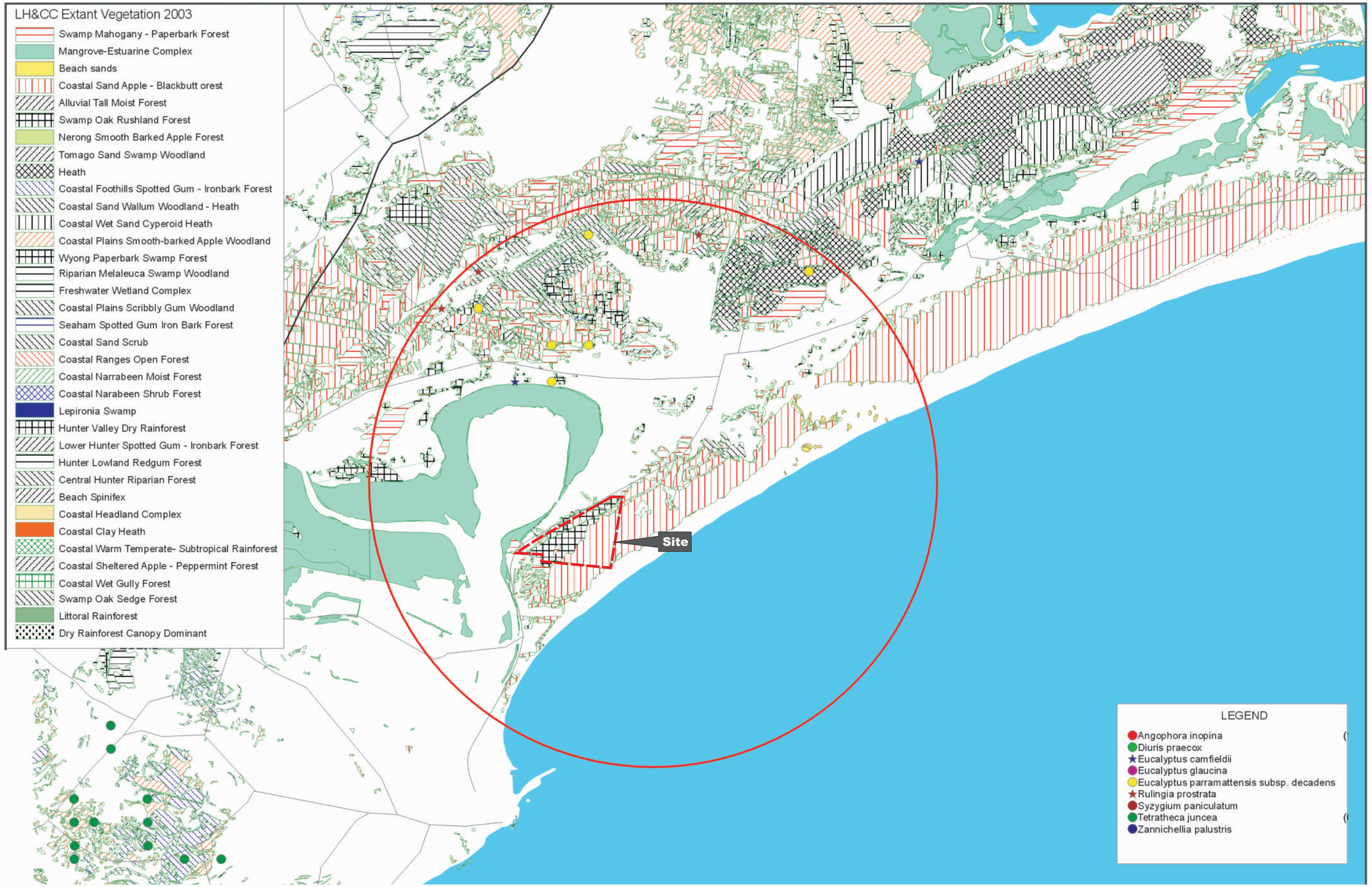
Table 5.6 Microchiropteran Bat Captures

Date Captured	Site	Common Name	Scientific Name	No. trapped	Vegetation Type
15 February 2005	1	lesser long-eared bat	*Nyctophilus geoffreyi*	1	Swamp forest
		little forest bat	*Vespadelus vulturnus*	2	
	3	little forest bat	*Vespadelus vulturnus*	1	Dry sclerophyll open forest
16 February 2005	2	little forest bat	*Vespadelus vulturnus*	1	Dry sclerophyll open forest
	3	little forest bat	*Vespadelus vulturnus*	3	Dry sclerophyll open forest
17 February 2005	4	lesser long-eared bat	*Nyctophilus geoffreyi*	1	Wet heath
		eastern broad-nosed bat	*Scotorepens orion*	1	
		little forest bat	*Vespadelus vulturnus*	5	
	5	lesser long-eared bat	*Nyctophilus geoffreyi*	4	Dry sclerophyll open forest
		greater broad-nosed bat	*Scoteanax rueppellii*	1	
		little forest bat	*Vespadelus vulturnus*	8	
18 February 2005	4	little forest bat	*Vespadelus vulturnus*	8	Dry sclerophyll open forest
	5	little forest bat	*Vespadelus vulturnus*	6	Wet heath
		Total Bat Species	**5 Species**	**42 Captures**	

Birds were the fauna group with the highest species diversity with 50 species recorded. A total 23 species were recorded in swamp forest, 29 in dry sclerophyll open forest and 15 in wet heath. The higher diversity in dry sclerophyll open forest may be related to availability of food resources, as most species recorded are nectivorous. Bird species assemblages differed in the study area according to season, with some species present during winter but not the summer surveys and vice versa.

5.8 SUBJECT SPECIES AND AFFECTED SPECIES

The DGRs for the SIS listed species and ecological communities to be considered for inclusion as subject species and subject communities (see *Annex A*). This list was refined to identify species that may be affected by the proposal (affected species) based on the results of database searches, vegetation mapping, habitat assessment, and flora and fauna surveys including targeted surveys, conducted by ERM and other consultants. *Figure 5.3a*, *Figure 5.3b* and *Figure 5.3c* show the locations of database records of threatened species in the locality. There are 37 potentially affected species and one affected ecological community, assessed from 41 subject species and two subject communities (see *Table 5.7*).



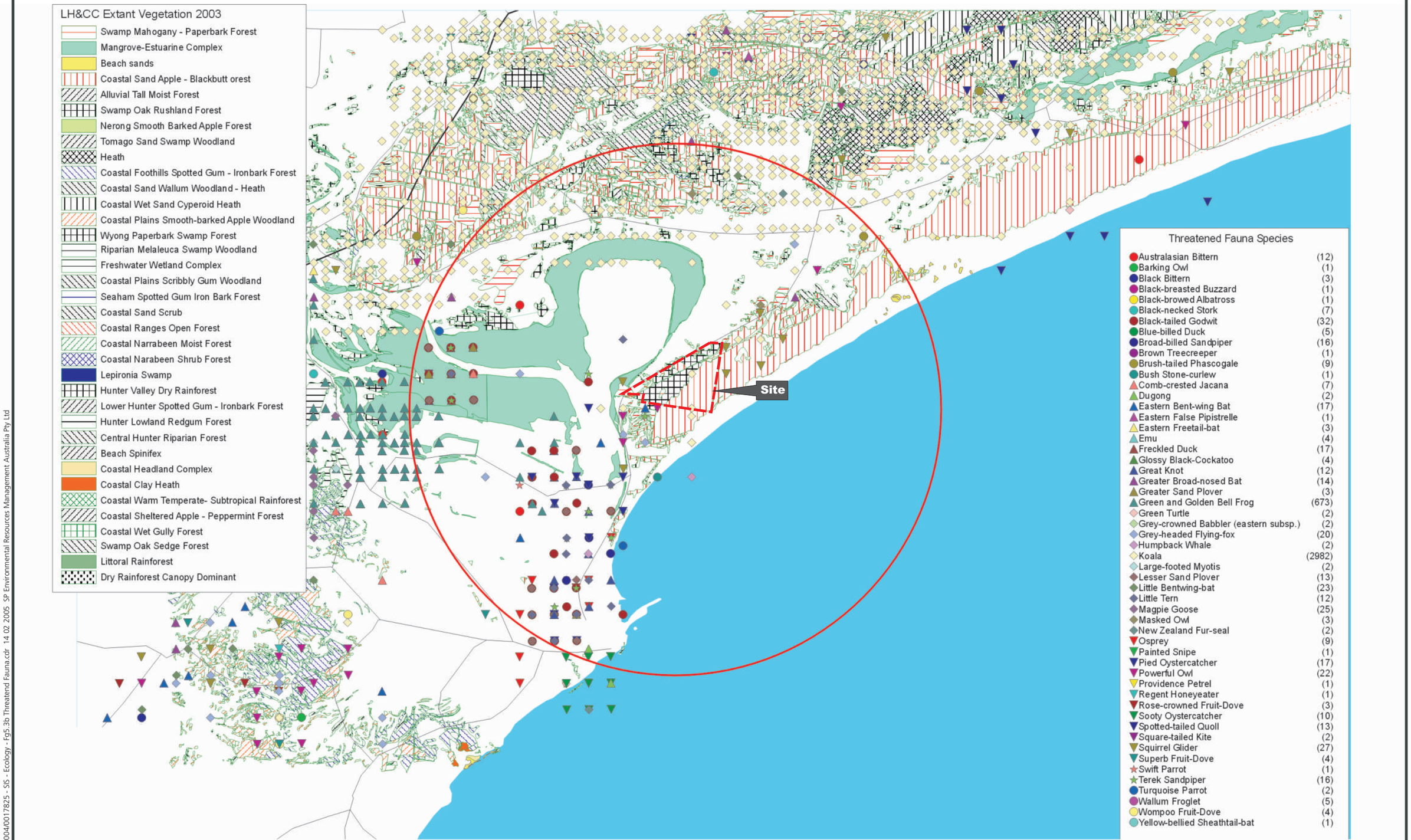
Jobs/2004/0017825 SIS - Ecology - Fg5.3a Threatened Flora.cdr 14.02.2005 SP Environmental Resources Management Australia Pty Ltd

ERM

0 2km

Figure 5.3a **Threatened Flora Records and Vegetation Communities**

Winten Property Group - CVC Limited - Fern Bay Estate - SIS



Jobs/2004/0017825 - SIS - Ecology - Fg5.3b Threatend Fauna.cdr 14 02 2005 SP Environmental Resources Management Australia Pty Ltd

ERM

Figure 5.3b **Threatened Fauna Records and Vegetation Communities**

Winten Property Group - CVC Limited - Fern Bay Estate

Site

Bird Records

- Bar-tailed Godwit
- Beach Stone-curlew
- Black-necked Stork
- Black-tailed Godwit
- Caspian Tern
- Great Knot
- Grey-crowned Babbler
- Lesser Sand Plover
- Little Tern
- Masked Owl
- Pied Oystercatcher
- Sanderling
- Sooty Oystercatcher
- Swift Parrot
- Terek Sandpiper

ERM

0 2km

Figure 5.3c **Birds Australia Records**

Winten Property Group - CVC Limited - Fern Bay Estate - SIS

Table 5.7 Identification of Affected Species

Name	TSC Act	Preferred Habitat	Likelihood of Occurrence
Hollow-dependent Birds			
glossy black-cockatoo *Calyptorhynchus lathamii*	V	Eucalypt woodlands and forests where *Allocasuarina/ Casuarina* are abundant in the understorey and mature trees provide large nesting hollows[1]. Rarely recorded far from preferred food resource[1].	Low to moderate. Preferred foraging resource (*Allocasuarina* spp.)[3] scarce in study area. Nesting habitat (large tree hollows) available, however rarely recorded far from preferred food resource[3]. **Potentially affected species.**
barking owl *Ninox connivens*	V	Open woodlands and dry open forests, nesting in the crown of mature trees[2].	Low to moderate likelihood based on habitat available but no records. **Potentially affected species.**
powerful owl *Ninox strenua*	V	Wet and dry sclerophyll forests, nesting (large tree hollows) and roosting in dense forest areas or dense gullies.	High. Roost tree present in study area. Local records, suitable foraging and nesting habitat also present in the study area. **Potentially affected species.**
masked owl *Tyto novaehollandiae*	V	Dry sclerophyll forest and woodland with a low sparse understorey, foraging in open or partly cleared land. Roosting and nest sites large tree hollows in sheltered aspects.	High. Recorded in study area. Suitable foraging and nesting habitat present. **Potentially affected species.**
Other Birds			
bush stone-curlew *Burhinus grallarius*	E	Lightly timbered open forest or woodland with a ground cover of short or sparse grass and few, or no shrubs. Occasionally in mangroves and saltmarsh where fringed by *Casuarina* thickets[3]. High fire frequency further reduces habitat suitability.	Low. Local records however preferred habitat (lightly timbered open forest or woodland with a ground cover of short sparse grass and few, or no shrubs[3]) absent from study area. High fire frequency further reduces habitat suitability.
brown treecreeper (eastern subspecies) *Climacteris picumnus victoriae*	V	Forest, woodlands and scrubs with fallen branches[4].	Moderate. Recorded in the study area and suitable habitat is present. **Potentially affected species.**
swift parrot *Lathamus discolor*	E	Migratory species frequenting eucalypt forest and woodland[5], following winter flowering eucalypts (eg swamp mahogany). Breeds in Tasmania.	Moderate. Suitable foraging habitat identified in the study area (swamp mahogany in swamp forest). **Potentially affected species.**
square-tailed kite *Lophoictinia isura*	V	Heathlands, woodlands, forests[4].	Moderate. Recorded in the locality and suitable foraging and nesting habitat is present in the study area. **Potentially affected species.**

Name	TSC Act	Preferred Habitat	Likelihood of Occurrence
osprey *Pandion haliaetus*	V	Forages over water; nests in large dead tree[6].	Moderate. Suitable foraging habitat (brackish or salt waterbody)[6] over Stockton Bight and Fullerton Cove. Nest site is commonly a tall tree, usually dead. Potential nest sites available. **Potentially affected species.**
grey-crowned babbler (eastern subspecies) *Pomatostomus temporalis temporalis*	V	Open forests, woodlands, scrublands[4].	Moderate. Recorded in the study area and suitable habitat is present. **Potentially affected species.**
wompoo fruit-dove *Ptilinopus magnificus*	V	Rainforest[4].	Moderate. Few local records, preferred habitat generally absent in the study area, although some rainforest elements are present. **Potentially affected species.**
rose-crowned fruit-dove *Ptilinopus regina*	V	Rainforest[4].	Moderate. Few local records. **Potentially affected species.**
superb fruit-dove *Ptilinopus superbus*	V	Rainforest, mangrove, eucalypt forest[4].	Moderate. Few local records. Lives in rainforest but will feed in mangroves or eucalypt forest[4]. Rainforest generally absent from the study area, although some rainforest elements are present. **Potentially affected species.**
regent honey eater *Xanthomyza phrygia*	E	Nomadic species following rich sources of nectar, primarily winter flowering species (eg swamp mahogany in coastal areas).	Moderate. Suitable foraging habitat identified in the study area (swamp mahogany in swamp forest). **Potentially affected species.**
Cave Roosting Bats			
large-eared pied bat *Chalinolobus dwyeri*	V	Roost by day in caves and mine tunnels.	Low to moderate likelihood of foraging. No roost sites present. Foraging habitat available. **Potentially affected species.**
little bentwing-bat *Miniopterus australis*	V	Roosts in caves, old mines, stormwater channels; forages in forested areas below the canopy.	Moderate to High. No suitable roost habitat. Foraging habitat available. **Potentially affected species.**
eastern bentwing-bat *Miniopterus schreibersii oceanensis*	V	Roosts in caves, old mines, stormwater channels; forages in forested areas above the canopy.	High. Recorded in the study area. Suitable foraging habitat. No roost sites identified or likely to be present. **Potentially affected species.**
large-footed myotis *Myotis adversus*	V	Roosts in caves, tunnels, under bridges & dense vegetation. Forage over nearby lakes, rivers, large streams.	Moderate to High. No suitable roost habitat. Foraging habitat available. **Potentially affected species.**
Hollow-dependent Mammals			
hoary wattled bat *Chalinolobus nigrogriseus*	V	A range of habitats including open forest and woodland, coastal scrub, sand dunes, grasslands and floodplains.	Low to moderate. No regional records although potential habitat available. **Potentially affected species.**

Name	TSC Act	Preferred Habitat	Likelihood of Occurrence
spotted-tailed quoll *Dasyurus maculatus*	V	Wide range of forested habitats including rainforest, open forest, coastal heath, riparian forest. Nests in rock caves, hollow logs or tree hollows.	Moderate to high. Local records and potential habitat available. **Potentially affected species.**
eastern false pipistrelle *Falsistrellus tasmaniensis*	V	Sclerophyll forests where they roost in tree hollows.	Moderate. No local records, although potential foraging habitat is present in the study area. **Potentially affected species.**
eastern freetail-bat *Mormopterus norfolkensis*	V	Dry eucalypt forest and woodland where they roost in tree hollows.	High. Recorded in the study area. Potential roost sites and foraging habitat identified throughout the study area. **Potentially affected species.**
squirrel glider *Petaurus norfolcensis*	V	Dry sclerophyll forest and remnant woodland containing mature or mixed aged stands with gum-barked and winter flowering trees, and mature *Acacia* species. Nests socially in tree hollows.	High. Recorded in the study area. Potential den sites and foraging habitat identified throughout the study area. **Potentially affected species.**
brush-tailed phascogale *Phascogale tapoatafa*	V	Largely arboreal, prefers open dry forest with little groundcover on ridges up to 600m altitude. Common trees inhabited include box, stringybark, ironbark and blackbutt.	Moderate. No local records, although recorded in the locality. Potential habitat is present in the study area. **Potentially affected species.**
yellow-bellied sheathtail-bat *Saccolaimus flaviventris*	V	Tree hollows, abandoned nests of sugar gliders (*Petaurus breviceps*), animal burrows for roosting; almost all habitats including forest and woodland for foraging.	High. Recorded in the study area. Habitat available however low number of local records. **Potentially affected species.**
greater broad-nosed bat *Scoteanax rueppellii*	V	Moist river and creek system of the ranges, roosting in tree hollows.	High. Recorded in the study area. Arboreal roosting habitat and foraging habitat available. **Potentially affected species.**
Other mammals			
koala *Phascolarctos cinereus*	V	Forests typically on high nutrient soils characterised by presence of preferred feed trees. In Port Stephens area preferred feed trees are *Eucalyptus tereticornis*, *E. robusta*, *E. parramattensis* subsp. *decadens*[7]. Numerous records for the Port Stephens area, in particular Tomago Sandbeds and Tilligerry Peninsula.	High. Recorded in the study area. No local records in past decade. Preferred koala habitat identified in study area, although no activity recorded. **Potentially affected species.**
long-nosed potoroo *Potorous tridactylus*	V	Coastal wallum. Requires dense cover for shelter and adjacent, more open foraging areas.	Low. Some suitable habitat is present but species is not known from the Port Stephens and Newcastle regions.
eastern chestnut mouse *Pseudomys gracilicaudatus*	V	Dense wet heathland on sand with thick sedges and grasses, nesting in dry grassy areas above or just below the ground[8].	Low. No known local records. Suitable habitat (dense wet heathland on sand with thick sedges and grasses)[8] absent.

Name	TSC Act	Preferred Habitat	Likelihood of Occurrence
grey-headed flying-fox *Pteropus poliocephalus*	V	Megachiropteran bat forages on fruits, blossom and nectar of eucalypts. In early summer roosts in large groups (camps) in forests or mangroves.	High. Potential foraging resource available (swamp mahogany, Banksia, paperbarks). Camp site at Fullerton Cove. **Potentially affected species.**
Frogs			
wallum froglet *Crinia tinnula*	V	Acid paperbark swamps, wallum sedgelands, wet heath and swamp forest[9].	Moderate to high. Suitable habitat within swamp mahogany – paperbark forest. Recorded in swamp forest in the approved subdivision. **Potentially affected species.**
green and golden bell frog *Litoria aurea*	E	Swamps, lagoons, streams and ponds with tall emergent vegetation such as *Typha* spp.[9]. Occupied ponds usually occur within 100 m of occupied ponds.	Low to moderate. Suitable permanent pond with tall emergent vegetation and ephemeral wetlands present. Nearest records are Kooragang Island and Medowie. **Potentially affected species.**
green-thighed frog *Litoria brevipalmata*	V	Temporary ponds in woodland, coastal heath, rainforest and adjacent cleared areas.	Low to moderate. Suitable habitat is present in the study area. No records in the locality. Nearest record is Karuah. **Potentially affected species.**
Flora			
netted bottlebrush *Callistemon linearifolius*	V	Red flowering bottlebrush growing in dry sclerophyll forest on coast and adjacent ranges from Georges River to Nelson Bay[10].	Low to moderate likelihood of occurring in open forest. Nearest record is Salamander Bay. **Potentially affected species.**
leafless tongue orchid *Cryptostylis hunteriana*	V	Terrestrial orchid grows in coastal swamp heath on sandy soil, eucalypt woodland, swamp fringes to bare hillsides in tall forest, with *Blandfordia nobilis*, *Cryptostylis erecta* and *Cryptostylis subulata*[11].	Low to moderate. Records in Port Stephens area restricted to volcanic hills, although potential habitat is present in the study area. **Potentially affected species.**
sand doubletail *Diuris arenaria*	V	Coastal heath forest and woodland dominated by *Corymbia gummifera* and *Angophora* sp. with a grassy or bracken understorey[12].	High. Preferred habitat present in the study area. **Potentially affected species.**
rough doubletail *Diuris praecox*	V	Grassy open areas within near-coastal open forest on sand hills and slopes[13], including easements where there is less competition for light.	High. Recorded along Nelson Bay Road in the north east corner of study area. Suitable habitat present in the study area. **Potentially affected species.**
Camfield's stringybark *Eucalyptus camfieldii*	V	Coastal shrub heath on sandy soils on sandstone, often of restricted drainage[14]. Restricted to coastal sand wallum woodland – heath.	Low. Preferred habitats absent from the study area.

Name	TSC Act	Preferred Habitat	Likelihood of Occurrence
Eucalyptus parramattensis subsp. *decadens*	V	Low woodland on sandy soil, often on Tomago sand swamp woodland. Recorded from swamp forest fringes in Salamander Bay area.	Moderate. Preferred habitat and vegetation community present in the study area. Hybrid species recorded in the study area. **Potentially affected species.**
dwarf kerrawang *Rulingia prostrata*	E	Locally recorded from Tomago sandbeds in scribbly gum open forest at ecotone with swamp mahogany.	Moderate. Some potential to be present within swamp forest in the study area. **Potentially affected species.**
heath wrinklewort *Rutidosis heterogama*	V	Heath, often along disturbed roadsides in coastal districts[15]. Local records at Kurri Kurri in dry sclerophyll forest and woodland in Kurri sand swamp woodland and lower Hunter spotted gum ironbark forest[16].	Low to moderate likelihood of occurring in dry sclerophyll forest and wet heath. **Potentially affected species.**.
Endangered Ecological Communities			
Sydney coastal estuary swamp forest	E	Waterlogged estuarine alluvial soils strongly influenced by periodically poor drainage conditions.	Low. Swamp forest in study area contains vegetation that characterises this community, although the soil is dominated by sand. Note that with gazettal of the swamp sclerophyll forest on coastal floodplains this community is omitted from the schedule.
swamp sclerophyll forest on coastal floodplains of the NSW north coast, Sydney basin and south east corner bioregions	E	Humic clay loams and sandy loams on waterlogged or periodically inundated alluvial flats and drainage lines associated with coastal floodplains[17].	High. Swamp forest adjacent to Nelson Bay Road is contiguous with the Fullerton Cove floodplain. Soil is sandy loam and many plant species occur in the swamp forest that characterises this community. **Potentially affected ecological community.** Note that with gazettal of this community the Sydney coastal estuary swamp forest was omitted from the schedule.

Status in NSW as per Schedules 1 and 2 of TSC Act: E = Endangered; V = Vulnerable.

1 = Clout (1989). 2 = Davey (1993). 3 = Marchant & Higgins (1993). 4 = Marchant & Higgins (1990). 5 = Blakers et al (1984). 6 = Clancy (1991). 7 = Port Stephens Council (2001). 8 = Fox (1991). 9 = Cogger (1992). 10 = Spencer and Lumley (2002). 11 = Leigh et al (1984). 12 = Jones, D. L. (1999). 13 = Jones, D. L. (1991). 14 = Hill (2002). 15 = Harden (1992a). 16 = Hunter Catchment Management Trust (2004). 17 = NPWS (2004).

Affected species that were actually recorded in the study area during flora and fauna surveys conducted by ERM for the SIS in 2004 and 2005 include:

- *Eucalyptus parramattensis* subsp. *decadens X Eucalyptus* spp. hybrid;
- wallum froglet (*Crinia tinnula*);
- hoary wattled bat (*Chalinolobus nigrogriseus*);
- greater broad-nosed bat (*Scoteanax rueppellii*);
- little bentwing-bat (*Miniopterus australis*);
- eastern bentwing-bat (*Miniopterus schreibersii oceanensis*);
- grey-headed flying-fox (*Pteropus poliocephalus*);
- powerful owl (*Ninox strenua*); and
- squirrel glider (*Petaurus norfolcensis*).

Previous investigations conducted by ERM and other consultants also identified the koala (*Phascolarctos cinereus*), eastern freetail bat (*Mormopterus norfolkensis*), yellow-bellied sheathtail-bat (*Saccolaimus flaviventris*), *Diuris praecox* and the masked owl (*Tyto novaehollandiae*).

Survey results and discussion of habitat use of all affected species are provided in *Sections 5.9, 5.10* and *5.11*. The results are discussed in the context of each species' local and regional abundance.

5.9 ENDANGERED ECOLOGICAL COMMUNITIES

The DGRs listed two endangered ecological communities for inclusion as subject communities (see *Table 5.7*).

5.9.1 Sydney Coastal Estuary Swamp Forest

The ecological community 'Sydney coastal estuary swamp forest' (SCESF) is restricted to waterlogged estuarine alluvial soils and is strongly influenced by periodically poor drainage conditions. The soils present in swamp forest in the study area do not satisfy these criteria, as they are sand-derived from swamp and aeolian landscapes (see *Section 3.1.4*). However, the dominant vegetation in swamp forest in the study area is characteristic of this community, including swamp mahogany, *Melaleuca quinquenervia*, *Melaleuca styphelioides*, *Blechnum indicum*, *Gahnia clarkei* and *Livistona australis*. Gunninah Consultants (2002) recorded 22 of the 30 plant species that are considered to be characteristic of SCESF. Although the floristic component of the swamp forest satisfies the criteria of the SCESF, the soils do not and therefore the swamp forest in the study area is not SCESF.

5.9.2 *Swamp Sclerophyll Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions*

The ecological community 'swamp sclerophyll forest on coastal floodplains of the NSW north coast, Sydney basin and south east corner bioregions' is represented in the swamp forest that adjoins Nelson Bay Road. Note that with gazettal of this community in December 2004 the Sydney coastal estuary swamp forest was omitted from Part 3, Schedule 1 of TSC Act.

Habitat Requirements

This community occurs on humic clay loams and sandy loams on waterlogged or periodically inundated alluvial flats and drainage lines associated with coastal floodplains (NPWS 2004). Swamp sclerophyll forest on coastal floodplains generally occurs below 20 metres elevation, often on small floodplains or where the larger floodplains adjoin lithic substrates or coastal sand plains in the New South Wales north coast, Sydney basin and south east corner bioregions (NPWS 2004). The structure of the community is typically open forest but can include fernland, tall reedlands, sedgelands and scrubs that form mosaics with other floodplain forest communities and wetlands. The composition of this community is primarily determined by the frequency and duration of waterlogging and the texture, salinity nutrient and moisture content of the soil (NPWS 2004).

Presence and Quality of Habitat

Areas of swamp forest adjacent to Nelson Bay Road are contiguous with the Fullerton Cove floodplain and occur on sandy soils. These areas would have received floodwaters from flooding of the Hunter River prior to the construction of Nelson Bay Road (Urban Water Cycle Solutions 2005). Culverts located under Nelson Bay Road will presently allow some floodwaters to enter the swamp forest in these areas during a flood.

The dominant vegetation in swamp forest adjoining Nelson Bay Road is also characteristic of this community, which includes over 30 species listed in the final determination for the community (NPWS 2004) (see *Table B1, Annex B*). The remaining areas of swamp forest are separated from the floodplain by Holocene sand dunes and therefore do not qualify as this ecological community, despite being similar floristically. A description of the structure and composition of this community is included in *Annex D*.

The presence of weed species such as lantana (*Lantana camara*) in some areas, and the high fire frequency, reduce the quality of habitat in this community. However, despite the level of disturbance, the swamp sclerophyll forest contains a structure and species composition very similar to that reported in the final determination (NPWS 2004), and should therefore be regarded as high quality.

Population Survey Results

A total of 29.0 hectares of swamp sclerophyll forest is present in the study area. The proposal will clear approximately 0.5 hectares and there is the potential for a range of other impacts such as weed invasion and altered hydrology. Therefore, this endangered ecological community will be affected by the proposal. Approximately 0.5 hectares has been cleared during construction of the approved subdivision for the southern ingress road.

Local and Regional Abundance

Swamp sclerophyll forest on coastal floodplains of the NSW north coast, Sydney basin and south east corner bioregions is known from the Local Government Areas of Tweed, Byron, Lismore, Ballina, Hastings, Port Stephens, Lake Macquarie, Wyong, Gosford and the Great Lakes. In the lower Hunter Region, this community includes 'swamp mahogany – paperbark forest' (map unit 37) in the LHCCREMS mapping (CRA Unit NPWS 2000). This community has been extensively cleared and modified and in the lower Hunter to NSW central coast region, approximately 30 percent of the original area of swamp mahogany – paperbark forest was estimated to remain in the 1990s (LHCC Councils 2003). Swamp sclerophyll forest is present in surrounding areas, including the caravan park south of the study area, and across Nelson Bay Road to the west where it adjoins the Fullerton Cove floodplain.

5.10 THREATENED FLORA

The species that were targeted in the flora surveys are discussed individually in this section. Threatened plant species that were recorded in the study area include rough doubletail *Diuris praecox*.

5.10.1 Netted bottlebrush (Callistemon linearifolius)

Habitat Requirements

Callistemon linearifolius inhabits open forest on sandy to clayey soils on sandstone on the coast and ranges in the Sydney basin bioregion mainly between Georges River and Hawkesbury River (Benson and McDougall 1998; Spencer and Lumley 2002). In the Lower Hunter and Central Coast Region habitat is provided in sheltered dry Hawkesbury woodland and swamp mahogany-paperbark forest (Murray *et al* 2002). In Werakata National Park near Cessnock, habitat was spotted gum - ironbark forest often with dense stands of *Melaleuca nodosa* (Bell 2004). As this species occurs mainly in the greater Sydney region, it is vulnerable to clearance for urban development and the remaining populations are at risk of extinction from low population numbers.

Presence and Quality of Habitat

The study area contains 130.5 hectares of dry sclerophyll forest, which is referenced as preferred habitat for this species. However, the only known population in the Port Stephens region occurs in sand at the ecotone of coastal sands apple blackbutt forest and swamp forest near the base of a rocky Nerong volcanic landscape at Soldiers Point (ERM 2004a). Therefore the species may occupy specialised niches within dry sclerophyll forest throughout its range in the Sydney basin. The study area does not contain rock outcropping or soils of the Nerong landscape or spotted gum - ironbark forest. The study area is therefore not likely to provide suitable habitat for *Callistemon linearifolius* in the locality.

Population Survey Results

No individual plants were recorded by ERM during the targeted searches or during surveys conducted by other consultants. Given the survey results, and the fact that it has not been recorded in the locality, the species is not expected to occur in the study area. The species will therefore not be affected by the proposal.

Local and Regional Abundance

No local populations of netted bottlebrush are known to occur within the locality. The nearest known population occurs on the Soldiers Point Peninsula at Port Stephens, where 131 individual plants were identified within swamp mahogany – paperbark forest and dry sclerophyll coastal sands apple-blackbutt forest ecotone (ERM 2004a).

5.10.2 Leafless tongue orchid (Cryptostylis hunteriana)

Habitat Requirements

Leafless tongue orchid grows in swampy heaths on sandy soils (Jones 1993; Bishop 1996), occupying a variety of habitats, from scrubby swamp fringes to steep bare hillsides in tall eucalypt forest (Jones 1993). In the Port Stephens area, the species appears to be restricted to open forest on volcanic hills where rock outcropping occurs, generally with a north east aspect. Conversely, the preferred habitat on the central coast appears to be open woodland with a heathy understorey on the coastal plains in coastal plains scribbly gum woodland and coastal plains smooth-barked apple woodland (Bell 2001).

Presence and Quality of Habitat

The study area does not support the preferred habitat of leafless tongue orchid in the Port Stephens area. There is no volcanic geology or rock outcropping in the study area, and the hills present are transgressive sand dunes. The high fire frequency in the study area may also reduce the quality of habitat for this species, as members of the *Cryptostylis* genus are often inhibited by summer fires (Jones 1993).

Population Survey Results

No individual plants were recorded by ERM during the targeted searches or during surveys conducted by other consultants. Given the survey results, and that preferred habitat is not present in the study area, the species is not expected to occur. The leafless tongue orchid will therefore not be affected by the proposal.

Local and Regional Abundance

Cryptostylis hunteriana rarely appears in large numbers and usually emerges and blooms for one or two seasons, then disappears, to resurface after a few years in a new location. However, in some locations such as the Port Stephens area, the species flowers regularly season after season forming small clumps and scattered colonies. Populations at Gan Gan Hill and Lemon Tree Passage support up to 50 individual plants each (Bell 2001). Other populations include Charmhaven (30 plants), Chain Valley Bay (one plant), Vales Point-Wyee (three plants), Wyee (one plant) and Freeman's Waterhole (15 plants). Given these numbers, the largest known populations are in the Port Stephens area.

5.10.3 Sand doubletail (Diuris arenaria)

Habitat Requirements

Sand doubletail (*Diuris arenaria*) grows in coastal heathy forest and woodland dominated by red bloodwood (*Corymbia gummifera*) and *Angophora* sp., with a grassy or bracken understorey (Jones 1999). The species is endemic to the Tomaree Peninsula and has not been found further south than Bob's Farm on Stockton Bight during other surveys (ERM 2003a).

Presence and Quality of Habitat

Suitable habitat is present in the study area. However, the study area may lie south of the species' restricted area of distribution.

Population Survey Results

No individual plants were recorded by ERM during the targeted searches or during surveys conducted by other consultants. Given the survey results during the species' flowering period, sand doubletail is not expected to occur in the study area. The species will therefore not be affected by the proposal.

Local and Regional Abundance

Approximately 160 plants were recorded by ERM in Tomaree National Park, 478 in the proposed Stockton Bight National Park and approximately 745 plants were recorded in the existing electricity easement that runs between Salt Ash and Anna Bay (ERM 2003a). This population is currently being subjected to development impacts from the upgrade of the Tomago to Tomaree electricity transmission line however mitigation measures are being employed by EnergyAustralia to minimise these impacts. These include such measures as fencing all recorded *Diuris arenaria* along the easement, undertaking construction outside the flowering season and positioning poles and stringing conductors to avoid significant clumps of *Diuris arenaria*. Other populations of *Diuris arenaria* have been recorded at Glovers Hill near Shoal Bay (Murray *et al* 2002).

5.10.4 Rough doubletail (Diuris praecox)

Habitat Requirements

Rough doubletail (*Diuris praecox*) prefers grassy open areas within near-coastal open forest on sand hills and slopes, including easements where there is less competition from other plants for light (Jones 1991). This coastal species is most frequently seen growing in heathland amongst bracken fern and grasses on deep grey white sand and shallow soils derived from laterite and conglomerate. It may also be found in scrubby woodland on the tops and slopes of rocky hills. The species dies back in summer and re-sprouts after soaking autumn rains to flower in late winter (Jones 1993).

Presence and Quality of Habitat

The study area contains suitable habitat, including disturbed open areas within dry sclerophyll open forest. Despite the presence of bitou bush in some clearings, given the location of the study area in Stockton Bight, the habitat is considered to be optimal for rough doubletail.

Population Survey Results

Two individual rough doubletails were recorded from two sites within dry open forest in the north east corner of the study area by ERM in July 2002 (see *Figure 5.1*). Both sites were along a track where there was a sparse ground vegetation layer. Given the presence of this population, rough doubletail has the potential to be affected by the proposal and should be regarded as an affected species.

Local and Regional Abundance

The largest known population of rough doubletail in the local area occurs within an electricity easement between Bob's Farm and Anna Bay, consisting of several hundred individual plants (ERM 2003a). This population is significant for survival of the species within the Port Stephens local government area. This is because it constitutes adult and juvenile plants with seed capsules while other records in the region are generally scattered individual plants. This population is currently being subjected to development impacts from the upgrade of the Tomago to Tomaree electricity transmission line however mitigation measures are being employed by EnergyAustralia to minimise these impacts. These include such measures as fencing all recorded *Diuris praecox* along the easement, undertaking construction outside the flowering season and positioning poles and stringing conductors to avoid significant clumps of *Diuris praecox*.

A total of 208 individual rough doubletail were recorded in September 2003 on Boral's freehold property near the Mineral Deposits access road, north east of the study area. These plants were mostly along walking tracks and roads or in previously disturbed areas.

Elsewhere in the region, a population of over 100 individual plants occurs in Glenrock State Recreation Area (Murray *et al* 2002).

5.10.5 Camfield's stringybark (Eucalyptus camfieldii)

Habitat Requirements

Camfield's stringybark typically occurs in sandy soils over lateritic soils on sandstone, often in areas of impeded drainage, in coastal scrub-heath or woodland (Hill 2002).

Presence and Quality of Habitat

The study area contains coastal scrub-heath although the geology is not sandstone, but Holocene sand. The study area does not support preferred habitat of this species.

Population Survey Results

No individual plants were recorded by ERM during the targeted searches or during surveys conducted by other consultants. Given the survey results, and the single record in the locality at Salt Ash, the species is not expected to occur in the study area. The species will therefore not be affected by the proposal.

Local and Regional Abundance

A population is known from Awabakal Nature Reserve, although the size is unknown. The largest populations occur further south on the central coast around the Mangrove Mountain and Somersby Plateau area in Gosford (Murray *et al* 2002).

5.10.6 Eucalyptus parramattensis subsp. *decadens*

Habitat Requirements

Eucalyptus parramattensis subsp. *decadens* favours low woodland on sandy soil in low, often wet places (Hill 2002). Occurrences can vary from waterlogged sites where it may grow with scattered *Melaleuca quinquenervia* or *Melaleuca sieberi* and a dense sedge understorey (Murray *et al* 2002).

Presence and Quality of Habitat

Potential habitat for this species occurs within the wet heath, which corresponds to the LHCCREMS mapping unit of Tomago sand swamp woodland on the 4000 year BP sand transgression. Records of *Eucalyptus parramattensis* subsp. *decadens* in the locality are restricted to Tomago sand swamp woodland on the older Pleistocene sand sheet. The reasons for this distribution are not clear.

Population Survey Results

Four individual *Eucalyptus parramattensis X Eucalyptus* ssp. hybrid trees were recorded in wet heath at two locations. Therefore, the species will be affected by the proposal. The species was not recorded from other areas of wet heath in the study area by ERM or by other consultants.

Local and Regional Abundance

Eucalyptus parramattensis subsp. *decadens* has been included in the revegetation of areas mined for heavy minerals in the Tomago sandbeds and Port Stephens areas (Bell 1997). A population is known from Werakata National Park and surrounds in the Kurri area where it grows in Kurri sand swamp woodland

and Kurri sand melaleuca scrub-forest (Bell 2004). The record is the southern distributional limit for the species. Interestingly, most populations of *Eucalyptus parramattensis* subsp. *decadens* in the locality occur on Pleistocene sands (eg Williamtown population), whereas the hybrids in the study area occurs on Holocene sands.

5.10.7 Dwarf kerrawang (Rulingia prostrata)

Habitat Requirements

Dwarf kerrawang (*Rulingia prostrata*) appears to be a successional species, favouring sub-climax communities in swamp mahogany – paperbark forest that has been recently burnt by fire or are regenerating after clearing (URS 2003).

Presence and Quality of Habitat

Potential habitat is present in the swamp forest, particularly where it forms an ecotone with dry open forest. However, there are few areas of sparse ground cover and open understorey within this habitat in the study area. Fire has not occurred within this habitat for over at least five years, which may delay the appearance of this species above ground if present in the study area, thereby reducing its detectability. However, the study area has a high fire frequency that may be ideal for dwarf kerrawang.

Population Survey Results

No individual plants were recorded by ERM during the targeted searches or during surveys conducted by other consultants. This may be because of the difficulty in detecting this species and that there has not been a fire in the swamp forest within the last year. Despite the survey results, the species has potential to occur within the swamp forest. Therefore, dwarf kerrawang has the potential to be impacted by the proposal and should be regarded as an affected species.

Local and Regional Abundance

Dwarf kerrawang has been recorded in Ourimbah State Forest and other locations south of Sydney (Murray *et al* 2002). The species' relative abundance has generally not been reported due to the difficulty in its detection.

5.10.8 *Heath Wrinklewort (Rutidosis heterogama)*

Habitat Requirements

Heath Wrinklewort (*Rutidosis heterogama*) occurs in dry sclerophyll forest and woodland, as well as in heath on the north coast of NSW (Harden 1992a) and on sand dunes (Hunter Catchment Management Trust 2004). It is often associated with disturbed areas and does not appear to favour particular soil types and it occurs at a range of altitudes. At Kurri Kurri, heath wrinklewort has been recorded in the Kurri sand swamp woodland and in lower Hunter spotted gum - ironbark forest (Hunter Catchment Management Trust 2004).

Presence and Quality of Habitat

Potential habitat is present in dry sclerophyll open forest and wet heath, particularly in disturbed areas such as tracks and clearings. It is not known what effect the high fire frequency would have on the ability of this species to persist in the study area.

Population Survey Results

No individual plants were recorded by ERM during the targeted searches or during surveys conducted by other consultants. Despite the survey results, the species has potential to occur within the dry sclerophyll open forest and wet heath. Therefore, heath wrinklewort has the potential to be impacted by the proposal and should be regarded as an affected species.

Local and Regional Abundance

There is very little information available about heath wrinklewort in terms of its distribution and abundance. It has been recorded recently at Kurri Kurri and at Cooranbong. It appears to have a disjunct distribution along the north coast from Maclean down to the Hunter and inland to the Torrington area (Hunter Catchment Management Trust 2004).

5.11 *CONSERVATION SIGNIFICANCE OF VEGETATION COMMUNITIES*

5.11.1 *Dry Sclerophyll Open Forest*

This community corresponds to the LHCCREMS mapping unit of coastal sand apple – blackbutt forest.

This community is not regarded as having conservation significance as it is widespread across the Tomago sandbeds and Stockton dune system in the

Port Stephens LGA. It extends along the narrow sand coastal strip south of Newcastle to the Central Coast wherever conditions are optimal. It is well represented in conservation reserves between Newcastle and Seal Rocks, such as Myall Lakes National Park and Tomaree National Park (Clements *et al* 1992; Gunninah Consultants 1996; Bell 1997). In the Lower Hunter and Central Coast regions it is not identified as vulnerable or regionally significant with approximately 9487 hectares (54 percent) of the projected pre European occupation distribution remaining (LHCC Councils 2003).

5.11.2 Swamp Forest

This community corresponds to the LHCCREMS mapping unit of swamp mahogany – paperbark forest.

Hager and Benson (1994) described this community as having intermediate conservation significance because, although moderate areas are located in reserves in the region, additional information on the size of an adequate sample is required. In the study area, significant areas of this community have been zoned 7(a) Environmental Protection. This community is likely to be extensively though patchily distributed along the north coast of NSW. Bell (1997) considers it to be not well represented in Tomaree National Park but adequately conserved in the north coast bioregion. In the Lower Hunter and Central Coast region swamp mahogany - paperbark forest has been identified as a regionally significant vegetation community that has been heavily cleared with an estimated 71 percent of its projected pre European distribution cleared (House 2003; LHCC Councils 2003). This community represents potential habitat for amphibians, the koala and also a seasonal foraging resource during winter and for migratory species such as the regent honeyeater. Habitat elements such as hollows are also moderately abundant in this community.

Swamp sclerophyll forest on coastal floodplains of the NSW North Coast, Sydney Basin and south east corner bioregions is an endangered ecological community that occurs in swamp forest in the study area where it adjoins the floodplain of the Fullerton Cove wetlands.

5.11.3 Wet Heath

On the 4000 year BP sand transgression, this community corresponds to the LHCCREMS mapping unit of Tomago sand swamp woodland, primarily due to the high frequency of *Leptospermum polygalifolium* in the mid-strata. One of the canopy species that is indicative of this community is *Eucalyptus parramattensis* subsp. *decadens* and a hybrid of this species with *Eucalyptus robusta,* is present.

Tomago sand swamp woodland is classified by LHCC Councils (2003) as a regionally significant community considered to be a vulnerable and specialised community as it has a total extant distribution of 287 hectares or 18 percent of the projected pre European occupation distribution. The

conservation significance of this community is likely to be high given the presence of the endangered *Eucalyptus parramattensis* subsp. *decadens* as a dominant species at other sites in the locality (eg Tomago sandbeds). Hybrids of *Eucalyptus parramattensis* were recorded in the study area and it is likely that wet heath in the study area is similar to that described in the LHCCREMS mapping unit. The wet heath associated with the 2000 year BP sand transgression is regarded as having particular conservation significance because it appears to be restricted to the Fern Bay area (Clements *et al* 1992).

5.12 THREATENED FAUNA

This section describes the habitat requirements of threatened species that are likely to inhabit the study area (see *Table 5.7*) and assesses the presence and quality of this habitat. The results of the targeted field surveys are also presented and records of threatened species recorded during these and other surveys undertaken in the study area are presented in *Figure 5.1.* Individual species are grouped into ecological guilds, which are based on species having similar ecological requirements, at risk from the same threats and likely to be impacted in similar ways by the proposed residential development.

Threatened fauna that were recorded in the study area during previous and current investigations include:

- grey-headed flying-fox (*Pteropus poliocephalus*);
- powerful owl (*Ninox strenua*);
- masked owl (*Tyto novaehollandiae*);
- hoary wattled bat (*Chalinolobus nigrogriseus*);
- eastern freetail bat (*Mormopterus norfolkensis*);
- little bentwing-bat (*Miniopterus australis*);
- eastern bentwing-bat (*Miniopterus schreibersii oceanensis*);
- yellow-bellied sheathtail-bat (*Saccolaimus flaviventris*);
- greater broad-nosed bat (*Scoteanax rueppellii*);
- squirrel glider (*Petaurus norfolcensis*); and
- wallum froglet (*Crinia tinnula*).

5.12.1 Hollow-dependent Birds

Four species of birds that are dependent on tree hollows are assessed as affected species:

- glossy black-cockatoo (*Calyptorhynchus lathamii*);
- barking owl (*Ninox connivens*);
- powerful owl (*Ninox strenua*); and
- masked owl (*Tyto novaehollandiae*).

Habitat Requirements

The glossy black-cockatoo is an obligate granivore, feeding exclusively on the seeds of *Allocasuarina littoralis* and *Allocasuarina torulosa* (Cleland and Sims 1968; Joseph 1982; Clout 1989; Pepper 1996; Pepper *et al* 2000). The distribution of this species is limited mainly by the availability of *Allocasuarina* stands (Clout 1989; Pepper 1996; Pepper *et al* 2000; Garnett *et al* 1998). The habitat of the glossy black-cockatoo in eastern Australia includes woodlands dominated by *Allocasuarina*, open sclerophyll forests and woodlands with a midstorey of *Allocasuarina* that are dominated by *Eucalyptus* or *Angophora* species (Higgins 1999). Large tree hollows constitute critical nesting habitat. The glossy black-cockatoo in New South Wales is considered sedentary or partially nomadic (Higgins 1999). The species has been recorded undertaking some movements over long distances and are often a regular or unpredictable visitors to some areas, usually during periods of dry conditions (Blakers *et al* 1984). These movements may be a result of the highly specialised diet, which is limited to the seeds of *Allocasuarina* spp. (Cleland and Sims 1968; Joseph 1982; Cayley 1984; Clout 1989; Pepper 1996). This diet limits the distribution of the species to areas where seed producing *Allocasuarina* species occur. In eastern Australia, the scattered records of glossy black-cockatoos throughout their distribution may be a result of movements of the birds tracking suitable resources. These movements may occur at certain times of the year, during peak seeding of *Allocasuarina* and/or after catastrophic events such as drought or fire (Blakers *et al* 1984).

The barking owl inhabits open forests, woodlands, dense scrubs and paperbark woodlands (Pizzey and Knight 2002). The habitat is typically dominated by eucalypts, including paperbarks *Melaleuca* species (Kavanagh *et al* 1995). It usually roosts in or under dense foliage in large trees including rainforest species of streamside gallery forests, *Casuarina* and *Allocasuarina* species, eucalyptus, *Angophora* and *Acacia* species (NPWS 2003a). Roost sites are often near watercourses or wetlands. The barking owl nests on decayed debris, in tree hollows from low to greater than 10 metres in height, and occasionally on the ground (Pizzey and Knight 2002). Nesting usually occurs in large hollows in large eucalypts, often near open country, watercourses and wetlands (Higgins 1999). Barking owls have been recorded in remnants of

forest and woodland and in clumps of trees at farms and golf courses (Debus 1997).

The powerful owl is associated with wet and dry sclerophyll forests containing ecologically mature trees. Nesting sites are large tree hollows along densely vegetated gullies; the powerful owl requires hollows only for nesting, not roosting (Debus and Chafer 1994). The powerful owl is considered to be a habitat generalist, occupying a wide range of tree species communities (Kavanagh 1990, 1991). The principle diet of the powerful owl is arboreal prey such as possums and gliders (Kavanagh 1988), and the major prey species over much of its range has been identified as the common ringtail possum (*Pseudocheirus peregrinus*) (Debus 1994).

The masked owl is a sedentary species inhabiting dry eucalypt forests and woodlands, forest margins, wooded watercourses, and isolated stands of trees within cleared areas (Garnett 1992). In forests it is frequently encountered in open forest with a sparse understorey or ground cover, or at the ecotone between closed forest or woodland (Hyem 1979; Davey 1993; Debus and Rose 1994). It requires a large home range, between 500 and 1,000 hectares per pair in coastal areas, with neighbouring pairs well separated (Debus and Rose 1994).

The masked owl uses tree hollows for diurnal roost and nest sites, and the same hollow may be used for a number of years (Hollands 1991). In addition, cliffs and caves have also been known to provide roost sites, as well as dense foliage occasionally (Debus and Rose 1994). Nest hollows used by the masked owl are generally located in large trees (Schodde and Mason 1980) within relatively dense forest or woodland (Debus and Rose 1994), although observations have also been made in more open habitats and even isolated trees (Debus and Rose 1994). Hollands (1991) observed that the nest tree is often an isolated stem or emergent above the canopy. Most recorded nest sites have been in live eucalypts, however the species has also been observed nesting in dead trees (Hollands 1991; Debus and Rose 1994). The main prey species are small to medium terrestrial mammals, arboreal mammals and birds (Garnett 1992), with terrestrial prey predominating in the diet (Hollands 1991; Davey 1993).

Presence and Quality of Habitat

The study area contains an abundance of large tree hollows with both live and dead smooth-barked apple and blackbutt trees suitable as nest sites for the four species. The presence and quality of foraging habitat for the four species, however, varies throughout the study area according to each species' habitat requirements. An assessment of habitat trees for hollow-dependent fauna is provided in *Section 5.6.2.*

There is limited foraging habitat for the glossy black-cockatoo, as there are few mature stands of *Allocasuarina littoralis* and *Allocasuarina torulosa* in the study area. The few stands that are present are composed of small trees generally

less than four metres in height that are unable to support fruiting cones. Large trees with mature cones occurred at low densities. Frequent fires in the study area have reduced the availability of seeding *Allocasuarina*. Therefore the study area does not presently support habitat suitable for the glossy black-cockatoo.

There is suitable foraging and roosting habitat for the barking owl in the swamp forest and dry sclerophyll open forest. Large tree hollows in the dry sclerophyll open forest constitute suitable nest sites. The species is known to inhabit fragments of woodland, including patches smaller than the study area.

Nesting habitat of the powerful owl is present within large hollows in trees such as smooth-barked apple and blackbutt that fringe the swamp forest in the well-vegetated slopes and gullies of the study area, mostly within the minimum 200 metre corridor. Roosting habitat for this species is present throughout the swamp forest. The major prey item of the powerful owl is the common ringtail possum and squirrel glider. Very few possums and gliders were observed in the study area. This is in contrast to the very high density of hollows recorded within the dry sclerophyll open forest.

The dry open forest contains large tree hollows that are suitable nest and diurnal roost sites for the masked owl. From the habitat tree analysis, it is apparent that there are approximately 300 *potential* roost trees for the masked owl. However, of these trees, probably only five percent (n = 15) are *suitable* roost trees (Michael Murray, pers. comm.). This discrepancy would only be resolved through direct inspection of the hollows from the tree canopy.

The dry open forest contains areas of sparse understorey and forms an ecotone with swamp forest, which constitute potential foraging habitat for the masked owl. Suitable prey items are common in this habitat, including small ground mammals such as bush rat (*Rattus fuscipes*).

Population Survey Results

The glossy black-cockatoo was not recorded in the study area by ERM or during previous field investigations by other consultants. No chewed *Allocasuarina* cones were found, which is an indicator of the presence of the glossy black-cockatoo. The powerful owl was recorded in the north west corner of the study area by Clements *et al* (1992), although the exact location was not reported. A roost tree was recorded by ERM in September 2002 in swamp forest and an individual was observed roosting nearby (see *Figure 5.1*). An individual responded to call playback in the vicinity of this roost tree on 24 and 31 January 2005. It is likely that a pair of powerful owls are nesting in the study area and that the same pair were recorded on each occasion.

The masked owl was recorded from call playback in 1997 on Boral Resources freehold property immediately north of the study area and from call playback conducted in September 2002 by ERM (see *Figure 5.1*). The species was not

recorded during the January 2005 surveys. No masked owl nest trees were recorded in the study area and given the survey effort, the species is not likely to be nesting in the study area. The barking owl was not recorded during current and previous nocturnal investigations in the study area.

Based on the survey results, foraging, roosting and potential nesting habitat of the powerful owl and masked owl will be affected by the proposal. Therefore, the powerful owl and masked owl will be affected by the proposal. The barking owl will not be affected.

Local and Regional Abundance

In New South Wales, the distribution of the glossy black-cockatoo occurs near-continuously east of the Great Dividing Range from the north coast/Queensland border to the south east corner/Victorian border, extending west to the south western slopes (Ekert 2000). An isolated population occurs in the Riverina of far-western NSW. The species is absent from parts of the north coast, Sydney basin, south east corner and from the New England Tablelands and south eastern highlands (Ekert 2000). In the Hunter region, records for the glossy black-cockatoo are widely distributed (Ekert 2000; Wildlife Atlas 2004).

The barking owl has been recorded at Edgeworth and New Lambton Heights (HBOC 1994) and Rankin Park (HBOC 1995), with scattered records on the central coast in Strickland State Forest and Wambina Nature Reserve (Murray *et al* 2002). The powerful owl is widespread in the lower Hunter and central coast, including Nelson Bay, Gateshead, Medowie and Tomago sandbeds and Blackbutt Reserve (Murray *et al* 2002). The masked owl has been recorded at Raymond Terrace, Salt Ash (ERM 2003a), Belmont North, Windale, Telarah, Awaba (HBOC 1997) and Glendale (Young 1999).

5.12.2 Raptor Birds

Two raptors are assessed as affected species:

- square-tailed kite (*Lophoictinia isura*); and
- osprey (*Pandion haliaetus*).

Habitat Requirements

The square-tailed kite occurs in temperate and tropical forest and woodlands including the coastal regions. In New South Wales the species occurs across a wide area mainly in the north and north east of the State. Known breeding has occurred on the mid-north coast of New South Wales (Bischoff *et al* 2000). The species prefers to hunt in Eucalypt open forest and woodland (Debus and Czechura 1989), where it feeds on small birds and foliage insects, and small mammals and lizards. Nesting sites are generally located along or near

watercourses, in the fork or on a large, horizontal limb of *Angophora* species or *eucalypt* species. (Cameron 1992; Jolly 1989).

The core habitat of the osprey includes bays, estuaries, mangrove swamps, beaches, dunes, cliffs, inshore waters of mainland and islands, and coral and rocky reefs (Roberts and Ingram 1976; Gosper 1981, 1983; Ekert and Brady 2004) as well as coastal wetlands, wide rivers, large lakes, reservoirs and swamps (Olsen 1995). A smaller number are found upstream of the estuarine reaches in some coastal rivers (Ekert and Brady 2004). The osprey may also be observed over terrestrial habitats on the coastal zone including lowland forest, swamps, heath, woodland or forest and during the autumn may venture inland along major river systems (Olsen 1995). In New South Wales, nests are sited in a tall tree, usually dead, in an exposed position providing ease of access and good visibility. Dead branches and sticks are mostly commonly sourced from tree species including the broad-leaved paperbark (*Melaleuca quinquenervia*), swamp oak (*Casuarina glauca*) (Clancy 1989, 1993) and red bloodwood (*Corymbia gummifera*) (Rose 2000). Osprey nests are constructed on a variety of sites most commonly in a fork or broken trunk in the upper part of a dead tree or dead crown of a live tree (Clancy 1993; Rose 2000). Other osprey nest sites have been reported on cliffs, the ground, and a number of artificial structures such as power poles and navigational markers (Poole 1989). Nests are usually within one kilometre of suitable feeding habitat. Birds traditionally return to the same nest each year providing it is still present and suitable (Clancy 1991).

Presence and Quality of Habitat

The presence of mature trees such as broad-leaved paperbark, smooth-barked apple (*Angophora costata*) and blackbutt (*Eucalyptus pilularis*), the availability of suitable nesting material (twigs, branches etc) in the study area and the relatively close proximity of the area to the Hunter River (and Stockton Bight) render habitats in the study area as potentially suitable habitat for the osprey. The presence of mature trees and nesting material also provides potential habitat for the square-tailed kite.

Population Survey Results

No square-tailed kites or ospreys were identified in the study area during previous and current investigations. No nest trees were encountered during the targeted surveys. It is unlikely that a breeding pair of these species depends on habitats in the study area, and as such, the species will not be affected by the proposal.

Local and Regional Abundance

In the Sydney Basin Bioregion the square-tailed kite is rare with only eight records during the second Birds Australia Atlas (Garnett *et al* 2001). Similarly, in the Hunter region, the species has previously been reported well north of

Newcastle at Cundletown, Purfleet and Crowdy Head NP (HBOC 1997,1998), and only two records in the lower Hunter, including Tarro (HBOC 1995) and Kooragang Island (HBOC 1999).

Breeding ospreys mainly occur from the Tweed to just south of Newcastle (Ekert and Brady 2004). In 2003, the catchments of the Mid North Coast and North Coast NPWS regions, in particular, the Bellinger and Clarence catchments, had the highest number of nests (Ekert and Brady 2004). To the south of Newcastle, active nests have been reported at Eraring (1984 to 1988), Blackalls Park (1985), while relatively recent nests, observed as newly constructed and active in 2003 include one at Naru Reserve, Marks Point and another at Morisset. To the north of Newcastle, osprey nests presently occur in Forster/Tuncurry, Coomba Park, Seal Rocks and Tea Gardens with one nest at Lemon Tree Passage reported as active only in 2002 (Ekert and Brady 2004).

However, ospreys have not been recorded as nesting in the Hunter region since 1984 to 1985. In the Hunter Catchment, osprey nests have only been recorded in 1984 and 1985 at Cooks Hill, Newcastle (Ekert and Brady 2004). Ospreys have been observed on irregular occasions at Seaham Swamp, Belmont Lagoon, Williamtown and Stockton Beach (HBOC 1998; Ekert unpubl. data). The paucity of sightings of osprey in the Hunter do not suggest a resident group of breeding ospreys occupies habitats in the study area.

5.12.3 Woodland Birds

There are two species that are restricted to woodland habitats throughout their range and are assessed as affected species:

- brown treecreeper (eastern subspecies) (*Climacteris picumnus victoriae*); and
- grey-crowned babbler (eastern subspecies) (*Pomatostomus temporalis temporalis*).

Habitat Requirements

The brown treecreeper is a facultative temperate forest and woodland and tropical woodland bird species (Garnett *et al* 2001). The brown treecreeper occupies *eucalypt* woodland and adjoining vegetation in subcoastal environments and the slopes of the Great Divide (Garnett *et al* 2001). It is sedentary within permanent territories, breeding in pairs or communally in small groups (Noske 1991). The brown treecreeper is an obligate insectivore and forages for insects on the trunks of live trees as well as fallen logs. The species nests most often in hollows (Noske 1979; Blakers *et al* 1984). The brown treecreeper requires mature *eucalypt* vegetation with the presence of fallen logs (for foraging) and hollows (for nesting) in dry open forest comprised of relatively sparsely distributed native understorey grasses. The species is generally absent from sites with a dense understorey (Noske 1991; Ekert 2004).

The grey-crowned babbler is a facultative temperate forest and woodland and tropical woodland bird species (Garnett *et al* 2001). The species inhabits open forests and woodlands and requires an open shrub layer with sparse ground cover and fallen timber and leaf litter. The species is rarely recorded in regrowth forest, large patches of forest or woodland, forest with dense understorey or grassland with few trees (Robinson and Traill 1996).

Presence and Quality of Habitat

The study area is mainly comprised of dry sclerophyll open forest and heathland, which, despite being a large area of contiguous habitat, was unsuitable for the brown treecreeper and grey-crowned babbler. In particular, the floristic composition of the heathland and the dry open forest (ie dense understorey of *Pteridium esculentum*, *Leptospermum*, and *Acacia longifolia*) and the subsequent paucity of understorey with an open shrub layer rendered the habitat unsuitable for these species. There was however, some moderate quality habitat for the grey-crowned babbler to the north east of the site in relatively low, open shrubland adjacent to the sand dunes.

Population Survey Results

The brown treecreeper and grey-crowned babbler were not recorded in the study area during targeted surveys. Given the lack of habitat for the brown treecreeper and the species' predominantly inland distribution in the Hunter region, a population is unlikely to be present in the study area and transient individuals are unlikely to occur. As such, the brown treecreeper will not be affected by the proposal. There is, however, potential habitat for the grey-crowned babbler in the north east corner of the study area and the species should be regarded as an affected species.

Local and Regional Abundance

In the Sydney Basin Bioregion, the brown treecreeper occurs at a relatively low proportion (0.1-1 percent) of all records within the bioregion (Garnett *et al* 2001). In the Hunter Region, the brown treecreeper occurs at a similarly low proportion. It is only found in open forest and woodland in the central, western and northern parts of the region (HBOC 1997, 1998; Ekert unpubl. data). Locations include Goulbourn River National Park (NP), Wingen, Isaacs Creek, Battery Rocks (HBOC 1997, 1998) as well as Singleton and in Hunter Lowland Redgum forest at Warkworth (Ekert unpubl. data).

In New South Wales, the grey-crowned babbler occurs mostly west of the Great Divide, and occurs in suitable habitat on the edges of State Forests and in the Liverpool Plains region (Ekert 2002, 2004). In the Hunter Region, the grey-crowned babbler mostly occurs in the central and western and northern parts of the region including Clarencetown, Gloucester, Seaham, Cessnock, Maitland Kurri Kurri, Singleton, Paterson, Dungog and Wingen (HBOC 1997,

1998; Wildlife Atlas 2004; Ekert unpubl. data). There are very few records on the coastal regions of the Hunter, with one notable recent (September 2004) record of two individuals with nests just north of the Fern Bay site near Lavis Lane (M. Evans, Energy Australia pers. comm.).

5.12.4 Bush Stone-curlew

Habitat Requirements

Inhabits lightly timbered, open forest or woodland habitat (Pizzey 1991; Marchant and Higgins 1993). Preferred habitat is often associated with woodlands of *Casuarina*, *Eucalyptus*, *Acacia* or *Epolycarpa* (NPWS 1999a). In coastal areas the species appears to be associated with swamp oak (*Casuarina glauca*) groves, saltmarsh, mangroves and paperbark (*Melaleuca quinquenervia*) woodlands, and have been observed on playing fields and golf courses (NPWS 2003b). The bush stone-curlew nests on the ground, near dead timber, usually under trees within open woodlands that have an understorey of short grass or among brushwood (Wilson 1989). Abundant leaf litter is required for foraging and roosting sites (NPWS 2003b).

Presence and Quality of Habitat

The study area is mainly comprised of dry sclerophyll open forest and heathland, which, despite being a large area of contiguous habitat, is unsuitable as habitat for the bush stone-curlew due to the dense understorey of *Pteridium esculentum*, *Leptospermum*, and *Acacia longifolia*, and lack of open woodland and grassland. The frequent fires over the study area have reduced the ground leaf litter cover in this habitat to a level that is probably sub-optimal for this species (Clements *et al* 1992). The swamp forest in the study area contains swamp oak and paperbark, but is not woodland due to the thick understorey and ground layer.

Population Survey Results

The bush stone-curlew was not recorded in the study area by ERM or during previous field investigations by other consultants. The species is not likely to be present based on the lack of records and preferred habitat in the study area. Therefore, it will not be affected by the proposal.

Local and Regional Abundance

The bush stone-curlew has been observed at Lemon Tree Passage and Tilligerry Peninsula (HBOC 1999), Karuah (NPWS 1999a) and Wyee (HBOC 1998). Population densities have not been reported, although they are likely to be low (ie one or several breeding birds). Flocks of bush stone-curlew are a rare sight in south eastern Australia (NPWS 2003b).

5.12.5 Nectivorous Birds

Two species that are migratory nectivorous birds that inhabit forests and woodlands are assessed as affected species:

- swift parrot (*Lathamus discolor*); and
- regent honey eater (*Xanthomyza phrygia*).

Habitat Requirements

The swift parrot breeds only in Tasmania, and occurs as a visitor throughout south eastern New South Wales and Victoria from March to November (Garnett 1992). The swift parrot inhabits eucalypt forest and woodland, almost invariably in small flocks (Blakers *et al* 1984). The species occurs primarily where eucalypts are flowering in profusion, feeding mainly on nectar, pollen and lerp (Klippel 1992). The swift parrot is dependent on winter flowering species, such as red ironbark (*Eucalyptus sideroxylon*), yellow gum (*E. leucoxylon*), white box (*E. albens*) and swamp mahogany (*E. robusta*). Due to the irregular nature of eucalypt flowering, the abundance of swift parrots within an area is highly variable.

The principal habitat of the regent honeyeater is temperate *eucalypt* woodland and dry open forest, forest edges, treed farmland and urban areas (Garnett 1992). The regent honeyeater is nomadic, searching for rich sources of nectar (Franklin *et al* 1989), although the birds will regularly appear in some districts each year when certain *eucalypts* and *banksias* flower (Blakers *et al* 1984). They feed predominantly on the nectar of eucalypts, in particular red ironbark (*Eucalyptus sideroxylon*), white box (*E. albens*), yellow box (*E. mellidora*) and yellow gum (*E. leucoxylon*) (Garnett 1992). On the New South Wales central coast they have been recorded feeding on swamp mahogany (*E. robusta*) (Garnett 1992).

Presence and Quality of Habitat

Potential foraging habitat for both species is present throughout the swamp forest, where swamp mahogany is common. Sub-optimal habitat is present in the wet heath, where swamp mahogany is less common and grows to a lower height than in the swamp forest. The swamp forest therefore provides a potential winter foraging resource for the swift parrot and regent honeyeater in the study area. These species do not nest in the region and therefore an assessment of nesting habitat is not applicable.

Population Survey Results

The swift parrot and regent honeyeater have not been recorded in the study area during previous and current field surveys. Given the low number of regional records, the regent honeyeater is not likely to occur in the study area

and will not be affected by the proposal. The swift parrot may occasionally use winter flowering species in years when its northward migration is coastal, but will not be affected by the proposal.

Local and Regional Abundance

Due to the irregular nature of eucalypt flowering, the abundance of swift parrots within an area is highly variable. In 2001 there were no local records of swift parrot but in 2002 there were significant numbers recorded at Williamtown, Medowie, Fingal Bay and Soldiers Point (HBOC 2002; HBOC 2003). Records of the regent honeyeater include Tomago, Morisset, Ellalong Lagoon and Mount Sugarloaf but are for one to several birds (Murray *et al* 2002).

5.12.6 Frugivorous Birds

There are three affected species of frugivorous birds that specialise in rainforest habitats:

- wompoo fruit-dove (*Ptilinopus magnificus*);
- rose-crowned fruit-dove (*Ptilinopus regina*); and
- superb fruit-dove (*Ptilinopus superbus*).

Habitat Requirements

These three fruit-doves are highly specialised obligate frugivorous (fruit-eating) pigeons that occur mostly in suitable habitat such as rainforest and wet-sclerophyll forest dominated by fruit-bearing rainforest species of the Moraceae (Figs), Myrtaceae (Acmena, Syzigium), and Lauraceae (Neolitsea, Litsea), and Arecaceae (*Archontophoenix* spp.) families. These pigeons occur in this suitable habitat at both high and low altitudes in north east New South Wales, however, their occurrence is greatest at sites with a seasonal abundance of fruit (Innis 1989). A general decline in fruit diversity and availability occurs at the higher elevations through winter and spring (Innis 1989), thus the presence of frugivorous pigeons is highest at lower altitudes during the winter and spring period (Kikkawa and Williams 1971).

In northern New South Wales, the rose-crowned, superb and wompoo fruit-doves have been recorded using the smaller remnants of rainforest between the high and low altitudes as 'stepping stones' to facilitate the movement between these areas (Date *et al* 1991; Ekert and Bucher 1999). Factors that affect the use of smaller low altitude remnants include the composition and abundance of fruit-bearing trees, size of the remnant, the isolation of the remnant and the proximity to urban areas (Innis 1989; Ekert and Bucher 1999).

Presence and Quality of Habitat

The paucity of fruit-bearing rainforest species in the study area would not suit the habitat requirements of these fruit-doves. However, the study area may be used as a stepping stone or staging point as these pigeons track suitable resources throughout the region.

Population Survey Results

The three pigeons were not recorded during the present study, despite the survey being conducted during the summer. Given the habitat present, survey results and the low number of local records, the wompoo, rose-crowned and superb fruit-doves are not likely to be dependent on habitats in the study area. Therefore, they will not be affected by the proposal.

Local and Regional Abundance

In the Hunter region, few records exist for these rainforest pigeons in smaller remnants, outside national park estate. The wompoo fruit-dove has been recorded mainly in the larger national parks of the region (ie Woko, Barrington Tops, Myall Lakes, Glenrock Lagoon) (HBOC 1997, 1998; Wildlife Atlas 2004). The rose-crowned and superb fruit-doves have been recorded at a number of locations throughout the region. The wompoo fruit-dove has been recorded at Eleebana, Blackbutt Reserve, Stockrington and Black Hill (Wildlife Atlas 2004) and Little Beach in Port Stephens (HBOC 1994). The superb fruit-dove has been recorded Blackbutt Reserve, Rankin Park and Cardiff (HBOC 1999). The rose-crowned fruit-dove has been recorded in Blackbutt Reserve and Cardiff Heights (Wildlife Atlas 2004).

5.12.7 Cave Roosting Bats

There are four affected species of microchiropteran bats that roost predominantly in natural and artificial caves:

- large-eared pied bat (*Chalinolobus dwyeri*);
- little bentwing-bat (*Miniopterus australis*);
- eastern bentwing-bat (*Miniopterus schreibersii oceanensis*); and
- large-footed myotis (*Myotis adversus*).

Habitat Requirements

The large-eared pied bat has been recorded from a range of vegetation types, including dry and wet sclerophyll forest, *Callitris* dominated forest, tall open eucalypt forest with a rainforest sub-canopy, sub-alpine woodland and

sandstone outcrop country (Schulz *et al* 1999). In south eastern Queensland the species has primarily been recorded from higher altitude moist tall open forest adjacent to rainforest. Little is known about the roosting requirements of this species but natural roosts may depend heavily on sandstone outcrops. It has been found roosting in disused mine shafts, caves and overhangs (Schulz *et al* 1999). It also possibly roosts in tree hollows. Currently, no maternity sites are known.

The little bentwing-bat occupies caves and tunnels during the day and at night forages for small insects beneath the canopy beneath the canopy of well timbered habitats including rainforest, *Melaleuca* swamps and dry sclerophyll forests. The species can also utilise a variety of structures such as buildings and stormwater drains as diurnal roosts. It is reliant on a limited number of caves for maternity and hibernation roosts. Large distances are often travelled between different roosts, according to seasonal and local needs. With the onset of spring, adult females move from widely scattered roosts to specific nursery caves, which are often shared with the common bentwing-bat (Strahan 1995).

The eastern bentwing-bat roosts and nests in caves, old mines, stormwater channels and occasionally buildings. It forages for insects in above the tree canopy in well-timbered valleys. Where conditions are favourable, colonies are often large with large distances are travelled between different roosts according to changing seasonal needs and the dictates of age and reproductive status. The pattern of movement varies in response to local climatic conditions and the dispersion of suitable roosting sites. With the onset of spring, adult females move from numerous widely scattered to specific nursery caves (Strahan 1995).

The large-footed myotis feeds over water, catching prey both in the air and from the water surface (Menkhorst 1996). Analysis of stomach contents show insects are the prime food source, but small fish are also taken (Ayers *et al* 1996). This species is always associated with permanent, usually slow-flowing, waterbodies. It has been recorded foraging over small creeks, coastal rivers, estuaries, lakes and inland rivers (Law and Anderson 1999). Records come from a wide range of vegetation communities associated with water (Menkhorst 1996). Recent literature review also suggests that this species can utilise farm dams and other smaller water bodies (Law *et al* 1998). Colonies roost by day in caves, mines, tunnels, tree hollows, disused bird's nests under bridges and buildings (NPWS 2000b).

Presence and Quality of Habitat

The study area provides suitable foraging habitat for the four species throughout the three habitats. Foraging habitat for the large-footed myotis occurs over the permanent pond in the south west corner of the study area. However, roosting habitat is generally unavailable, as there are no rock outcrops, caves, mines or tunnels in the study area. Sub-optimal roosting

habitat is available for the large-footed myotis and large-eared pied bat in tree hollows.

Population Survey Results

The eastern bentwing-bat and large-footed myotis were recorded in the study area during previous investigations, however, the location of these records is not reported (Ecotone 1994 as sited in Gunninah Consultants 1996 revised 1997, Gunninah Consultants 2002). The large-eared pied bat has not been recorded in the study area during current or previous investigations. The little bentwing-bat and eastern bentwing-bat were recorded from site 1 in swamp forest and the eastern bentwing-bat was also recorded from site 4 in wet heath. Therefore, the eastern bentwing-bat, little bentwing-bat and large-footed myotis will be affected by the proposal.

Local and Regional Abundance

There are no records of the large-eared pied bat in the region. The little bentwing-bat has been recorded throughout the region at Gan Gan, Edgeworth, Charlestown, Glendale, Belmont, Swansea and Morisset (Murray *et al* 2002). The eastern bentwing-bat is widespread in the lower Hunter and central coast. It has been recorded at Edgeworth, Belmont, Charlestown, Awaba and Morisset (Murray *et al* 2002). The large-footed myotis is known from scattered sites within the lower Hunter and central coast including Morisset, Awaba, Kooragang Island, Dora Creek and Vales Point (Murray *et al* 2002). Maternity roost sites of the little bentwing-bat and large-footed myotis have been recorded at Yacaba Head, Port Stephens and Balickera canal north of Raymond Terrace, respectively.

5.12.8 Tree Hollow Roosting Bats

There are five affected species of microchiropteran bats that roost in tree hollows:

- hoary wattled bat (*Chalinolobus nigrogriseus*);
- eastern false pipistrelle (*Falsistrellus tasmaniensis*);
- eastern freetail-bat (*Mormopterus norfolkensis*);
- yellow-bellied sheathtail-bat (*Saccolaimus flaviventris*); and
- greater broad-nosed bat (*Scoteanax rueppellii*).

Habitat Requirements

The hoary wattled bat inhabits a wide range of habitat types, including monsoon forest, tall open forest, open woodland, vine thickets, coastal scrub, sand dunes, grasslands and floodplains (Churchill 1998). Hoary wattled bats roost in tree hollows in eucalypt trees. Individuals recorded from northern New South Wales have been captured in eucalypt open forest and woodland (Milledge *et al* 1992).

The eastern false pipistrelle inhabits sclerophyll forests and generally roosts in hollow trunks of eucalypt trees (Churchill 1998). The eastern freetail-bat inhabits dry eucalypt forest and woodland and roosts in tree hollows (Churchill 1998).

The yellow-bellied sheathtail-bat occurs in a wide range of habitats, foraging high and fast over the canopy (Strahan 1995). Seasonal movements of these bats are unknown, although there is speculation they may migrate to southern Australia in late summer and autumn (NPWS 2000b). Usually solitary, but occasionally occurring in colonies of less than ten individuals, the species roosts in tree hollows and has been found in abandoned nests of sugar gliders. Occasionally it is found resting on walls of buildings in broad daylight.

The greater broad-nosed bat occurs in a variety of habitats including rainforest, dry and wet sclerophyll forest and eucalypt woodland (Parnaby 1984). Its roosting requirements are poorly known. Individuals have been recorded roosting in tree hollows, cracks and fissures in the trunk and boughs of stags, and under exfoliating bark (Schulz *et al* 1999). Maternity sites have not been documented for this species.

Presence and Quality of Habitat

The study area provides potential roost sites throughout the dry sclerophyll open forest and foraging habitat throughout the entire study area. An assessment of habitat trees for hollow-dependent fauna is provided in *Section 5.6.2*.

Population Survey Results

The hoary wattled bat was recorded from site 4 in February 2005. The eastern false pipistrelle was not found in the study area during current or previous investigations. The eastern freetail-bat and greater broad-nosed bat were recorded in January and February 2001 from three unknown locations in the study area (Gunninah Consultants 2002). The yellow-bellied sheathtail-bat was recorded from an unknown location by Clements *et al* (1992). The greater broad-nosed bat was recorded by ERM in 2002 from dry sclerophyll open forest. It was also recorded in February 2005 from site 1 in swamp forest and site 4 in wet heath (see *Figure 5.1*). No roost trees of any species were located.

Given these survey results, populations of the hoary wattled bat, eastern freetail-bat, greater broad-nosed bat and yellow-bellied sheathtail-bat will be affected by the proposal.

Local and Regional Abundance

There are no records of hoary wattled bat in the region. The nearest known record is Kempsey. Therefore, the record in the study area is a southern range extension for the species in Australia. Records of the eastern false pipistrelle are restricted to moderate and high elevations in the Watagan and associated ranges. The eastern freetail-bat has been recorded at Swansea and Vales Point (Murray *et al* 2002), and Sandgate (ERM 2004b). The record of the yellow-bellied sheathtail-bat is the sole record of this species in the region. The greater broad-nosed bat appears to be more common than the former species. It is known from scattered localities including Edgeworth, Swansea, Awaba, Morisset, Cooranbong and Salamander Bay (Murray *et al* 2002). No roost sites of these species have been reported.

5.12.9 Hollow-dependent Mammals

There are three mammals that are dependent on tree hollows as nest and den sites:

- spotted-tailed quoll (*Dasyurus maculatus*);
- squirrel glider (*Petaurus norfolcensis*); and
- brush-tailed phascogale (*Phascogale tapoatafa*).

Habitat Requirements

The spotted-tailed quoll occurs in a wide range of habitats including rainforest, open forest, woodland, coastal heath and inland riparian forest (Edgar and Belcher 1995). The animals are opportunistic predators and will feed on a variety of prey including macropods, birds, reptiles, arboreal mammals and small terrestrial mammals (Mansergh 1983). The home range of a male spotted-tailed quoll may be in excess of 580 hectares and up to 875 hectares (Watt 1993). Hence it requires large tracts of forest. The spotted-tailed quoll nests in rock shelters, small caves, hollow logs or tree hollows, and utilises numerous dens within its home range (Ayers *et al* 1996).

The squirrel glider inhabits dry sclerophyll forest and woodland, and is generally absent from rainforest and closed forest (Menkhorst *et al* 1988). The squirrel glider has a home range of between 1.5 and 10 hectares and a density of 0.1 to 1.9 animals per hectare, depending upon habitat quality (Smith 2002). The home-range of a family group is likely to vary according to habitat quality and availability of resources (Quin 1995). The squirrel glider requires abundant hollow-bearing trees and a mix of eucalypts, acacias and banksias.

Within a suitable vegetation community at least one flora species should flower heavily in winter and one or more of the eucalypts should be smooth-barked (Menkhorst *et al* 1988; Quin 1995). The species forages in the upper and lower forest canopies, and in the shrub layer of dry eucalypt forests and woodland (NPWS 1999b). It feeds on insects, eucalypt and wattle sap, nectar, pollen and seeds and requires a winter flowering resource, (NPWS 2000b). Given that insects and exudates are scarce and energy requirements are high, winter is a time of critical food shortage (Smith 2002). The squirrel glider is nocturnal and shelters in tree hollows (Suckling 1995). This species lives in family groups of between two and 10, generally comprising of one male, at least two females and juveniles (Quin 1995; Suckling 1995). Births occur throughout the year and are likely to reflect the availability of food, particularly pollen and nectar. Squirrel gliders are agile climbers and can glide for more than 50 metres in one movement. Nightly movements are estimated as between 300 and 500 metres (Quin 1995).

The preferred habitat of the brush-tailed phascogale is dry sclerophyll open forest, with a sparse ground cover of herbs, grasses, scleromorphic shrubs or leaf litter (Soderquist 1995). However, individuals may also inhabit heathland, swamps, rainforest and wet sclerophyll forest (Dickman and McKechnie 1985). The small, mainly arboreal species is an agile climber and forages preferentially in rough-barked trees (Soderquist 1993). The species is nocturnal and carnivorous, feeding on invertebrates and arthropods (such as spiders, centipedes, beetles and cockroaches), nectar and occasionally small vertebrates (Soderquist 1995). The females inhabit territories of approximately 20 to 60 hectares, while the males maintain territories of up to 100 hectares. The territory of a female is exclusive, however, the territory of a male may overlap with other females and males (Soderquist 1993). The brush-tailed phascogale nests and shelters in tree hollows, using many different hollows over a short time span. Suitable hollows are 25 to 40 millimetres wide (Ayers *et al* 1996), lined with leaves and shredded bark (Soderquist 1995). Mating occurs between May and July, during which time males can travel long distances well beyond their territories and die soon after the mating season.

Presence and Quality of Habitat

The study area supports foraging habitat and den sites for the spotted-tailed quoll. This habitat is near-contiguous with similar habitat at sites where the species is known to occur, such as Tomaree National Park.

An assessment of the quality of habitat in the study area for hollow-dependent arboreal mammals is provided in *Section 5.6.2*.

In the lower Hunter, the brush-tailed phascogale prefers rough-barked eucalypt woodlands and forests composed predominantly of ironbark (*Eucalyptus crebra*). There are no rough-barked eucalypt species present in the study area. Therefore, despite the presence of nesting hollows, this species is not likely to be present in the study area and will not be affected by the proposal.

Population Survey Results

The spotted-tailed quoll was not recorded during current or previous investigations in the study area. No evidence of its presence was recorded, including scats and latrine sites. However, individuals may forage in the study area intermittently as part of a large home range centring on habitats in Tomaree National Park. The species therefore has potential to be affected by the proposal.

The squirrel glider was recorded during recent field investigations by ERM in 2002 in swamp forest and dry sclerophyll open forest. Two individuals were trapped in September 2002 and individuals were recorded while spotlighting Transect 1 and Transect 3. Squirrel gliders have been recorded on Boral's property to the north of the study area over several years (ERM Resource Planning 1994; ERM 2003b). The most recent record on Boral's property was the trapping of one individual in September 2004 adjacent to the northern corner of the study area, made during annual monitoring of the population by ERM. Gunninah Consultants (1996 revised 1997) recorded the squirrel glider from habitats in the approved subdivision footprint.

Three squirrel gliders were captured by Forest Fauna Surveys Pty Ltd at site 3 in the south east corner of the study area (see *Figure 5.1, Table 5.8*).

Table 5.8 Squirrel Glider Capture Data, February 2005

Date	Site	Species	Weight (g)	Sex	Age Class	Reproductive Condition
15 February 2005	3	*Petaurus norfolcensis*	135	M	< 1 yr	Testes immature
16 February 2005	3	*Petaurus norfolcensis*	232	F	2-3 yr	No pouch young, enlarged pouch, evidence of young
17 February 2005	3	*Petaurus norfolcensis*	142	M	< 1 yr	Testes immature

The young males captured are likely young of the older female. The age of the young suggest they were born in the previous winter, which is consistent with other known locations in the lower Hunter region and Central Coast. Female gliders gave birth the previous season in late winter and early spring (Smith and Murray 2003). No evidence of gliders from trapping was recorded at sites 1, 2, 4 and 5, despite suitable habitat present in all five sites, and number of past records of the species distributed across the study area.

Despite the survey effort, the capture rate of three gliders for 150 trap nights averaged 2.0 percent, which is lower than the average capture rate at Wyong (6.5 percent)(Smith and Murray 2003) and 8 to 16 percent at Port Macquarie (Quin 1996). However, Quin (1995) noted that capture rates are lower during flowering due to the excess of nectar and pollen associated with flowering eucalypts. During this survey, blackbutt (*Eucalyptus pilularis*) and red

bloodwood (*Corymbia gummifera*) were in moderate flower, which have reduced trappability of gliders in the study area.

Following release of the captured gliders, the two juvenile gliders remained in the release tree and did not return to their den tree. However, the female glider captured immediately returned to her den tree (blackbutt) upon release. No gliders were observed to emerge during stag-watching of habitat trees.

An estimate of glider abundance was derived from the trapping results for this study. This density estimation is consistent with earlier work of Smith (2000) and Smith and Murray (2003). Density of gliders was estimated by dividing the corrected number of gliders in study site by the effective trap area. The corrected factor for the study site used the same estimate (1.12) as the Wyong and Lake Munmorah survey (see Smith and Murray 2003). Density of gliders in the Fern Bay fragment was estimated at 0.36 gliders per hectare. Therefore, the squirrel glider will be affected by the proposal.

The brush-tailed phascogale was not recorded in the study area during previous and current investigations. As it is not likely to occur in the study area, the brush-tailed phascogale will not be affected by the proposal.

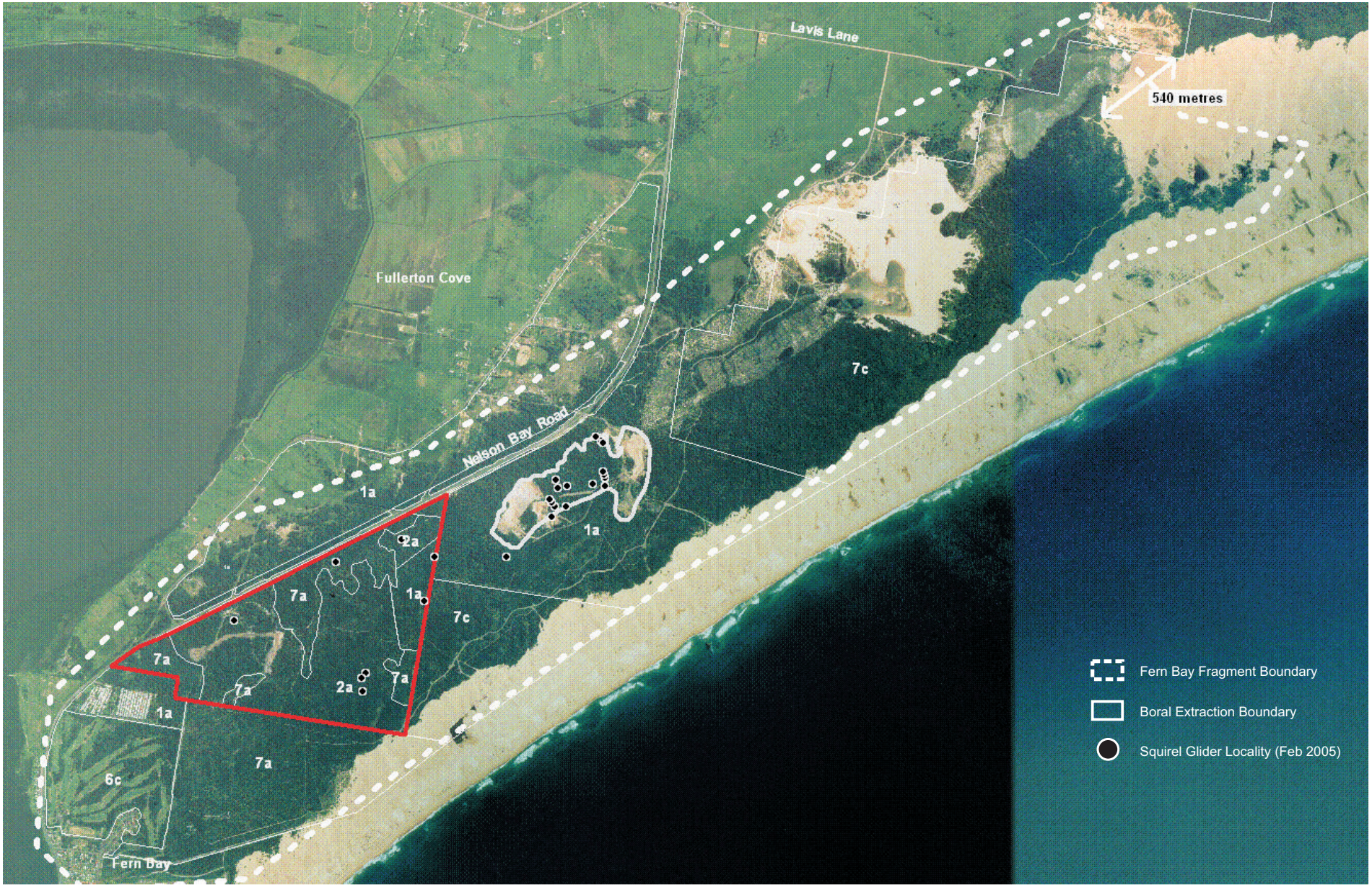
Local and Regional Abundance

The spotted-tailed quoll has been recorded from Medowie and the Tomago sandbeds, Raymond Terrace, Paterson and Awaba (Murray *et al* 2002). The brush-tailed phascogale has been recorded from Williamtown, Karuah, Seaham and Lemon Tree Passage (Murray *et al* 2002). The squirrel glider has been recorded from Tomaree National Park where it is considered to be widespread. It has been recorded over the Tomago sandbeds and Port Stephens from a range of localities that support high quality habitat. A local population is resident in the study area and within the local fragment of coastal swamp forest and open forest in Stockton Bight. The brush-tailed phascogale is known from Williamtown and Lemon Tree Passage, although the population size is unknown (Murray *et al* 2002).

Squirrel Glider Fragmentation Analysis

The remnant open forest in the study area is part of a larger fragment of remnant forest occupying an area of 1,268 hectares (based on 2003 LHCCREMS vegetation mapping). This large fragment is hereafter referred to as the "Fern Bay fragment" (see *Figure 5.4*). The boundary of the Fern Bay fragment is defined by the following areas of unsuitable habitat for the squirrel glider:

- the western boundary of the Fern Bay Fragment is cleared agricultural land and the Hunter River;



ERM

Figure 5.4 **Fern Bay Habitat Fragment Plan**

Winten Property Group - CVC Limited - Fern Bay Estate - SIS

- the northern and north eastern boundary is cleared agricultural land off Fullerton Cove Road;

- the eastern boundary ceases near Lavis Lane near Williamtown, where there is a gap of 540 metres separating the Fern Bay fragment from more extensive areas of habitat to the north east. This large gap is a result of a drifting sand dune, and

- the southern boundary is the residential suburb of Fern Bay and sand dunes associated with Stockton Beach.

Extent of Vegetation

The extent of vegetation types within the Fern Bay fragment was analysed by reference to the LHCCREMS (House 2003) regional vegetation mapping see *Table 5.9*).

Table 5.9 ***Extent of LHCCREMS (House 2003) Vegetation Types, Fern Bay Fragment***

LHCCREMS Vegetation Community	Map Unit	Total Area (ha)	Fern Bay Estate (ha)	Nelson Bay Road Corridor (ha)	Fern Bay Fragment (ha)
coastal sand apple – blackbutt forest	33	985.64	132.06	9.94	843.63
swamp mahogany – paperbark forest	37	89.57	2.57	0.04	86.96
swamp oak rushland forest	40	141.46	70.02	10.52	60.92
coastal sand scrub	50	46.25	0.0	0.0	46.25
		1,262.92	**204.65**	**20.50**	**1,037.76**

The Fern Bay fragment is isolated from adjoining fragments due to incursion of shifting sands on the eastern boundary. The gap in forest created by the shifting sand is 540 metres at the closest point. Gaps in tree cover greater than 75 metres have been identified as an isolating distance for regular movement of the squirrel glider (van der Ree *et al* 2003; Claridge and van der Ree 2004). Movements of gliders across cleared landscapes have been documented up to distances of 300 to 400 metres (van der Ree *et al* 2003; M. Murray, unpublished data). However, the large expanse of sand, with no remnant vegetation connectivity, has resulted in isolation of the Fern Bay fragment glider population to populations further east of this barrier.

At present, Nelson Bay Road is not considered a barrier to glider movement into forest north of the study area. The minimum gap of Nelson Bay Road is presently 35 metres, with tall trees on either side of the road. This distance, coupled with remnant trees on the road boundary, is not considered to inhibit movement of gliders.

The extent of suitable habitat in the Fern Bay Fragment (which includes the study area) is 1,075.21 hectares. Two of the vegetation units mapped by House (2003) for LHCCREMS (2003), swamp oak rushland (Map Unit 40) and coastal sand scrub (MU 50) were excluded as habitat suitable for the squirrel glider.

Squirrel Glider Population Estimate

Based on an estimate density of 0.36 gliders per hectare in 1,075.21 hectares of suitable habitat, the population size of the Fern Bay Fragment is potentially 387 gliders. This estimate is likely to overestimate population size, as the vegetation analysis does not incorporate vegetation condition. For example, regrowth stunted forest in proximity to the ocean and disturbance, are likely to support lower glider density.

Based on land use zones in the Fern Bay Fragment, the extent of suitable habitat for the squirrel glider conserved (including the study area) is 580.49 hectares, or approximately 54.0 percent of the extent of mapped habitat. Based on an estimate density of 0.36 gliders per hectare, the population size of the Fern Bay Fragment in secure habitat is approximately 208 gliders.

This population estimate in secure habitat approaches the precautionary threshold identified by Smith (2002) to ensure long-term (>100 year) persistence of the squirrel glider. Strategic planning is required for the Fern Bay Fragment (including the Fern Bay Estate) to ensure security of habitat and connectivity in order to prevent fragmentation of habitat (and subsequent reduction in population size) toward this precautionary threshold.

The approved subdivision within the study area allows for development up to Nelson Bay Road, which would have the effect of fragmenting the habitat of the squirrel glider and other threatened species. In order to maintain habitat connectivity a minimum 200 metre wide ecological corridor will be retained along the northern boundary of the site adjacent to Nelson Bay Road. Therefore those approved lots and roads within this corridor will not be constructed. This will prevent the disturbance of approximately 7.2 hectares of vegetation. If the Master Plan for the site is approved, WPG will seek the rezoning of the 2(a) Residential zoned land within this ecological corridor as well as other parts of the site that do not form part of the proposed development footprint, to 7(a) Environment Protection.

5.12.10 Koala

Habitat Requirements

The koala (*Phascolarctos cinereus*) is an inhabitant of forests containing medium to tall trees, including rainforest genera (Reed *et al* 1990). These forests typically occur along the coast on high nutrient soils from sea level to 1200 metres elevation and are characterised by preferred forage trees.

In New South Wales, the koala is associated with several forage trees, including forest red gum (*Eucalyptus tereticornis*), tallowwood (*E. microcorys*), ribbon gum (*E. viminalis*), grey gum (*E. punctata*), river red gum (*E. camaldulensis*), swamp mahogany (*E. robusta*), Sydney blue gum (*Eucalyptus saligna*), blackbutt (*E. pilularis*), flooded gum (*E. grandis*) and small-fruited grey gum (*E. propinqua*) (Reed *et al* 1990). A recent study of koala habitat in Port Stephens LGA found that forest red gum (*Eucalyptus tereticornis*), swamp mahogany (*E. robusta*) and Parramatta red gum (*E. parramattensis* subsp. *decadens*) are preferentially utilised feed trees (Phillips *et al* 1996).

Koalas typically occur at low densities and a breeding population may consist of as few as five or six individuals (Callaghan *et al* 1994). Estimates of home ranges in Victoria are 1.7 hectares for males and 1.18 hectares for females with extensive overlap where feed trees are relatively dense (Mitchell 1990). In an area where feed trees are relatively sparse, home ranges were found to be 3.14 and 2.08 hectares for males and females respectively (Mitchell 1990). In coastal NSW populations have been estimated to range from one animal every 45 hectares to one every 4.5 hectares (on average 20 to 25 hectares) (Austeco 1994). Most young disperse at two to three years old and females remain in their natal area (Martin and Handasyde 1995). If no suitable habitat is found by young individuals then they become nomadic.

Presence and Quality of Habitat

The study area contains swamp forest and wet heath that is potential koala habitat as defined by SEPP 44 and is preferred koala habitat as defined in the CKPoM Koala Habitat Mapping (see *Section 5.5*). This is due to the presence of swamp mahogany as a canopy tree species. Areas of swamp forest constitute a potential koala movement corridor from preferred koala habitat at Newcastle Golf Course to preferred habitats north of the study area in the Tomago sandbeds.

The study area forms a local corridor of mainly supplementary koala habitat that extends along the coast north to the Tomago sandbeds, Stockton Bight and the Tomaree Peninsula. Isolated patches of preferred koala habitat occur between the study area and larger areas of preferred habitat around Williamtown.

Population Survey Results

No koalas or evidence of their presence in the study area (ie faecal pellets) were recorded in the study area by ERM or during previous field investigations by other consultants. Therefore, the koala will not be affected by the proposal however koala habitat will be affected.

Local and Regional Abundance

Numerous records of the koala exist for the Port Stephens LGA (see *Figure 5.3b*). Port Stephens is considered to support the largest koala population in the Sydney Basin bioregion. The population occurs from Raymond Terrace across the Tomago sandbeds to Tilligerry Peninsula and further east to the Tomaree Peninsula.

The last known record of a koala in the study area is from a road-killed individual from Nelson Bay Road in November 1989, although a local resident reported a koala sighting in 1992 (Clements *et al* 1992). The absence of the koala in the study area, despite the presence of suitable habitat, is probably due to the high fire frequency, presence of Nelson Bay Road which bisects preferred koala habitat (ie swamp forest), the presence of domestic and feral dogs, and the fragmentation of movement corridors to surrounding preferred koala habitat in the locality (Clements *et al* 1992).

5.12.11 Long-nosed Potoroo

Habitat Requirements

Inhabits rainforest, adjacent to wet sclerophyll forest and coastal wallum (Menkhorst and Knight 2001). The species requires dense cover for shelter and adjacent, more open foraging sites. In the lower Hunter and central coast region, the long-nosed potoroo has been recorded in coastal Narrabeen moist forest and exposed Hawkesbury woodland (Murray *et al* 2002).

Presence and Quality of Habitat

The study area contains wet heath and swamp forest that is potential habitat for the species. However, preferred habitat on Hawkesbury sandstone is not present.

Population Survey Results

No long-nosed potoroos were recorded in the study area by ERM or during previous field investigations by other consultants. The species is not likely to be present based on the lack of records and preferred habitat in the study area. Therefore, it will not be affected by the proposal.

Local and Regional Abundance

Few records are available for this species, being restricted to the central coast district (Wambina Nature Reserve, Brisbane Water National Park and Strickland State Forest) (Murray *et al* 2002).

5.12.12 Eastern Chestnut Mouse

Habitat Requirements

Inhabits range of vegetation from grassy and heathy open forests to heath and swampy depressions (Menkhorst and Knight 2001). Highest densities in heath reached three to four years after fire. In the lower Hunter and central coast region, the eastern chestnut mouse has been recorded in exposed Hawkesbury woodland and scrub (Murray *et al* 2002).

Presence and Quality of Habitat

The study area contains wet heath that is potential habitat for the species. However, preferred habitat on Hawkesbury sandstone is not present.

Population Survey Results

The eastern chestnut mouse was not recorded in the study area by ERM or during previous field investigations by other consultants. Surveys conducted by ERM in wet heath occurred four years after a large fire, and the species was not trapped. The species is not likely to be present based on the lack of records and preferred habitat in the study area. Therefore, it will not be affected by the proposal.

Local and Regional Abundance

Few records are available for this species, being restricted to the central coast district (Brisbane Water National Park). One individual was trapped in sedge heathland along a riparian corridor at Piles Creek, Somersby (AMBS 1997).

5.12.13 Grey-headed Flying-fox

Habitat Requirements

The grey-headed flying-fox is a canopy-feeding frugivore, blossom-eater and nectarivore of rainforests, open forests, woodlands, paperbark swamps and Banksia woodlands. As such, it plays an important ecosystem function by providing a means of seed dispersal and pollination for many indigenous tree species (Eby 1996; Pallin 2000). Grey-headed flying-foxes also feed on introduced trees. Grey-headed flying-foxes congregate in large numbers at roosting sites (camps) that may be found in rainforest patches, paperbark stands, mangroves, riparian woodland or modified vegetation in urban areas. Individuals forage opportunistically, often at distances up to 30 kilometres from camps, and occasionally up to 60 to 70 kilometres per night, in response to patchy food resources (Augee and Ford 1999; Tidemann 1999).

Grey-headed flying-foxes show a regular pattern of seasonal movement. Much of the population concentrates in May and June in northern New South Wales and Queensland where animals exploit winter-flowering trees such as swamp mahogany, forest red gum (*Eucalyptus tereticornis*) and paperbark (*Melaleuca quinquenervia*) (Eby *et al* 1999). Food availability, particularly nectar flow from flowering gums, varies between places and from year to year.

Presence and Quality of Habitat

The study area provides seasonal foraging habitat in the swamp forest where flowering resources such as swamp mahogany and paperbark are present. Elsewhere, Banksia and eucalypts provide blossoms and nectar in the dry sclerophyll open forest and wet heath. The study area does not provide roosting habitat as this species roosts in specific camps, the nearest being Fullerton Cove.

Population Survey Results

Individuals were regularly observed foraging in the swamp forest throughout the year while spotlighting (winter and summer). No camp sites were found in the study area. Foraging individuals are considered to be members of the Fullerton Cove camp site. The grey-headed flying-fox may be affected by the proposal and should be regarded as an affected species.

Local and Regional Abundance

Records of the grey-headed flying-fox are widespread throughout the lower Hunter and central coast region. This nomadic species ranges widely following flowering and fruiting trees, and may be present in an area for several days or weeks, then absent until suitable food resources are again present (Murray *et al* 2002). Known camps within the region have been recorded at Blackbutt Reserve, Kooragang Island, Glenrock State Recreation Area and Matchem near Gosford.

5.12.14 Wallum froglet (Crinia tinnula)

Habitat Requirements

The wallum froglet inhabits temporary sedgelands and swamps in wallum country (Ehmann 1996a). The species is usually associated with landscapes such as swamps and lowland meandering watercourses on coastal plains. Many of the swamps where the species occurs are dominated by tea-tree species such as *Melaleuca* and *Leptospermum* (Ehmann 1996a). The wallum froglet is found in fringing and emergent plants within these wetlands. The waterbodies inhabited are generally shallow acid swamps (usually temporary

or semi-permanent) and associated connecting channels and deeper (often permanent) waterholes (Ehmann 1996a).

Presence and Quality of Habitat

Potential habitat for the wallum froglet occurs within the swamp forest throughout the study area. However, there are limited areas of suitable ephemeral or permanent wetland habitat within the swamp forest. The only suitable habitat is an ephemeral sedge swamp dominated by *Baumea* sp., *Schoenus* sp. and *Typha orientalis*. This swamp is situated within the approved development footprint. The swamp forest within the proposed development footprint is not likely to support a viable population of wallum froglet as there is no standing water available, which is necessary for breeding to occur. Given the absence of emergent vegetation that is usually associated with the breeding habitat of the wallum froglet, the swamp forest in the proposed development footprint is probably too dry most of the time to sustain the life cycle of a local population.

Population Survey Results

The wallum froglet was not recorded in the study area by Gunninah Consultants (1996 revised 1997, 2002). However, these surveys were conducted outside the winter breeding season of the wallum froglet. Targeted surveys conducted by ERM in winter 2004 did not detect the species within swamp forest in the proposed development footprint. However, up to ten individuals were heard calling from the sedge swamp at midday on 25 August 2004 while undertaking other field activities (see *Figure 5.1*). The record was made after a period of heavy rain in the locality, and the site was inundated. The sites where targeted surveys were conducted did not contain standing water at this time. Another record of the species was made on 21 February 2005 when a chorus of several individuals was heard calling from the vicinity of this sedge swamp to the north. This date was within two weeks of heavy rain in the locality, which had inundated some areas of swamp forest.

Potential habitat in swamp forest within the proposed development footprint was surveyed by quiet listening within one hour of hearing the chorus in August 2004. No individuals were heard. Further surveys in February 2005 for threatened frogs did not record the wallum froglet in other areas of swamp forest, despite the chorus present in the sedge swamp. It is therefore likely that the wallum froglet population within the study area is restricted to the sedge swamp. This swamp is within the approved subdivision footprint. Given the survey results, it is unlikely that the wallum froglet will be affected by the current proposal.

Local and Regional Abundance

Populations of the wallum froglet occur throughout swamp mahogany – paperbark forest and sedgelands in the Tomago sandbeds. The species is known from Newcastle airport (URS 2003), across the Tilligerry Peninsula to the Tomaree Peninsula where populations occur in Tomaree National Park. These populations may number at least several hundred individuals. There are populations south of the study area at Redhead, Belmont golf course and Jewell's Swamp. The population identified in the study area is the southern-most known population in Stockton Bight. The wallum froglet also occurs around Lake Macquarie at Wyee and Lake Mannering (Murray *et al* 2002).

5.12.15 Pond Breeding Frogs

There are two frog species that breed in ponds:

- green and golden bell frog (*Litoria aurea*); and
- green-thighed frog (*Litoria brevipalmata*).

Habitat Requirements

The green and golden bell frog inhabits a wide variety of freshwater wetlands, such as swamps, ponds, lagoons, dams and the still backwaters of rivers (Courtice and Grigg 1975; Cogger 2000). Pyke and White (1996) presented a habitat model that suggested the species preferred to breed in waterbodies that are still, ephemeral, unshaded, unpolluted and free of the predatory mosquitofish (*Gambusia holbrooki*). However, a habitat model presented by Hamer *et al* (2002) showed that it will breed in waterbodies occupied by mosquitofish and that most occupied waterbodies are close to other occupied waterbodies, suggesting a strong spatial component to the structure of populations. The green and golden bell frog usually resides amongst emergent vegetation in permanent and ephemeral ponds and requires suitable terrestrial habitats, preferably grassland with debris for shelter, dispersal and foraging. A landscape mosaic of wetlands that vary in permanency and are mixed with terrestrial habitats, are necessary to maintain a viable population of the species, as the species moves frequently among different wetlands (Hamer 2002).

The green-thighed frog inhabits riparian rainforest, wet sclerophyll forest, dry sclerophyll forest and woodland (Ehmann 1996b). Breeding aggregations occur after very heavy summer rain around grassy semi-permanent ponds. Most known breeding sites are temporary and include ponds, waterholes in creeks, oxbows, depressions and artificial dams, scrapes and ditches (Ehmann 1996b). Most are filled from local runoff during heavy rain.

Presence and Quality of Habitat

There is only one waterbody in the study area that is potential habitat for the green and golden bell frog. It is a permanent pond in the south west corner of the swamp forest near the caravan park. Ephemeral wetlands occur in swamp forest in the approved subdivision footprint, although none were found elsewhere in the study area. The predatory plague minnow is not present in wetlands in the study area.

Population Survey Results

No tadpoles of the green-thighed frog or green and golden bell frog were recorded during the targeted surveys. No green and golden bell frogs were found during the diurnal surveys. The surveys occurred within two weeks of a significant rainfall event during which 92.4 mm was recorded on 10 and 11 February 2005, respectively. If the species were present in the study area, it is highly likely breeding would have occurred at this ideal time for reproduction in both species. All suitable waterbodies were sampled. At two weeks of age, the tadpoles of both species would have been easily identified using an accepted guide, such as Anstis (2002). No tadpoles of any frog species were found during the surveys. Therefore, the green-thighed frog and green and golden bell frog will not be affected by the proposal.

Local and Regional Abundance

Populations of green-thighed frog are known from Karuah, Martinsville, Gap Creek, Olney State Forest, Ourimbah State Forest (Murray *et al* 2002). Breeding congregations of 10 to 25 calling males have been reported for Ourimbah State Forest although population sizes for other sites have not been reported (Ehmann 1996b).

A population of green and golden bell frogs on Kooragang Island is estimated to number several thousand individuals (Hamer 2002). A population at Sandgate is estimated at several hundred individuals. Populations of less than ten individuals have been recorded around Maitland, including Gillieston Heights, Farley and Ravensfield, and at Medowie.

6 ASSESSMENT OF LIKELY IMPACTS

6.1 INTRODUCTION

There are a range of potential impacts arising from the proposal that could affect affected species and ecological communities in the study area. The potential impacts are predicted to vary in magnitude depending on the individual species and their dependence on habitats in the study area. The purpose of this section is to identify the potential impacts of the proposal on affected species. This section also addresses the likely cumulative loss of habitat for affected species in the locality. The impact of the proposal on local and regional wildlife movement corridors for affected species are identified and described. Mitigation measures are discussed in *Section 7*.

6.2 POTENTIAL IMPACTS OF THE PROPOSAL

6.2.1 Habitat Loss

The proposed residential estate (including the asset protection zone) will involve the direct loss of approximately 70.2 hectares of vegetation comprising swamp forest, wet heath and dry sclerophyll open forest. A total of 30 hectares of vegetation has already been approved to be cleared under the existing development consent that applies over part of the study area. However, 7.2 hectares is not now proposed to be cleared and will be retained in a vegetated fauna movement corridor. Therefore the net area of vegetation to be cleared as a result of the proposal (ie excluding the approved 22.8 hectares that can be cleared) is 70.2 hectares (see *Table 2.1*). It should be noted that a conservative approach has been adopted in calculating the extent of vegetation clearance required for the proposed estate. In reality the amount of clearing will be less than the estimate provided as some vegetation will be retained in the open space and residential areas of the estate as well as within the asset protection zone. No vegetation will be disturbed with the Aboriginal heritage reserve.

The clearance of native vegetation is a key threatening process listed in the TSC Act. Most of the vegetation that will be cleared is dry sclerophyll open forest. Relative to the area that will be conserved, the greatest loss of habitat in the study area will be wet heath, with only 27 percent of the total area being conserved. Approximately 70 percent of the swamp forest will be conserved, mostly within the minimum 200 metre wide ecological corridor. Over half of the dry sclerophyll forest in the study area will be conserved.

The loss of vegetation in the study area will directly impact on the affected species, through the loss of foraging, nesting, roosting and breeding habitat. The loss of swamp forest in particular will reduce the availability of winter

forage habitat for the squirrel glider, swift parrot and regent honeyeater in the locality.

6.2.2 *Habitat Fragmentation*

The proposed residential subdivision will remove approximately 35 percent of the native vegetation in the study area, and vegetation communities are likely to be fragmented. This vegetation forms part of the existing vegetation corridor along the sand dunes of Stockton Bight. However, given that a minimum 200 metre wide ecological corridor will be retained along the northern boundary of the site, the proposal will ensure that connectivity of swamp forest is maintained in the Fern Bay area. The ingress of two roads into the development area will fragment this corridor somewhat, although it is currently fragmented by a powerline easement. Two areas of wet heath will be cleared, leaving a smaller area isolated in the northern portion of the study area. Although an area of wet heath occurs on Boral's land holdings to the north, it is discontinuous with wet heath in the study area.

Dry sclerophyll open forest will be fragmented throughout the study area, leaving the only intact corridor of this vegetation around the eastern boundary of the study area. The design facilitates the retention of approximately 300 metres of existing bushland between the proposed residential allotments and the cleared areas of Stockton Bight dune system, providing a movement corridor for fauna through dry sclerophyll open forest. This corridor is within the 100 year dune hazard zone, and therefore the corridor width may decrease over time. However, in order to maintain this corridor and protect the residential areas of the estate from sand dune encroachment, periodic removal of sand will be considered as a future option for managing dune migration. WPG are in the process of developing a strategy to address this issue.

The corridors of swamp forest and dry sclerophyll open forest will facilitate the movement of fauna so that affected species and affected ecological communities will not become isolated from the currently interconnecting areas of habitat to the south and north. Fauna movement west of the study area is presently disrupted by Nelson Bay Road, although some fauna such as the squirrel glider may be able to glide across the canopy above the road. Cleared agricultural land west of Nelson Bay Road also presents a barrier to the movement of terrestrial fauna.

6.2.3 *Local and Regional Connectivity*

The study area forms part of a local corridor of native vegetation that extends along the coast north to the Tomago sandbeds, Stockton Bight and the Tomaree Peninsula. The study area forms part of a regional corridor from the coastal forests of Stockton Bight to estuarine habitats in Fullerton Cove, and further west to wetland habitats on Kooragang Island and in Hexham Swamp, to the forested foothills of Mount Sugarloaf. This corridor has been mapped as a regional corridor in the National Parks and Wildlife Service's "Key Habitats and Corridors – a Landscape Framework for Regional Conservation

Programs in North East New South Wales" (NPWS 2002). This project is designed to provide an indicative representation of potential high conservation value areas for priority forest fauna, and habitats that link across the landscape. The fragment of vegetation that the study area is situated within has also been mapped as a key habitat. Key habitats define areas identified as centres of high native species diversity for a range of fauna assemblages (NPWS 2002).

The proposal will remove key habitat from the regional corridor. However, the retention of a minimum 200 metre wide ecological corridor and other local corridors in the study area are designed to maintain the integrity of this corridor (see *Section 7.2*).

6.2.4 Hydrology and Water Quality

The absence of streams and drainage lines in the study area reduces the potential issue of erosion and sedimentation on site as a result of the proposal. However, urban development usually increases the proportion of impervious surfaces in a stormwater catchment that increase runoff volumes and peak discharges to a receiving environment whilst decreasing or eliminating infiltration of rainwater into soils (Urban Water Cycle Solutions 2005). Increases in stormwater runoff will also convey pollutants (including high nutrient loads) that are generated by urban development to receiving waters creating adverse environmental impacts (Urban Water Cycle Solutions 2005). Weed invasion in the study area is already a problem and increased stormwater runoff with the increase of hard surfaces and nutrients could increase the level of weed invasion of the reserved areas.

Currently, water movement in the study area is generally confined to sub-surface flows associated with the water table. Groundwater in the study area flows north east towards Stockton Bight and south west towards Fullerton Cove. Groundwater levels vary with ground surface levels with groundwater levels more likely to be higher in locations where the ground surface levels are higher (Urban Water Cycle Solutions 2005). Stormwater currently discharges from low lying areas near Nelson Bay Road (ie swamp forest) towards Fullerton Cove. However, the swamp forest adjoining Nelson Bay Road acts as a biological filter to the wetlands of Fullerton Cove and may reduce the potential for offsite water quality impacts (Clements *et al* 1992).

The use of traditional pipe drainage and regional basin methods would result in the discharge of stormwater runoff towards Fullerton Cove, which has the potential to change the hydrological regime in the coastal wetlands situated between Fullerton Cove and the study area (Urban Water Cycle Solutions 2005). Increased loads of contaminants may also be discharged to this area. The combination of changed hydrological regime and contamination could have harmful impacts on the coastal wetlands, which includes SEPP 14 wetland number 821 (Urban Water Cycle Solutions 2005).

6.2.5 Road Traffic and Off-road Vehicles

The construction of roads within the study area increases the risk of traffic strike to fauna, particularly where the two roads traverse the minimum 200 metre ecological corridor. Fauna are particularly vulnerable to being killed when crossing roads especially in urban areas and/or areas where prime habitat has been fragmented. Fauna may also be impacted by machinery associated with the construction phases of the proposal through direct strikes. Road traffic may impact on fauna such as birds, microchiropteran bats, ground-dwelling and arboreal mammals including koalas, frogs and reptiles. For example, in the Port Stephens area, 325 koalas were hit by vehicles between December 1987 and March 1998 of which 241 were fatal (Port Stephens Council 2001). Nocturnal fauna are most vulnerable to traffic strike, as they cross roads while foraging or dispersing and may be temporarily blinded by oncoming vehicle lights. Microchiropteran bats may forage for insects over roads at night and be particularly susceptible to traffic strike. Road-related mortality is therefore likely to impact affected species in the study area, and mitigation measures for this impact are presented in *Section 7*.

Off-road vehicles were noted to be one of the main disturbance factors currently in the study area (Clements *et al* 1992). They have the potential to harm native vegetation, kill and maim fauna, increase soil erosion, contribute to water pollution and act as vectors for weed dispersal. However, the proposal will result in a reduction of off-road vehicles that currently illegally access the Stockton Bight foredune.

6.2.6 Rubbish Dumping

With residential development of the study area, garden rubbish dumping may become a greater problem and could potentially introduce more weeds to the reserves. Rubbish dumping also introduces nutrients and provides ideal conditions for the establishment of the dumped weeds. The sheer weight of the rubbish can smother and break native plants (Buchanan 1989).

6.2.7 Fire Frequency

The current fire frequency has been previously noted to be the most important human impact influencing the composition, structure and diversity of the vegetation communities in the study area (Clements *et al* 1992). Currently the vegetation cover of the study area has been reduced due to the frequency of intense fires (Clements *et al* 1992). Fire is generally more frequent in the study area than in surrounding areas, due to human use of the foredune and hind dune vegetation communities. As a result, surrounding habitats generally have a higher floristic diversity than those in the study area. For example, annual flora surveys in the remnant dry sclerophyll open forest on Boral's land holdings on the northern and eastern perimeter of the study area have recorded up to 95 native species (ERM 2003b). High frequency fire can disrupt plant and animal life cycles, and can change vegetation structure and composition.

It is likely that fire occurs within the drier habitats in the study area, such as the dry sclerophyll open forest and wet heath, at least once every five years. Fire is likely to be less frequent in the wetter habitats such as the swamp forest, but nonetheless, the frequency of fire is likely to be higher than pre-European settlement times.

The proposal will reduce fire frequency in the study area due to bushfire hazard management and control of ignition sources. Deliberate human activity is the most likely source of fire ignition in the study area at present.

6.2.8 Noise

Noise will be generated by several sources during the construction and operational phases of the proposal. During the construction phase, noise will result from heavy machinery required to clear trees and other vegetation, and to undertake other activities. Construction will be limited to between 6 am and 6 pm. Construction noise may alter the foraging behaviour of diurnally active birds or result in roost sites for owls, gliders and microchiropteran bats becoming unsuitable. Roost sites may ultimately be abandoned. As construction noise will be generally limited to daylight hours, the impact on the foraging and social behaviour of nocturnal fauna, apart from roosting, is not likely to be affected. Once developed, the presence of resident humans and road vehicles in the study area has the potential to contribute to increased background noise levels.

6.2.9 Predation by Feral Animals

Feral animals such as dogs, cats and red foxes are already present in the study area. The proposal may result in an increase in the density of dogs and cats in the absence of restrictions on pet ownership, thereby directly impacting fauna through predation. The proposal has the potential to aid in the dispersal of feral animals in the study area through road, trail and track construction.

Various measures are proposed to minimise predation by feral animals as a result of the proposed development. These measures, which are documented in *Section 7.7*, include educating residents about responsible pet ownership and contributing funds towards the preparation of a vertebrate pest animal management plan by Port Stephens Council or DEC.

6.2.10 Weed Dispersal

Weeds are currently a problem in the study area, particularly in swamp forest where densities are highest (ERM 2005c). Weed invasion into low nutrient environments such as dry sclerophyll forest is a potential impact, given this vegetation community will be fragmented by the proposed development.

Most weeds produce prolific numbers of seeds or other propagules. They typically benefit from disturbance to soils or native vegetation through rapid

colonisation of bare substrates and disturbance niches, although some are aggressive and can invade relatively undisturbed vegetation. Clearing and fires can trigger major outbreaks of weeds. Such outbreaks often occur from seeds that have laid dormant in the soil until the disturbance provides the conditions necessary for germination. Weeds can spread from infested areas to weed free areas via wind or water or by travelling as seeds or propagules on vehicles, people or animals from one place to another. A reduction in tree cover and the undertaking of earthworks are likely to facilitate weed dispersal and establishment.

6.2.11 Indirect Impacts

Edge effects associated with habitat loss are a potential impact. Edge effects are likely to be greatest in the dry sclerophyll open forest due to the large interface area between this community and the development footprint, although there is potential for edge effects within the swamp forest, including the EEC 'swamp sclerophyll forest on coastal floodplains of the NSW North Coast, Sydney Basin and south east corner bioregions'. Edge effects may increase weed encroachment into affected species habitat and reduce the quality of habitat. It may also involve increased noise and light penetration that may interfere with the behaviour of some species, particularly birds and arboreal mammals. The loss of vegetation through clearing may increase wind erosion of exposed sand dunes in the study area, although the absence of streams and drainage lines in the study area reduces the potential issue of sedimentation.

The subdivision of Fern Bay Estate will be carried out under Community Title. This means that a Community Association will be established to implement a Community Management Plan (CMP) that will be prepared for the estate. The CMP will not only contain design guidelines for future urban development but will also identify how the open space areas and the recreational and community facilities will be managed by the Community Association. Therefore it is the Community Association (established via Community Title) that will be responsible for ensuring that appropriate action is taken to minimise edge effects, the spread of weeds and predation by feral animals, and to maintain asset protection zones and the public areas of the estate.

6.2.12 Key Threatening Processes

The following key threatening process (TSC Act) is considered relevant to this proposal:

- clearing of native vegetation.

The clearing of native vegetation has the potential to impact all species identified as affected species, and is therefore relevant to each species. The purpose of this SIS is to assess impacts and recommend mitigation and offset

measures to minimise the net impact that clearing native vegetation will have in the locality. Other key threatening processes that are relevant include:

- invasion of native plant communities by exotic perennial grasses;
- invasion of native plant communities by bitou bush (*Chrysanthemoides monilifera*);
- high frequency fire resulting in the disruption of life cycle processes in plants and animal and loss of vegetation structure and composition;
- predation by the fox (*Vulpes vulpes*);
- predation by the feral cat (*Felis catus*);
- predation by the plague minnow (*Gambusia holbrooki*);
- competition and grazing by the feral European rabbit (*Oryctolagus cuniculus*);
- competition from feral honeybees (*Apis mellifera*); and
- removal of dead wood and dead trees.

Clearing of native vegetation

The proposal will clear approximately 70.2 hectares of native vegetation from the study area. This includes 9.7 hectares of swamp forest (preferred koala habitat), 15.0 hectares of wet heath (preferred koala habitat) and 45.5 hectares of dry sclerophyll open forest.

Invasion of native plant communities by exotic perennial grasses

Exotic perennial grasses are present in disturbed areas within the study area, particularly where vegetation has been cleared and in associated access tracks, including the powerline easement.

Invasion of native plant communities by bitou bush (Chrysanthemoides monilifera)

Bitou bush is present in the study area, especially along tracks and other cleared areas. The weed has the potential to spread over hind dunes seaward of the 100 year dune hazard line, particularly with increased human presence associated with the proposal.

As the estate will be managed under Community Title, the Community Association (using funding provided by the residents of the estate) will be responsible for ensuring ongoing weed management of the public areas of the estate. The Community Association will also be responsible for taking

appropriate action to address other key threatening processes such as predation by feral animals and bushfires.

High frequency fire resulting in the disruption of life cycle processes in plants and animal and loss of vegetation structure and composition

The proposal will increase fire sources in the study area. However, the frequency of bushfire is likely to decrease due to fire management (see ERM 2005b). Development and management of the bushfire hazard interface and frequent monitoring of bushfire threat by residents is likely to reduce the frequency of fires in the study area.

Predation by the red fox

The proposal may increase predation on fauna by the fox through the construction of trails and opening areas of bushland.

Predation by the feral cat

Feral cats are known to inhabit the study area. Domestic cats introduced into the proposed residential estate by future home owners may become feral.

Predation by the plague minnow

The introduced plague minnow is known to eat the eggs and tadpoles of threatened frog species in New South Wales. However, this species is not present in the wetlands in the study area.

Competition and grazing by the feral European rabbit

The proposal may increase the occurrence of the European rabbit in the study area, due to the clearance of vegetation.

Competition from feral honeybees

Feral honeybees compete with hollow-dependent birds and mammals for large tree hollows. They may also affect seed set in several plant species and displace native pollinators. The presence of feral honeybees in the study area has not been determined.

Removal of dead wood and dead trees

Clearance of vegetation will remove dead wood and dead trees from areas designated for residential development in the study area. Some dead trees may contain hollows suitable as roost and den sites for affected species such as hollow-dependent birds and mammals. Dead wood on the ground

provides habitat for ground-dwelling fauna including spotted-tailed quoll and prey species for owls.

6.2.13 Threat Abatement Plans

The 'predation by the red fox' threat abatement plan (TSC Act) is considered relevant to this proposal. This plan examines the impacts of red foxes on native animals and outlines the management actions necessary to abate the threat. The bitou bush draft threat abatement plan is also considered relevant, but remains to be finalised. The draft plan calls for a fundamental change in bitou bush control for the conservation of native plant communities in New South Wales.

6.2.14 Cumulative Impacts

The proposal represents one potential source of habitat loss in the locality. Currently, there are several other developments proposed that have the potential to contribute to an overall reduction in habitat along Stockton Bight. The approved subdivision in the study area will remove approximately 22.8 hectares of native vegetation, including swamp forest, wet heath and dry sclerophyll open forest (see *Table 2.1*).

The approved subdivision will remove an area of the endangered ecological community 'swamp sclerophyll forest on coastal floodplains of the New South Wales north coast, Sydney basin and south east corner bioregions' to accommodate an access road that links to Fullerton Cove Road. Boral Resources (NSW) Pty Ltd currently have approval to clear 44.5 hectares of dry sclerophyll open forest to the north and east of the study area, as part of its sandmining. Both approvals have the potential to affect threatened species and ecological communities.

The squirrel glider (*Petaurus norfolcensis*) is the most affected threatened species from these two proposals/activities. Boral currently undertake annual surveys to monitor the population of squirrel gliders on their holdings. Gunninah Consultants (1996 revised 1997) prepared the eight-part test to assess the impact of the proposal on threatened species. They identified the squirrel glider population in the study area as representing "a viable local population" which could potentially be adversely affected by the proposed development to a significant extent. Gunninah Consultants added that the proposal may result in a portion of the local population being rendered non-viable as a result of habitat removal, but did not conclude that a species impact statement was required.

Within the context of current proposals and activities within the fragment of coastal woodland in Stockton Bight, the proposal has the potential to result in the extinction of a viable local population. Hence, a species impact statement has been prepared that includes the squirrel glider. A number of other species have the potential to be affected by the cumulative impact of sand extraction and residential development in the locality. As such, the squirrel glider

should be considered as a "flagship species" for the conservation of other threatened species and ecological communities in the study area and wider Stockton Bight area, particularly within the Fern Bay fragment.

6.3 *IMPACTS ON AFFECTED SPECIES AND ECOLOGICAL COMMUNITIES*

The proposal will impact on affected species and ecological communities in different ways according to each species' individual habitat requirements, local and regional abundance, presence in the study area and ability to respond to disturbance. The loss of affected species habitat is the most significant impact, given the areas to be cleared for construction of the proposal (see *Table 6.1*). The following section provides information on the conservation status of each affected species, key threatening processes and threat abatement plans considered relevant to each species, and whether a recovery plan has been prepared or is in preparation. The aim of recovery plans in the TSC Act is to recover threatened species, populations and ecological communities to a position of viability in nature in New South Wales. An assessment of the proposal is presented for each species and ecological community, based on the impacts discussed in the following.

Table 6.1 Loss of Affected Species Habitat in the Study Area (approximate hectares)

Potential habitat	Area of known or potential habitat to be cleared (hectares)	Affected Species, Species Guild or Ecological Community
dry open forest[1]	45.5	*Diuris* spp. orchids heath wrinklewort woodland birds
swamp forest[2]	9.7	dwarf kerrawang nectivorous birds frugivorous birds frogs
dry open forest[3] swamp forest[4] wet heath[5]	70.2	hollow-dependent birds raptor birds cave roosting bats tree hollow roosting bats hollow-dependent mammals koala grey-headed flying-fox
wet heath	15.0	*Eucalyptus parramattensis* subsp. *decadens* heath wrinklewort

1. foraging and nesting habitat for the grey-crowned babbler
2. foraging habitat for birds; breeding habitat for frogs
3. nest, roost and den sites for hollow-dependent birds and mammals, and tree hollow roosting bats
4. foraging habitat for all species including preferred koala habitat
5. preferred koala habitat; foraging habitat for all species

An assessment of the conservation status of affected flora species follows Briggs and Leigh (1996). Individual fauna species are grouped into ecological guilds, which are based on species having similar ecological requirements, at risk from the same threats and likely to be impacted in similar ways by the proposed residential development.

6.3.1 Swamp Sclerophyll Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions

Local, Regional and State Conservation status

Swamp sclerophyll forest is listed as an endangered ecological community. The extent of its distribution prior to European settlement has not been mapped across its entire range. It is estimated that the current distribution of swamp sclerophyll forest on coastal floodplains is likely to be less than 30 percent of its original range (NPWS 2004). The community has been extensively cleared and modified. In the Lower Hunter and Central Coast region, approximately 30 percent of the original area of swamp mahogany – paperbark forest was estimated to remain in the 1990s (LHCC Councils 2003). Land clearing continues to threaten the community. Few remnants of swamp sclerophyll forest remain unaffected by weeds as a result of dumping of rubbish and garden refuse, polluted runoff from urban areas and the construction of roads (NPWS 2004). Given its current range and the processes that threaten remaining remnants, swamp sclerophyll forest on coastal floodplains is likely to become extinct in New South Wales unless the circumstances and factors threatening its survival or evolutionary development cease to operate (NPWS 2004). Nelson Bay Road currently fragments a large area of swamp forest in the locality.

Relevant Key Threatening Processes

Key threatening processes considered to be relevant to the ecology of this species in the study area include:

- invasion of native plant communities by exotic perennial grasses;
- invasion of native plant communities by bitou bush (*Chrysanthemoides monilifera*); and
- high frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition.

The exotic whisky grass (*Andropogon virginicus*) and bitou bush are present in cleared and disturbed areas around the perimeter of swamp sclerophyll forest in the study area. The exotic lantana (*Lantana camara*) dominates the understorey in some areas. The community has been subjected to regular fire over the last ten years, which may increase the incidence of weed invasion and suppress recruitment of fire sensitive indigenous plant species.

Relevant Recovery Plans or Threat Abatement Plans

There is no recovery plan prepared or in preparation for swamp sclerophyll forest on coastal floodplains. The draft bitou bush threat abatement plan is considered relevant to the viability of this species in the study area and Port Stephens area.

The Community Association (established under Community Title) will be responsible for implementing the vegetation management plan for the subject site and for managing the open space areas of the site, including the areas of swamp sclerophyll forest on coastal floodplains.

Assessment of Impacts

Approximately 0.5 hectares of swamp sclerophyll forest will be cleared, although 28.0 hectares of the endangered community will be retained in the minimum 200 metre wide ecological corridor and within land zoned 7(a). Swamp sclerophyll forest retained in the study area, however, will be fragmented by the two ingress roads across the corridor. Additional impacts to retained areas may occur from weed invasion. A reduction in fire frequency, which is anticipated during the operation phase of the proposal, will improve the quality (ie composition, structure and health) of this community in the study area.

6.3.2 Rough doubletail (Diuris praecox)

Local, Regional and State Conservation status

Rough doubletail has a risk code of 2VC- indicating that the species' geographic range is less than 100 kilometres, it is vulnerable with at least one population reserved in a national park or other proclaimed reserve(s), and the reserved population size is not adequately known. It is listed in the TSC Act as vulnerable. In the Lower Hunter and Central Coast Region habitat is provided in coastal foothills spotted gum – ironbark forest, coastal plains smooth-barked apple woodland and coastal headland complex (Murray *et al* 2002). It is known from Glenrock State Recreation Area (probably less than 200 plants, Bell 1998), Munmorah State Recreation Area (unknown population size), Tomaree National Park (unknown population size, Bell 1997) and Wyrrabalong National Park (approximately 300 plants).

Relevant Key Threatening Processes

Key threatening processes considered to be relevant to the ecology of this species in the study area include:

- invasion of native plant communities by exotic perennial grasses;

- invasion of native plant communities by bitou bush (*Chrysanthemoides monilifera*);
- competition from feral honeybees; and
- high frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition.

It is not known to what extent feral honeybees would affect rough doubletail, as this species is pollinated by small native bees that may be displaced if feral honeybees are present in the study area (Riley and Banks 2002).

Relevant Recovery Plans or Threat Abatement Plans

There is no recovery plan prepared or in preparation for rough doubletail. The draft bitou bush threat abatement plan is considered relevant to the viability of this species in the study area and Port Stephens area.

Assessment of Impacts

The proposal will clear approximately 45.5 hectares of dry sclerophyll open forest that is potential habitat for rough doubletail. However, the population recorded is restricted to habitat in the northern portion of the study area, which will be conserved in land currently zoned 1(a) and will not be developed. Therefore, potential impacts from habitat loss will not be significant. Retention of this area will ensure that habitat for the rough doubletail in the study area is contiguous with habitat to the north on Boral's holdings. The proposal will reduce the high fire frequency in the study area, thereby improving conditions for the growth and survival of this species. The implementation of the vegetation management plan will reduce competition between rough doubletail and weed species and exotic grasses for light and nutrients. The Community Association (established under Community Title) will be responsible for implementing the vegetation management plan and for managing the open space areas of the site (including the area where *Diuris praecox* was recorded).

6.3.3 Sand doubletail (Diuris arenaria)

Local, Regional and State Conservation status

Sand doubletail has a risk code of 2VC- indicating that the species' geographic range is less than 100 kilometres, it is vulnerable with at least one population reserved in a national park or other proclaimed reserve(s), and the reserved population size is not adequately known. It is listed in the TSC Act as endangered. In the Lower Hunter and Central Coast Region habitat is provided in coastal sand apple – blackbutt forest (Murray *et al* 2002). It is known from Tomaree National Park (unknown population size) (Bell 1997).

Approximately 160 plants were recorded in an electricity easement in Tomaree National Park (ERM 2003a).

Relevant Key Threatening Processes

Key threatening processes considered to be relevant to the ecology of this species include:

- invasion of native plant communities by exotic perennial grasses;
- invasion of native plant communities by bitou bush (*Chrysanthemoides monilifera*);
- competition from feral honeybees; and
- high frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition.

It is not known to what extent feral honeybees would affect sand doubletail as it is likely to be pollinated by native bees.

Relevant Recovery Plans or Threat Abatement Plans

There is no recovery plan prepared or in preparation for sand doubletail. The draft bitou bush threat abatement plan is considered relevant to the viability of this species in the Port Stephens area.

Assessment of Impacts

The proposal will clear approximately 45.5 hectares of dry sclerophyll open forest that is potential habitat for sand doubletail. However, no populations were recorded in the study area. Dry sclerophyll open forest will be conserved in land currently zoned 1(a) and will not be developed. Therefore, potential impacts from habitat loss will not be significant. The proposal is likely to reduce the high fire frequency in the study area, thereby improving conditions for the growth and survival of this species. The implementation of the vegetation management plan will reduce competition between sand doubletail and weed species and exotic grasses for light and nutrients. The Community Association (established under Community Title) will be responsible for implementing the vegetation management plan and for managing the open space areas of the site.

6.3.4 *Leafless tongue orchid (Cryptostylis hunteriana)*

Local, Regional and State Conservation status

Leafless tongue orchid has a risk code of 3VC- indicating that that the species' geographic range is greater than 100 kilometres, it is vulnerable with at least one population reserved in a national park or other proclaimed reserve(s), and the reserved population size is not adequately known. It is listed in the TSC Act as vulnerable. In the Lower Hunter and Central Coast Region habitat is provided in coastal plains smooth-barked apple woodland, coastal plains scribbly gum woodland, Nerong smooth-barked apple forest and coastal sand apple – blackbutt forest (Murray *et al* 2002). It is known from Ku-ring-gai National Park (unknown population size) but is not known to be reserved in the Port Stephens area.

Relevant Key Threatening Processes

Key threatening processes considered to be relevant to the ecology of this species include:

- invasion of native plant communities by exotic perennial grasses;
- invasion of native plant communities by bitou bush (*Chrysanthemoides monilifera*); and
- high frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition.

Sand doubletail is pollinated by male *Lissoplima excelsa* wasps. It is not known if these wasps compete with feral honeybees.

Relevant Recovery Plans or Threat Abatement Plans

There is no recovery plan prepared or in preparation for leafless tongue orchid. The draft bitou bush threat abatement plan is considered relevant to the viability of this species in the Port Stephens area.

Assessment of Impacts

The leafless tongue orchid was not recorded in the study area and is not likely to be present due to the lack of preferred habitat. Therefore, no impacts from the proposal are anticipated on a population of this species.

6.3.5 *Dwarf kerrawang (Rulingia prostrata)*

Local, Regional and State Conservation status

Dwarf kerrawang has a risk code of 2ECi indicating that it is an endangered species with a geographic range less than 100 kilometres, and at least one population reserved in a national park or other proclaimed reserve(s), although less than 1000 plants are known to occur within a conservation reserve(s). It is listed in the TSC Act as endangered. In the Lower Hunter and Central Coast Region habitat is provided in coastal sand apple – blackbutt forest and coastal sand wallum woodland – heath (Murray *et al* 2002). It is not currently reserved in the region, although it is afforded some protection within Hunter Water reserves in the Tomago sandbeds.

Relevant Key Threatening Processes

Key threatening processes considered to be relevant to the ecology of this species include:

- invasion of native plant communities by exotic perennial grasses;
- competition from feral honeybees; and
- invasion of native plant communities by bitou bush (*Chrysanthemoides monilifera*).

This species is also threatened by the presence of lantana within swamp forest. Lantana reduces the amount of open ground cover which dwarf kerrawang prefers in the locality. It is not known to what extent the native pollinator of dwarf kerrawang competes with feral honeybees.

Relevant Recovery Plans or Threat Abatement Plans

There is no recovery plan prepared or in preparation for dwarf kerrawang. The draft bitou bush threat abatement plan is considered relevant to the viability of this species in the Port Stephens area.

Assessment of Impacts

The proposal will clear approximately 9.7 hectares of swamp forest that is potential habitat for dwarf kerrawang. However, the species was not recorded in the study area. Swamp forest will be conserved within the minimum 200 metre wide ecological corridor and within land zoned 7(a). Therefore, potential impacts from habitat loss will not be significant. The proposal is likely to reduce the high fire frequency in the study area, thereby improving conditions for the growth of this species. However, a natural fire regime is required for this species, as it occurs in sub-climax ecological communities. The implementation of the vegetation management plan will

reduce impacts from weed species such as lantana. The Community Association (established under Community Title) will be responsible for implementing the vegetation management plan and for managing the open space areas of the site.

6.3.6 Heath wrinklewort (Rutidosis heterogama)

Local, Regional and State Conservation status

Heath wrinklewort has a risk code of 2VCa indicating that it is a vulnerable species with a geographic range less than 100 kilometres. It is listed in the TSC Act as vulnerable. It is considered to be adequately reserved in Torrington State Recreation Area.

Relevant Key Threatening Processes

Key threatening processes considered to be relevant to the ecology of this species include:

- invasion of native plant communities by exotic perennial grasses;
- invasion of native plant communities by bitou bush (*Chrysanthemoides monilifera*); and
- high frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition.

Relevant Recovery Plans or Threat Abatement Plans

There is no recovery plan prepared or in preparation for heath wrinklewort. The draft bitou bush threat abatement plan is considered relevant to the viability of this species in the Port Stephens area.

Assessment of Impacts

The proposal will clear approximately 45.5 hectares of dry sclerophyll open forest and 15.0 hectares of wet heath that is potential habitat for heath wrinklewort. However, the species was not recorded in the study area. Approximately 69.5 hectares of dry sclerophyll open forest will be conserved in the study area, and approximately 7.0 hectares of wet heath will be conserved in land zoned 1(a). Therefore, potential impacts from habitat loss will not be significant. The proposal is likely to reduce the high fire frequency in the study area, thereby improving conditions for the growth and recruitment of this species. The implementation of the vegetation management plan will reduce competition of seedlings with exotic weeds and grasses. The Community Association (established under Community Title)

will be responsible for implementing the vegetation management plan and for managing the open space areas of the site.

6.3.7 *Eucalyptus parramattensis* subsp. *decadens*

Local, Regional and State Conservation status

Eucalyptus parramattensis subsp. *decadens* has a risk code of 2V indicating that it is a vulnerable species with a geographic range less than 100 kilometres. It is listed in the TSC Act as vulnerable. In the Lower Hunter and Central Coast Region habitat is provided in lower Hunter spotted gum – ironbark forest, coastal sand apple – blackbutt forest, Kurri sand swamp woodland, heath, swamp mahogany – paperbark forest and swamp oak rushland forest (Murray *et al* 2002). The species is known from the Werakata National Park (Bell 2004) and is currently afforded some protection within Hunter Water reserves in the Tomago sandbeds.

Relevant Key Threatening Processes

Key threatening processes considered to be relevant to the ecology of this species include:

- invasion of native plant communities by exotic perennial grasses;
- invasion of native plant communities by bitou bush (*Chrysanthemoides monilifera*); and
- high frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition.

Relevant Recovery Plans or Threat Abatement Plans

There is no recovery plan prepared or in preparation for *Eucalyptus parramattensis* subsp. *decadens*. The draft bitou bush threat abatement plan is considered relevant to the viability of this species in the Port Stephens area.

Assessment of Impacts

The proposal will clear approximately 15.0 hectares of wet heath that is potential habitat for *Eucalyptus parramattensis* subsp. *decadens*. Four individual trees of *Eucalyptus parramattensis* hybrids were recorded in wet heath at two locations. Both locations are within the development footprint and so the known local population of hybrid *Eucalyptus parramattensis* in the study area will be destroyed. Given that there are only two known locations in the study area, and given that the nearest known population occurs at Newcastle airport, the local population should be considered as a significant repository of genetic diversity for *Eucalyptus parramattensis* subsp. *decadens* in the locality.

Development has the potential to further isolate the population in the study area.

Approximately 7.0 hectares of wet heath will be conserved in land zoned 1(a), which will be contiguous with wet heath to the north on Boral's holdings, however, the species was not recorded in this area. The proposal will reduce the high fire frequency in the study area, thereby improving conditions for the growth and recruitment of this species. The implementation of the vegetation management plan will reduce competition of seedlings with exotic weeds and grasses. The Community Association (established under Community Title) will be responsible for implementing the vegetation management plan and for managing the open space areas of the site.

6.3.8 Camfield's stringybark (Eucalyptus camfieldii)

Local, Regional and State Conservation Status

Camfield's stringybark has a risk code of 2VCi indicating that it is a vulnerable species with a geographic range less than 100 kilometres. At least one population is reserved in a national park of other proclaimed reserve(s), however, less than 1000 plants are known to occur within a conservation reserve(s). In the Lower Hunter and Central Coast Region habitat is provided in exposed Hawkesbury woodland, Hawkesbury coastal Banksia woodland, scrub, coastal sand wallum woodland – heath, coastal wet sand cyperoid heath, Norah Head endangered heath – woodland and coastal sand scrub. The species is known from Awabakal Nature Reserve (less than 25 plants, Bell 1998), Brisbane Water National Park (unknown population size) and Popran National Park (unknown population size)(Murray *et al* 2002).

Relevant Key Threatening Processes

Key threatening processes considered to be relevant to the ecology of this species include:

- invasion of native plant communities by exotic perennial grasses;
- invasion of native plant communities by bitou bush (*Chrysanthemoides monilifera*); and
- high frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition.

Relevant Recovery Plans or Threat Abatement Plans

There is no recovery plan prepared or in preparation for Camfield's stringybark. The draft bitou bush threat abatement plan is considered relevant to the viability of this species in the Port Stephens area.

Assessment of Impacts

The proposal will clear approximately 45.5 hectares of dry sclerophyll open forest that is potential habitat for Camfield's stringybark. However, no populations were recorded in the study area. Dry sclerophyll open forest will be conserved in land currently zoned 1(a) and will not be developed. Therefore, potential impacts from habitat loss will not be significant. The proposal is likely to reduce the high fire frequency in the study area, thereby improving conditions for the growth and recruitment of this species.

6.3.9 Netted bottlebrush (Callistemon linearifolius)

Local, Regional and State Conservation status

Netted bottlebrush has a risk code of 2RCi indicating that it is a rare plant with a geographic range less than 100 kilometres and at least one population is reserved in a national park or other proclaimed reserve(s). Less than 1,000 plants are known to occur within a conservation reserve(s). It is listed in the TSC Act as vulnerable. Netted bottlebrush is known from Ku-ring-gai Chase NP, Lion Island NR, Spectacle Island NR and Yengo NP (NPWS 1999c). There are no records in the local Tomaree NP. In the Lower Hunter and Central Coast Region habitat is provided in sheltered dry Hawkesbury woodland and swamp mahogany – paperbark forest (Murray *et al* 2002). It is known from Brisbane Waters NP, Munmorah State Recreation Area and Lower Hunter NP (Murray *et al* 2002).

Relevant Key Threatening Processes

Key threatening processes considered to be relevant to the ecology of this species include:

- invasion of native plant communities by exotic perennial grasses;
- invasion of native plant communities by bitou bush (*Chrysanthemoides monilifera*);
- competition from feral honeybees; and
- high frequency fire resulting in the disruption of life cycle processes in plants and animal and loss of vegetation structure and composition.

Feral honeybees may affect the reproductive cycle of netted bottlebrush.

Relevant Recovery Plans or Threat Abatement Plans

There is no recovery plan prepared or in preparation for netted bottlebrush. The draft bitou bush threat abatement plan is considered relevant to the viability of this species in the Port Stephens area.

Assessment of Impacts

The proposal will clear approximately 45.5 hectares of dry sclerophyll open forest that is potential habitat for netted bottlebrush. However, no populations were recorded in the study area. Dry sclerophyll open forest will be conserved in land currently zoned 1(a) and will not be developed. Therefore, potential impacts from habitat loss will not be significant. The proposal is likely to reduce the high fire frequency in the study area, thereby improving conditions for the growth and survival of this species. The implementation of the vegetation management plan will reduce competition between netted bottlebrush and exotic weed and grass species for light and nutrients. The Community Association (established under Community Title) will be responsible for implementing the vegetation management plan and for managing the open space areas of the site.

6.3.10 Hollow-dependent Birds

- glossy black-cockatoo (*Calyptorhynchus lathamii*);
- barking owl (*Ninox connivens*);
- powerful owl (*Ninox strenua*); and
- masked owl (*Tyto novaehollandiae*).

Local, Regional and State Conservation status

The glossy black-cockatoo is reserved in Wambina Nature Reserve (NR), Wallaroo NR, Watagans National Park (NP), Brisbane Water NP, Dharug NP, Popran NP and Bouddi NP (Murray *et al* 2002). It is listed as near threatened in the Action Plan for Australian Birds (Garnett and Crowley 2000) and vulnerable in the TSC Act.

The barking owl is known from Dharug NP and Wambina NR (Murray *et al* 2002). The powerful owl is known from Wallaroo NR, Tilligerry NR, Brisbane Water NP, Munmorah State Recreation Area (SRA), Wambina NR, Popran NP, Yengo NP and Dharug NP (Murray *et al* 2002). The masked owl is known from Brisbane Water NP, Dharug NP, Bouddi NP, Tomaree NP, Glenrock SRA, Yengo NP and Wallaroo NP (Murray *et al* 2002). The masked and barking owls are listed as near threatened (Garnett and Crowley 2000). All three species are listed as vulnerable in the TSC Act.

Relevant Key Threatening Processes

Key threatening processes considered to be relevant to the ecology of these species include:

- invasion of native plant communities by exotic perennial grasses: may reduce the visibility of owl prey species;
- invasion of native plant communities by bitou bush (*Chrysanthemoides monilifera*): may reduce the visibility of owl prey species;
- high frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition: may reduce prey populations and destroy roost and nest sites, suppresses recruitment of *Allocasuarina*;
- predation by the fox: on young birds if they are on the ground;
- predation by the feral cat: on young birds in nests and on the ground, and on owl prey species;
- competition from feral honeybees: that may reduce the availability of large tree hollows as nest sites; and
- removal of dead wood and dead trees: may reduce owl prey populations through loss of habitat and may impact owls through loss of roosting and nesting sites.

Relevant Recovery Plans or Threat Abatement Plans

There is no recovery plan prepared or in preparation for glossy black-cockatoo, powerful or masked owl. A draft recovery plan for the barking owl has been prepared (NPWS 2003a). There is presently insufficient knowledge to predict the ability of the species to recover in the long-term in New South Wales. Habitat loss and degradation is the major threatening process for the barking owl.

The draft bitou bush threat abatement plan is considered relevant to the viability of this species in the Port Stephens area. The removal of bitou bush would increase the ability of the owl species (particularly masked owl) to detect prey in the study area.

Assessment of Impacts

The proposal will remove approximately 70.2 hectares of potential foraging, roosting and nesting habitat for the masked and powerful owl, which are known to occur in the study area. The loss of habitat will affect prey populations, including possums and squirrel gliders that are hunted by the powerful owl, and small ground mammals such as bush rat that are hunted by the masked owl. No known nest sites will be cleared or disturbed by the

proposal. A 100 metre buffer will be established around the known powerful owl roost tree in which no clearing or disturbance will be permitted. Approximately 495 hollow-bearing trees will be cleared, that are potential roost trees for the owl species or their prey, such as the common ringtail possum and squirrel glider. However, approximately 777 hollow-bearing trees (54 percent of the total habitat tree estimate) will be retained. The proposal will remove marginal foraging habitat for the glossy black-cockatoo although no known habitat of the barking owl will be removed.

An increase in fox numbers may impact the powerful and masked owl through predation on young birds. Weed invasion, particularly bitou bush, may reduce the foraging ability of the masked owl in dry sclerophyll open forest. A reduction in fire frequency may result in an increase in prey population numbers in the study area. Noise has the potential to impact on owl roost and nest sites. However, noise may have negligible impact on roost sites of the powerful owl, as this species is known to roost in urban and light manufacturing estates (eg Gateshead industrial estate, Naomi Buchhorn, ERM pers. obs.).

Therefore, potential impacts from habitat loss and increases in feral animals will be significant for the powerful owl and masked owl. Noise and weed invasion are potential significant impacts to the masked owl. The glossy black-cockatoo and barking owl will not be significantly affected by the proposal.

To minimise impacts on these species the Community Association will implement the Vegetation Management Plan that has been prepared for the estate, educate residents about responsible pet ownership and contribute funds towards the preparation of a vertebrate pest animal management plan by Port Stephens Council or DEC.

6.3.11 Raptor Birds

- square-tailed kite (*Lophoictinia isura*); and
- osprey (*Pandion haliaetus*).

Local, Regional and State Conservation status

The square-tailed kite is not represented in conservation reserves in the region. The osprey has been recorded in Munmorah SRA, Tomaree NP, Brisbane Water NP, Cockle Bay NR. Most nest records occur on land outside of conservation reserves (Clancy 1991). Both species are listed as vulnerable in the TSC Act.

Relevant Key Threatening Processes

Key threatening processes considered to be relevant to the ecology of these species include:

- high frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition: may destroy potential perch and nest sites;
- predation by the fox: on young birds if they are on the ground;
- predation by the feral cat: on young birds in nests; and
- removal of dead wood and dead trees: may impact through loss of potential nest sites.

Relevant Recovery Plans or Threat Abatement Plans

There is no recovery plan prepared or in preparation for the square-tailed kite and osprey. No threat abatement plans are considered relevant to these species.

Assessment of Impacts

The loss of approximately 70.2 hectares of habitat throughout the study area reduces the number of potential nest sites for these species. Approximately 45.5 hectares of potential foraging habitat for the square-tailed kite will be removed. However, the square-tailed kite and osprey were not recorded in the study area. The proposal may result in an increase in the number of foxes and feral cats, however, no nest sites were recorded and the species are not likely to occur in the study area. Therefore, potential impacts from habitat loss and increases in feral animals will not significantly affect these species.

6.3.12 Woodland Birds

- brown treecreeper (eastern subspecies) (*Climacteris picumnus victoriae*); and
- grey-crowned babbler (eastern subspecies) (*Pomatostomus temporalis temporalis*).

Local, Regional and State Conservation status

The brown treecreeper has not been recorded in conservation reserves in the lower Hunter region, although the grey-crowned babbler has been recorded in Seaham Swamp Nature Reserve (Murray *et al* 2002). Both species are listed as vulnerable in the TSC Act and as near threatened (Garnett and Crowley 2000).

Relevant Key Threatening Processes

Key threatening processes considered to be relevant to the ecology of these species include:

- high frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition: may destroy nest sites and reduce insect populations;
- predation by the fox: on young birds if they are on the ground;
- predation by the feral cat: on young birds in nests; and
- removal of dead wood and dead trees: may impact through loss of potential nest sites.

Relevant Recovery Plans or Threat Abatement Plans

There is no recovery plan prepared or in preparation for the brown treecreeper and grey-crowned babbler. No threat abatement plans are considered relevant to these species.

Assessment of Impacts

Approximately 45.5 hectares of potential foraging and nesting habitat for these species will be removed. However, the majority of this habitat is unsuitable for these species due to its floristic structure. An area of habitat for the grey-crowned babbler is present in the north east of the study area, however, this habitat will be retained and impacts are not anticipated. Therefore, potential impacts from habitat loss will not be significant. Potential increases in fox and feral cat numbers may decrease the survival of grey-crowned babblers.

6.3.13 Bush Stone-curlew

Local, Regional and State Conservation status

The bush stone-curlew is known from Riley's Island Nature Reserve and Pelican Island Nature Reserve (Murray *et al* 2002). It is therefore under-represented in conservation reserves in the region. A local population has been reported from Lemon Tree Passage, although its viability is uncertain due to land tenure. It is listed as endangered in the TSC Act and near threatened by Garnett and Crowley (2000).

Relevant Key Threatening Processes

Key threatening processes considered to be relevant to the ecology of this species include:

- invasion of native plant communities by exotic perennial grasses: renders habitat unsuitable;

- invasion of native plant communities by bitou bush (*Chrysanthemoides monilifera*): renders habitat unsuitable;
- high frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition: may destroy nest sites and prey populations, and alter habitat suitability;
- predation by the fox: thought to be a major cause of the species' decline on the mainland;
- predation by the feral cat: on the species; and
- removal of dead wood and dead trees: may impact through loss of potential roost and nest sites.

Relevant Recovery Plans or Threat Abatement Plans

A draft recovery plan has been prepared for the bush stone-curlew in New South Wales (NPWS 2003b). Evidence suggests that the species is capable of increasing in numbers if the general level of human disturbance is low, predation by introduced predators is reduced and suitable habitat is available. The 'predation by the red fox' threat abatement plan is considered relevant to this species, as the red fox is the major cause of the species' decline on the mainland (NPWS 2003b).

Assessment of Impacts

Approximately 45.5 hectares of low quality habitat for the bush stone-curlew will be removed in the study area. The species was not recorded in the study area and is not likely to be present. Therefore, impacts to this species as a result of the proposal will be negligible.

6.3.14 Nectivorous Birds

- swift parrot (*Lathamus discolor*); and
- regent honey eater (*Xanthomyza phrygia*).

Local, Regional and State Conservation status

The swift parrot has been recorded in Wyrrabalong NR and Wollemi NP. The regent honeyeater has been recorded in Cockle Bay NR and Brisbane Water NP (Murray *et al* 2002). Both species are listed as endangered in the TSC Act and Action Plan for Australian Birds (Garnett and Crowley 2000). The extent of use of other conservation reserves in the region by these species during migratory periods is not known.

Relevant Key Threatening Processes

Key threatening processes considered to be relevant to the ecology of these species include:

- invasion of native plant communities by exotic perennial grasses: renders habitat unsuitable;
- invasion of native plant communities by bitou bush (*Chrysanthemoides monilifera*): renders habitat unsuitable;
- high frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition: may destroy foraging sites, and alter habitat suitability;
- predation by the fox: on the species; and
- predation by the feral cat: on the species.

Relevant Recovery Plans or Threat Abatement Plans

Both the regent honeyeater and swift parrot have national recovery plans prepared, although no state plans exist (Swift Parrot Recovery Team 2000; Menkhorst *et al* 1999). The national recovery plan for the swift parrot addresses the long-term viability of breeding habitat in Tasmania and the threats to non-breeding habitat on the mainland. The plan for the regent honeyeater addresses the long-term persistence of populations, particularly those in core breeding areas. The 'predation by the red fox' threat abatement plan is considered relevant to these species.

Assessment of Impacts

Approximately 9.7 hectares of swamp forest containing foraging habitat for both species will be removed from the study area. However, approximately 30.5 hectares will be retained in an ecological corridor and land zoned 7(a). This will retain a significant area of swamp mahogany in the study area and so potential impacts from habitat loss will not be significant. Both species do not nest in the region and therefore impacts to breeding habitat will not occur. A reduction in fire frequency is likely to improve recruitment of swamp mahogany in the study area. Noise is not likely to affect foraging behaviour of both species as they are known to feed on flowering trees in suburban areas. Potential increases in foxes and feral cat numbers will increase the risk of predation.

6.3.15 Frugivorous Birds

- wompoo fruit-dove (*Ptilinopus magnificus*);
- rose-crowned fruit-dove (*Ptilinopus regina*); and

- superb fruit-dove (*Ptilinopus superbus*).

Local, Regional and State Conservation status

The wompoo fruit-dove and rose-crowned fruit-dove have been recorded in John Gould NR. The superb fruit-dove has been recorded in Wyrrabalong NR and Brisbane Water NP. All three species are listed as vulnerable in the TSC Act.

Relevant Key Threatening Processes

Key threatening processes considered to be relevant to the ecology of these species include:

- invasion of native plant communities by exotic perennial grasses: decreases recruitment of rainforest feed species;
- invasion of native plant communities by bitou bush (*Chrysanthemoides monilifera*): decreases recruitment of rainforest feed species;
- high frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition: may destroy foraging habitat and inhibit recruitment of feed species;
- predation by the fox: on the species; and
- predation by the feral cat: on the species.

Relevant Recovery Plans or Threat Abatement Plans

There are no recovery plans presently available or in preparation for the wompoo fruit-dove, superb fruit-dove and rose-crowned fruit-dove. The 'predation by the red fox' threat abatement plan is considered relevant to these species, as the three species may be eaten by foxes.

Assessment of Impacts

Approximately 9.7 hectares of swamp forest containing foraging habitat for the three species will be removed from the study area. However, approximately 30.5 hectares will be retained in an ecological corridor and land zoned 7(a). Nonetheless, the preferred habitat requirements of these species are not met within the swamp forest. The retention of the corridor will ensure that the study area can be used as a stepping stone for seasonal movements throughout the region. The construction of ingress roads will not decrease the effectiveness of this corridor for the fruit-doves. Therefore, potential impacts from habitat loss will not be significant. Potential increases in foxes and feral cat numbers will increase the risk of predation. However, various measures are proposed to minimise predation by feral animals as a result of the

proposed development. These measures, which are documented in *Section 7.7*, include educating residents about responsible pet ownership and contributing funds towards the preparation of a vertebrate pest animal management plan by Port Stephens Council or DEC.

6.3.16 Cave Roosting Bats

- large-eared pied bat (*Chalinolobus dwyeri*);
- little bentwing-bat (*Miniopterus australis*);
- eastern bentwing-bat (*Miniopterus schreibersii oceanensis*); and
- large-footed myotis (*Myotis adversus*).

Local, Regional and State Conservation status

The large-eared pied bat, little bent-wing bat, eastern bent-wing bat and large-footed myotis are expected to occur in reserves in the local area and broader region based on habitat availability and regional records. It is not known whether this species is adequately represented in conservation reserves in the region. These species have been recorded in Bouddi NP, Cockle Bay NR, John Gould NR, Karuah NR, Lake Macquarie SRA, Wallaroo NR, Dharug NP, Popran NP, Wyrrabalong NP, Glenrock SRA and Yengo NP. All four species are listed as vulnerable in the TSC Act.

Relevant Key Threatening Processes

Key threatening processes considered to be relevant to the ecology of these species include:

- high frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition: may destroy foraging habitat and reduce insect populations;
- predation by the fox: on the species; and
- predation by the feral cat: on the species.

Relevant Recovery Plans or Threat Abatement Plans

There are no recovery plans presently available or in preparation for the cave-roosting bats. The 'predation by the red fox' threat abatement plan is considered relevant to these species, as the four species may be eaten by foxes.

Assessment of Impacts

Approximately 70.2 hectares of foraging habitat for the four species will be removed. Preferred foraging habitat for the large-footed myotis (ie open water) will not be removed. Therefore, potential impacts from loss of foraging habitat will significantly affect the little bentwing-bat and eastern bentwing-bat, which were recorded in the study area. No known roost sites will be destroyed and potential roost sites are not present in the study area. Potential increases in foxes and feral cat numbers will increase the risk of predation. However, measures are proposed to minimise predation by feral animals as a result of the proposed development. These measures, which are documented in *Section 7.7*, include educating residents about responsible pet ownership and contributing funds towards the preparation of a vertebrate pest animal management plan by Port Stephens Council or DEC. There is potential for traffic strike to individuals foraging over the study area, particularly along the ingress roads in the ecological corridor. A reduction in fire frequency is likely to increase insect populations due to an increase in plant diversity.

6.3.17 Tree Hollow Roosting Bats

- hoary wattled bat (*Chalinolobus nigrogriseus*);
- eastern false pipistrelle (*Falsistrellus tasmaniensis*);
- eastern freetail-bat (*Mormopterus norfolkensis*);
- yellow-bellied sheathtail-bat (*Saccolaimus flaviventris*); and
- greater broad-nosed bat (*Scoteanax rueppellii*).

Local, Regional and State Conservation status

The hoary wattled bat is not known from any conservation reserves in the region. The record in the study area is a southern range extension. The eastern false pipistrelle is known from Brisbane Water NP, Lower Hunter NP and Wallaroo NR. The eastern freetail-bat has been recorded in Dharug NP and Tomaree NP. Known localities of greater broad-nosed bat in conservation reserves include Dharug NP, Karuah NR, Wallaroo NR, Wambina NR, Wyrrabalong NP and Yengo NP. The yellow-bellied sheathtail-bat has only been recorded from Wambina NR. All four species are listed as vulnerable in the TSC Act.

Relevant Key Threatening Processes

Key threatening processes considered to be relevant to the ecology of these species include:

- high frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition: may destroy foraging and roosting habitat and reduce insect populations;
- removal of dead wood and dead trees: may remove potential roost sites;
- predation by the fox: on the species; and
- predation by the feral cat: on the species.

Relevant Recovery Plans or Threat Abatement Plans

There are no recovery plans presently available or in preparation for the tree-roosting bats. The 'predation by the red fox' threat abatement plan is considered relevant to these species, as the four species may be eaten by foxes.

Assessment of Impacts

Approximately 70.2 hectares of foraging and potential roosting habitat for the four species will be removed. No known roost sites will be destroyed although significant numbers of potential roost sites are present in the study area. Approximately 495 potential roost trees will be cleared (see *Table 5.4*), however, approximately 777 potential roost trees (54 percent of the total habitat tree estimate) will be retained. Potential impacts from habitat loss will be significant for these species, with the exception of the eastern false pipestrelle, which was not recorded in the study area during current or previous investigations. Potential increases in foxes and feral cat numbers will increase the risk of predation. However, various measures are proposed to minimise predation by feral animals as a result of the proposed development. These measures, which are documented in *Section 7.7*, include educating residents about responsible pet ownership and contributing funds towards the preparation of a vertebrate pest animal management plan by Port Stephens Council or DEC. The loss of habitat for other microchiropteran bats, which may reduce their abundance in the study area, may reduce a food source for the greater broad-nosed bat, which is known to prey on other microchiropteran bats. There is potential for traffic strike to individuals foraging over the study area, particularly along the ingress roads in the ecological corridor. An increase in noise associated with construction may result in the abandonment of roosts situated close to the development footprint. A reduction in fire frequency is likely to increase insect populations due to an increase in plant diversity, and increase the stability of roost sites.

6.3.18 Hollow-dependent Mammals

- spotted-tailed quoll (*Dasyurus maculatus*);
- squirrel glider (*Petaurus norfolcensis*); and
- brush-tailed phascogale (*Phascogale tapoatafa*).

Local, Regional and State Conservation status

Within the Sydney Basin bioregion, conservation reserves and other areas which offer a degree of protection and contain known or potential habitat for the spotted-tailed quoll include Bouddi NP, Brisbane Water NP, Dharug NP and Popran NP.

The squirrel glider has been recorded in Wyrrabalong NR, Brisbane Water NP, Cockle Bay NR, Lake Macquarie SRA, Munmorah SRA, Moffats Swamp NR and Glenrock SRA.

The brush-tailed phascogale has been recorded in Dharug NP and Tilligerry NR. The three species are listed as vulnerable in the TSC Act.

Relevant Key Threatening Processes

Key threatening processes considered to be relevant to the ecology of these species include:

- high frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition: direct mortality of individuals, may destroy foraging and nesting habitat, den sites, reduce foraging resources including small ground mammals, insects and flowering swamp mahogany;
- competition from feral honeybees: reduces the availability of nest sites;
- removal of dead wood and dead trees: may remove potential roost and den sites, including habitat for spotted-tailed quoll prey;
- predation by the fox: on the species and prey species for the spotted-tailed quoll; and
- predation by the feral cat: on the species.

Relevant Recovery Plans or Threat Abatement Plans

There are no recovery plans presently available or in preparation for the tree-roosting bats. The 'predation by the red fox' threat abatement plan is considered relevant to these species, as the squirrel glider and brush-tailed phascogale may be eaten by foxes.

Assessment of Impacts

Approximately 70.2 hectares of habitat for hollow-dependent fauna will be removed. Therefore, potential impacts from habitat loss will be significant for the squirrel glider, although the brush-tailed phascogale and spotted-tailed quoll will not be significantly impacted because they were not recorded in the study area during current or previous investigations. The squirrel glider is

known to be susceptible to habitat degradation or loss (Suckling 1995). At least one known roost site of the squirrel glider will be destroyed, and significant numbers (approximately 495) of potential roost trees will be cleared. However, approximately 777 potential roost trees (54 percent of the total habitat tree estimate) will be retained. Preferred habitat for the squirrel glider (ie swamp forest) will be fragmented by the construction of two ingress roads through the corridor. Noise associated with construction of the proposal may result in the abandonment of nest sites close to the development footprint. A reduction in fire frequency will increase the stability of nest trees and promote an increase in prey for the brush-tailed phascogale. There is potential for traffic strike to individuals moving through the study area, particularly along the ingress roads in the ecological corridor. Potential increases in foxes and feral cat numbers will increase the risk of predation and domestic dogs may kill or injure these species. However various measures are proposed to minimise these impacts including educating residents about responsible pet ownership and contributing funds towards the preparation of a vertebrate pest animal management plan by Port Stephens Council or DEC.

Squirrel Glider Habitat Security, Fern Bay Fragment

The extent of mapped LHCCREMS vegetation in the Fern Bay fragment in each land use zone (Port Stephens Council LEP 2000) was analysed with respect to squirrel glider habitat (see *Table 6.2*).

Table 6.2 ***Extent of LHCCREMS (House 2003) Vegetation Types in Land Use Zones Within Fern Bay Fragment***

Vegetation Community	Map Unit	1a	2a	6c	7a	7c	Nelson Bay Road Corridor	Total
Fern Bay Estate								
coastal sand apple – blackbutt forest	33	16.46	91.52		24.08			**132.06**
swamp mahogany – paperbark forest	37		2.16		0.41			**2.57**
swamp oak rushland forest	40		38.87		30.15			**69.02**
Total		**16.46**	**132.55**		**54.64**			**203.65**
Fern Bay Fragment								
coastal sand apple – blackbutt forest	33	294.95	0.0	24.96	114.61	400.50	8.60	843.62
swamp mahogany – paperbark forest	37	66.94	0.0	19.33	0.57	0.06	0.04	86.94
swamp oak rushland forest	40	51.46	0.0	0.0	1.82	0.0	7.64	60.92
coastal sand scrub	50	6.85	0.0	0.0	0.0	39.40	0.0	46.25
Total		**420.2**		**44.29**	**117.0**	**439.96**	**16.28**	**1,037.73**

Key to Land Use Zone
1a – Rural
2a – Residential
6c - Special Recreation
7a – Environment Protection
7c – Environment Protection (Water Catchment)

Within the study area, the extent of suitable habitat for the squirrel glider conserved by land use zoning is approximately 24.49 hectares, or 12.02 percent of the study area. Within the Fern Bay Fragment (excluding the study area), the extent of suitable habitat for the squirrel glider conserved by land use zones is 556 hectares, or 53.6 percent. Whilst the study area conserves only a small portion of habitat for the squirrel glider (24.49 hectares), the Fern Bay Fragment conserves a more significant area of suitable habitat. However, the extent of high quality habitat (swamp mahogany – paperbark forest) is poorly represented in land use zones in both the Fern Bay Estate and Fern Bay Fragment to conserve this vegetation type. Swamp mahogany forests have been identified as regionally significant habitats for the squirrel glider and other nectar and pollen dependent fauna species, including threatened grey-headed flying-fox, regent honeyeater, swift parrot and many protected species. Swamp mahogany forests provide fauna with a winter source of nectar and pollen, often a time of limited foraging resources for many fauna species (Smith *et al* 2002).

Existing land use zones in the Fern Bay Fragment have the potential to fragment the squirrel glider population. However, all development proposals are subject to assessment in accordance with the TSC Act therefore it is unlikely that proposals which result in the fragmentation of this squirrel glider population would be approved. To the south of the study area is land zoned 7(a), which is proposed as a Regional Park. This area supports habitat for the squirrel glider. Land use zones within the study area (Fern Bay Estate) could potentially isolate this squirrel glider population however, the estate has been designed to prevent this occurring by the retention of a minimum 200 metre wide ecological corridor adjacent to Nelson Bay Road. This means that those approved lots and roads within this corridor will not be constructed. This will prevent the disturbance of approximately 7.2 hectares of vegetation. If the Master Plan for the site is approved, WPG will seek the rezoning of the 2(a) Residential zoned land within this ecological corridor as well as other parts of the site that do not form part of the proposed development footprint, to 7(a) Environment Protection.

The land to the immediate east of the study area in Boral's landholding is zoned 1(a), with a small pocket of 7(c) land for a proposed State Conservation Area. With limited security of vegetation in the Boral landholding (based on land use zones), fragmentation of the Fern Bay Fragment could potentially occur. However, it is likely that a minimum 200 metre ecological corridor would be maintained adjacent to Nelson Bay Road in any development proposal on the Boral landholding in order to secure connectivity of habitat in the Fern Bay Fragment.

6.3.19 Koala

Local, Regional and State Conservation status

Conservation reserves within the Sydney Basin bioregion that contain preferred koala habitat include Tomaree NP, Moffats Swamp NR, Tilligerry NR, Karuah NR, Worimi NR, Brisbane Water NP, Yengo NP and Watagan NP (Murray *et al* 2002). Within Port Stephens, the koala does not appear to be adequately represented in reserves, as the area of conserved koala habitat is considered by Callaghan *et al* (1994) to be too small and too fragmented.

The study area is part of the Fullerton Cove/Stockton Bight Koala Management Unit (KMU), as outlined in the CKPoM. The Fullerton Cove/Stockton Bight KMU is located in the south of the Port Stephens LGA and extends from the Hunter River just south of Heatherbrae to the Tomaree Peninsula. Many of the remaining patches of preferred koala habitat in this KMU occur as small, generally isolated patches in a predominantly cleared landscape (Port Stephens Council 2001). This represents a sub-optimal situation for the safe movement of koalas between areas of preferred koala habitat. The small size and largely fragmented nature of these patches of preferred koala habitat renders them vulnerable to edge effects.

There are large patches of supplementary koala habitat along Stockton Bight associated with large transgressive sand dunes. The quality of supplementary habitat is compromised by traffic volumes along Nelson Bay Road, and habitat loss caused by the inland movement of the sand dunes and sand mining and extraction. Proposed residential subdivision at Fern Bay has been identified as a threat to the long-term viability of supplementary koala habitat in the Fullerton Cove/Stockton Bight KMU (Port Stephens Council 2001).

Relevant Key Threatening Processes

Key threatening processes considered to be relevant to the ecology of this species include:

- high frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition: direct mortality of individuals, loss of foraging habitat;
- invasion of native plant communities by exotic perennial grasses: may inhibit recruitment of preferred feed tree species;
- invasion of native plant communities by bitou bush (*Chrysanthemoides monilifera*): may inhibit recruitment of preferred feed tree species;
- predation by the fox: on the species; and
- predation by the feral cat: on the species young.

Relevant Recovery Plans or Threat Abatement Plans

There are no recovery plans presently available or in preparation for the koala. A Comprehensive Koala Plan of Management (CKPoM) has been prepared for the population of koalas in the Port Stephens local government area (Port Stephens Council 2001). This plan presents habitat mapping of preferred and supplementary koala habitat and shows habitat links and corridors. Performance criteria that must be addressed in development applications are outlined.

The 'predation by the red fox' threat abatement plan is considered relevant to the koala.

Assessment of Impacts

The proposed development will remove approximately 24.7 hectares of preferred koala habitat (swamp forest and wet heath) (see *Table 6.3*). Although a significant area of preferred habitat will be removed, the koala will not be affected because no individuals (or evidence thereof) have been recorded in the study area during current or previous investigations i.e. over the last ten years.

Habitat buffers of 50 metres around preferred koala habitat will in some cases also be removed. Approximately 42.0 hectares of preferred koala habitat and associated habitat buffers (ie 50 metre habitat buffer over supplementary) are to be retained within parts of the study area by:

- retaining a minimum 200 metre wide ecological corridor between Nelson Bay Road and the proposed development; and
- retaining areas of wet heath and swamp forest in areas currently zoned 1(a), 2(a) and 7(a), respectively.

Table 6.3 Removal and Retention of Koala Habitat in the Study Area (approximate hectares)

Vegetation Community	Koala Habitat	Total hectares native vegetation in study area	Hectares removed by approved subdivision	Hectares removed by this subdivision proposal	Hectares retained in study area
swamp forest	preferred	43.5	3.3	9.7	30.5
wet heath	preferred	26.0	4.0	15.0	7.0
dry sclerophyll open forest	supplementary/ 50 metre habitat buffer over supplementary	130.5	15.5	45.5	69.5
TOTAL		**200.0**	**22.8**	**70.2**	**107.2**

Degradation of preferred koala habitat and habitat buffers on site has the potential to occur as a result of the proposed development, including weed invasion and increased feral animal access to these habitats. However, edge effects will be greatest in the habitat buffers, rather than in the preferred koala habitat, which is the function of habitat buffers. The proposal is likely to result in a reduced fire frequency, which will increase the stability of koala habitat in the study area.

The koala is vulnerable to being killed when crossing roads especially in urban areas and/or areas where prime habitat has been fragmented. Two ingress roads will be constructed through preferred koala habitat and habitat linking areas, compromising the safe movement of koalas through the ecological corridor.

Dog ownership has the potential to impact on koalas through death and injury. Within urbanised areas dogs are known to contribute substantially to koala deaths and injuries. Koala populations under environmental pressures, primarily habitat fragmentation, are more susceptible to the development of *Chlamydia* related diseases (Hume 1990). Fragmentation of habitats may result in koalas being nutritionally stressed, increasing the susceptibility to disease. It is not known to what extent disease is currently affecting koalas in the Fullerton Cove/Stockton Bight KMU.

Inappropriate property design, including backyard fencing, can suppress the movement of koalas. Koalas can drown in backyard swimming pools. Performance criteria outlined in the CKPoM are addressed in the 'response report' (ERM 2005a).

6.3.20 Long-nosed Potoroo

Local, Regional and State Conservation status

The long-nosed potoroo is known from Wambina NR and Brisbane Water NP (Murray *et al* 2002). It is listed as vulnerable in the TSC Act.

Relevant Key Threatening Processes

Key threatening processes considered to be relevant to the ecology of this species include:

- high frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition: direct mortality of individuals, loss of foraging habitat;
- invasion of native plant communities by exotic perennial grasses: may reduce suitability of foraging sites;
- invasion of native plant communities by bitou bush (*Chrysanthemoides monilifera*): may reduce suitability of foraging sites;

- removal of dead wood and dead trees: loss of ground shelter;
- predation by the fox: on the species; and
- predation by the feral cat: on the species young.

Relevant Recovery Plans or Threat Abatement Plans

A national recovery plan is currently being prepared by the Department of Environment and Heritage. A state recovery plan has not been prepared or is in preparation. The 'predation by the red fox' threat abatement plan is considered relevant to the long-nosed potoroo.

Assessment of Impacts

As the study area does not contain suitable preferred habitat for the long-nosed potoroo, the species is not likely to be present and will therefore not be affected by the proposal.

6.3.21 Eastern Chestnut Mouse

Local, Regional and State Conservation status

The eastern chestnut mouse is known from Brisbane Water NP (Murray *et al* 2002).

Relevant Key Threatening Processes

Key threatening processes considered to be relevant to the ecology of this species include:

- high frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition: direct mortality of individuals, loss of foraging and nesting habitat;
- invasion of native plant communities by exotic perennial grasses: may reduce suitability of foraging sites;
- invasion of native plant communities by bitou bush (*Chrysanthemoides monilifera*): may reduce suitability of foraging sites;
- removal of dead wood and dead trees: loss of ground shelter;
- predation by the fox: on the species; and
- predation by the feral cat: on the species young.

Relevant Recovery Plans or Threat Abatement Plans

A recovery plan has not been prepared or is in preparation for this species. The 'predation by the red fox' threat abatement plan is considered relevant to the eastern chestnut mouse.

Assessment of Impacts

As the study area does not contain suitable preferred habitat for the eastern chestnut mouse, the species is not likely to be present and will therefore not be affected by the proposal.

6.3.22 Grey-headed Flying-fox

Local, Regional and State Conservation status

The grey-headed flying-fox has a roost camp at Blackbutt Reserve in Newcastle and Fullerton Cove within Kooragang NR. The species is expected to forage widely across the region, including the majority of conservation reserves within its range.

Relevant Key Threatening Processes

Key threatening processes considered to be relevant to the ecology of this species include:

- high frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition: direct mortality of individuals, loss of foraging habitat;
- invasion of native plant communities by exotic perennial grasses: may inhibit recruitment of feed species;
- invasion of native plant communities by bitou bush (*Chrysanthemoides monilifera*): may inhibit recruitment of feed species;
- predation by the feral cat: on the species.

Relevant Recovery Plans or Threat Abatement Plans

A recovery plan has not been prepared or is in preparation for this species. No threat abatement plans are considered relevant to the grey-headed flying-fox.

Assessment of Impacts

Approximately 70.2 hectares of potential foraging habitat for the grey-headed flying-fox will be removed, with approximately 9.7 hectares of primary forage habitat in swamp forest being removed. Therefore, potential impacts from loss of foraging habitat will be significant. Increased noise levels as a result of construction activities are unlikely to impact on this species, as it is known to forage in urban areas. No camp sites are present in the study area and therefore impacts to camp sites will not occur. As electricity within the development footprint will be supplied via underground cables the potential for individuals to collide with powerlines will be eliminated. There is potential for individuals to succumb to traffic strike while flying over roads in the proposed residential estate. Increases in fox numbers and domestic pets may lower the survival of individuals in the study area however residents will be educated about responsible pet ownership and funds will be contributed towards the preparation of a vertebrate pest animal management plan by Port Stephens Council or DEC. The suppression of fire frequency will enhance recruitment of feed species such as paperbark and swamp mahogany.

6.3.23 Wallum froglet (Crinia tinnula)

Local, Regional and State Conservation status

The wallum froglet occurs predominantly within swamp forest dominated by broad-leafed paperbark (*Melaleuca quinquenervia*), which is adequately conserved in the region (Benson 1989). Regional conservation reserves containing potential habitat for the wallum froglet include Tomaree NP, Munmorah SRA, Lake Macquarie SRA, Wyrrabalong NP and Moffats Swamp NR (Murray *et al* 2002).

Relevant Key Threatening Processes

Key threatening processes considered to be relevant to the ecology of this species include:

- high frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition: direct mortality of individuals and loss of habitat;
- invasion of native plant communities by exotic perennial grasses: may decrease the quality of preferred habitat;
- invasion of native plant communities by bitou bush (*Chrysanthemoides monilifera*): may decrease the quality of preferred habitat;
- removal of dead wood and dead trees: loss of shelter sites on the ground;
- predation by the fox: on the species;

- predation by the feral cat: on the species; and
- predation by the plague minnow: on the species' tadpoles.

Relevant Recovery Plans or Threat Abatement Plans

A recovery plan has not been prepared or is in preparation for this species. The 'predation by the red fox' and 'predation by the plague minnow' threat abatement plans are considered relevant to the wallum froglet. Although the red fox is known to inhabit the study area, the plague minnow has not been recorded in any wetlands in the study area.

Assessment of Impacts

The wallum froglet was recorded from swamp forest in the approved subdivision footprint, but was not found elsewhere in the study area. Approximately 9.7 hectares of swamp forest will be removed, although the retention of swamp forest in an ecological corridor will maintain a dispersal path for the species around the Fullerton Cove wetlands. Therefore, potential impacts from habitat loss will not be significant. Invasion of swamp forest by weeds may reduce the suitability of habitat such as calling sites, however the Community Association will implement the vegetation management plan that has been prepared for the estate and will ensure that weed removal and prevention measures are undertaken. Water quality and hydrological impacts are not likely to be significant in the swamp forest, provided a water sensitive urban design is implemented in the proposal. Impacts from predatory fish will not occur, due to their absence from wetlands in the study area. There is potential for individuals to be killed while crossing the two ingress roads in the swamp forest. A reduction in fire frequency is likely to improve conditions for survival of a population of wallum froglets in the study area. Increases in fox numbers and domestic pets may lower the survival of individuals, however measures such as educating residents about responsible pet ownership and contributing funds towards the preparation of a vertebrate pest animal management plan by Port Stephens Council or DEC, will assist in minimising these impacts.

6.3.24 Pond Breeding Frogs

Local, Regional and State Conservation status

The green and golden bell frog is known from Myall Lakes NP, Kooragang NR and Hexham Swamp NR (Murray *et al* 2002). No populations of the green-thighed frog are known to occur in any reserves in the region.

Relevant Key Threatening Processes

Key threatening processes considered to be relevant to the ecology of these species include:

- high frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition: direct mortality of individuals and loss of habitat;
- invasion of native plant communities by exotic perennial grasses: may decrease the quality of preferred habitat;
- invasion of native plant communities by bitou bush (*Chrysanthemoides monilifera*): may decrease the quality of preferred habitat;
- removal of dead wood and dead trees: loss of shelter sites on the ground;
- predation by the fox: on the species;
- predation by the feral cat: on the species; and
- predation by the plague minnow: on the species' tadpoles.

Relevant Recovery Plans or Threat Abatement Plans

A draft recovery plan has been prepared for the green and golden bell frog (NPWS 2001). No recovery plans for the green-thighed frog have been prepared or are in preparation. The 'predation by the red fox' and 'predation by the plague minnow' threat abatement plans are considered relevant to these species. Although the red fox is known to inhabit the study area, the plague minnow has not been recorded in any wetlands in the study area.

Assessment of Impacts

The green and golden bell frog and green-thighed frog were not recorded in the study area. Approximately 9.7 hectares of swamp forest will be removed that is potential habitat, although the retention of swamp forest in an ecological corridor will maintain potential habitat and a dispersal path for the species around the Fullerton Cove wetlands. Therefore, potential impacts from habitat loss will not be significant. Suitable habitat for the green and golden bell frog is present in Long Bight Swamp approximately three kilometres north west of the study area. If a population of green and golden bell frog is present in this swamp, individuals may disperse into habitats in the study area during favourable conditions (eg heavy rain) in search of new wetland habitats to colonise, or in search of suitable overwintering sites. The retention of swamp forest along Nelson Bay Road will retain this link and protect the permanent waterbody in the south west corner of the study area.

Invasion of swamp forest by weeds may reduce the suitability of habitat such as calling sites for both species, and basking sites for the green and golden bell frog, however the Community Association will implement the vegetation management plan that has been prepared for the estate and will ensure that weed removal and prevention measures are undertaken. Water quality and hydrological impacts are not likely to be significant in the swamp forest, provided a water sensitive urban design is implemented in the proposal. Impacts from predatory fish will not occur, due to their absence from wetlands in the study area. There is potential for individuals to be killed while crossing the two ingress roads in the swamp forest. A reduction in fire frequency is likely to improve conditions for survival of these species in the study area. Increases in fox numbers and domestic pets may lower the survival of individuals, however measures such as educating residents about responsible pet ownership and contributing funds towards the preparation of a vertebrate pest animal management plan by Port Stephens Council or DEC, will assist in minimising these impacts.

7 IMPACT MITIGATION MEASURES

7.1 INTRODUCTION

Mitigation measures are designed to minimise the impact of the loss of habitats used by the affected species, which includes swamp forest, dry sclerophyll open forest and wet heath. These measures aim to reduce the impact of the construction and operation of the proposed residential development. This includes the retention of native vegetation in ecological corridors, provision of compensatory habitat and the management of habitat for affected species in the study area.

7.2 HABITAT LOSS AND REGIONAL CONNECTIVITY

To mitigate impacts to affected species and communities arising from habitat loss and the potential disruption to regional corridors, the following mitigation measures are proposed:

- a minimum 200 metre wide ecological corridor will be retained between Nelson Bay Road and the proposal (see *Figure 1.2*). This corridor will include swamp forest (including swamp sclerophyll forest endangered ecological community) and dry sclerophyll open forest on land zoned 2(a) and 7(a). DEC has stated that 200 metres is generally accepted as a minimum corridor width to assist in minimising edge effects and other disturbance. This means that those approved lots and roads within this corridor will not be constructed. This will prevent the disturbance of approximately 7.2 hectares of vegetation. If the Master Plan for the site is approved, WPG will seek the rezoning of the 2(a) Residential zoned land within this ecological corridor as well as other parts of the site that do not form part of the proposed development footprint, to 7(a) Environment Protection;

- areas of native vegetation, including swamp forest, will generally be retained in areas currently zoned 7(a) Environment Protection;

- vegetation will be retained within land currently zoned 1(a) Rural Agriculture, with the exception of approximately 0.5 hectares along the western boundary of this zone; and

- that part of the 33kV powerline that traverses the site within the proposed development footprint will be placed underground and the easement revegetated. All electricity supplied throughout the estate will be via underground cables (as opposed to overhead lines) to minimise vegetation clearance and maximise visual amenity.

Retention of native vegetation within these areas will conserve approximately 30.5 hectares of swamp forest, 7.0 hectares of wet heath and 69.5 hectares of dry sclerophyll open forest. Asset Protection Zones will not be included in areas of native vegetation retained as affected species habitat. The retention of native vegetation in the study area will maintain the integrity of the regional corridor.

The concept plan facilitates the retention of approximately 300 metres of existing bushland between the proposal and the cleared areas of Stockton Bight dune system, providing a movement corridor for fauna through dry sclerophyll open forest east of the proposal. This corridor is within the 100 year dune hazard zone, and therefore the corridor width may decrease over time. However, in order to maintain this corridor and protect the residential areas of the estate from sand dune encroachment, periodic removal of sand will be considered as a future option for managing dune migration. WPG are in the process of developing a strategy to address this issue.

Dead wood and dead trees removed during construction will be placed within reserves to reduce the impact of the key threatening process 'removal of dead wood and dead trees' in the study area.

7.3 EDGE EFFECTS

Edge effects in swamp forest have been minimised by the inclusion of a 50 metre wide buffer around the boundary of the communities to be reserved. Most edge effects disappear over the first 50 metres into a remnant of native vegetation (Murcia 1995). Edge effects are likely to be greatest in the dry sclerophyll open forest due to the large interface area between this community and the development footprint.

Physical changes that have the potential to occur at the interface between the proposal and natural bushland include changes in soil and water conditions and potentially an increase in light penetration to the understorey. However, this can be prevented through effective rehabilitation and ongoing monitoring and management of the reserves and in particular the interface.

The Community Association (via Community Title) will be responsible for the maintenance of the open space areas of Fern Bay Estate and for ensuring that ongoing weed removal and other environmental management measure are carried out.

7.4 NATIVE VEGETATION MANAGEMENT

A vegetation management plan (VMP) has been prepared for the study area in relation to the proposal (ERM 2005c). This VMP aims to enhance and protect native vegetation and fauna habitat through regeneration, reconstructive landscaping and maintenance of natural areas, and applies to land to be

dedicated as parks and conservation reserves (approximately 107 hectares). The main objective of this plan is the prescription of management strategies and methods to mitigate impacts of development on natural and modified vegetation communities, threatened flora and fauna species, and habitats that may occur as a result of the proposal. Greening Australia will be involved in implementing the VMP.

The condition of the vegetation communities and habitat within those areas to be retained is generally similar to the condition of habitats proposed for retention. For example, weed abundance within intact vegetation communities is low, with the exception of those communities that adjoin cleared areas. The areas proposed for retention contain similar affected species habitat to the areas proposed to be cleared. The number of habitat trees that will be conserved in the study area is approximately 777 (54 percent of the total habitat tree estimate), with approximately 495 trees to be cleared. Areas of affected species habitat to be conserved therefore contain greater habitat resources than areas within the development footprint. Affected species habitat will be managed according to the mitigation measures presented below.

7.5 WEED MANAGEMENT

Weed removal and treatment is required as part of restoration works within the reserves and the proposed development area. This should be followed by ongoing management and monitoring of weeds in the study area to remove regrowth. Works will focus on areas particularly susceptible to weed invasion, such as road edges, asset protection zones and parks. These works will be implemented through the vegetation management plan for the study area. Greening Australia will be involved in implementing this management plan.

7.6 FAUNA DISPLACEMENT

Pre-clearance surveys of hollow-bearing trees will be conducted by a suitably qualified wildlife professional. Individuals recovered will be released in conservation reserves in the study area at appropriate times. Injured fauna will be taken to a wildlife carers organisation for rehabilitation prior to release in the study area. If microchiropteran bat roosts are located, there is the possibility of relocating these structures to nearby habitat in reserved areas. Microhabitat features such as hollow logs and branches will be removed from the development area and carefully re-located to areas within the reserves and open space and/or used within the landscaping in accordance with bushfire hazard requirements.

Construction activities will be generally restricted to daylight hours to minimise impacts to nocturnal fauna such as the powerful owl that is known to roost in the study area.

7.7 VERTEBRATE PEST AND PET MANAGEMENT

A vertebrate pest animal management plan should be implemented that will target the control of red fox and European rabbit in Stockton Bight. It is recommended that the proponent contribute funds towards the preparation by Port Stephens Council or DEC of such a management plan. Responsible dog and cat ownership will be promoted to reduce potential impacts by unrestrained domestic pets on fauna in the study area and surrounds. Dog owners will be encouraged to erect fencing to ensure dogs are kept within the confines of backyards and are not permitted to roam free. Dog owners will also be encouraged to walk dogs on leashes.

7.8 HYDROLOGY AND WATER QUALITY

A stormwater management strategy will be implemented that incorporates a water sensitive urban design for development in the study area (Urban Water Cycle Solutions 2005). It is proposed to use pipe drainage, infiltration trenches, roads with one-way cross-falls, bio-retention swales, gross pollutant traps, infiltration swales and infiltration trenches to manage stormwater quantity and quality. The stormwater management strategies proposed will protect the proposed urban development from flooding whilst mitigating potential stormwater impacts of urban development on receiving environments. The strategy will not require maintenance efforts in excess of the requirements of traditional pipe drainage systems. Further details are outlined in the stormwater management strategy for the proposal (Urban Water Cycle Solutions 2005). The strategy will protect the swamp forest, including swamp sclerophyll forest, from groundwater impacts, which will ensure no off site impacts to the wetlands of Fullerton Cove.

7.9 ROAD DESIGN

The presence of roads in the study area, particularly the two ingress roads through the ecological corridor, have the potential to result in fauna mortality due to traffic strike. To mitigate this potential impact, low speed zones of 40 kph and signage warning motorists of the presence of wildlife will be erected on the two ingress roads. Maximum motor vehicle speeds within the subdivision should be 50 kph.

It is proposed to construct underpasses (such as cross drainage structures) under the northern ingress road to maintain connectivity of terrestrial habitat

in the ecological corridor. These would allow movement of ground-dwelling fauna such as small mammal, frogs and reptiles to occur under the road, and reduce the risk of mortality that may otherwise occur. Ground cover such as logs and vegetation will be placed in underpasses to encourage their use by small fauna.

7.10 BUSHFIRE MANAGEMENT

The study area is regarded as having a high bushfire hazard potential. A Bushfire Hazard Assessment (ERM 2005b) has been prepared for the study area. This identifies various bushfire management measures to reduce bushfire hazard including the provision of appropriate asset protection zones around future residential areas. These are to be established and maintained in accordance with the requirements of *Planning for Bushfire Protection* (NSW Rural Fire Service 2001). Habitat trees will be retained in asset protection zones where possible.

7.11 RESIDENTIAL PROPERTY DESIGN

To facilitate koala movement through the study area during the operation phase of the proposal, it is recommended in the Port Stephens CKPoM that design specifications for fencing include:

- Colorbond® or similar fences where the bottom of the fence is a minimum of 200 millimetres above ground level that would allow koalas to move underneath;
- fences that facilitate easy climbing by koalas. For example, timber fences flush with the ground with timber posts on both sides at regular intervals of approximately 20 metres; or
- open post and rail or post and wire (definitely not barbed wire on the bottom strand).

Design guidelines on private land will require landscaping with native indigenous plant species only.

7.12 IMPACT MITIGATION MEASURES FOR AFFECTED SPECIES AND ECOLOGICAL COMMUNITIES

Specific mitigation measures are required to mitigate the potential impacts on affected species and ecological communities that may occur as a result of the proposal. The most significant potential impact (habitat loss) has been addressed through the retention of vegetation communities into the ecological corridor or in land zoned 1(a) and 7(a) as indicated in *Table 7.1*.

Table 7.1 ***Retention of Affected Species Habitat in the Study Area (approximate hectares)***

Affected Species, Species Guild or Ecological Community	Potential habitat	Area of known or potential habitat to be retained (hectares)
Diuris spp. orchids heath wrinklewort woodland birds	dry open forest[1]	69.5
dwarf kerrawang nectivorous birds frugivorous birds frogs	swamp forest[2]	30.5
hollow-dependent birds raptor birds cave roosting bats tree hollow roosting bats hollow-dependent mammals koala grey-headed flying-fox	dry open forest[3] swamp forest[4] wet heath[5]	107.0
Eucalyptus parramattensis subsp. *decadens* heath wrinklewort	wet heath	7.0

1. foraging and nesting habitat for the grey-crowned babbler
2. foraging habitat for birds; breeding habitat for frogs
3. nest, roost and den sites for hollow-dependent birds and mammals, and tree hollow roosting bats
4. foraging habitat for all species including preferred koala habitat
5. preferred koala habitat; foraging habitat for all species

Several affected species and species groups require specific mitigation measures that cannot be addressed within a general framework of impact amelioration such as habitat retention, and water, weed, fire and pest animal management. They are outlined in the following sections.

7.12.1 *Eucalyptus parramattensis* subsp. *decadens*

Four individual *Eucalyptus parramattensis* X *Eucalyptus* spp. hybrid trees were identified in the study area in land zoned 2(a) that is included in the proposed development footprint. One of these species has been identified as *Eucalyptus parramattensis* subsp. *decadens* X *Eucalyptus robusta* while other specimens collected were identified as *Eucalyptus parramattensis* X *Eucalyptus resinifera* and *Eucalyptus parramattensis* X *Eucalyptus punctata*.

Eucalyptus parramattensis is not known to occur elsewhere in the study area. At present, the population will be destroyed if the proposal proceeds. It is recommended that seed be collected from each individual tree and a population established in approximately 7.0 hectares of wet heath in land zoned 1(a) that will be retained along the eastern perimeter of the study area. This action will be undertaken within the guidelines of the Australian Network for Plant Conservation. The potential for the establishment of these hybrid species at new locations, providing it is within similar habitat, appears

to be high given that *Eucalyptus parramattensis* subsp. *decadens* has been successfully used as a canopy species in the rehabilitation of sand mined areas in the Tomago sandbeds (see URS 2003).

7.12.2 Hollow-dependent Fauna

Approximately 495 hollow-bearing trees will be cleared, which represent potential roost sites for large forest owls, tree roosting microchiropteran bats and hollow-dependent arboreal mammals (see *Table 5.4*). However, it is estimated that approximately 777 habitat trees will be conserved in the study area, the majority of which (83 percent) will be retained in dry sclerophyll open forest. Ameliorative measures to offset the impact of habitat loss by the proposed development on the habitat and local population of the squirrel glider and other hollow-dependent fauna are outlined below.

To minimise mortality to adult and juvenile squirrel gliders during tree clearing operations associated with development, the tree clearing operation should follow that presented in the Squirrel Glider Conservation Management Plan (Smith 2002). The procedure follows that which was formulated by Michael Murray (Forest Fauna Surveys Pty Ltd) and has been successfully applied for all habitat clearing works. The strategy involves the clearing of all non-habitat trees first, followed by an interval of three weeks before felling of habitat trees. This typically results in abandonment of the habitat trees by resident gliders, due to the loss of foraging resources (ie canopy resources – pollen, nectar, insects, and understorey *Banksia serrata* and *Acacia sp.*).

This report does not recommend the use of salvaged tree hollows and nest boxes suitable for the squirrel glider (and other hollow dependent fauna) due to the abundance of natural tree hollows in the conservation areas. Translocation of individuals or a colony of the squirrel glider is not considered a component to management of the species within the study area. Previous experience in removal of gliders from known habitat resulted in individuals returning to the den tree (M. Murray, personal data). The preferred option for displacement of resident squirrel gliders from approved development areas in the study area is by the tree clearing strategy discussed above. This strategy has been successful in the past in the forced dispersal of individuals of their own accord from proposed development sites.

7.13 MONITORING

Regular monitoring of the effectiveness of management measures and regeneration will be undertaken. Changes in vegetation should be monitored to assess the effectiveness of management. Parameters to be monitored include changes in species composition, extent of regeneration of native species, changes in weed densities and the general health of the native vegetation at the site. The success of re-planted species will be monitored.

Affected species populations and communities will be monitored during construction and post-construction to assess their presence and condition (respectively) in the study area to determine the effectiveness of mitigation measures.

The health of preferred koala food trees such as swamp mahogany will be monitored where they occur within the minimum 200 metre wide ecological corridor and at the interface with the development footprint. This will determine whether edge effects such as nutrient runoff are resulting in the deterioration of tree condition through, for example, die-back. This monitoring could be performed by a volunteer group of local residents in liaison with the Native Animal Trust Fund and the Hunter Koala Preservation Society, both of which are active groups within the Fullerton Cove/Stockton Bight KMU. However, an ecologist would need to be consulted in the event of significant tree die-back. This local community group could also monitor the incidence of weeds and report sightings of koalas.

8 CONCLUSIONS

The study area contains swamp forest, dry sclerophyll open forest and wet heath that supports habitat for a range of threatened species and ecological communities listed in the TSC Act. It forms part of a larger fragment of coastal woodland in the Fern Bay area and adjoins the floodplain of the Fullerton Cove wetlands, which are mapped as SEPP14 and conserved within the Kooragang Nature Reserve. The study area is a component of a regional corridor in the Lower Hunter region and the fragment contains key habitats for threatened species in the region.

The proposal has the potential to affect 37 threatened species and one endangered ecological community. The most significant impact will be the loss of approximately 70 hectares of habitat and loss of habitat resources such as hollow-bearing trees and winter-flowering trees. The concept plan strategically conserves 107 hectares of habitat for affected species and communities within a minimum 200 metre ecological corridor and in areas that will maintain connectivity throughout the Fern Bay Fragment.

There is potential for the cumulative loss of habitat as a result of land uses on other land within the Fern Bay Fragment and therefore a reduction in the ecological integrity of this fragment and the isolation of populations of affected species. However, all development proposals are subject to assessment in accordance with the TSC Act. Therefore it is unlikely that proposals which result in the isolation of populations of affected species would be allowed to proceed. The estate has been designed to retain a minimum 200 metre wide ecological corridor adjacent to Nelson Bay Road. This means that those approved lots and roads within this corridor will not be constructed. This will prevent the disturbance of approximately 7.2 hectares of vegetation. If the Master Plan for the site is approved, WPG will seek the rezoning of the 2(a) Residential zoned land within this ecological corridor as well as other parts of the site that do not form part of the proposed development footprint, to 7(a) Environment Protection.

The proposal will manage hydrology and water quality, fire, pest animals and weeds to reduce any deleterious impacts to affected species and communities. These measures address seven key threatening processes currently operating in the study area. The risk of traffic strike to fauna will be reduced by appropriately designed and sign posted urban roads, including fauna underpasses on the northern ingress road. Impacts to the Port Stephens koala population will be managed by implementing the performance criteria of the Port Stephens Council CKPoM.

The habitat retention strategy aims to conserve and manage affected species and communities' habitat in the long-term, and maintain local and regional connectivity. Management of native vegetation in the study area will involve the rehabilitation of disturbed areas and management of the bushfire regime in order to increase floristic diversity in the study area. The retention of approximately 54 percent of the estimated number of habitat trees and

retention of movement corridors in the study area will ensure the long-term viability of the squirrel glider population, which is a flagship species for the conservation of threatened species in the study area and wider locality.

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Annex A

DEC Director-General's Requirements

Table A.1 Compliance with Sections 109 & 110 of the TSC Act

Section	Description	Compliance	Location
109	**Form of species impact statements**		
1.	A species impact statement must be in writing	Yes	This report
2.	A species impact statement must be signed by the principle author of the statement and by:	Yes	This report
	a. The applicant for the licence, or	Yes	This report
	b. If the species impact statement is prepared for the purposes of the Environment Planning and Assessment Act 1979, the applicant for development consent or the proponent of the activity proposed to be carried out (as the case requires).		
110	**Content of species impact statements**		
1.	A species impact statement must include a full description of the action proposed, including its nature, extent, location, timing and layout and, to the fullest extent reasonably practicable, the information referred to in this section.	Yes	Section 2
2.	A species impact statement must include the following information as to threatened species and populations:		
	a. A general description of the threatened species or population known or likely to be present in the area that is the subject of the action and in any area that is likely to be affected by the action,	Yes	Section 5
	b. An assessment of which threatened species or populations known or likely to be present in the area are likely to be affected by the action,	Yes	Section 5 and 6
	c. For each species or population likely to be affected, details of its local, regional and State-wide conservation status, the key threatening processes generally affecting it's habitat requirements and any recovery plan or threat abatement plan applying to it,	Yes	Section 6
	d. An estimate of the local and regional abundance of those species or populations,	Yes	Section 5
	f. A full description of the type, location, size and condition of the habitat (including critical habitat) of those species and populations and details of the distribution and condition of similar habitats in the region,	Yes	Section 5 and 6
	h. A description of any feasible alternatives to the action that are likely to be of lesser effect and the reasons justifying the carrying out of the action in the manner proposed, having regard to the biophysical, economic and social considerations and the principles of ecologically sustainable development,	Yes	Refer to ERM (2004e)
	i. A full description and justification of the measures proposed to mitigate any adverse effect of the action on the species and populations, including a compilation (in a single section of the statement) of those measures,	Yes	Section 6
	j. A list of any approvals that must be obtained under any other Act or law before the action may be lawfully carried out, including details of the conditions of any existing approvals that are relevant to the species or population.	Yes	Section 1

Section	Description	Compliance	Location
3.	A species impact statement must include the following information as to ecological communities:		
	a. A general description of the ecological community present in the area that is subject of the action and in any area that is likely to be affected by the action,	Yes	Section 3 and 5
	b. For each ecological community present, details of its local, regional and State-wide conservation status, the key threatening processes generally affecting it, its habitat requirements and any recovery plan or any threat abatement plan applying to it,	Yes	Section 6
	c. A full description of the type, location, size and condition of the habitat of the ecological community, and details of the distribution and condition of similar habitat in the region,	Yes	Section 5 and 6
	e. A description of any feasible alternatives to the action that are likely to be of lesser effect and the reasons justifying the carrying out of the action in the manner proposed, having regard to the biophysical, economic and social considerations and the principles of ecologically sustainable development,	Yes	Refer to ERM (2004e)
	f. A full description and justification of the measures proposed to mitigate any adverse effect of the action on the ecological community, including a compilation (in a single section of the statement) of those measures,	Yes	Section 6 and 7
	g. A list of any approvals that must be obtained under any other Act or law before the action may be lawfully carried out, including details of the conditions of any existing approvals that are relevant to the ecological community.	Yes	Section 1
4.	A species impact statement must include details of the qualifications and experience in threatened species conservation of the person preparing the statement and of any other person who has conducted research or investigations relied on in preparing the statement.	Yes	Annex F
5.	The requirements of subsections (2) and (3) in relation to information concerning the State-wide conservation status of any species or population, or any ecological community, are taken to be satisfied by the information in that regard supplied to the principal author of the species impact statement by the National Parks and Wildlife Service, which information that Service is by this subsection authorised and required to provide.	Yes	Section 6

Table A.2 Compliance with Director General's requirements (Matters to be Addressed) for this SIS

Section	Description	Compliance	Location
1	**Matters to be addressed**		
	The SIS must address all the matters specified in Sections 109 and 110 of the TSC Act, with the exception of those matters that have been limited or modified in **Section 3** above. The requirements outlined in Sections 109 and 110 (excluding the matters limited above) are detailed below, together with the specific DGRs for the proposal. **Previous surveys and assessments that are relevant to the locality may be used to assist in addressing these requirements.**	Yes	This report
	Section 111 (1) of the TSC Act states that an applicant must comply with the DGRs concerning the **form** and **content** of the SIS. **Failure to fully comply with the DGRs is therefore a potential breach of the legislation, and may result in the DEC being unable to grant concurrence to a request by the consent authority to carry out the activity**. Accordingly, the SIS **must** be formatted to follow the sections and subsections provided in the DGRs.		
1.1	**Form of the species impact statement**		
	Section 109 (1) and (2) of the TSC Act states that:		
	• *" A species impact statement must be in writing";*	Yes	This report
	• *"A species impact statement must be signed by the principal author of the statement and by:*	Yes	Inside cover
	• *the applicant for the licence, or*	Yes	Inside cover
	• if the species impact statement is prepared for the purposes of the Environmental Planning and Assessment Act 1979, the applicant for development consent".	N/A	
	As it is a statutory requirement that the SIS be signed by the applicant for development consent, the DEC will assume that the applicant is aware of and will support the inclusion in the DA of any avoidance, amelioratory or compensatory measures contained in the SIS.	Yes	Section 6 and 7
	The SIS must, wherever possible, utilise definitive and quantifiable words (eg "will") and numeric figures (ranges are acceptable)), rather than vague or unquantifiable words (eg "may", "could", "likely", "possible", "some", "majority", "small amount"), particularly with respect to identifying impacts and proposed amelioratory measures.	Yes	This report
2	**Contextual information**		
	Section 110(1) of the TSC Act states that: "*A species impact statement must include a full description of the action proposed, including its nature, extent, location, timing and layout*".	Yes	Section 2

Section	Description	Compliance	Location
2.1	**Description of the proposal**		
	A full description of all components of the proposed action (including those to be implemented during the pre-construction, construction and maintenance phases) and all associated actions must be provided. Associated actions may occur on or off the subject site, and may include, but not be restricted to: construction and maintenance of utilities, auxiliary infrastructure, asset protection and fire management zones, access routes, and actions resulting in changes to sub-surface or surface water flows. The number of hectares of each vegetation community within the study area that will be removed or affected by the proposal, must also be provided.	Yes	Section 2
2.2	**Definition of study area**		
	The location, size (ha) and dimensions of the study area must be provided. In defining the boundaries of the study area, consideration shall be given to possible indirect effects of the proposal on the area surrounding the subject site. Examples of such indirect effects include habitat fragmentation, severance of vegetation corridors, altered hydrological regimes, soil erosion, pollution, increased presence of people and domestic pets, and fauna road deaths.	Yes	Section 2 and 3
2.3	**Description of study area**		
	The description of the study area must include:	Yes	Section 3
	• The vegetation types, including identification of the classification system used in the SIS and a listing of the number of hectares of each vegetation community in the study area.		
	• An examination of previous land uses and events, and the effect of these land uses and events on the study area. Examples of such land uses and events are major fires, clearing, timber felling, under-scrubbing, draining, recreational use and agricultural activities.	Yes	Section 3
	• The local government land zone(s) and any proposed rezoning, and an examination of the degree of protection that current zone(s) and any proposed rezoning provide or will provide to native vegetation and threatened species in the study area.	Yes	Section 3
	• The land tenure(s) and any proposed changes (eg acquisition by DEC as DEC estate), and an examination of the degree of protection that current land tenure(s) and any proposed land tenures provide or will provide to native vegetation and threatened species in the study area.	Yes	Section 3
	• Relevant State Environmental Planning Policies (eg Coastal Wetlands, Koala Habitat Assessment) and an examination of the degree of protection these Policies provide to native vegetation and threatened species in the study area.	Yes	Section 3

Section	Description	Compliance	Location
2.4	**Provision of supporting maps, plans and photographs**		
	All maps and aerial photographs of the study area should be presented where practicable at the same scale (similarly for all maps and aerial photographs of the locality) so that they can be overlain. They must indicate the scale utilised. The symbols, colours, lines, infills etc utilised must unambiguously distinguish the depicted features from each other and from background information. Comprehensive and clear legends must be provided.	Yes	All figures
	One or more maps of the study area must be provided that show (at a scale of 1:25 000 or more detailed): • the location of the proposal and proposed actions; • the boundaries of the study area and subject site; • vegetated and cleared areas; • vegetation types; and • local government zones.	Yes	Figure 1.1, 1.2, 1.3, 5.1, 5.4
	An aerial photograph (or reproduction of a photograph), preferably in colour, of the locality must be provided that shows: • the locations of the proposal and actions; and • the boundaries of the study area and subject site.	Yes	Figure 1.3, 5.4
	• One or more maps of the locality must be provided that show topography and the locations of: • the study area; • major and proposed land tenure units (eg DEC estate, State Forests); • landscape or vegetation features that are the subject of major or proposed state environmental planning instruments (eg SEPP14 Coastal Wetlands); • areas of major human activity (eg towns, major roads); and • all threatened species records that have been identified from the processes outlined in Section 3 below.	Yes	Figure 1.1, 1.3, 5.1, 5.3, 5.4
3	**Identification and description of subject species**		
	Sections 110(2)(a) and 110(3)(a) of the TSC Act state, respectively, that the SIS must provide: *"A general description of the threatened species or populations known or likely to be present in the area that is the subject of the action and in any area that is likely to be affected by the action".* *"A general description of the ecological community present in the area that is the subject of the action and in any area that is likely to be affected by the action".*	Yes	Section 5 Table 5.7

Section	Description	Compliance	Location
	The SIS must **consider**, but need not be limited to, the following subject species:		
	Fauna		
	Litoria aurea Green and Golden Bell Frog		
	Litoria brevipalmata Green-thighed Frog		
	Crinia tinnula Wallum Froglet		
	Burhinus grallarius Bush Stone-curlew		
	Calyptorhynchus lathamii Glossy Black-cockatoo		
	Climacteris picumnus victoriae Brown Treecreeper (eastern subspecies)		
	Lathamus discolor Swift Parrot		
	Lophoictinia isura Square-tailed Kite		
	Ninox connivens Barking Owl		
	Ninox strenua Powerful Owl		
	Pandion haliaetus Osprey		
	Pomatostomus temporalis temporalis Grey-crowned Babbler (eastern subspecies)		
	Ptilinopus magnificus Wompoo Fruit-dove		
	Ptilinopus superbus Superb Fruit-dove		
	Ptilinopus regina Rose-crowned Fruit-dove		
	Tyto novaehollandiae Masked Owl		
	Xanthomyza phrygia Regent Honeyeater		
	Chalinobus dwyeri Large-eared Pied Bat		
	Dasyurus maculatus Spotted-tailed Quoll		
	Falsistrellus tasmaniensis Eastern False Pipistrelle		
	Miniopterus australis Little Bentwing-bat		
	Miniopterus schreibersii oceanensis Eastern Bentwing-bat		
	Mormopterus norfolkensis Eastern Freetail-bat		
	Myotis adversus Large-footed Myotis		
	Petaurus norfolcensis Squirrel Glider		
	Phascogale tapoatafa Brush-tailed Phascogale		
	Phascolarctos cinereus Koala		
	Potorous tridactylus Long-nosed Potoroo		

Section	Description	Compliance	Location
	Pseudomys gracilicaudatus Eastern Chestnut Mouse		
	Pteropus poliocephalus Grey-headed Flying-fox		
	Saccolaimus flaviventris Yellow-bellied Sheathtail-bat		
	Scoteanax rueppellii Greater Broad-nosed Bat		
	Flora		
	Callistemon linearifolius Netted Bottlebrush		
	Cryptostylis hunteriana Leafless Tongue Orchid		
	Diuris arenaria Sand Doubletail		
	Diuris praecox Rough Doubletail		
	Eucalyptus camfieldii Camfield's Stringybark		
	Eucalyptus parramattensis subsp. *decadens*		
	Rulingia prostrata Dwarf Kerrawang		
	Rutidosis heterogama Heath Wrinklewort		
	Endangered Ecological Communities Swamp Sclerophyll Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions (Preliminary Determination) Sydney Coastal Estuary Swamp Forest Complex in the Sydney Basin bioregion		
	This list is not necessarily exhaustive. The applicant must carry out their own process of determining the subject species. This process should incorporate consideration of: • the vegetation communities, soil types, landforms and geology present within the study area; • the presence, quantity, quality and degree of fragmentation of likely habitat for individual threatened species; • recent (within the last ten years) records of threatened species, populations and ecological communities in the locality; and • the known distribution of threatened species, populations and ecological communities. The DEC Atlas of NSW Wildlife, Australian Museum and Royal Botanic Gardens databases, the Birds Australia and NSW Bird Atlases databases (for birds) and other relevant databases should be used to assist in compiling or assessing the list. The Data Licensing Officer at DEC Head Office should be contacted on (02) 9585 6684 to obtain information on the Atlas database.		

Section	Description	Compliance	Location
	Threatened species, populations and ecological communities on the above list may be excluded from further consideration as subject species **only** if a fully documented justification, robust to external examination, is provided. This documentation must address, as a minimum, the criteria for determining subject species that are listed above. In particular, threatened species that are cryptic or mobile or little surveyed or combinations of these parameters (eg bats), and for which the study area provides suitable habitat and falls within the species' range, must **not** be excluded solely on the basis of a lack of records in the locality. Furthermore, threatened species that occur in a range of habitats must **not** be excluded on the basis that their core habitat is not present in the study area or locality. Relevant determinations by the Scientific Committee must be referred to when determining whether an endangered ecological community is present in the study area. Any threatened species, populations and ecological communities listed in the TSC Act between the date of these DGRs and the submittal of the SIS (as part of a formal DA or EP & A Act Part 5 approval application) must be evaluated to determine if they are subject species, and assessed in accordance with the DGRs if they are determined to be subject species.		
4	**Survey and habitat mapping**		
4.1	**Introduction**		
	A fauna and flora survey must be conducted in the study area. Targeted surveys must be conducted for all subject species determined in accordance with Section 4.3 above. **Recent (less than 5 years old) surveys and assessments may be used to assist in addressing this requirement**. However, previous surveys will **not** be considered to have addressed this requirement if they have: been undertaken in seasons or weather conditions when the target subject species are unlikely to be detected or present; or utilised methodologies, survey sampling intensities, timeframes or baits that are not the most appropriate ones for detecting the target subject species; unless these differences can be clearly demonstrated to be likely to have had an insignificant impact upon the outcomes of the surveys. Surveys must be undertaken by appropriately experienced persons. A recognised expert, from institutions such as the Australian Museum (Sydney), the National Herbarium at the Royal Botanic Gardens (Sydney) or the Queensland Herbarium (Brisbane), or who is otherwise considered acceptable by the DEC, must be used to determine or confirm the identity of any species of which the surveyor is uncertain.	Yes	Section 4

Section	Description	Compliance	Location
	As a minimum, surveys for subject species must follow the methods, frequencies and intensities detailed in the appendix, unless justification for proposed variations is provided in writing to, and agreed in writing by, the DEC, **prior to commencement of the surveys**. Survey methods adopted must be those considered by experienced wildlife surveyors to be the ones most likely to detect the targeted subject species (more than one survey method must be utilised for those subject species for which complementary methods have the potential to result in a significant increase in detection). Survey effort (including intensity, repetition and coverage) must be at a level that can be reasonably expected to detect the subject species if present in the study area. **Surveys must be undertaken at the time of year when the subject species are most likely to be detected and, where possible, in appropriate weather conditions**. Surveys must encompass the whole of the study area so that the threatened species values of individual parts of the study area can be identified and assessed. This information is likely to be relevant to the development of measures to mitigate the adverse effects of the proposal on threatened species and their habitats. The locations of transects, random meanders, trap sites etc must not be controlled by or constrained to existing tracks.		
4.2	**Description of survey techniques and survey sites**		
	Survey techniques must be described and the subject species targeted by each survey technique listed.	Yes	Section 4
	Survey sites must be identified on a map, which must be at the same scale as relevant maps referred to in Section 4.2.4 above, and comply with the map requirements outlined in that section. The size, orientation and dimensions of all quadrats and transects surveyed must be provided. Full Australian Map Grid (AMG) references must be provided for all survey sites.	Yes	Section 4, Figure 4.1, 4.2, 4.3
4.3	**Documenting survey effort**		
	The time taken to complete each survey must be provided in the SIS. For example, number of person hours per transect, duration of call playback, number of nights on which traps were set. **It is not sufficient to aggregate all time spent on all survey techniques. Effort must be expressed for each separate survey technique and each vegetation community.** Environmental conditions must be recorded at the completion of each survey.	Yes	Section 4
	The names of all survey personnel (and contact details if not an employee of the organisation employing the author of the SIS) must be provided. The names and contact details of the persons that identified or confirmed any species not definitively identified by the survey personnel must also be provided.	Yes	Annex F
5	**Survey results**		
5.1	**Subject species survey results**		
	All occurrences of subject species identified in the study area must be recorded, together with the vegetation community in which they were located. Information on all records of threatened species made during the surveys must be provided in an Appendix to the SIS and, within one month of finalisation of the SIS, to DEC on NSW Wildlife Atlas data recording cards or	Yes	Section 5

Section	Description	Compliance	Location
	sheets or electronically in a format acceptable to the DEC's GIS Division. All data fields listed on these cards and sheets must be completed.		
	Factors that may have limited the success of the individual survey techniques employed or surveys in general (for example, sampling intensity and locations, detectability of species, influence of season and weather conditions, denial of access) must be identified and discussed with respect to the results of the survey. Any subject species not detected by the SIS or previous surveys but which, by virtue of the presence of suitable habitat, have the potential to occur in the study area, must be identified.	Yes	Section 4 and 5
5.2	**Fauna and flora species survey results**		
	A list of the fauna and flora species found during surveys must be provided. This list must indicate which species are introduced, a measure of abundance and the vegetation community/ies in which each species was recorded. The information must be utilised to identify and discuss the biodiversity and habitat quality of each vegetation community.	Yes	Annex B and E
5.3	**Subject species habitat mapping**		
	Areas identified as known or potential habitat in the study area for the subject species must be depicted on maps. These maps must be at the same scale as relevant maps referred to in Section 4.2.4 above, and must depict all records of the relevant subject species in the study area, including records from, the NSW Wildlife Atlas, surveys undertaken for the SIS and records from other surveys (as outlined in Section 4.2.4). The type of habitat present (eg, foraging areas, roost, den and nest trees and sites) must be identified where possible.	Yes	Figure 5.1, 5.2, 5.3
	Whilst the identification of potential habitat can be difficult, the SIS should provide the best expert estimate of threatened species habitat in the study area, to provide the basis for conclusions regarding the significance of habitat loss as a result of the proposal. Information which can be used in preparing these maps includes records of threatened species, maps of vegetation communities and broad habitat types in the locality, knowledge of habitat requirements of threatened species, and site-specific data obtained through field survey and inspection during preparation of the SIS and other site-related environmental assessment documents.	Yes	Figure 5.1, 5.2, 5.3
6	**Assessment of likely impacts on threatened species, populations and ecological communities** **This section is only required to be addressed for those subject species assessed as likely to be affected by the proposal** (for assessment considerations, see below and Section 6.1).		
	Assessment must consider indirect as well as direct impacts. It should also incorporate the impacts of associated activities including, but not restricted to: • installation and maintenance of utilities; • construction and maintenance of asset protection and fire management zones; • construction and utilisation of access and transport routes; • changes in surface and sub-surface water flows;	Yes	Section 6

Section	Description	Compliance	Location
	• pollution; • noise; and • increases in the numbers of people, domestic pets and road traffic. These actions or impacts may occur on or off the subject site.		
6.1	**Assessment to determine affected subject species** Section 102(2)(b) of the TSC Act states that the SIS must include: *"An assessment of which threatened species or populations known or likely to be present in the area are likely to be affected by the action".* Each subject species must be assessed to identify those threatened species, populations and ecological communities likely to be affected by the proposal, and to identify the nature, extent and degree of the impacts. The assessment process must incorporate survey results, habitat mapping, identification and analysis of likely impacts, and any other relevant information.	Yes	Section 5 and 6 Table 5.7
6.2	**Conservation status, habitat requirements and relevant key threatening processes, recovery and threat abatement plans** Section 110(2)(c) of the TSC Act states that the SIS must provide the following information for each threatened species and population likely to be affected by the proposal: *"For each species or population likely to be affected, details of its local, regional and State-wide conservation status, the key threatening processes generally affecting it, its habitat requirements and any recovery plan or threat abatement plan applying to it".* Section 110 (3) (b) of the TSC Act states that the SIS must provide the following information for each endangered ecological community likely to be affected by the proposal: *"For each endangered ecological community present, details of its local, regional and State-wide conservation status, the key threatening processes generally affecting it, its habitat requirements and any recovery plan or any threat abatement plan applying to it".* The information provided should include identification and discussion of: • the likely impacts of the proposal and relevant key threatening processes on each affected subject species' conservation status, particularly at the local scale; • whether the likely impacts of the proposal may increase or decrease the impacts of relevant key threatening processes on each affected subject species' local conservation status; and • the information provided in relevant recovery plans; and how this information, particularly proposed actions, may contribute to reducing the impacts of the proposal. Key threatening processes, approved and publicly exhibited draft and final recovery plans and threat abatement plans are listed and can be viewed on the threatened species section of the DEC website at www.environment.nsw.gov.au.	Yes	Section 5 and 6

Section	Description	Compliance	Location
6.3	**Local and regional abundance**		
	Section 110(2)(d) of the TSC Act states that the SIS must provide, for each threatened species and population likely to be affected by the proposal: *"An estimate for the local and regional abundance of those species or populations".* An identification and discussion of all known populations of each affected subject species in the locality must be provided. This information must include (unless stated that it is not available): • population size, using either relative or absolute measures of abundance and the extent (in hectares) of each population; • their locations relative to each other and depicted on a map; • the long term security of the habitats of other populations in the locality; • an assessment of the conservation significance of populations in the study area, including an assessment of the significance of the population in the study area in the context of the species' occurrence in the locality; and • an indication of the degree to which the size and structure of any population in the study area would be affected by the likely impacts of the proposal. Information and a discussion of the regional abundance of each affected subject species must be provided. This must include (unless stated that it is not available): • measures of abundance (relative, qualitative or absolute); • the distribution pattern of the abundance; and • a determination of the conservation significance of the study area with respect to regional abundance.	Yes	Section 5
6.4	**Habitat**		
	Section 110(2)(f) of the TSC Act states that the SIS must provide, for each threatened species and population likely to be affected by the proposal: *"A full description of the type, location, size and condition of the habitat (including critical habitat) of those species and populations and details of the distribution and condition of similar habitats in the region".*	Yes	Section 5
	Section 110(3)(c) of the TSC Act states that the SIS must provide, for each endangered ecological community likely to be affected by the proposal: *"A full description of the type, location, size and condition of the habitat of the ecological community and details of the distribution and condition of similar habitats in the region".*	Yes	Section 5
	A description of the type, location, size and condition of each vegetation community in the study area must be provided. As a minimum, the description must include information where appropriate in these categories (presence or absence, nature, and estimates of extent (hectares and as a % of total area) and intensity) for each of the following habitat-related parameters: • canopy, shrub and groundcover layers – composition and condition;	Yes	Section 3 and 5 Annex D

Section	Description	Compliance	Location

	• small scale features (for example, hollow-bearing trees, stags, culverts, rock outcrops and overhangs, caves, disused mine workings, quarries and pits, bridges, tunnels, ephemeral or isolated water bodies,) that are utilised for specific habitat requirements (eg breeding, roosting, feeding) – location, density, evidence of use;
	• introduced plant species – identification and numbers of species;
	• impacts of land-use activities and resultant processes, including:
	  • erosion;
	  • introduced grazing animals (eg trampling, grazing);
	  • human activities (eg dumping of rubbish, emplacement and utilisation of informal road and foot tracks);
	  • clearing (total or selective, under scrubbing);
	  • logging;
	  • mineral, sand and gravel extraction; and
	  • fire history (including estimated of frequency and time since last fire).		

	An assessment of the potential for regeneration from the seed bank of disturbed/degraded or recently cleared areas within each vegetation community within the study area must be provided.	Yes	Section 6
	Lists must be provided of all affected subject species known to occur, or likely to occur, in each vegetation community. The purpose(s) (ie breeding, roosting or foraging) for which these species are likely to use the vegetation community must also be provided.	Yes	Section 5
	A description of the type, location, size and condition of the known and likely habitats of each affected subject species in the study area must be provided. This description must, where appropriate, encompass the habitat-related parameters outlined above.	Yes	Section 5
	Details of the distribution and condition of similar habitats in the region must be provided for each affected subject species. The conservation significance of the habitat of each affected subject species in the study area, in comparison with similar habitats in the region, must be identified and discussed.	Yes	Section 5
	The location, nature and extent (as a percentage of the total area of the habitat in the subject site) of habitat removal or modification that is likely to result from the proposal must be identified and discussed for each affected subject species. The likely impacts of this habitat removal or modification on the future viability of each affected endangered ecological community occurrence and each population of each affected subject species in the study area must be identified and discussed.	Yes	Section 6
	The likely cumulative loss of habitat (utilising vegetation communities as a surrogate) within the locality, based on the aggregate of: • areas identified for development; • areas for which development applications or approvals for proposed actions have been lodged; and	Yes	Section 6

Section	Description	Compliance	Location
	• areas for which development consents have been granted or proposed actions approved but which have not yet been developed; must be identified. The likely impacts of this cumulative removal or modification of habitat on the future viability of populations of the affected subject species in the locality must be identified and discussed.		
	Areas within the locality that may form part of local or regional wildlife movement corridors for affected threatened species must be identified and described. The affected subject species that are likely to utilise these corridors must be identified. A map showing these corridors must be provided. The likely impacts of the proposal on these corridors and on movements of the affected threatened species identified as likely to utilise them, must be identified and discussed. The NPWS's "Key Habitats and Corridors – a Landscape Framework for Regional Conservation Programs in North East New South Wales" project, which identifies and ranks wildlife corridors and identifies assemblages of species that may utilise these corridors, must be utilised in this assessment. However, this does not preclude the utilisation of the results of other wildlife corridor studies	Yes	Section 6
	The likely impacts of the proposal on areas of land within the study area that possess the potential, through current status, rehabilitation or restoration, to link endangered ecological community remnants, must be identified and discussed.	Yes	Section 5
7	**Measures to mitigate adverse effects**		
	Section 110(2)(i) of the TSC Act states that the SIS must provide: *"A full description and justification of the measures proposed to mitigate any adverse effect of the action on the species and populations, including a compilation (in a single section of the statement) of those measures"*.	Yes	Section 7
	Section 110(3)(f) of the TSC Act states that the SIS must provide: *"A full description and justification of the measures proposed to mitigate any adverse effect of the action on the ecological community, including a compilation (in a sin*gle section of the statement) of those measures".	Yes	Section 7
	Ameliorative measures must be considered and discussed for each affected subject species. Measures proposed to address the impacts of the proposal must be developed using the following approach: • step 1: where possible, AVOID (eg eliminate, locate elsewhere) the action causing the impact; • step 2: where step 1 is not possible, AMELIORATE (reduce the intensity, extent or other undesirable characteristics (or any combinations of these three) of the impact); • step 3: where steps 1 and 2 are not possible, COMPENSATE for the impact	Yes	Section 7
	A detailed description and justification of the measures proposed to address any adverse effects of the proposal on all affected subject species must be provided. Each measure identified must indicate which of the above three categories the measure relates to.	Yes	Section 7

Section	Description	Compliance	Location

	The information provided on each identified measure must include:
	• objective(s);
	• justification;
	• description;
	• geographic scope: extent and location (within the subject site and all areas within the study area within the control of the proponent that are likely to be affected, directly or indirectly, by the proposal);
	• time frame:
	  • relative to the implementation stages (pre-construction, construction and operation) of the proposal; and
	  • absolute (duration);and
	  • frequency of application;
	• the person(s) and/or organisations responsible for implementation; and
	• performance management criteria (specific and measurable).
	The measures may include, but are not limited to:
	fire, pest and weed management;
	habitat creation, rehabilitation or enhancement;
	increased protection (through changes in land tenure or zoning, or the application of other planning instruments etc) of areas of high conservation significance;
	facilitating movements of wildlife;
	actions addressing specific stages (eg pre-construction, construction, post-construction) and actions of the proposal; and
	offsets (see Section.7.1).
	Any proposed measures for habitat creation, rehabilitation or enhancement must aim to minimise the time between impacts of the proposal on the habitat and commencement of the measure.
	The techniques used in the outlined measures will preferably have been trialed and found appropriate in similar contexts elsewhere. They should employ current best practice. Where available, literature references outlining the techniques or its use must be provided. Proposed techniques or measures that have not been used elsewhere may be utilised. However, they must be implemented utilising experimental design conditions and their effectiveness rigorously monitored.
	The potential for conflict between avoidance, amelioratory or compensatory measures to protect threatened species and their habitats, and fire management measures required by legislation, must be addressed. Any proposed avoidance, amelioratory or compensatory measures must ensure that the provisions or application of the *Rural Fires and Environmental Assessment Legislation Amendment Act* 2002, and consequent documents such as "Planning for Bushfire Protection – a Guide for Councils, Planners, Fire Authorities, Developers and Home Owners (2001) NSW Rural Fire Service" and "Building in Bush Fire Prone		

Section	Description	Compliance	Location
	Areas – Guidelines for Subdivision Applications (2004) NSW Rural Fire Service", do not partially or totally nullify them. It is recognised that any identified measures are proposed approaches that will be subject to subsequent discussion and potential modification, particularly with regard to detail, prior to their implementation.		
7.1	**Offset (compensatory) strategies** If the impacts of the proposal on affected subject species cannot be avoided or significantly reduced by amelioratory measures, offsets must be considered. Offsets must contribute significantly to the long term conservation of one or more affected subject species. The extent and cost of these offsets should reflect the extent and conservation significance of the endangered ecological communities and of the habitat(s) of threatened species and endangered populations being impacted by the proposal, and the intensity of the degradation or destruction of the habitats that are being offset. The proposed actions of an offset strategy must be located (in order of preference) within the study area, locality or region. Offset strategies may involve one or more of, but are not limited to: • the reservation of lands under Part 4 of the NP & W Act or the entry into a Voluntary Conservation Agreement under that Act; • actions to restore the habitat of affected subject species on the land referred to in the previous point; • the contribution of money to DEC for one or more of the above purposes; and • the identification and implementation of measures (for example, changes in land tenure or zoning, or the application of other planning instruments) to improve the level of protection of areas of high conservation significance. They must outline desired outcomes and proposed implementation mechanisms. Where relevant, the strategies must include comparisons (including extent, numbers and abundance of affected threatened species, habitat condition) between the impacted and proposed offset areas. If proposed offset strategies require the involvement of individuals, community groups or organisations external to the proponent, these potential stakeholders must be consulted where appropriate regarding the strategy and their likely responses provided. Proposed offset strategies should be discussed with DEC prior to finalisation of the SIS to determine their likelihood of acceptance by DEC. More than one offset strategy may be outlined if considered appropriate, to identify and facilitate discussion of alternative approaches.	N/A	

Section	Description	Compliance	Location
7.2	**Translocation** Translocation will **not** be considered as an offset strategy, and not in most circumstances, as an amelioratory measure. Most translocations have been costly and eventually unsuccessful, in part because they usually require ongoing monitoring and actions over a significant period of time beyond the time frame of the original translocation. The provision of long term funding and resources is usually incompatible with the time frame of the environmental assessment and construction of most developments. The DEC will only consider a proposal to translocate an affected subject species in situations where: • the location of the habitat of the threatened species will be destroyed or degraded to an extent that most or all of the population of the threatened species will not be able to continue to function or exist at that location; and • appropriate habitats for translocation are available within the locality. The DEC will **not** consider translocation proposals that involve transfer of populations or individuals of affected subject species to captive breeding or propagation facilities, unless the prime purpose of such translocations is to conserve identified genetic characteristics that are not or only rarely present in other populations of the species. All translocation proposals for threatened flora species must consider the Australian Network for Plant Conservation's (1997) translocation guidelines. All translocation proposals for threatened fauna species must comply with the DEC's threatened fauna translocation policy (NPWS Threatened Species Management Policy and Procedure Statement no. 9 (2001)).	Yes	Section 6
8	**Description of feasible alternatives and justification for the proposal** Sections 110(2)(h) and 110(3)(e) of the TSC Act state that the SIS must provide, for threatened species and populations, and for endangered ecological communities, respectively: *"A description of any feasible alternatives to the action that are likely to be of lesser effect and the reasons justifying the carrying out of the action in the manner proposed, having regard to the biophysical, economic and social considerations and the principles of ecologically sustainable development".* If a Statement of Environmental Effects, Environmental Impact Statement, Review of Environmental Factors or similar document accompanying the DA adequately addresses these matters, the SIS may refer to the relevant section(s) of these documents. Otherwise, the SIS must provide relevant information, including identifying social and economic considerations justifying the proposal and outlining how the proposal addresses the principles of ecologically sustainable development. The SIS must describe the current and proposed future uses of those parts of the study area that will not be impacted by the proposal, and discuss whether these parts are potential alternative locations for the proposal.	Yes	Section 6 Refer to ERM (2004e)

Section	Description	Compliance	Location
9	**Additional information**		
9.1	**Qualifications and experience of SIS author(s) and researcher(s)**		
	Section 110(4) of the TSC Act states that the SIS: *"must include details of the qualifications and experience in threatened species conservation of the person preparing the statement and of any other person who has conducted research or investigations relied on in preparing the statement".* **Details** of the experience in threatened species conservation must be provided; it is not sufficient to provide generalities.	Yes	Annex F
9.2	**Other approvals required prior to undertaking the proposal**		
	Section 110(2)(j) of the TSC Act states that the SIS must provide: *"A list of any approvals that must be obtained under any other Act or law before the action may be lawfully carried out, including details of the conditions of any existing approvals that are relevant to the species or population".*	Yes	Section 1
	Section 110(3)(g) of the TSC Act states that the SIS must provide: *"A list of any approvals that must be obtained under any other Act or law before the action may be lawfully carried out, including details of the conditions of any existing approvals that are relevant to the ecological community".* The list must include, for each approval: • the name of the organisation responsible for granting the approval; • the title and section of the legislation under which the approval is to be or has been granted; and • the date (day/month/year) or the proposed or likely date (month/year) of granting of the approval.	Yes	Section 1
9.3	**Licences and approvals required prior to undertaking surveys**		
	Persons conducting flora and fauna surveys must possess appropriate licences and approvals. The relevant legislation and associated licences and approvals that may be required are: <u>NP & W Act:</u> • Licence (Section 132C) authorising a person to pick threatened species and ecological communities and damage their habitat for scientific investigation. These licences must include, where appropriate, the DEC's "Guidelines for the Collection of Threatened Plants and Plants that occur in Endangered Ecological Communities for Identification and Herbarium Voucher Purposes" and the "Guidelines for the Collection of Land Snails for Identification and Research Purposes".	Yes	Annex F

Annex B

Flora Species List

Table B.1 Flora Species List

Scientific Name	Common Name	Site 1		Site 2		Site 3		Site 4		Site 5		Site 6		Site 7		Site 8		Site 9	
		Q1	Q2	Q1	Q2	Q1	Q2	Q1	Q2	Q1	Q2	Q1	Q2	Q1	Q2	Q1	Q2	Q1	Q2
AIZOACEAE																			
Carpobrotus glaucescens	pig face									+									
AMARYLLIDACEAE																			
Crinum pedunculatum								1											
APIACEAE																			
Actinotus helianthi	flannel flower											2	2	3	3	1		1	
#*Centella asiatica*				2	1			2	2										
*#*Hydrocotyle bonariensis*	pennywort				1	2	2												
Platysace ericoides																1	1		
Platysace lanceolata										2	3	2	2			1	3		
APOCYNACEAE																			
#*Parsonsia straminea*	monkey rope	1	1			3		3	3									1	
ARECACEAE																			
#*Livistona australis*	cabbage tree palm	3	3	5	3	1	3	3	3										
ASCLEPIADACEAE																			
Marsdenia rostrata		2		2	1														
ASTERACEAE																			
Chrysanthemoides monilifera subsp. *rotundata*	bitou bush							1		1	1	1				1		1	
Senecio hispidulus		1	1			1	1	1		1									
BIGONIACEAE																			
Pandorea pandorana	wonga wonga vine	1	1	2				2	2	3	2	2	2					1	
BLECHNACEAE																			
#*Blechnum indicum*		5	5	1	2	6	6	2											

Scientific Name	Common Name	Site 1		Site 2		Site 3		Site 4		Site 5		Site 6		Site 7		Site 8		Site 9	
CAMPANULACEAE																			
Wahlenbergia gracilis										1		1							
CASUARINACEAE																			
#*Allocasuarina littoralis*	black she-oak											1							
Allocasuarina torulosa	forest she-oak									+		1							
#*Casuarina glauca*	swamp she-oak				1		1	2											
COMMELINACEAE																			
Commelina cyanea		1	2	1	2	2	2	1											
CONVOLVULACEAE																			
Calystegia marginata				1		1													
CYPERACEAE																			
#*Baumea articulata*						2	2	1											
#*Carex appressa*				2		3	3	4	4										
**Cyperus sp.*										1									
#*Gahnia clarkei*		2	2	2	2		3	2	2									1	2
Schoenus ericetorum																2	1		
DENNSTAEDTIACEAE																			
Histiopterus incisa	batswing fern	2			2	3	4	2	2										
#*Pteridium esculentum*	bracken	3	2	2						5	6	5	5	3	3			3	3
DICKSONIACEAE																			
#*Calochlaena dubia*	false bracken	2	2	2				2											
DILLENIACEAE																			
Hibbertia fasciculata										1	1		1	1		1			
Hibbertia linearis												1							
ELEOCARPACEAE																			
Elaeocarpus obovatus	blueberry ash	1	1	2			1		1										
EPACRIDACEAE																			
Brachyloma daphnoides												1		1	1	3	2	1	

Scientific Name	Common Name	Site 1		Site 2		Site 3		Site 4		Site 5		Site 6		Site 7		Site 8		Site 9	
Monotoca elliptica												1	1	1		1		2	2
Monotoca scoparia																3	1		
EUPHORBIACEAE																			
Amperea xiphoclada	broom spurge											2		1	2	2			
#*Breynia oblongifolia*	breynia	1	1	1					1	1	1								
#*Glochidion ferdinandi*	cheese tree	1	1		1		2	3											
#*Omalanthus populifolius*	bleeding heart	1	3	2	2	1	2	2	2										
Ricinocarpos pinifolius	wedding bush									1	1	2	2	1		1	1	1	
FABACEAE - FABOIDEAE																			
Aotus ericoides	aotus									1	1	2	2					2	
Bossiaea heterophylla										1	2		2	1	2				
Bossiaea rhombifolia										1	1								
Desmodium varians										2	3								
Dillwynia retorta var. *retorta*	heathy parrot pea									3	3	3	3	4	4	2	2	2	
Glycine microphylla				1						2			1						
Glycine tabacina				1															
Gompholobium latifolium	broad-leaf wedge-pea										3		1						
Hardenbergia violacea	false sarsaparilla									1	1	1	1						
Indigophora australis														1					
Jacksonia scoparia	dogwood									2	1								
Kennedia rubicunda	dusky coral pea	1	2	1	1													1	1
FABACEAE - MIMOSOIDEAE																			
#*Acacia irrorata*		3	1	2						1	1								
#*Acacia longifolia*	Sydney golden wattle		1							1	1		1			1		1	

Scientific Name	Common Name	Site 1		Site 2		Site 3		Site 4		Site 5		Site 6		Site 7		Site 8		Site 9	
Acacia suaveolens											2	1		1		1			
Acacia ulicifolia	prickly moses									1	2	1	1	3	3	2	2	1	
HALORAGACEAE																			
Gonocarpus teucrioides	germander raspwort									3	3	3	3	2	2			1	
LAURACEAE																			
Cassytha pubescens	common devils twine			2												3	1		
Endiandra sieberi	corkwood		1																
LILIACEAE																			
Tricoryne elatior	yellow rush-lily									1									
LOBELIACEAE																			
#*Pratia purpurascens*	white root			1															
LOMANDRACEAE																			
#*Lomandra longifolia*	spiny-headed mat-rush											1	1	2	2	2	4	2	2
MENISPERMACEAE																			
#*Stephania japonica* var. *discolor*	snake vine	1	1	1		1		2	2										
MENYANTHACEAE																			
#*Villarsia exaltata*	erect marsh-flower	1																	
MORACEAE																			
Maclura cochinchinensis	cockspur thorn			1															
MYRSINACEAE																			
Rapanea variabilis				1				1											
MYRTACEAE																			
#*Acmena smithii*	lilly pilly			1				2	2										
Angophora costata	smooth-barked apple	1	1							3	3	3	3	3	2	2	2	3	3

Scientific Name	Common Name	Site 1		Site 2		Site 3		Site 4		Site 5		Site 6		Site 7		Site 8		Site 9	
Calytrix tetragona																3	1	1	
Corymbia gummifera	red bloodwood													+					
Eucalyptus pilularis	blackbutt		1	1						1		1	1						
#*Eucalyptus robusta*	swamp mahogany	3		1		1	2	1										1	3
Leptospermum laevigatum	coast tea-tree															2	1		
#*Leptospermum polygalifolium*	lemon-scented tea-tree															4	3	4	6
Leptospermum trinervium										1		1	1	1	2				
#*Melaleuca linariifolia*				1		1													
Melaleuca nodosa																		3	
#*Melaleuca quinquenervia*	broad-leaved paperbark			3	3	5	5	3	3										
#*Melaleuca sieberi*																+			
#*Melaleuca styphelioides*	prickly-leaved paperbark				2														
OLEAECEAE																			
Notelaea longifolia				1				1	1										
PHILESIACEAE																			
Eustrephus latifolius	wombat berry			1				1											
Genitonoplesium cymesum								1											
PHORMIACEAE																			
#*Dianella caerulea* var. *producta*				1						3	3	2	2	2		1	2	2	
PITTOSPORACEAE																			
Billardiera scandens	apple berry									+									
POACEAE																			
#*Entolasia marginata*								3	3										
#*Entolasia stricta*		2	3	2	3	2	3	1										1	3
Eragrostis benthamii																1	1	1	

Scientific Name	Common Name	Site 1		Site 2		Site 3		Site 4		Site 5		Site 6		Site 7		Site 8		Site 9	
#*Imperata cylindrica* var. *major*	blady grass		1							4	4	2	2						
Isachne globosa						1													
Microlaena stipoides								1											
#*Oplismenus aemulus*				1			1												
#*Phragmites australis*	common reed																		
#*Themeda australis*	kangaroo grass									2	3		1	1	1				
POLYGALACEAE																			
Comesperma ericinum	heath milkwort											1	1						
POLYGONACEAE																			
Persicaria strigosa				1	2			1	1										
POLYPODIACEAE																			
Pyrossia rupestris								2	2										
PROTEACEAE																			
Banksia serrata	old man banksia							1			1	3	3	1	2	2	3	3	2
Conospermum ellipticum																1	2		
Persoonia levis	smooth geebung																		
RANUNCULACEAE																			
Clematis aristata			1																
RESTIONACEAE																			
Restio tetraphyllus	cord rush	2																2	3
RHAMNACEAE																			
Alphitonia excelsa	red ash			1															
Pomaderris sp.				1															
ROSACEAE																			
Rubus parvifolius				1															
RUBIACEAE																			
Pomax umbellata	pomax		1	1							1	1	1			1	2	1	

Scientific Name	Common Name	Site 1		Site 2		Site 3		Site 4		Site 5		Site 6		Site 7		Site 8		Site 9	
RUTACEAE																			
Zieria smithii				1															
SAPINDACEAE																			
Cupaniopsis anarchardioides	tuckeroo			1				1											
SMILACACEAE																			
Smilax australis			+					3	3										
Smilax glyciphylla				1															
TYPHACEAE																			
Typha orientalis	bullrush																		
VERBENACEAE																			
Clerodendrum tomentosum				1				1											
**Lantana camara*	lantana	3	2	3	2	1		6	6										
VIOLACEAE																			
#Viola hederaceae					2		2												
VITACEAE																			
Cayratia clematidea									1										

1. sites 1, 2, 3, 4 = swamp forest; sites 5, 6, 7 = dry sclerophyll open forest; sites 8, 9 = wet heath
2. * introduced species
3. + = recorded along transects outside quadrat sites.
4. # species indicative of 'swamp sclerophyll forest on coastal floodplains of the NSW north coast, Sydney basin and south east corner bioregions'
5. cover abundance scale (modified Braun-Blanquet scale):
   1 = < 5% cover and few individuals
   2 = < 5% cover and many individuals
   3 = 5 - 25% cover
   4 = 25-50% cover
   5 = 50-75% cover
   6 = 75-100% cover

Annex C

Bird Survey Effort

Table C.1 Bird Survey Effort

Site	Easting	Northing	Date	Start	Finish	Temperature	Site/Vegetation Description	Targeted Species
FB1	388156	6363325	1/02/2005	630	700	24.8	Swamp Mahogany Forest w/ rainforest species, adjacent to mobile home village; small stand of *Allocasuarina*, no chewed cones	rose-crowned, superb, wompoo fruit-dove (call playback), glossy black-cockatoo, osprey, square-tailed kite
FB1	388156	6363325	2/02/2005	605	705	18.5	Swamp Mahogany Forest w/ rainforest species, adjacent to mobile home village; small stand of *Allocasuarina*, no chewed cones	rose-crowned, superb, wompoo fruit-dove, glossy black-cockatoo, osprey, square-tailed kite
FB1	388156	6363325	3/02/2005	613	713	17.6	Swamp Mahogany Forest w/ rainforest species, adjacent to mobile home village; small stand of *Allocasuarina*, no chewed cones	rose-crowned, superb, wompoo fruit-dove, glossy black-cockatoo, osprey, square-tailed kite
FB1A	387944	6363202	1/02/2005	700	720	24.8	260m east of FB1	brown treecreeper, grey-crowned babbler, glossy black-cockatoo, osprey, square-tailed kite
FB1B	388408	6363246	1/02/2005	700	720	24.4	East of FB1A	brown treecreeper, grey-crowned babbler, glossy black-cockatoo, osprey, square-tailed kite
FB2	388081	6362675	1/02/2005	735	755	24.4		brown treecreeper, grey-crowned babbler, glossy black-cockatoo, osprey, square-tailed kite
FB2A	388581	6362541	1/02/2005	755	815	24.4		brown treecreeper, grey-crowned babbler, glossy black-cockatoo, osprey, square-tailed kite
FD2	388180	6363835	1/02/2005	830	930	26.0	Melaleuca, rainforest species adjacent to Nelson Bay Road	rose-crowned, superb, wompoo fruit-dove (call playback), osprey, square-tailed kite
FB3	388416	6363949	1/02/2005	950	1010	26.0	Apple/Blackbutt Forest, along powerline easement then south east	brown treecreeper, grey-crowned babbler, glossy black-cockatoo, osprey, square-tailed kite
FB3A	388241	6363847	1/02/2005	1010	1030	26.0	Apple/Blackbutt Forest, along powerline easement then south east	brown treecreeper, grey-crowned babbler, glossy black-cockatoo, osprey, square-tailed kite
FB3B	388530	6363895	1/02/2005	1032	1052	26.0	Apple/Blackbutt Forest, along powerline easement then south east	brown treecreeper, grey-crowned babbler, glossy black-cockatoo, osprey, square-tailed kite
FB4	388453	6362423	1/02/2005	1055	1115	28.0	Apple/Blackbutt Forest, along powerline easement then south east	brown treecreeper, grey-crowned babbler, glossy black-cockatoo, osprey, square-tailed kite

Site	Easting	Northing	Date	Start	Finish	Temperature	Site/Vegetation Description	Targeted Species
FB4A	388659	6362408	1/02/2005	1117	1137	28.0	Apple/Blackbutt Forest, along powerline easement then south east	brown treecreeper, grey-crowned babbler, glossy black-cockatoo, osprey, square-tailed kite
FB5	389049	6362675	5/02/2005	1530	1550	26.9	Wet Heath; offsite	brown treecreeper, grey-crowned babbler, glossy black-cockatoo, osprey, square-tailed kite
FB5A	388973	6363038	5/02/2005	1550	1610	25.6	Heath understorey, Angophora/Blackbutt Forest	brown treecreeper, grey-crowned babbler, glossy black-cockatoo, osprey, square-tailed kite
FB5B	388794	6363168	5/02/2005	1610	1630	29.5		brown treecreeper, grey-crowned babbler, glossy black-cockatoo, osprey, square-tailed kite
FB5C	388492	6363253	5/02/2005	1640	1700	26.8	Angophora/Blackbutt Forest adjacent to recently cleared area	brown treecreeper, grey-crowned babbler, glossy black-cockatoo, osprey, square-tailed kite
FB6	388924	6363808	5/02/2005	1710	1730	27.3	North of cleared area (near previous regent honeyeater/swift parrot site) - Angophora Forest, some Blackbutt, *Casuarina glauca*, *Allocasuarina littoralis* seedlings, gully with s/w aspect	brown treecreeper, grey-crowned babbler, glossy black-cockatoo, osprey, square-tailed kite
FB6A	388955	6363949	5/02/2005	1735	1755	27.3	Just north of FB6; Melaleuca/Angophora/Cabbage Tree Palm Forest in gully; some rainforest species in understorey	rose-crowned, superb, wompoo fruit-dove (call playback), glossy black-cockatoo, osprey, square-tailed kite
FB6B	389241	6364359	5/02/2005	1800	1820	25.0	Melaleuca/Angophora/Cabbage Tree Palm Forest in gully 200m from Nelson Bay Road; some rainforest species present, Angophora/Blackbutt present on ridge	rose-crowned, superb, wompoo fruit-dove (call playback), glossy black-cockatoo, osprey, square-tailed kite
FB7	389024	6363930	6/02/2005	705	725	17.3	Angophora/Blackbutt Forest; some *Allocasuarina* (3 individuals) searched, no evidence GBC; heath understorey, ridge surrounds gullies	brown treecreeper, grey-crowned babbler, glossy black-cockatoo, osprey, square-tailed kite
FB7A	389220	6363856	6/02/2005	730	750	17.4	Heath - *Banksia serrata*; *Angophora costata* on western edge of site; some swamp mahogany present; *Allocasuarina littoralis* (2) individuals present, no cones present	brown treecreeper, grey-crowned babbler, glossy black-cockatoo, osprey, square-tailed kite

Site	Easting	Northing	Date	Start	Finish	Temperature	Site/Vegetation Description	Targeted Species
FB7B	389483	6363805	6/02/2005	752	812	18.4	Apple/blackbutt forest, heath understorey	brown treecreeper, grey-crowned babbler, glossy black-cockatoo, osprey, square-tailed kite
FB7C	389529	6363673	6/02/2005	815	835	22.8	Apple/blackbutt forest, heath understorey	brown treecreeper, grey-crowned babbler, glossy black-cockatoo, osprey, square-tailed kite
FB7D	389692	6363924	6/02/2005	837	857	21.1	Banksia (mature), Angophora, Blackbutt forest, heath understorey, *Allocasuarina littoralis* (8) in fruit, no chewed cones, another 40 *Allocasuarina littoralis* (1-2m high) no fruit; gully site	brown treecreeper, grey-crowned babbler, glossy black-cockatoo, osprey, square-tailed kite
FB7E	389862	6364214	6/02/2005	900	920	23.2	Blackbutt/Angophora forest; heath (Banksia) dominated understorey	brown treecreeper, grey-crowned babbler, glossy black-cockatoo, osprey, square-tailed kite
FB7F	389935	6364596	6/02/2005	927	947	24.2	Angophora/blackbutt forest, heathy understorey; *Allocasuarina littoralis* (15) in clusters by 3; no evidence glossy black-cockatoo	brown treecreeper, grey-crowned babbler, glossy black-cockatoo, osprey, square-tailed kite
FB7G	389374	6364418	6/02/2005	951	1011	24.4	Within 200m of Nelson Bay Road, Angophora Forest; *Allocasuarina littoralis* (5 mature individuals) present, no fruit present; another 75 juveniles 1-3m high, unsuitable for glossy black-cockatoo. @ 389375E 6364417N *Allocasuarina torulosa* (10) w/ fruit, no evidence of glossy black-cockatoo	brown treecreeper, grey-crowned babbler, glossy black-cockatoo, osprey, square-tailed kite
FB8	389149	6363349	6/02/2005	1024	1044	26.2	Angophora, Blackbutt, Banksia	brown treecreeper, grey-crowned babbler, glossy black-cockatoo, osprey, square-tailed kite
FB8A	388994	6363190	6/02/2005	1050	1110	27.0	Intersection of trails, heath	brown treecreeper, grey-crowned babbler, glossy black-cockatoo, osprey, square-tailed kite
FB8B	389396	6363069	6/02/2005	1115	1135	28.1	Angophora, blackbutt, banksia - max. height 20m, medium size, mallee habit with *Acacia sophorae* present	brown treecreeper, grey-crowned babbler, glossy black-cockatoo, osprey, square-tailed kite
FB8C	388745	6362435	7/02/2005	635	655	16.3	Heathland @ extreme edge of site, possibly offsite; *Acacia sophorae*, Bitou, mallee blackbutt, *Banksia serrata*, Bracken	brown treecreeper, grey-crowned babbler, glossy black-cockatoo, osprey, square-tailed kite

Site	Easting	Northing	Date	Start	Finish	Temperature	Site/Vegetation Description	Targeted Species
FB8D	389173	6362793	7/02/2005	702	722	24.0	Edge of dunes; heath; dune vegetation (pigface)	brown treecreeper, grey-crowned babbler, glossy black-cockatoo, osprey, square-tailed kite
FB8E	390998	6364253	7/02/2005	730	750	20.5	Edge of dunes, Banksia dominated w/ *Acacia sophorae*, small mallee Eucalypts and *Angophora costata*	brown treecreeper, grey-crowned babbler, glossy black-cockatoo, osprey, square-tailed kite
FB8F	391693	6364937	7/02/2005	755	815	21.8	*Angophora costata*; *Melaleuca quinquenervia*, Banksia woodland	brown treecreeper, grey-crowned babbler, glossy black-cockatoo, osprey, square-tailed kite
FB8G	391836	6365565	7/02/2005	820	840	25.3	*Angophora costata*, *Leptospermum laevigatum* woodland merging into denser more mature Angophora forest	brown treecreeper, grey-crowned babbler, glossy black-cockatoo, osprey, square-tailed kite

Annex D

Vegetation Community Descriptions

D.1 SWAMP FOREST

Swamp forest occurs in low lying areas of the study area and includes the endangered ecological community 'swamp sclerophyll forest on coastal floodplains of the NSW north coast, Sydney basin and south east corner bioregions'. The endangered community occurs adjacent to Nelson Bay Road where it is contiguous with the floodplain of the Hunter River around Fullerton Cove. The dominant canopy species are swamp mahogany (*Eucalyptus robusta*), broad-leaved paperbark (*Melaleuca quinquenervia*) and cabbage tree palm (*Livistona australis*) up to 18 metres in height with a projected vegetative cover of approximately 50 percent. The understorey is dominated by *Acacia irrorata*, bleeding heart (*Omalanthus populifolius*) and blueberry ash (*Elaeocarpus obovatus*) up to 4 metres in height, with a vegetative foliage cover of approximately 10 percent. The exotic weed lantana (*Lantana camara*) dominates the understorey in some areas, where it can have 80 percent vegetative cover. Despite the presence of lantana and evidence of fire within the last 5 years, this community is in good condition. Other exotic species present include pennywort (*Hydrocotyle bonariensis*), although this species does not dominate any strata. The ground layer is composed of a variety of life forms, including ferns such as *Blechnum indicum*, false bracken (*Calochlaena dubia*) and batswing fern (*Histiopterus incisa*), vines such as monkey rope (*Parsonsia straminea*) and snake vine (*Stephania japonica* var. *discolor*), and grasses such as *Entolasia marginata*. The ground layer is generally up to 1.5 metres in height with a projected foliage cover of up to 75 percent. Rainforest genera are present in the swamp forest in some areas, including blueberry ash, red ash (*Alphitonia excelsa*), *Notelaea longifolia*, lilly pilly (*Acmena smithii*) and cheese tree (*Glochidion ferdinandi*). Wetter areas provide suitable conditions for wetland species such as *Persicaria strigosa* and *Baumea articulata*.

This community corresponds to the LHCCREMS mapping unit of swamp mahogany – paperbark forest.

D.2 DRY SCLEROPHYLL OPEN FOREST

Dry sclerophyll open forest dominates the vegetation of the study area. It is present on the Holocene transgressive sand dunes that are generally amphitheatre-shaped. The dominant canopy species are blackbutt (*Eucalyptus pilularis*) and smooth-barked apple (*Angophora costata*) up to 16 metres in height, with a projected vegetative cover of approximately 25 percent. Both the canopy height and vegetative cover decrease towards the coast. For example, site 7, which is the closest to the coast, has a canopy height of 8 metres with a projected vegetative cover of 15 percent, whereas site 5 has canopy height of 16 metres and a vegetative cover of 35 percent. The understorey is dominated by Sydney golden wattle (*Acacia longifolia*), immature blackbutt and smooth-barked apple, prickly moses (*Acacia ulicifolia*) and heathy parrot pea (*Dillwynia retorta* var. *retorta*) up to 4 metres in height

with a projected foliage cover of approximately 5 percent. The ground layer is dominated by blady grass (*Imperata cylindrica* var. *major*), bracken (*Pteridium esculentum*), *Dianella caerulea* var. *producta* and kangaroo grass (*Themeda australis*) up to 1 metre in height. Other species include shrubs and herbs such as *Bossiaea rhombifolia*, *Gonocarpus teucrioides*, *Platysace lanceolata* and wedding bush (*Ricinocarpos pinifolius*). Flannel flower (*Actinotus helianthi*) becomes a common species in the ground layer at sites closer to the coast, such as site 7. Vines such as wonga wonga (*Pandorea pandorana*) are common. The ground layer has a projected vegetative cover of approximately 20 percent, although bracken can account for up to 80 percent of the ground cover in some areas. This community has been regularly subjected to fire, at least once every 5 years and often more frequently. As a result, plant species indicative of high fire frequency are common, such as bracken and blady grass, and species diversity is low compared to surrounding areas of dry sclerophyll open forest. There is some invasion of bitou bush (*Chrysanthemoides monilifera* subsp. *rotundata*) at all sites. Disturbance in this community has resulted from off-road vehicle tracks and rubbish dumping.

This community corresponds to the LHCCREMS mapping unit of coastal sand apple – blackbutt forest.

D.3 WET HEATH

Wet heath occurs in low lying areas between the Holocene sand dunes in two distinct age series in the study area. The older series on the 4000 year BP sand mass is where most of this community occurs in the study area. The overstorey is stunted and consists of smooth-barked apple, old man Banksia (*Banksia serrata*) and the occasional swamp mahogany up to 8 metres in height with a projected vegetative cover of approximately 10 percent. The understorey is more vegetated, dominated by lemon-scented tea-tree (*Leptospermum polygalifolium*) up to 3 metres in height with a foliage cover of approximately 35 percent. *Melaleuca nodosa* also forms a component of the understorey in some areas. The ground layer is dominated by a range of life forms from sedges such as cord rush (*Restio tetraphyllus*) to herbs and shrubs such as *Calytrix tetragona*, *Brachyloma daphnoides* and *Pomax umbellata*. Grasses and grass-like forms such as *Lomandra longifolia*, *Gahnia clarkei* and *Entolasia stricta*, and twiners such as *Cassytha pubescens* also dominate the ground layer. The ground layer is up to 1 metre in height, with a projected vegetative cover of approximately 10 percent. The exotic species bitou bush occurs in some areas.

This community corresponds to the LHCCREMS mapping unit of Tomago sand swamp woodland.

Annex E

Fauna Species List

Table E.1 Fauna Species List

Scientific Name	Common Name
Frogs	
Crinia tinnula[V]	wallum froglet
Limnodynastes peronii	striped marsh frog
Reptiles	
Egernia major	land mullet
Varanus varius	lace monitor
Birds	
Gymnorhina tibicen	Australian magpie
Corvus coronoides	Australian raven
Geopelia humeralis	bar-shouldered dove
Coracina novaehollandiae	black-faced cuckoo shrike
Coturnix ypsilophora	brown quail
Acanthiza pusilla	brown thornbill
Melithreptus brevirostris	brown-headed honeyeater
Coracina tenuirostris	cicadabird
Eudynamys scolopacea	common koel
Platycercus eximius	eastern rosella
Acanthorhynchus tenuirostris	eastern spinebill
Psophodes olivaceus	eastern whipbird
Eopsaltria griseogularis	eastern yellow robin
Lichenostomus fuscus	fuscous honeyeater
Pachycephala pectoralis	golden whistler
Cracticus torquatus	grey butcherbird
Rhipidura fuliginosa	grey fantail
Accipiter novaehollandiae	grey goshawk
Colluricincla harmonica	grey shrike-thrush
Dacelo novaeguineae	laughing kookaburra
Myiagra rubecula	leaden flycatcher
Meliphaga lewinii	Lewins honeyeater
Anthochaera chrysoptera	little wattlebird
Dicaeum hirundinaceum	mistletoebird
Philemon corniculatus	noisy friarbird
Cracticus nigrogularis	pied butcherbird
Neochmia temporalis	red-browed finch
Rhipidura rufifrons	rufous fantail
Pachycephala rufiventris	rufous whistler
Zosterops lateralis	silvereye
Dicrurus bracteatus	spangled drongo
Pardalotus punctatus	spotted pardalote
Pardalotus striatus	striated pardalote
Cacatua galerita	sulphur-crested cockatoo
Malurus cyaneus	superb fairy-wren
Malurus lamberti	variegated fairy-wren
Sericornis frontalis	white-browed scrubwren
Phylidonyris nigra	white-cheeked honeyeater
Melithreptus lunatus	white-naped honeyeater
Gerygone olivacea	white-throated gerygone
Cormobates leucophaeus	white-throated treecreeper
Lichenostomus chrysops	yellow-faced honeyeater
Gerygone mouki	brown gerygone
Ninox strenua[V]	powerful owl
Acanthiza lineata	striated thornbill
Anthochaera chrysoptera	brush wattlebird

Scientific Name	Common Name
Myzomela sanguinolenta	scarlet honeyeater
Chrysococcyx lucidus	shining-bronze cuckoo
Acanthiza nana	yellow thornbill
Strepera graculina	pied currawong
Mammals	
Chalinolobus gouldii	Gould's wattled bat
Chalinolobus morio	chocolate wattled bat
Chalinolobus nigrogriseus	hoary wattled bat
Miniopterus australis[V]	little bentwing-bat
Miniopterus schreibersii oceanensis[V]	eastern bentwing-bat
Mormopterus sp. 2	little freetail-bat
Nyctophilus sp.	long-eared bat
Nyctophilus geoffreyi	lesser long-eared bat
Petaurus norfolcensis[V]	squirrel glider
Pseudocheirus peregrinus	common ringtail possum
Trichosurus vulpecula	common brushtail possum
Pteropus poliocephalus[V]	grey-headed flying-fox
Antechinus stuartii	brown antechinus
Rattus fuscipes	bush rat
*Rattus rattus**	black rat
Rattus lutreolus	swamp rat
Scoteanax rueppellii[V]	greater broad-nosed bat
Scoteanax orion	eastern broad-nosed bat
Scotorepens sp.	broad-nosed bat
Vespadelus vulturnus	little forest bat

1. Compilation of fauna recorded in study area by ERM 2004-05 and Forest Fauna Surveys Pty Ltd 2005.
2. V = vulnerable under the TSC Act
3. * introduced species

Annex F

Curriculum Vitae of Project Personnel

Table F.1 Personnel Names, Contact and Licence Details

Name	Company	Role	Contact Phone Number	NPW Act Section 132c Licence	Animal Research Act, 1985 Authority
Steve O'Connor	ERM	Project Director	(02) 4964 2150	N/A	N/A
Dr. Andrew Hamer	ERM	Ecologist	(03) 8606 4147	S10338	AW95/047
Bianca Hamilton	ERM	Ecologist	(02) 4964 2150	S10338	AW95/047
Joanne Woodward	ERM	Ecologist	(02) 4964 2150	S10338	AW95/047
Jane Mactier	ERM	Ecologist	(02) 4964 2150	S10338	AW95/047
Michael Murray	Forest Fauna Surveys Pty Ltd	Bat and arboreal mammal surveys	(02) 4946 2977	S10736	AW94/056
Glenn Hoye	Fly by Night Bat Surveys Pty Ltd	Bat call analysis	(02) 4947 7794	N/A	N/A
Peter Ekert	Ekerlogic Consulting Services	Bird surveys	(02) 4950 0573	S10638	N/A
Barbara Triggs	Dead Finish	Mammal hair analysis	(03) 5158 0445	N/A	N/A

Steve O'Connor

Managing Partner, Hunter Valley
Australia

Steve holds the position of Managing Partner, Hunter and North Coast office with ERM Australia. He has been responsible for undertaking a wide range of major planning studies and environmental assessments during the past 25 years while working as a professional planner and environmental manager.

Steve has been the principal for a wide range of infrastructure projects including the provision of water pipelines, railways, electricity transmission lines, sewerage schemes, gas pipelines and major arterial roads. He has also been the principal in charge of major projects for mining, extractive industries, commercial, tourism, industrial and residential development, recreational infrastructure and waste management projects.

Prior to joining ERM Steve worked in the public sector at both the State and Local Government level in Australia. He therefore has valuable public and private sector experience at senior levels across a range of organisations.

Steve heads up a team of over 30 staff who focus on undertaking projects in the Hunter Valley and on the North Coast of NSW. His team covers an array of disciplines including environmental engineers, town planners, acoustic engineers, geologists, ecologists, social scientists, archaeologists, site contamination and remediation specialists and environmental auditors. This multidisciplinary team also services national and international clients both in Australia and overseas.

Professional Affiliations and Registrations

- Fellow of the Planning Institute of Australia
- Justice of the Peace

Fields of Competence

- Urban, rural and coastal planning
- Environmental impact assessment
- Strategic and statutory planning
- Sustainable development
- Social planning and community consultation
- Expert evidence
- Project management

Education

- Bachelor of Town Planning (Hons)
- Masters of Science (Hons)
- Local Government Town and Country Planning Certificate

Languages

- English

Key Industry Sectors

- Mining and Extractive
- Infrastructure
- Waste
- Government
- Manufacturing
- Land Development
- Defence
- Legal

Key Projects

Infrastructure, Premiers Department of NSW

Preparation of a environmental impact statement for a port and seven kilometre long infrastructure corridor comprising a road and conveyor to service a new technology steel mill with an estimated output of over $1 billion worth of finished products per annum. The ports and associated transport infrastructure was located adjacent to sensitive environmental areas.

Nelson Bay Road Upgrade, Roads and Traffic Authority

Preparation of a Review of Environmental Factors for a seven kilometre dual carriage way arterial road. The project was highly controversial and required extensive ecological and archaeological investigations.

Toronto Retail Centre, Lake Macquarie City Council

Represented Council as an expert witness in the successful defence of Council`s refusal of a proposed expansion of a supermarket and specialty shops.

Vincentia Compulsory Acquisition, Morton and Harris

Preparation of a series of reports assessing the development potential of land acquired for community uses by Shoalhaven City Council. The final judgement substantially favoured Council.

Bulga Open Cut Continued Mining EIS, Bulga Coal

Comprehensive coal mining environmental impact statement which was subsequently approved to allow 10 million tonnes of coal to be extracted annually.

Port Stephens Composting Plant, Bedminster

Preparation of an environmental impact statement for new technology to compost municipal waste which became the first such plant constructed in Australia.

Gunnedah Sewage Effluent Reuse, Gunnedah Council

Environmental impact statement for a project which has redirected effluent which previously discharged into the Gwyder River, so it irrigates recreation and agricultural areas.

Bulahdelah Bypass Environmental Monitoring, Thiess

Ongoing environmental monitoring of a 27 kilometre highway bypass during the three year construction period.

Williamtown RAAF Base Groundwater Investigations, Department of Defence

The Salt Ash Air Weapons Range and the Williamtown RAAF Base were the subject of detailed groundwater monitoring and modelling to ascertain the potential for contamination of valuable acquifer in close proximity to base and weapons range.

Maitland Settlement Strategy, Maitland City Council

Assessment of physical and social constraints to development and formulation of comprehensive urban settlement strategy for the city of Maitland.

Soldiers Point Project, Port Stephens Council

Masterplan and environmental assessment for tourist development which assisted in securing permits which facilitated the substantial upgrading of this tourist complex.

Summerhill Recycling Study, Newcastle City Council

Waste reuse and recycling strategy for Newcastle including masterplan for development of Council`s waste centre to maximise sustainability.

Gateway Rezoning, Nelson Bay, Port Stephens, Winten Property Group

Preparation of a comprehensive rezoning report in support of a proposal to develop an 80 hectare site adjacent to a water catchment area for residential purposes in an environmentally sensitive manner.

Andrew Hamer

Ecologist
Australia

Andrew Hamer is an Ecological Consultant with over 7 years commercial experience and is based in ERM's Hunter Valley office. He has a Bachelor of Science, a Master of Environmental Studies and a PhD from the University of Newcastle. His PhD thesis documented aspects of the ecology of the endangered green and golden bell frog. Andrew has extensive experience in scientific research and has published three papers in leading international conservation journals, with further publications anticipated.

Andrew has conducted targeted threatened flora and fauna surveys for environmental assessments, species impact assessments, ecological constraints analyses and management plans. He has conducted biodiversity assessments for a range of clients. He has also reviewed species impact statements and public submissions.

Andrew has been a consultant for the Olympic Co-ordination Authority, and has conducted many ecological assessments required for the 2000 Summer Olympic Games venues in the Sydney Basin. He has also been involved in long-term monitoring projects at Homebush Bay.

Andrew has presented lectures in vertebrate ecology at the University of Newcastle and has been an active participant in the ecology group at this institution

Professional Affiliations

- Australian Society of Herpetologists

Fields of Competence

- Ecological and biodiversity assessments
- Flora and fauna surveys
- Targeted threatened species surveys
- Amphibian habitat management and creation
- Ecological research and data analysis
- Scientific publication
- Species impact statements and impact monitoring

Education

- Doctor of Philosophy, University of Newcastle 2003
- Master of Environmental Studies, University of Newcastle 1999
- Bachelor of Science, University of Newcastle 1994

Languages

- English

Publications

- Hamer, A.J., Lane, S.J. and Mahony, M.J. 2003. Retreat site selection during winter in the green and golden bell frog *Litoria aurea* Lesson. *Journal of Herpetology* 37: 541-545.
- Hamer, A.J., Lane, S.J. and Mahony, M.J. 2002. Management of freshwater wetlands for the endangered green and golden bell frog (*Litoria aurea*): roles of habitat determinants and space. *Biological Conservation* 106: 413-424.
- Hamer, A.J., Lane, S.J. and Mahony, M.J. 2002. The role of introduced mosquitofish (*Gambusia holbrooki*) in excluding the native green and golden bell frog (*Litoria aurea*) from original habitats in south-eastern Australia. *Oecologia* 132: 445-452.
- Hamer, A.J. 1996. A survey of the frog fauna of Redhead Lagoon, Awabakal Nature Reserve, New South Wales. *Herpetofauna* 26: 8-14.

Key Projects

Flora and Fauna Assessments

NSW Premier's Department. Species Impact Statement, proposed Kooragang Port and Transport Corridor, Kooragang Island, NSW.

Project Plan. Flora and Fauna Assessment of proposed residential development, Whitebridge and Gateshead, NSW.

Project Plan. Flora and Fauna Assessment of proposed residential development, Fennell Bay, NSW.

Transgrid. Flora and Fauna Investigations for 132 kV pole replacements, Armidale-Kempsey, NSW.

RTB Engineering. Aquatic and Terrestrial Ecology Assessments for proposed borehole water extraction, Teralba, NSW.

GHD. Flora and Fauna Impact Assessment of Coal Fines Recovery Project, Singleton-Muswellbrook, NSW.

Olympic Co-ordination Authority (OCA). Species Impact Statement, green and golden bell frog, for the Water Reclamation and Management Scheme and Frog Habitat Works at the Sydney 2000 Olympic venue, Homebush Bay, NSW.

Olympic Co-ordination Authority (OCA). Fauna surveys and ecological assessment for the Sydney International Equestrian Centre Development Site, Horsley Park, NSW.

British Petroleum Australia. Fauna surveys and ecological assessment of threatened species for proposed Solar Cell Facility, Belrose, NSW.

Environmental Partnership. Fauna surveys and species impact statement for the proposed War Veterans Village, Narrabeen, NSW.

Gosford City Council. Fauna surveys and species assessment report for the Somersby Industrial Estate, NSW.

NSW National Parks and Wildlife Service. Fauna surveys for the Fire Management Plan, Mount Royal National Park, NSW.

Management Plans

Olympic Co-ordination Authority (OCA). Management Plan for the green and golden bell frog at the Sydney 2000 Olympic venue, Homebush Bay, NSW.

Long-term Monitoring Projects

NSW Premier's Department. Monitoring study of the green and golden bell frog, Kooragang Island, NSW.

Roads and Traffic Authority. Annual monitoring of the green-thighed frog, Nerong, NSW.

Olympic Co-ordination Authority (OCA). Monitoring the green and golden bell bell frog (1996 – 2000) at the Sydney 2000 Olympic venue, Homebush Bay, NSW.

Pacific Power. Frog monitoring. Lyell Reservoir Flow Study, Stages 1 – 3, Lithgow, NSW.

Reviews

Department of Urban Affairs and Planning. Review of the Species Impact Statement for the proposed Transgrid Power Transmission Line Upgrade, Northern NSW.

Roads and Traffic Authority. Review of Public Submissions on the West Charlestown Bypass Fauna Impact Statement, NSW.

Targeted Surveys

Energy Australia. Targeted surveys for the orchids *Cryptostylis hunteriana*, *Diuris arenaria* and *Diuris praecox*, Port Stephens, NSW.

John Grossi. Growling grass frog habitat assessment, Berwick, VIC.

NSW National Parks and Wildlife Service. Targeted surveys for the yellow-spotted frog, Central Tablelands, NSW.

Roads and Traffic Authority. Targeted survey for the green-thighed frog, proposed highway upgrade, Coolongolook – Wang Wauk, NSW.

NSW National Parks and Wildlife Service. Amphibian survey. Sick and dying frog study, Northern NSW.

Gosford City Council. Targeted surveys for the red-crowned toadlet and giant burrowing frog, Somersby Industrial Estate, NSW.

Pacific Power. Targeted survey for the green and golden bell frog, proposed Tallawarra Power Station, NSW.

Department of Defence. Amphibian Survey. Resource Assessment Study and Environmental Management Plan, Singleton Military Area, NSW.

Bianca Hamilton

Ecologist
Australia

Bianca Hamilton is an ecologist in ERM's Hunter Valley office. She has a Bachelor of Environmental Science majoring in Management from Newcastle University and a Certificate II in Bushland Regeneration.

Bianca has undertaken terrestrial ecological assessments and management plans. This has involved targeted flora and fauna surveys, Mapinfo Geographic Information System (GIS) mapping and report preparation. This includes the preparation of flora and Fauna Assessments, Threatened Species Assessments, Vegetation Management Plans and Habitat Restoration Plans and Bushfire Hazard Assessments.

She has three years of experience as an ecologist in private consulting working primarily within the Port Stephens, Gosford, Wyong and Cessnock local government areas. Additionally she has one year of bush regeneration and native plant nursery experience.

Fields of Competence

- Flora and Fauna surveys
- Targeted Threatened Species Surveys
- Ecological and Biodiversity Assessments
- Ecological Research and Data Analysis
- Impact Monitoring
- GIS Mapping
- Bushfire Hazard Assessments
- Project Management

Education

- Bachelor of Environmental Science
- Certificate II Bushland Regeneration

Key Industry Sectors

- Residential, Industrial and Tourism Development
- Infrastructure
- Local Government
- Community Programs

Key Projects

Threatened Species Assessments

Field surveys and preparation of reports and mapping for residential, tourist and industrial development. This is in relation to the legislative requirements of the Threatened Species Conservation Act and Environmental Protection and Biodiversity Conservation Act. The reports have utilised information and guidelines available from NSW National Parks and Wildlife Service, Local Councils, The NSW Scientific Committee and Lower Hunter and Central Coast Regional Environmental Management Strategy. These have been undertaken at various sites including:

Green Point	Patonga
Phegans Bay	Ourimbah
Narara	Somersby
Woongarrah	Wadalba
Dooralong	Chitaway Point
Pokolbin	Lovedale
Cessnock	Lake Munmorah
Pambulong	Belmont
Karuah	Williamtown

Flora surveys have included species identification and community description. Fauna surveys have included arboreal and terrestrial Elliott trapping and fauna handling, spotlighting, microchiropteran bat detection and call analysis, and amphibian, bird and reptile surveys.

GIS Mapping

Workspaces have been created for inclusion in reports using the Mapinfo Geographic Information System (GIS). This program has also been used to gain relevant database and site specific information.

DCP Vegetation Management Plans

Preparation of reports to satisfy Wyong Councils Development Control Plan 14 – Tree Management and Gosford Council general requirements. This included field surveys involving identification, tagging and data recording of significant trees. Additionally data entry, manipulation, report writing and mapping. These reports aimed to identify important habitat trees and ameliorate the impact of development.

Riparian Vegetation Management Plans

Preparation of vegetation management plans as required by Department of Infrastructure Planning and Natural Resources (DIPNR) under the Rivers and Foreshores Improvement Act. This involved the undertaking of vegetation surveys, mapping and preparation of reports for three drainage lines at Woongarrah, Wyoming and Cessnock. These included strategies and recommendations for the management and rehabilitation of these drainage lines and riparian vegetation during and after residential development.

Habitat restoration Plans

The preparation of plans as required by Wyong Shire Council for sites at Wadalba and Woongarrah. These reports contained strategies for the management and regeneration of vegetation communities and augmentation of fauna habitat on sites approved for residential development.

Bushfire Hazard Assessments

Bushfire hazard assessment of proposed subdivision at Karuah. Included assessment of Bushfire risks and recommendations to minimise bushfire threats.

Koala Assessments

Surveys and assessment of koala habitat on land in Karuah and Williamtown. This is in relation to State Environmental Planning Policy (SEPP) 44 and the Port Stephens Comprehensive Koala Plan of Management (CKPoM).

Joanne Woodhouse

Environmental Scientist
Australia

Joanne Woodhouse is an environmental scientist with over four years experience and is based in ERM's Hunter Valley office. She has a Bachelor of Environmental Science majoring in environmental management from Newcastle University and a Diploma of Indigenous Archaeology from the University of New England.

Joanne has undertaken threatened flora and fauna surveys for environmental impact assessments, species impact statements, ecological constraint analyses, reveiws of environmental factors and environmental management plans. She has also undertaken field surveys and habitat appraisals for vegetation management plans, habitat restoration plans and bushfire hazard assessments.

Joanne has gained experience in research, community consultation and field archaeology surveys for the production of Aboriginal archaeological heritage assessments within the hunter region.

Fields of Competence

- Ecological and biodiversity assessments
- Flora and fauna surveys
- Ecological constraint assessments
- Targeted threatened species surveys
- Ecological research and data analysis
- Species impact statements and impact monitoring
- GIS Mapping
- Bushfire hazard assessments
- Archaeological surveys and excavations
- Project Management

Key Industry Sectors

- Mining
- Residential, Industrial and Tourism Development
- Infrastructure
- Local Government

Education

- Bachelor of Environmental Science, Newcastle University.
- Diploma of Indigenous Archaeology, University of New England.

Languages

- English

Publications

Worth, G. and Woodhouse, J. (2001). *The mapping of potential Koala habitat and Koala activity in the urban area of Tea Gardens, NSW.* Proceedings from the conference on the status of the Koala in 2001, Australian Koala Foundation.

Key Projects

Species Impact Statements

Species Impact Statement for the proposed reconstruction of an existing prawn farm at Micalo Island.

Vegetation Management Plans

Vegetation Management Plan for compensatory habitat at Mt Vincent.

Vegetation Management Plan for a residential subdivision at Bolwarra Heights.

Flora and Fauna Assessments

Annual Ecosystem Monitoring at Ravensworth Mine.

Koala Habitat Assessment for a proposed residential subdivision at Anna Bay.

Pest and Weed Management Plan at Ravensworth Mine.

Statement of Effect on Threatened Flora and Fauna for a proposed residential subdivision at Catherine Hill Bay.

Statement of Effect on Threatened Flora and Fauna for a proposed residential development at Singleton.

Targeted Squirrel Glider Impact Assessment for a proposed residential development at Teralba.

Tetratheca juncea Impact Assessment for a proposed residential development at Teralba.

Aboriginal Heritage Assessments

Aboriginal Archaeological Heritage Impact Assessment for a proposed powerline easement at Tanilba Bay.

Aboriginal Archaeological Heritage Impact Assessment for a proposed development at Whitebridge.

Preliminary Aboriginal Archaeological Heritage Assessment for a proposed electricity substation at Morisset.

Preliminary Aboriginal Archaeological Heritage Assessment for a proposed residential development at Singleton.

Preliminary Aboriginal Archaeological Heritage Assessment for a proposed aged-care facility at Elermore Vale.

Test Excavations for a proposed development at Adamstown.

Bushfire Hazard Assessments

Bushfire Protection and Attack Assessment for a proposed aged-care facility at Tingira Heights.

Bushfire Protection and Attack Assessment for a proposed residential development at Charlestown.

Bushfire Hazard Assessment for a residential development at Dudley.

Bushfire Hazard Management Plan for an existing public reserve at Rathmines.

Jane Mactier

Environmental Scientist
Australia

Jane Mactier is an Environmental Scientist with ERM Australia's Hunter Valley office. Jane is responsible for undertaking a range of environmental projects including ecology, flora and fauna assessments, environmental modelling, hydrological assessments, site investigation and remediation and, wastewater design and application.

Prior to joining ERM, Jane worked as an Environmental Scientist for Envirowest Consulting. During this time her responsibilities involved experience with environmental effects, wastewater management systems, geotechnical classification, contaminated site investigation, groundwater monitoring, water quality impacts, salinity, soil erosion, soil conservation, sediment modelling, and bushfire assessments

Other experience includes data collection and collaboration for species lists and diversity of population genetics, and study of Australian marsupials and reptile ecology, nutrition, development and behaviour.

Additionally Jane has had laboratory experience with field sampling, laboratory testing and sample analysis for data interpretation for inclusion in reports. These accompany submissions of development applications to local councils.

Professional Affiliations and Registrations

- Royal Australian Corps of Transport 2000

Fields of Competence

- Wastewater management, design and application
- Water quality impact – sediment and nutrient modelling
- Contaminated site investigation and remediation
- Geotechnical site classification

Key Industry Sectors

- Government
- Agriculture
- Construction and Engineering
- Defence

Education

- Bachelor of Science (Biology)
  University of Sydney, Australia 2003

Courses

- Construction Industry Safety Induction (2005)
- On-site Wastewater Management (2004)
- Chemcert Farm Chemical Accreditation (2004)
- Military Driver Training (2000)
- Dangerous Goods (2000)

Key Projects

Environmental studies

CPC Land Development Consultants Goulburn
Detailed assessment incorporating water quality impacts, bushfire hazard assessment and wastewater design and application areas selected for extensive subdivision of four major properties into approximately ninety 40-hectare lots. Key issues included water quality of the development impacting on Lake Burragorang, which forms part of the Sydney Hydrological Catchment. The site although used for grazing of livestock is covered by extensive native and exotic vegetation and steep terrain susceptible to soil erosion and salinity. Selective clearing was required and effluent treatment systems where designed for suitability in shallow soil and to have a positive impact on development requiring revegetation plans post development.

Site investigation and remediation

Private client, Young NSW
Preliminary site investigation required for 18-lot subdivision of orchard into rural residential lots. Key issues involved the sampling of soil for heavy metals and organochlorine pesticides and the possibility of chemical dumping in an on-site tip and chemical mixing areas and storage sheds.

BP Westoil Petroleum NSW
Ongoing groundwater monitoring and service station remediation for government compliance. Key issues involved possibilities of storage tank leakage and groundwater contamination and quality of runoff leaving sites entering council sewers and adjacent property. Quality control measures are in place to remediate prior contaminants.

Geotechnical Site Classification

Brooklands Estate, B & N Turner, Orange NSW
60 residential lots assessed for geotechnical site classification. Key issues included approval of development proposal and ensuring stability in the structure of houses being built in the development taking into account compaction of fill and proximity to creek.

'Yackerboon', Fenlor Group, Orange NSW
20 residential lots assessed for geotechnical site classification. Key issues involved the controlled fill and compaction of soil along edge of swamp and underground aqueous springs surfacing within the development.

Flora and Fauna Projects

Private client, Forest Reefs, NSW
Threatened or endangered species study of 25-hectares into 9-lots in accordance with 5A and 79C of the environmental assessment act 1979 and the State Environmental Protection Plan (SEPP) 44. Key issues involved possible disturbance and disruption of threatened and endangered species.

Private client, Lyndhurst NSW
Koala habitat assessment for subdivision of 230-hectares into 3-lots. Key issues were determining that the area was not going to adversely impact any Koala habitat in accordance with SEPP 44.

Bushfire Hazard Assessment

Private client, Cowra NSW
Bushfire Hazard assessment carried out for 33-lot subdivision of a 435-hectare grazing and farming property. Key issues included determining fuel loading of existing vegetation and establishment of appropriate asset protection zones and implementation of alternative access routes where necessary.

Effluent Management

Windera Estate, Daytime Pty Ltd, Orange NSW
On-site evaluation for effluent for 20-lots in a rural residential development west of Orange in the Central West. Key issues included topography, slope, dispersivity and depth of soil and the design of the system and recommended application area.

Individual sites

Geotechnical site assessments
Site assessments carried out for over 200 individual building sites throughout the Central west region for various owners and developers.

On-site application of effluent assessment
Site assessments carried out for over 100-lots individually owned by landowners and developers. These require design and application of effluent with respect to climate, locality and council regulation.

CURRICULUM VITAE

NAME: MICHAEL JOHN MURRAY

ACADEMIC QUALIFICATIONS: Bachelor of Science (Hons),
University of Newcastle, 1990.
Pathology Technicians Certificate
Tighes Hill Technical College, 1985.

LICENCE: NPWS Scientific Licence S10736
Animal Research Authority AW94/056
NSW Agriculture Director-General's Animal Care and Ethics Committee (78/99)

PROFESSIONAL EXPERIENCE

Extensive experience in undertaking detailed fauna surveys. Undertaken many studies in the range of environments within the Newcastle/Lake Macquarie area, Hunter Valley, Sydney Basin, Western Slops and Plains, NE NSW, and riverine and mallee areas of Western Division of NSW.

May 1995 - present **Established FOREST FAUNA SURVEYS (Incorporated 1998).**

October 1994 - present Has undertaken long term wildlife monitoring project for open cut coal mine in the upper Hunter Valley. This work includes the establishment and monitoring of procedures, and formulation of amelioration measures for the maintenance and enhancement of habitat for protected and threatened fauna species, particularly the Squirrel Glider.

September 1998 Specialist Team Member (Large Forest Owls Survey)

NPWS CRA Sydney Region (Comprehensive Regional Assessments) undertook targeted threatened large forest owl surveys in the Central Coast (Gosford City Council reserves), Strickland, Ourimbah, MacPherson, Wyong, Olney, Watagan, Heaton, Awaba, Corrabare, Cessnock and Yango State Forests, Singleton Army Base, Manobolai Nature Reserve.

February 1997 - March 1998 Specialist Team Member (Mammals and Nocturnal Birds) for the NSW National Parks and Wildlife Service Sydney Zone CRA (Comprehensive Regional Assessments) undertaking regional fauna surveys. Areas targeted include Wollemi N.P., Yengo N.P., Goulburn River N.P., Blue Mountains N.P., Illawarra Water Catchment, Newnes S.F., Gardens of Stone N.P., Wallaroo and Medowie S.F.

June 1995 to April 1996 CONSULTANT BIOLOGIST - TUNRA (The University of Newcastle Research Associates Ltd)

1994 - June 1995 ENVIRONMENTAL SCIENTIST
ERM Mitchell McCotter

Undertook many fauna investigations, including fauna impact statements, environmental impact statements and environmental assessments.

October - November 1994 FBN BAT SURVEYS

Assistant to FBN Bat Surveys in bat survey for fauna impact statement, State Forests of New South Wales, Western Division.

1992 - July 1994	PROJECT OFFICER SWC CONSULTANCY
1991 - 1992	RESEARCH OFFICER SHORTLAND WETLANDS CENTRE

EXAMPLE OF PUBLICATIONS:

Murray, M. (1990) The re-introduction of the Magpie Goose *Anseranas semipalmata* to the Shortland Wetlands. BSc (Hons) thesis, Department of Biological Sciences, University of Newcastle.

Murray, M. and Winning, G. (1992). Flight behaviour and collision mortality of waterbird species into 330kV electricity transmission lines adjacent to the Shortland Wetlands. Report to Pacific Power by the Shortland Wetlands Centre.

Winning, G. and Murray, M. (1992). NSW Important Wetlands - the First Chapter. Recommended important wetlands in NSW, in support of the Directory of Important Wetlands in Australia. Report to NSW Department of Water Resources.

Murray, M. (1993). Review of Literature on High Country Wetlands of New South Wales and Victoria. Report to Australian Nature Conservation Agency by Shortland Wetlands Centre.

Murray, M. (1996) Eleebana Local Squirrel Glider Study. Report to Lake Macquarie City Council by SWC Consultancy.

Kavanagh, R.P. and Murray, M. (1996). Home range, habitat and behaviour of the Masked Owl (Tyto novaehollandiae) near Newcastle, New South Wales. Emu. 96, 157-170

Hoye, G., Murray, M. and Mahony, M. (1996) Mount Owen Coal Mine Wildlife Management Pilot Study. Report to HLA-Envirosciences by Fly By Night Bat Surveys Pty Ltd and TUNRA Ltd.

Hoye, G., Murray, M., Mahony, M. and Clulow, J. (1997, 1998, 1999, 2000, 2001, 2002, 2003) Mount Owen Coal Mine Wildlife Management - Annual Report(s). Report by Fly By Night Bat Surveys Pty Ltd, Forest Fauna Surveys P/L and TUNRA Ltd.

Murray, M., Maryott-Brown, K. and Hoye, G. (1996) Species Impact Statement, SRA Land, Glendale. Report to Lake Macquarie City Council by Forest Fauna Surveys, in association with EcoPro P/L and Fly By Night Bat Surveys P/L.

Murray, M., Maryott-Brown, K. and Hoye, G. (1997) Flora and Fauna Survey Guidelines. Report to Lake Macquarie City Council by Forest Fauna Surveys, Fly By Night Bat Surveys P/L and EcoPro P/L.

Murray, M. (1999) Characterisation of Habitats and Distribution of Large Forest Owls in the City of Lake Macquarie. Report to Lake Macquarie City Council.

Murray, M. (2001) Salt Ash Air Weapons Range - Fauna and Habitat Assessment. Report to URS Pty Ltd and Department of Defence.

Bell, S.A.J. and Murray, M. (2001). The ecological significance of Bow Wow Creek Gorge, Mulbring, lower Hunter Valley, New South Wales: a nationally significant site. Report to Cessnock City Council by Eastcoast Flora Survey and Forest Fauna Surveys Pty Ltd.

Murray, M., Bell, S.A.J., Hoye, G. (2001). Flora and Fauna Survey Guidelines v.2. Report to Lake Macquarie City Council by Forest Fauna Surveys P/L, Eastcoast Flora Survey and Fly By Night Bat Surveys P/L.

Murray, M., Bell, S.A.J., Hoye, G. (2002). Flora and Fauna Survey Guidelines. Lower Hunter and Central Coast Report to Lower Hunter and Central Coast Regional Environment Management Strategy (LHCCREMS) by Forest Fauna Surveys P/L, Eastcoast Flora Survey and Fly By Night Bat Surveys P/L.

Smith, A.P., Watson, G. and Murray, M. (2002). Fauna Habitat Modelling and Wildlife Linkages in Wyong Shire. Austeco, Armidale, 2350.

Smith, A.P. and Murray, M. (2003). Habitat requirements of the squirrel glider (Petaurus norfolcensis) and associated possums and gliders on the New South Wales central coast. Wildlife Research 30, 291-301.

Murray, M., Hoye, G., Mahony, M. and Clulow, J. (2003). Mt Owen Operations Species Impact Statement. Prepared for Umwelt (Australia) Pty Ltd on behalf of Mt Owen Mine by Forest Fauna Surveys Pty Ltd, Fly By Night Bat Surveys P/L and TUNRA Ltd.

Bell, S.A.J. and Murray, M. (2004). Warnervale Business Park Species Impact Statement. Stage 1. Prepared for Wyong Shire Council by Eastcoast Flora Survey and Forest Fauna Surveys Pty Ltd.

PROFESSIONAL PROFILE

FULL NAME:	**Peter Andrew EKERT**
DATE OF BIRTH:	3rd April, 1973
POSTAL ADDRESS:	4 Bowen Street Wallsend NSW 2287
TELEPHONE:	02 49500573 0410 566104
E-MAIL:	peter@ekerlogic.com.au
TERTIARY EDUCATION:	1995-1997 Southern Cross University, Lismore, NSW Bachelor of Applied Science (Environmental Resource Management)

EMPLOYMENT

I have 10 years professional experience researching fauna and flora, specialising in the long-term monitoring of birds and undertaking impact assessment. I have been manager of a number of bird research projects, with Federal and State government agencies, non-governmental conservation organisations and volunteer groups including Environment Australia, Olympic Co-ordination Authority, NSW National Parks and Wildlife Service, NSW Department of Commerce, Department of Infrastructure, Planning and Natural Resources (DIPNR), Birds Australia, Liverpool Plains Land Management Committee and Wetland Care Australia, North Sydney Council and Environmental Resources Management (ERM). I have produced a numerous scientific reports, publications, articles, as well as featured on local ABC radio and Television. I am currently the Director of Ekerlogic Consulting Services (ECS), a small environmental consultancy based in Newcastle. I am on the Committee of the Australian Bird Study Association (ABSA) and the consultant ornithologist and member of the Lower Hunter Estuary Rehabilitation Program (LHERP) taskforce.

The following is a summary of recent employment/projects:

2003-current Ekerlogic Consulting Services; Liverpool Plains Land Management Committee (LPLMC): **Woodland Bird Monitoring Program and Focal Species Analysis**

2003-current Ekerlogic Consulting Services, NSW National Parks and Wildlife Service and NSW Dept Commerce**: Lower Hunter Estuary Rehabilitation Program (LHERP)**

2000-current Ekerlogic Consulting Services & NSW National Parks and Wildlife Service **Monitoring Rufous Scrub-birds in Central Eastern Rainforest Reserves in NSW**.

2003-current Ekerlogic Consulting Services; Dept. Infrastructure, Planning and Natural Resources (DIPNR), Dora Creek Catchment Committee: **Dora Creek Wetland Action Plan**

2002-2004 Ekerlogic Consulting Services & NSW National Parks and Wildlife Service: **'Warragamba Special Area Fauna Survey Program'**

2003-2004 Ekerlogic Consulting Services; NSW National Parks and Wildlife Service: **A Review of the Status of the Osprey in NSW**

2002-current Ekerlogic Consulting Services & Environmental Resources Management Australia: **Impact assessment surveys of threatened species at Vincentia; Impact Assessment (SIS) of threatened bird species at Fern Bay; Surveys of birds at proposed Wind Farms at Black Springs, Oberon.**

2002-2003 Ekerlogic Consulting Services & North Sydney Council: **'The North Sydney Bushland Continuing Bird Survey'**

2001-2002 Wetland Care Australia: **'Bungawalbin Bird Monitoring Project'**

2001-2003 2000-2002 Birds Australia Project Manager **'Saving the Woodland Birds of The Liverpool Plains Project'**

1999-2001 Birds Australia Project Co-ordinator: **'Homebush Bay Bird Monitoring Project'**

1999-2000 Birds Australia and NSW National Parks and Wildlife Service Project **'Glossy Black Cockatoo Baseline Study'**

1999-2000 Birds Australia and NSW National Parks and Wildlife Service Project Manager **Monitoring Rufous Scrub-birds in Central Eastern Rainforest Reserves in NSW.**

1997-1999 Project Officer Environment Australia (Australian Bird and Bat Banding Scheme) Canberra, ACT **Study of the Breeding Biology of the Nankeen Kestrel in rural/urban ACT**

PUBLICATIONS, PRESENTATIONS & MEDIA

Ekert, P.A. (2003). The Conservation Status of the Rufous Scrub-bird (*Atrichornis rufescens*) in NSW. In: Olsen, P. (2003) (Ed.) *State of Australia's Bird Report.* Report prepared for Environment Australia.

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ABC Local Radio (Newcastle – October 2000) – Interview with Phil Ashley Brown informing the general public about the Rufous Scrub-bird surveys and the biology of the species

ABC Local Radio (Tamworth – Feburary 2002) - Morning Show With Peter Gunders - interview informing the general public about the Liverpool Plains Woodland Bird Project and the decline of woodland birds in s/e Australia

ABC North Coast and Newcastle (July 2003) – Morning Show with Fiona Wiley – interview on the biology, distribution and abundance of Osprey in NSW as well as numerous news grabs.

ABC Local Radio – North Coast, Tamworth, Newcastle (November 2004) – Numerous interviews with these radio stations discussing the 2004 Rufous Scrub-bird surveys in NE NSW

The Wetlands Centre Australia Ramsar Website 2002. http://www.wetlands.org.au – an informative electronic resource providing information to the community on the values of Australia's newest internationally recognised Ramsar site.

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REFEREES

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RELEVANT EXPERIENCE

ENVIRONMENTAL MANAGEMENT

- Demonstrated knowledge of: the ecology of Australian terrestrial plant and animal communities; environmental management and processes involved in the protection of biodiversity;
- Demonstrated ability to collect, collate and report on ecological data in scientific format and to provide management recommendations;
- Demonstrated knowledge of relevant State, National and International legislation, Policies and Agreements pertaining to the protection of threatened species and their habitats;
- Effective communication and liaison skills with government agencies and clients.

FLORA/ FAUNA SAMPLING

- Highly skilled in the identification of avifauna from both visual sightings and call interpretation;
- Skilled in the identification of a wide range of flora and fauna, particularly in NSW;
- Demonstrated use of sampling methods for fauna: (radio telemetry, Bal-chatri traps, mist nets, harp traps, hair tubes, Elliott traps, cage traps, pitfall traps, spotlighting, playback for nocturnal avifauna, active searches for frogs and reptiles, and the use of Anabat);
- Demonstrated ability to work in a team environment and to work in remote locations for extended periods.

INFORMATION TECHNOLOGY

- Demonstrated use of operating software - MS-DOS, MS Windows 3.11/95/98/NT, MS Word 6.0/95/97/2000, MS Excel 5.0/6.0/97/2000, MS Access, MS PowerPoint, SPSS, Statview Student V.1.0;
- Skilled in GIS and Remote sensing (PC ARC INFO; Idrisi and ArcView 3.2);
- Skilled in the use of the internet (Netscape; MS Internet Explorer) and email (Eudora, Lotus Mail, MS Outlook; Outlook Express, and Thunderbird) software;
- Skilled in a range of literature search engines (internet, catalogues, libraries, databases);
- Fast and accurate keyboard skills; data input and analysis; report formatting.

PROJECT MANAGEMENT

- Demonstrated ability to liaise with a wide range of Government agencies, and volunteers from the general public to conduct surveys;
- Demonstrated ability to address tender submissions, formulate project proposals, manage project budget, and regular report submission to government clients, project steering committees and fellow staff.

OTHER

- Demonstrated ability to drive a 4WD vehicle in remote locations under extreme weather conditions;
- Demonstrated ability to work and perform professionally as an individual or within a group framework

MEMBERSHIPS, JOURNAL SUBSCRIPTIONS & COMMITTEES

ORNITHOLOGY

- Birds Australia (Royal Australasian Ornithologists Union (RAOU))
- Bird Observers Club of Australia
- Hunter Valley Bird Observers Club
- Tweed Bird Observers Club

ECOLOGY

- Australian Ecological Society
- The Linnean Society of New South Wales

COMMITTEES

- Australian Bird Study Association (ABSA) – Committee member, Newsletter Editor

Annex G

Habitat Tree GPS Co-ordinates

Ref	Tree Species	Easting (AGD66)	Northing (AGD66)	Distance	Angle
1	Eucalyptus pilularis	389424.00	6364209.00	0	0
2	Eucalyptus pilularis	389469.22	6364174.30	57	115
3	Eucalyptus pilularis	389430.25	6364187.91	22	151
4	Dead Stag	389422.08	6364189.09	20	173
5	Angophora costata	389503.71	6364200.27	31	0
6	Eucalyptus pilularis	389498.22	6364189.96	20	351
7	Dead Stag	389517.50	6364165.45	21	90
8	Eucalyptus pilularis	389508.41	6364160.26	15	118
9	Dead Stag	389494.13	6364148.19	22	175
10	Eucalyptus pilularis	389481.10	6364150.71	25	207
11	Eucalyptus pilularis	389470.00	6364090.00	0	0
12	Eucalyptus pilularis	389473.55	6364088.15	4	105
13	Eucalyptus pilularis	389480.58	6364082.45	13	113
14	Eucalyptus pilularis	389482.25	6364085.66	13	97
15	Dead Stag	389502.41	6364063.28	42	117
16	Eucalyptus pilularis	389491.63	6364063.76	34	128
17	Dead Stag	389474.96	6364052.33	38	160
18	Dead Stag	389476.92	6364052.64	38	157
19	Angophora costata	389464.22	6364061.58	29	179
20	Dead Stag	389458.87	6364054.71	37	185
21	Eucalyptus pilularis	389413.80	6364068.99	60	237
22	Angophora costata	389441.25	6364086.21	29	250
23	Eucalyptus pilularis	389471.53	6364124.97	35	350
24	Eucalyptus pilularis	389479.11	6364114.35	26	8
25	Dead Stag	389488.05	6364098.61	20	52
26	Eucalyptus pilularis	389494.93	6364097.38	26	61
27	Eucalyptus pilularis	389514.53	6364078.48	46	92
28	Angophora costata	389460.51	6364132.75	74	66
29	Dead Stag	389490.05	6364150.18	107	60
30	Eucalyptus pilularis	389414.46	6364123.38	27	66
31	Eucalyptus pilularis	389411.18	6364082.98	42	134
32	Dead Stag	389359.62	6364103.22	32	230
33	Dead Stag	389365.00	6364129.00	0	0
34	Dead Stag	389332.95	6364117.65	34	238
35	Dead Stag	389355.01	6364129.44	10	260
36	Melaleuca decora	389321.24	6364281.89	35	333
37	Melaleuca decora	389227.95	6364287.34	77	340
38	Eucalyptus robusta	389231.09	6364271.61	61	341
39	Eucalyptus robusta	389214.14	6364254.94	50	319
40	Angophora costata	389185.00	6364196.30	55	242
41	Corymbia gummifera	389224.58	6364217.69	15	284
42	Eucalyptus pilularis	389742.96	6364555.54	23	35
43	Eucalyptus pilularis	389721.68	6364485.17	55	172
44	Angophora costata	389750.98	6364506.24	42	131

Ref	Tree Species	Easting (AGD66)	Northing (AGD66)	Distance	Angle
45	Eucalyptus pilularis	389767.35	6364500.76	57	121
46	Angophora costata	389698.00	6364489.00	0	0
47	Eucalyptus pilularis	389692.00	6364479.00	0	0
48	Eucalyptus pilularis	389705.97	6364479.85	14	74
49	Angophora costata	389773.62	6364471.14	82	83
50	Eucalyptus pilularis	389734.58	6364442.63	56	118
51	Eucalyptus pilularis	389716.33	6364501.29	33	35
52	Angophora costata	389702.72	6364453.13	28	145
53	Dead Stag	389685.36	6364493.56	16	323
54	Dead Stag	389660.07	6364495.62	36	285
55	Dead Stag	389659.76	6364489.79	34	276
56	Eucalyptus pilularis	389671.29	6364482.47	21	267
57	Dead Stag	389657.03	6364480.53	35	260
58	Dead Stag	389652.08	6364458.22	45	230
59	Angophora costata	389665.02	6364468.37	29	236
60	Eucalyptus pilularis	389672.17	6364463.78	25	220
61	Eucalyptus pilularis	389681.55	6364464.35	18	203
62	Eucalyptus pilularis	389660.00	6364442.00	0	0
63	Eucalyptus pilularis	389662.00	6364223.00	0	0
64	Angophora costata	389689.01	6364245.26	35	38
65	Dead Stag	389697.81	6364244.94	42	46
66	Angophora costata	389686.37	6364236.79	28	48
67	Eucalyptus pilularis	389666.77	6364418.50	5	95
68	Eucalyptus pilularis	389668.59	6364415.47	8	112
69	Angophora costata	389656.46	6364409.36	12	195
70	Angophora costata	389637.06	6364409.67	27	235
71	Eucalyptus pilularis	389618.31	6364428.03	21	5
72	Eucalyptus pilularis	389629.12	6364424.82	24	33
73	Dead Stag	389629.23	6364388.53	26	126
74	Eucalyptus pilularis	389622.72	6364382.13	28	145
75	Dead Stag	389605.91	6364415.93	10	310
76	Dead Stag	389588.00	6364407.79	24	257
77	Dead Stag	389587.50	6364403.02	25	246
78	Eucalyptus pilularis	389571.26	6364403.36	41	251
79	Eucalyptus pilularis	389579.15	6364411.16	33	263
80	Eucalyptus pilularis	389516.00	6364394.00	0	0
81	Eucalyptus pilularis	389511.02	6364387.74	8	206
82	Eucalyptus pilularis	389515.47	6364455.00	61	347
83	Eucalyptus pilularis	389495.97	6364450.56	60	328
84	Dead Stag	389494.58	6364359.04	41	199
85	Eucalyptus pilularis	389461.28	6364453.72	81	305
86	Eucalyptus pilularis	389465.00	6364370.00	0	0
87	Dead Stag	389418.02	6364402.29	57	292
88	Dead Stag	389439.56	6364400.86	40	308

Ref	Tree Species	Easting (AGD66)	Northing (AGD66)	Distance	Angle
89	Eucalyptus pilularis	389356.33	6364331.35	21	278
90	Angophora costata	389144.30	6364101.90	15	341
91	Eucalyptus pilularis	389082.35	6364061.13	8	115
92	Eucalyptus pilularis	389088.52	6364056.04	16	116
93	Eucalyptus pilularis	389081.54	6364055.36	12	140
94	Angophora costata	389080.75	6364024.27	42	161
95	Dead Stag	389087.36	6364010.14	57	156
96	Angophora costata	389071.97	6364024.19	42	173
97	Angophora costata	389080.31	6364033.28	33	160
98	Eucalyptus pilularis	389062.64	6364041.39	28	196
99	Dead Stag	389053.60	6364052.80	26	227
100	Dead Stag	389054.32	6364058.32	23	238
101	Angophora costata	389052.21	6364062.87	24	250
102	Dead Stag	389042.10	6364063.33	34	253
103	Angophora costata	389037.33	6364071.09	39	265
104	Eucalyptus pilularis	389066.74	6364073.63	12	297
105	Eucalyptus pilularis	389077.53	6364069.70	4	10
106	Eucalyptus pilularis	389085.59	6364068.84	10	61
107	Angophora costata	389075.66	6364105.00	39	347
108	Dead Stag	389045.00	6364100.00	0	0
109	Angophora costata	389058.25	6364114.98	20	29
110	Eucalyptus pilularis	389042.80	6364122.89	23	342
111	Eucalyptus pilularis	389021.17	6364075.75	34	212
112	Eucalyptus robusta	389199.76	6364218.81	46	303
113	Angophora costata	389241.97	6364208.93	25	11
114	Angophora costata	389258.41	6364249.75	69	10
115	Angophora costata	389247.35	6364094.28	93	158
116	Eucalyptus pilularis	389156.73	6364190.73	57	281
117	Eucalyptus pilularis	389187.58	6364125.04	48	194
118	Eucalyptus pilularis	389216.76	6364121.64	47	158
119	Dead Stag	389271.29	6364097.60	94	126
120	Dead Stag	389247.60	6364083.00	83	135
121	Angophora costata	389250.28	6364078.78	88	135
122	Eucalyptus pilularis	389158.45	6364071.35	20	129
123	Dead Stag	389176.12	6364065.51	37	113
124	Dead Stag	389168.84	6364048.23	45	137
125	Dead Stag	389157.27	6364043.43	45	153
126	Dead Stag	389136.07	6364071.99	18	201
127	Dead Stag	389128.89	6364061.15	31	201
128	Angophora costata	389119.73	6364016.75	75	188
129	Eucalyptus pilularis	389125.26	6364079.66	22	238
130	Dead Stag	389122.07	6364085.12	24	253
131	Dead Stag	389113.10	6364084.41	33	253
132	Angophora costata	389099.48	6364105.33	50	279

Ref	Tree Species	Easting (AGD66)	Northing (AGD66)	Distance	Angle
133	Eucalyptus pilularis	389122.79	6364109.03	32	301
134	Angophora costata	389132.03	6364108.93	26	315
135	Eucalyptus pilularis	389034.00	6364103.00	0	0
136	Eucalyptus pilularis	389002.00	6364119.00	0	0
137	Eucalyptus pilularis	389022.85	6364132.80	25	44
138	Dead Stag	389041.09	6364163.19	59	29
139	Dead Stag	389028.71	6364156.45	46	23
140	Dead Stag	389005.39	6364144.78	26	355
141	Dead Stag	389002.40	6364165.00	46	348
142	Eucalyptus pilularis	388984.35	6364151.52	37	319
143	Eucalyptus pilularis	388974.99	6364141.26	35	297
144	Dead Stag	388978.53	6364130.19	26	283
145	Dead Stag	388979.67	6364127.80	24	279
146	Eucalyptus pilularis	388962.66	6364133.71	42	278
147	Eucalyptus pilularis	388952.62	6364131.77	51	272
148	Eucalyptus pilularis	388948.10	6364129.97	55	269
149	Dead Stag	388997.14	6364184.95	49	350
150	Eucalyptus pilularis	389019.99	6364220.38	88	4
151	Eucalyptus pilularis	389029.44	6364219.15	90	10
152	Angophora costata	388968.50	6364121.99	19	346
153	Angophora costata	388966.77	6364107.47	5	321
154	Dead Stag	388937.30	6364132.05	43	300
155	Dead Stag	388934.05	6364137.34	49	302
156	Eucalyptus pilularis	388984.54	6364086.04	23	125
157	Dead Stag	388959.05	6364085.58	32	42
158	Eucalyptus pilularis	388947.95	6364065.82	15	82
159	Eucalyptus pilularis	388236.76	6364034.84	10	90
160	Eucalyptus pilularis	388966.10	6364049.33	41	60
161	Dead Stag	388993.94	6364039.92	67	75
162	Dead Stag	388968.96	6364023.77	44	95
163	Eucalyptus pilularis	388978.45	6364004.22	61	110
164	Dead Stag	388938.93	6364015.03	25	139
165	Eucalyptus pilularis	388941.71	6363997.66	42	147
166	Angophora costata	388912.25	6364034.27	15	247
167	Eucalyptus robusta	388882.27	6364047.74	46	271
168	Eucalyptus pilularis	388904.14	6364057.94	31	300
169	Angophora costata	388931.59	6364025.91	12	145
170	Dead Stag	388920.00	6363970.00	0	0
171	Eucalyptus pilularis	388926.98	6364004.30	35	359
172	Eucalyptus pilularis	388924.26	6363984.38	15	4
173	Eucalyptus pilularis	388930.32	6363979.46	14	35
174	Eucalyptus pilularis	388949.67	6363990.39	36	43
175	Angophora costata	388964.35	6363988.37	48	55
176	Eucalyptus pilularis	388977.73	6363975.56	58	72

Ref	Tree Species	Easting (AGD66)	Northing (AGD66)	Distance	Angle
177	Eucalyptus pilularis	388952.85	6363966.84	33	83
178	Eucalyptus pilularis	388947.66	6363961.28	29	95
179	Eucalyptus pilularis	388956.76	6363956.98	39	97
180	Eucalyptus pilularis	388952.15	6363946.21	40	114
181	Eucalyptus pilularis	388933.43	6363948.92	25	135
182	Eucalyptus pilularis	388924.62	6363961.13	10	140
183	Angophora costata	388901.74	6363946.20	30	205
184	Angophora costata	388888.12	6363951.22	37	227
185	Eucalyptus pilularis	388903.37	6363963.11	18	235
186	Eucalyptus pilularis	388914.46	6363967.70	6	235
187	Angophora costata	388903.89	6363978.03	18	284
188	Eucalyptus pilularis	388898.03	6363981.93	25	286
189	Eucalyptus pilularis	388888.08	6364000.29	44	301
190	Eucalyptus pilularis	388918.67	6363986.95	17	343
191	Dead Stag	388869.09	6363941.44	12	318
192	Eucalyptus robusta	388855.09	6363949.24	27	300
193	Eucalyptus robusta	388853.30	6363947.06	27	294
194	Eucalyptus robusta	388853.92	6363944.43	25	290
195	Eucalyptus robusta	388841.26	6363952.49	40	290
196	Eucalyptus robusta	388833.73	6363948.94	45	281
197	Eucalyptus robusta	388814.53	6363959.84	67	283
198	Angophora costata	388866.38	6363925.92	10	227
199	Angophora costata	388854.78	6363913.11	27	216
200	Angophora costata	388852.10	6363903.22	36	207
201	Eucalyptus pilularis	388861.04	6363898.90	35	191
202	Eucalyptus pilularis	388880.41	6363913.83	18	150
203	Eucalyptus pilularis	388885.78	6363907.34	26	143
204	Angophora costata	388902.72	6363942.48	30	55
205	Angophora costata	388884.74	6363943.69	16	25
206	Angophora costata	388879.31	6363940.03	10	13
207	Angophora costata	388857.00	6363907.00	0	0
208	Dead Stag	388851.00	6363903.00	0	0
209	Angophora costata	388851.00	6363882.00	0	0
210	Eucalyptus pilularis	388860.54	6363878.99	10	95
211	Angophora costata	388849.00	6363847.00	0	0
212	Eucalyptus pilularis	388870.98	6363846.04	22	80
213	Eucalyptus robusta	388826.20	6363844.00	23	250
214	Angophora costata	388855.96	6363829.32	19	146
215	Angophora costata	388851.60	6363824.15	23	161
216	Eucalyptus robusta	388810.85	6363832.13	38	295
217	Eucalyptus robusta	388831.76	6363805.17	10	235
218	Angophora costata	388858.99	6363809.47	18	76
219	Eucalyptus pilularis	388854.86	6363803.26	15	100
220	Dead Stag	388874.90	6363806.33	34	82

Ref	Tree Species	Easting (AGD66)	Northing (AGD66)	Distance	Angle
221	Eucalyptus pilularis	388817.90	6363799.43	25	235
222	Eucalyptus pilularis	388867.51	6363780.28	15	44
223	Eucalyptus pilularis	388880.98	6363773.13	26	75
224	Dead Stag	388851.04	6363737.22	35	174
225	Dead Stag	388846.18	6363740.20	33	183
226	Eucalyptus pilularis	388872.32	6363751.54	36	30
227	Eucalyptus pilularis	388876.17	6363747.41	36	39
228	Eucalyptus pilularis	388872.98	6363726.09	25	75
229	Eucalyptus pilularis	388886.08	6363716.56	39	90
230	Eucalyptus pilularis	388871.13	6363718.59	24	93
231	Eucalyptus pilularis	388881.40	6363709.07	37	103
232	Eucalyptus pilularis	388879.33	6363707.27	36	107
233	Dead Stag	388856.95	6363720.54	10	104
234	Angophora costata	388864.62	6363693.07	36	140
235	Angophora costata	388853.65	6363694.52	31	157
236	Eucalyptus pilularis	388836.07	6363703.03	25	196
237	Eucalyptus pilularis	388796.55	6363700.46	57	232
238	Eucalyptus pilularis	388813.12	6363712.65	37	238
239	Eucalyptus pilularis	388782.47	6363743.17	68	273
240	Eucalyptus pilularis	388803.29	6363730.09	45	264
241	Eucalyptus pilularis	388839.05	6363729.46	10	284
242	Eucalyptus pilularis	388823.01	6363739.72	29	288
243	Eucalyptus robusta	388828.09	6363768.68	48	323
244	Eucalyptus pilularis	388916.54	6363695.54	24	136
245	Dead Stag	388902.27	6363698.08	18	173
246	Angophora costata	388897.80	6363722.53	9	304
247	Eucalyptus pilularis	388903.35	6363730.99	15	345
248	Eucalyptus pilularis	388916.25	6363745.56	32	10
249	Dead Stag	388924.32	6363744.49	35	23
250	Dead Stag	388929.79	6363756.48	48	20
251	Angophora costata	388920.73	6363730.29	22	37
252	Angophora costata	388928.69	6363736.35	32	38
253	Angophora costata	388914.13	6363727.06	15	30
254	Angophora costata	388934.49	6363736.96	37	43
255	Angophora costata	388927.02	6363730.11	27	46
256	Angophora costata	388955.52	6363735.26	55	57
257	Dead Stag	388944.18	6363724.17	41	66
258	Dead Stag	388932.10	6363705.49	30	98
259	Angophora costata	388908.00	6363806.00	0	0
260	Angophora costata	388908.44	6363815.99	10	350
261	Angophora costata	388924.43	6363829.90	29	22
262	Angophora costata	388926.43	6363822.89	25	35
263	Angophora costata	388914.00	6363863.00	0	0
264	Angophora costata	388890.53	6363851.81	26	232

Ref	Tree Species	Easting (AGD66)	Northing (AGD66)	Distance	Angle
265	Eucalyptus pilularis	388919.37	6363854.57	10	135
266	Angophora costata	388931.05	6363840.79	28	130
267	Dead Stag	388933.40	6363854.96	21	100
268	Eucalyptus pilularis	388887.35	6363683.41	89	43
269	Eucalyptus pilularis	388877.46	6363676.61	77	43
270	Eucalyptus pilularis	388859.67	6363659.90	53	47
271	Eucalyptus pilularis	388877.70	6363662.03	70	53
272	Eucalyptus pilularis	388876.32	6363651.46	65	61
273	Eucalyptus pilularis	388848.41	6363639.38	35	67
274	Dead Stag	388878.00	6363633.56	64	77
275	Angophora costata	388833.99	6363632.48	20	79
276	Angophora costata	388831.23	6363643.15	20	47
277	Angophora costata	388833.63	6363652.97	28	32
278	Dead Stag	388825.57	6363648.07	19	25
279	Dead Stag	388779.58	6363669.27	50	304
280	Eucalyptus pilularis	388796.59	6363642.85	20	287
281	Dead Stag	388785.69	6363639.28	29	270
282	Angophora costata	388777.00	6363632.68	37	257
283	Eucalyptus pilularis	388796.77	6363602.54	35	197
284	Angophora costata	388809.71	6363604.32	29	176
285	Eucalyptus pilularis	388822.28	6363620.49	15	134
286	Angophora costata	388857.93	6363623.26	45	90
287	Dead Stag	388870.05	6363622.61	57	88
288	Dead Stag	388811.23	6363581.25	52	270
289	Dead Stag	388828.29	6363574.44	34	265
290	Angophora costata	388840.46	6363582.69	25	288
291	Dead Stag	388829.06	6363567.99	33	254
292	Eucalyptus pilularis	388823.43	6363564.24	39	249
293	Angophora costata	388859.16	6363560.41	10	184
294	Eucalyptus pilularis	388864.83	6363545.16	25	161
295	Eucalyptus pilularis	388871.77	6363563.03	12	113
296	Eucalyptus pilularis	388895.84	6363566.74	34	83
297	Dead Stag	388870.87	6363574.62	10	50
298	Eucalyptus pilularis	388876.22	6363574.76	15	59
299	Dead Stag	388877.87	6363582.18	20	40
300	Angophora costata	388875.01	6363601.41	34	10
301	Angophora costata	388867.10	6363597.53	28	358
302	Dead Stag	388854.74	6363598.08	29	333
303	Eucalyptus pilularis	388840.60	6363516.81	30	341
304	Eucalyptus pilularis	388837.46	6363514.23	28	334
305	Eucalyptus pilularis	388838.48	6363495.34	10	314
306	Eucalyptus pilularis	388832.06	6363488.15	12	263
307	Eucalyptus pilularis	388819.34	6363491.13	25	267
308	Eucalyptus pilularis	388822.83	6363471.90	26	222

Ref	Tree Species	Easting (AGD66)	Northing (AGD66)	Distance	Angle
309	Eucalyptus pilularis	388832.96	6363470.32	20	201
310	Eucalyptus pilularis	388852.77	6363470.15	19	140
311	Angophora costata	388855.94	6363488.15	12	72
312	Eucalyptus pilularis	388882.88	6363483.94	39	82
313	Eucalyptus pilularis	388871.34	6363493.06	28	65
314	Eucalyptus pilularis	388872.56	6363508.92	36	40
315	Eucalyptus pilularis	388844.65	6363491.96	5	355
316	Angophora costata	388848.25	6363516.64	15	0
317	Angophora costata	388881.69	6363459.12	53	36
318	Angophora costata	388857.68	6363445.98	27	23
319	Angophora costata	388846.33	6363443.53	20	0
320	Angophora costata	388842.13	6363439.00	15	348
321	Angophora costata	388836.99	6363443.36	20	333
322	Angophora costata	388806.85	6363443.09	40	286
323	Eucalyptus pilularis	388824.71	6363431.88	19	282
324	Angophora costata	388832.00	6363424.26	10	259
325	Angophora costata	388856.45	6363419.99	15	93
326	Eucalyptus pilularis	388871.97	6363422.69	30	80
327	Angophora costata	388873.36	6363430.38	32	66
328	Eucalyptus pilularis	388831.41	6363359.84	10	274
329	Angophora costata	388832.38	6363362.08	10	288
330	Angophora costata	388812.57	6363373.75	33	288
331	Eucalyptus pilularis	388806.35	6363388.75	47	300
332	Angophora costata	388821.08	6363382.04	32	309
333	Angophora costata	388838.03	6363374.75	18	338
334	Eucalyptus pilularis	388796.59	6363331.26	15	217
335	Eucalyptus pilularis	388787.02	6363334.38	22	240
336	Eucalyptus pilularis	388730.55	6363713.00	51	347
337	Eucalyptus pilularis	388713.26	6363671.23	20	285
338	Eucalyptus pilularis	388704.83	6363674.48	29	283
339	Dead Stag	388690.72	6363677.06	43	278
340	Angophora costata	388689.02	6363671.31	43	270
341	Angophora costata	388721.02	6363661.39	10	254
342	Dead Stag	388702.90	6363651.49	30	237
343	Angophora costata	388717.69	6363655.07	15	230
344	Eucalyptus pilularis	388731.44	6363652.01	10	165
345	Eucalyptus pilularis	388641.09	6363668.69	10	250
346	Dead Stag	388643.16	6363682.79	15	316
347	Angophora costata	388621.74	6363717.75	56	316
348	Angophora costata	388613.38	6363731.39	72	316
349	Eucalyptus robusta	388607.60	6363753.38	94	320
350	Angophora costata	388626.64	6363747.25	81	330
351	Angophora costata	388625.21	6363769.72	103	333
352	Dead Stag	388654.88	6363758.92	89	350

Ref	Tree Species	Easting (AGD66)	Northing (AGD66)	Distance	Angle
353	Eucalyptus pilularis	388658.67	6363749.63	80	353
354	Angophora costata	388659.87	6363729.34	60	356
355	Dead Stag	388660.52	6363712.96	44	0
356	Eucalyptus pilularis	388667.50	6363719.31	52	6
357	Eucalyptus pilularis	388675.97	6363722.35	58	13
358	Eucalyptus pilularis	388684.44	6363724.57	64	19
359	Dead Stag	388671.22	6363697.33	34	24
360	Dead Stag	388692.00	6363679.09	42	65
361	Dead Stag	389417.22	6363426.61	26	250
362	Angophora costata	389430.94	6363438.92	15	294
363	Dead Stag	389445.16	6363439.76	10	0
364	Dead Stag	389464.00	6363430.18	21	77
365	Eucalyptus pilularis	389500.85	6363379.77	30	108
366	Angophora costata	389494.26	6363403.37	21	54
367	Dead Stag	389475.31	6363399.99	5	351
368	Angophora costata	389456.39	6363387.67	20	236
369	Dead Stag	389509.67	6363323.47	20	180
370	Angophora costata	389513.61	6363357.99	15	346
371	Angophora costata	389496.58	6363304.78	42	192
372	Angophora costata	389516.07	6363304.12	24	253
373	Dead Stag	389512.92	6363318.92	30	283
374	Eucalyptus pilularis	389507.44	6363329.23	40	293
375	Eucalyptus pilularis	389504.91	6363292.81	39	297
376	Dead Stag	389509.95	6363261.05	26	242
377	Angophora costata	389471.37	6363224.77	43	272
378	Eucalyptus pilularis	389477.52	6363232.47	40	285
379	Eucalyptus pilularis	389481.27	6363238.35	40	295

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