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Transport
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Services







Foxground and Berry bypass

Princes Highway upgrade

Environmental assessment

Volume 2 – Appendix F

Technical paper: Terrestrial flora and fauna

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Princes Highway upgrade

Prepared for

Roads and Maritime Services

Prepared by

Biosis Research Pty Ltd
18-20 Mandible Street, Alexandria NSW 2015

In association with

AECOM Australia Pty Ltd
Level 11, 44 Market Street, Sydney NSW 2000

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Executive summary

Biosis Research Pty. Ltd. was commissioned by AECOM on behalf of the Roads and Maritime Services of NSW (RMS) to carry out a terrestrial ecological assessment of the Foxground and Berry bypass (the project).

RMS is seeking approval under Part 3A of the *Environmental Planning and Assessment Act 1979* for the upgrade of 11.6 kilometres of the Princes Highway between Toolijooa Road north of Foxground and Schofields Lane south of Berry, in New South Wales (NSW) (the project), to achieve a four lane divided highway (two lanes in each direction) with median separation. The project includes bypasses of Foxground and Berry.

The project is one of a series of upgrades to sections of the Princes Highway which aims to provide a four lane divided highway between Waterfall and Jervis Bay Road, Falls Creek. This would improve road safety and traffic efficiency, including for freight, on the NSW south coast.

The aim of this terrestrial flora and fauna assessment is to address the Department of Planning and Infrastructure Director-General's requirements for the project, including the identification of issues of conservation significance associated with the project. The specific objectives were to:

- Gather existing information regarding terrestrial flora and fauna within and surrounding the study area, focussing on threatened species, populations and ecological communities.
- Examine the nature, extent and condition of fauna habitats and vegetation associations within the study area, through a combination of desktop and field studies.
- Determine areas supporting vegetation associations that are, or are likely to be, of conservation significance, or support resources that may be utilised by species or populations of conservation significance.
- Assess the potential occurrence of flora and fauna species or populations of conservation significance, in particular, threatened species and populations.
- Determine areas that may be of importance as habitat corridors.
- Assess the potential impacts of the project on threatened species and populations (including their habitats) and endangered ecological communities.
- Evaluate the impact of the project on threatened biota listed under the NSW *Threatened Species Conservation Act 1995* (TSC Act) by undertaking assessments of significance in line with requirements of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act) and Director-General's requirements for the project and following the Part 3A Guidelines for Threatened Species Assessment (DEC and DPI, 2005).
- Evaluate the impact on Matters of National Environmental Significance (MNES) under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) for the project by implementing significant impact criteria for threatened biota and migratory species as outlined in the EPBC Act Policy Statement 1.1 Significant Impact Guidelines: Matters of National Significance (2009).

The terrestrial ecological field investigations of the project were conducted during February 2007, November 2008, May 2009, June 2011 and November 2011. Surveys were carried out using a combination of habitat-based assessment, trapping, anabat recording, spotlighting and targeted sampling techniques. The study area consists of the area of earthworks for the proposed road and Town Creek downstream of the proposed diversion point (subject site), and a buffer of about 50 metres on either side of the subject site to account for potential indirect impacts.

Endangered ecological communities (EEC)

One endangered ecological community (EEC) was recorded in the study area: Riverbank forest. This community meets the criteria for the EEC *River-flat eucalypt forest on coastal floodplains of the North Coast, Sydney Basin and South East Corner bioregions* listed under the TSC Act. An assessment of significance was carried out for this EEC and it was determined that despite the direct impacts to about 2.9 hectares and indirect impacts to about 7.1 hectares of this ecological community the project is unlikely to have a significant impact upon this EEC.

Subtropical dry rainforest was recorded more than 0.2 kilometres from the study area. This community is included within the EEC *Illawarra subtropical rainforest in the Sydney Basin bioregion* listed under the TSC Act. The preferred option avoids impacts on this community.

Flora

A total of 17 vascular flora species listed on the TSC Act and/or the EPBC Act, or their habitat, have been previously recorded within a 10 kilometre radius of the study area. An additional 14 species are recorded from the NSW Office of Environment and Heritage (OEH) Illawarra sub-region of the Southern Rivers catchment management authority with a further four species identified by OEH for consideration in the environmental assessment.

No threatened flora species were recorded in the study area, however, based on the proximity of previous records and the presence of identified habitat preferences, potential habitat may exist within the study area for four threatened flora species including: White-flowered Wax Plant (*Cynanchum elegans),* Illawarra Socketwood (*Daphnandra* sp. 'Illawarra'), Delicate Cress (*Irenepharsus trypherus)* and Hill Zieria (*Zieria granulata*).

Additionally OEH have identified five flora species to be assessed as subject species for the project including two of the species cited above and an additional three species. The additional three flora subject species are Illawarra Greenhood (*Pterostylis gibbosa*), Leafless Tongue Orchid (*Cryptostylis hunteriana*) and Bauer's Midge Orchid (*Genoplesium baueri*).

Assessments of significance carried out for these seven threatened flora species determined that the project is unlikely to have a significant impact upon any of these species. A referral to the Australian Government Minister for Sustainability, Environment, Water, Population and Communities is therefore not required for any threatened flora species.

Fauna

Fauna habitat within the study area ranged from predominantly cleared areas, which have low to moderate habitat quality in terms of fauna habitat characteristics, to fragmented patches of native vegetation, that contained important habitat features such as tree hollows, rocky shelters, riparian vegetation, fallen logs and feeding resources.

A total of 114 fauna species listed on the TSC Act and/or the EPBC Act, or their habitat, have been previously recorded within a 10 kilometre radius of the study area or within the Illawarra sub-region of the Southern Rivers catchment management authority. Nine threatened and six migratory species were recorded during the field surveys. Based on the proximity of current and previous records and the presence of identified habitat preferences, known and/or potential habitat exists within the study area for 51 threatened and 29 migratory fauna species.

Impacts to the known/potential habitat of 27 threatened species were considered negligible and therefore, assessments of significance were not conducted for these species. Assessments of significance were carried out for the remaining 24 threatened fauna species; the Part 3A assessments of significance for TSC Act-listed species concluded the project would be unlikely to result in a significant impact. The significant impact criteria assessments for EPBC Act-listed species concluded the project would be unlikely to result in a significant impact provided the mitigation measures outlined in this report are implemented. A referral to the Australian Government Minister for Sustainability, Environment, Water, Population and Communities is therefore not required for any threatened fauna species.

Impacts to the known/potential habitat of the 29 migratory species were considered negligible. Individuals of these species that may occur in the study area were not considered likely to be an ecologically significant proportion of the population. Further, potential habitat in the study area was not considered important for the migratory species. As such, no significance assessments under the EPBC Act were carried out for these species. A referral to the Commonwealth Minister for Sustainability, Environment, Water, Population and Communities is therefore not required for any migratory species.

Wildlife corridors and connectivity

Of particular importance for this project is the Seven Mile Beach National Park – Barren Grounds Nature Reserve wildlife corridor. Remnant bushland in the Seven Mile Beach and Coomonderry Swamp area is isolated by several kilometres of cleared land from the escarpment forests to the north of Berry. Scattered patches of bushland exist between these two areas, including Toolijooa Ridge, Harley Hill, Moeyan Hill, along Broughton Creek and along public roads (Shoalhaven City Council 2005), providing limited connectivity between the two largely intact areas for fauna. The project crosses some of these areas of bushland and is likely to impact on local and/or regional wildlife corridors due to habitat fragmentation.

Mitigation

Important ecological features have been avoided during the initial route selection stage, where possible. The following mitigation measures would be implemented to ameliorate impacts on terrestrial flora and fauna, including:

- Enhancement of riparian corridor vegetation including control of exotic aquatic species. All works in waterways would be undertaken works in accordance with Guide 10 Aquatic habitats and riparian zones of the RMS 'Biodiversity Guidelines' (2011).
- Four dedicated fauna underpasses with fauna fencing and fauna 'furniture'.
- Incidental fauna passage under all bridges.
- Rope bridges at eight separate locations along the route.
- Restoration, regeneration and rehabilitation of areas of native vegetation in the vicinity of the project. The preparation of a Vegetation Management Plan (VMP) to guide and provide a monitoring framework should be prepared in consultation with local Landcare groups and the Catchment Management Authority (CMA) committing to input local expertise and resources during implementation.
- Monitoring and control of weed populations that establish on disturbed areas, with particular attention to eradication of noxious weeds. The monitoring and control should be undertaken by persons experienced in weed management and in accordance with Guide 6 Weed management of the RMS 'Biodiversity Guidelines' (RTA 2011).
- Fencing and protection of EECs and potential habitat of threatened species that occur within the impact zone following the RMS 'Biodiversity Guidelines' (RTA 2011).
- Minimising disturbance to stream banks and streambeds wherever possible.

Clearing of vegetation would follow Guide 1 Pre-clearing process of the RMS 'Biodiversity Guidelines' (RTA 2011).

Biodiversity offsets

A Biodiversity Offset Strategy has been prepared to guide offsetting of residual impacts that cannot be mitigated, such as the unavoidable loss of Riverbank forest (River-flat eucalypt forest EEC). The following two offset actions are proposed in order to achieve a “maintain or improve” biodiversity outcome for the region as a result of the project:

Action 1 Revegetation and rehabilitation of riparian vegetation in strategic locations.

Action 2 Use an appropriate legal instrument to secure native vegetation to ensure that the land is managed for conservation.

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1 Introduction

1.1 Background

RMS is seeking approval under Part 3A of the *Environmental Planning and Assessment Act 1979* for the upgrade of 11.6 kilometres of the Princes Highway between Toolijooa Road north of Foxground and Schofields Lane south of Berry, in New South Wales (NSW) (the project), to achieve a four lane divided highway (two lanes in each direction) with median separation. The project includes bypasses of Foxground and Berry.

The project is one of a series of upgrades to sections of the Princes Highway which aims to provide a four lane divided highway between Waterfall and Jervis Bay Road, Falls Creek. This would improve road safety and traffic efficiency, including for freight, on the NSW south coast.

The project comprises the following key features:

- Construction of a four lane divided highway (two lanes in each direction) with median separation (wire rope barriers or concrete barriers where space is constrained, such as at bridge locations).
- Bypasses of the Foxground bends and the Berry township.
- Construction of around 6.6 kilometres of new highway where the project deviates from the existing highway alignment at Toolijooa Ridge, the Foxground bends and the Berry township.
- Provision for the possible widening of the highway (if required in the future) to six lanes within the road corridor and, in some areas, construction of the road formation to accommodate future additional lanes where safety considerations, traffic disruption and sub-optimal construction practices are to be avoided.
- Grade-separated interchanges at:
  - Toolijooa Road.
  - Austral Park Road.
  - Tindalls Lane.
  - East of Berry at the existing Princes Highway, referred to as the northern interchange for Berry.
  - West of Berry at Kangaroo Valley Road, referred to as the southern interchange for Berry.
- A major cutting at Toolijooa Ridge (around 900 metres long and up to 26 metres deep).
- Six lanes (two lanes plus a climbing lane in each direction) through the cutting at Toolijooa Ridge for a distance of 1.5 kilometres.
- Four new highway bridges:
  - Broughton Creek bridge 1, a four span concrete structure around 170 metres in length and nine metres in height.
  - Broughton Creek bridge 2, a three span concrete structure around 75 metres in length and eight metres in height.
  - Broughton Creek bridge 3, a six span concrete structure around 190 metres long and 13 metres in height.
  - A bridge at Berry, an 18 span concrete structure around 600 metres long and up to 12 metres in height.

- Three highway overbridges:
  - Austral Park Road interchange, providing southbound access to the highway.
  - Tindalls Lane interchange, providing southbound access to and from the highway.
  - Southern interchange for Berry, providing connectivity over the highway for Kangaroo Valley Road along its existing alignment.
- Eight underpasses including roads, drainage structures and fauna underpasses:
  - Toolijooa Road interchange, linking Toolijooa Road to the existing highway and providing northbound access to the upgrade.
  - Property access and fauna underpass in the vicinity of Toolijooa Ridge at chainage 8400.
  - Dedicated fauna underpass in the vicinity of Toolijooa Ridge at chainage 8450.
  - Property access underpass between Toolijooa Ridge and Broughton Creek at chainage 9475.
  - Combined drainage and fauna underpass in the vicinity of Austral Park Road at chainage 12770.
  - Combined drainage and fauna underpass in the vicinity of Tindalls Lane at chainage 13320.
  - Dedicated fauna underpass in the vicinity of Tindalls Lane at chainage 13700.
  - Property access underpass between the Tindalls Lane interchange and the northern interchange for Berry in the vicinity of at chainage 15100.
- Modifications to local roads, including Toolijooa Road, Austral Park Road, Tindalls Lane, Gembrook Lane, North Street, Queen Street, Kangaroo Valley Road, Hitchcocks Lane and Schofields Lane
- Diversion of Town Creek into Bundewallah Creek upstream of its confluence with Connollys Creek and to the north of the project at Berry.
- Modification to about 47 existing property accesses.
- Provision of a bus stop at Toolijooa Road and retention of the existing bus stop at Tindalls Lane.
- Dedicated u-turn facilities at Mullers Lane, the existing highway at the Austral Park Road interchange, the extension to Austral Park Road and Rawlings Lane.
- Roundabouts at the southern interchange for Berry and the Woodhill Mountain Road junction with the exiting Princes Highway.
- Two culs-de-sac on North Street and the western end of Victoria Street in Berry.
- Tie-in with the existing highway about 75 metres north of Toolijooa Road and about 440 metres south of Schofields Lane.
- Left in/left out only provisions for direct property accesses to the upgraded highway.
- Dedicated public space with shared pedestrian/cycle facilities along the southern side of the upgraded highway from the playing fields on North Street to Kangaroo Valley Road.
- Ancillary operational facilities, including permanent detention basins, stormwater treatment facilities and a permanent ancillary facility site for general road maintenance.

Construction activities as part of the project would include the following:

- Site preparation and establishment works.
- Temporary construction facilities, including construction compounds, stockpile sites, creek crossings, sediment control basins and haulage roads.
- Temporary works, including relocation/protection of services, tie-ins, traffic facilities and side tracks.
- Earthworks and bridge construction.
- Pavement construction.
- Drainage construction.
- Road furniture installation.
- Site restoration.

The project and the key features of the project are shown in **Figure 1.1**.

This terrestrial flora and fauna assessment should be read in conjunction with the *Aquatic Ecology and Water Quality Management Assessment*, which is provided at Appendix G of the environmental assessment (CEL 2012).

During detailed design, refinements could be made to the design features and construction methods (refer to Chapter 4 of the environmental assessment).

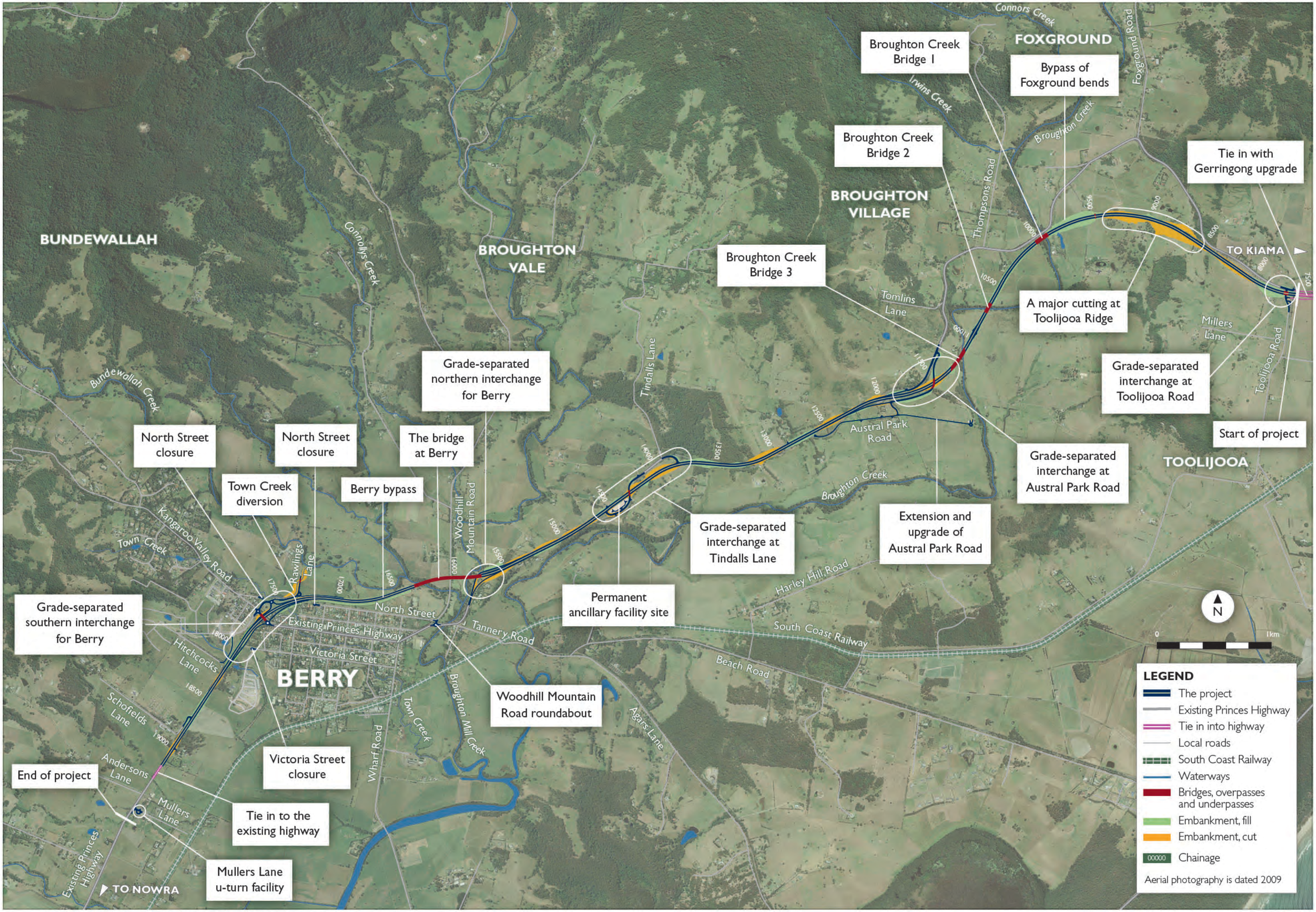


Figure 1-1: Foxground and Berry bypass project area

1.2 Objectives of the report

Biosis Research Pty. Ltd. (Biosis Research) was engaged to investigate potential terrestrial flora and fauna issues in relation to the project. The terrestrial flora and fauna assessment involved two major components:

a) Preliminary investigations to assist the process of selecting a preferred route option (Biosis Research 2007).

b) Detailed investigations of the preferred option for the project (this report).

The overall objective of this report is to address the Department of Planning and Infrastructure's Director-General's requirements (DGRs) for the project. The DGRs relevant to the flora and fauna assessment are provided in **Table 1.1**. This report focuses on the terrestrial ecology requirements. The aquatic ecology requirements are addressed in Foxground and Berry bypass Aquatic Ecology and Water Quality Management Assessment, (CEL 2012).

Table 1.1: DGRs relevant to terrestrial ecology

Director-General's requirements
Flora and Fauna – including but not limited to:
An assessment of all project components on flora and fauna and their habitat (both terrestrial and aquatic, as relevant) consistent with the Draft Guidelines for Threatened Species Assessment (DEC 2005). The EA must provide details of the survey methodology employed including survey effort and representativeness for species targeted.
Specific consideration of impacts to threatened species, populations, ecological communities and/or critical habitat listed under both State and Commonwealth legislation that have been recorded on the site and surrounding land.
Details on the existing site conditions (both terrestrial and aquatic) and quantity and likelihood of disturbance (including quantifying the worst case extent of impact on the basis of vegetation type and total native vegetation disturbed).
As relevant, consideration of weed infestation and edge effects; habitat fragmentation, impacts to wildlife and riparian corridors; impacts to groundwater-dependent communities, riparian and aquatic habitat (including impacts on SEPP 14 wetlands and fish passage).
Provide details of how flora and fauna impacts would be managed during construction and operation for all project components, including adaptive management and maintenance protocols and monitoring programs.
Demonstrate actions to be undertaken to avoid, mitigate or offset impacts associated with the project (all components) consistent with the principles of "improve or maintain". Sufficient details must be provided to demonstrate the availability of viable and achievable options to offset the impacts of the project, where offset measures are proposed to address residual impacts.

The report also presents the results of surveys and the assessment of potential impacts upon terrestrial flora and fauna values within the project study area. The potential impacts have been assessed in accordance with relevant State and Commonwealth threatened species legislation.

The specific objectives of this terrestrial flora and fauna assessment were to:

- Gather existing information regarding terrestrial flora and fauna within and surrounding the study area, focussing on threatened species, populations and ecological communities.
- Examine the nature, extent and condition of fauna habitats and vegetation associations within the study area, through a combination of desktop and field studies.
- Determine areas supporting vegetation associations that are, or are likely to be, of conservation significance, or support resources that may be utilised by species or populations of conservation significance.
- Assess the potential occurrence of flora and fauna species or populations of conservation significance, in particular, threatened species and populations.
- Determine areas that may be of importance as habitat corridors.
- Assess the potential impacts of the project on threatened species and populations (including their habitats) and endangered ecological communities (EEC).
- Evaluate the impact of the project on threatened biota listed under the NSW Threatened Species Conservation Act 1995 (TSC Act) by undertaking assessments of significance in line with requirements of the NSW EP&A Act 1979 and DGRs for the project and following the Part 3A Guidelines for Threatened Species Assessment (Department of Environment and Conservation (DEC) and DP&I, 2005).
- Evaluate the impact on Matters of National Environmental Significance (MNES) under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) for the project by implementing significant impact criteria for threatened biota and migratory species as outlined in the EPBC Act Policy Statement 1.1 Significant Impact Guidelines: Matters of National Significance (2009).

1.3 Legislative framework

1.3.1 *NSW Environmental Planning and Assessment Act 1979 (EP&A Act)*

The EP&A Act and Environmental Planning and Assessment Regulations 2000 (EP&A Regulations) provide the statutory context for environmental assessment of the project and ultimately planning approval. The current project is to be assessed under Part 3A and other relevant provisions of the EP&A Act.

One objective of the EP&A Act is to encourage the protection of the environment, including the protection and conservation of native fauna and flora, including threatened species, populations and ecological communities and their habitats. A second objective is to encourage the principles of ecologically sustainable development, including the precautionary principle as defined under the Protection of the Environment Administration Act 1991. The precautionary principle is defined as:

> *Where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation* (IGAE 1992).

1.3.2 NSW *Threatened Species Conservation Act 1995* (TSC Act)

The TSC Act protects all threatened flora and fauna native to NSW (with the exception of fish and marine plants). It provides for the identification, conservation and recovery of threatened species and their populations and communities. It also aims to reduce the threats faced by those species.

1.3.3 Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act)

The EPBC Act is a Commonwealth mechanism that requires proposed actions to be assessed in terms of their potential impact upon MNES. MNES currently listed under the Act are:

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

Where a potential impact on a MNES is likely to occur as a result of a proposed action, the significance of that impact must be assessed. Guideline criteria for determining whether an impact is significant are provided under the Act. Where a proposed action would, or is likely to, have a significant impact on a MNES, a referral to the Commonwealth Minister for Sustainability, Environment, Water, Population and Communities must be prepared. The purpose of the referral is to determine whether a proposed action requires approval and/or controls under the EPBC Act.

1.3.4 SEPP 14 wetlands

State Environmental Planning Policy 14 Coastal Wetlands (SEPP 14) aims to protect and preserve coastal wetlands. The areas covered by SEPP 14 are shown on a series of maps held by the Department of Planning and Infrastructure (DP&I). Over 1300 coastal wetlands have been mapped under SEPP 14, representing seven per cent of all coastal wetlands in NSW. Under SEPP 14, a person must not clear land, construct a levee, drain land or fill land which is covered by SEPP 14 except with the consent of the local council and the concurrence (agreement) of the NSW Minister for Planning.

1.3.5 SEPP 44 Koala habitat protection

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, ensuring a permanent free living population over their present range and attempting to reverse the current trend of Koala population decline.

SEPP 44 applies to land within the Local Government Areas (LGAs) listed under SEPP 44, Schedule 1 (including the Kiama and Shoalhaven LGAs. Under this policy the distinction is made between ‘potential’ and ‘core’ Koala habitat. Although the RMS is exempt in this case, the implications of SEPP 44 have been considered (Section 3.8.5).

1.4 Study area

1.4.1 Definitions

New South Wales threatened species legislation applies particular definitions to the site of a proposed development and the area likely to be impacted by a proposed development. In addition, the present NSW and Commonwealth Government approach to biodiversity conservation recognises a system of “bioregions” and “subregions”. In order to provide clarity of reporting and consistency with current legislation and policy, the following definitions apply throughout this document:

Project - proposed upgrade (widening in sections and realigning in sections) of the Princes Highway between about the junction of Toolijooa Road and the Princes Highway and about the junction of Schofields Lane and the Princes Highway on the NSW south coast (Foxground and Berry bypass).

Direct impacts – those that directly affect habitat and individuals. Direct impacts can include, but are not limited to, removal of vegetation and habitat, trampling of habitat or individuals, and fragmentation of habitat.

Indirect impacts – occur when project-related activities affect species, populations or ecological communities in a manner other than direct loss. Indirect impacts can include, but are not limited to, loss of individuals through starvation, exposure, predation, competition for reduced resources, erosion, weed invasion, or increased human activity within or adjacent to sensitive habitat areas.

Residual impacts – these are impacts that remain following actions to avoid and mitigate direct and indirect impacts.

Subject site – the area to be directly affected by the project (ie the development “footprint”).

Study area – the subject site and any additional areas which are likely to be affected by the project, either directly or indirectly. In the case of the project, the study area includes the subject site and a 50 metre buffer to account for any indirect impacts.

Locality – for the purposes of this report, the “locality” is defined as the area within a five kilometre radius of the perimeter of the study area.

Region – the region and sub-region in which the project would be located, as defined by the Interim Biogeographic Regionalisation of Australia. The Interim Biogeographic Regionalisation of Australia is based on Thackway and Cresswell (1995) and Morgan and Terry (1992) and periodically updated by Parks Australia. Interim Biogeographic Regionalisation of Australia Version 6.1 was current at the time of this study. The project is located in the Illawarra sub region at the southernmost portion of the Sydney basin bioregion.

Threatened biota – threatened species, populations and ecological communities, or their potential habitats, as listed under the TSC Act or the EPBC Act.

Subject species, populations or ecological communities – those threatened species, populations or ecological communities that are known or considered likely to occur in the locality. Subject species have been determined from desktop assessments and field surveys by Biosis Research, or are specifically included as a result of consultation with OEH and are included in Attachment 2 of the OEH correspondence dated 31 January 2011.

1.4.2 Location and description

The project is 11.6 kilometres in length and is located west of Gerringong, between the intersection of the Princes Highway and Toolijooa Road, and the intersection of the Princes Highway and Schofields Lane. The project traverses Toolijooa Ridge, bypasses Foxground, crosses Broughton Creek in three locations and bypasses the town of Berry. The project lies partly within the Kiama LGA and partly within the Shoalhaven LGA.

An overview of the study area is provided in **Figure 1.1**. The study area mainly comprises the existing road reserve, privately owned rural agricultural, rural residential and suburban (Berry) properties. Patches of native vegetation and isolated remnant trees are scattered throughout the majority cleared agricultural landscape. The main agricultural land use in the study area is cattle grazing.

Conservation reserves that occur in the locality include the Cambewarra Range Nature Reserve, the Seven Mile Beach National Park, the Barren Grounds Nature Reserve and the Saddleback Mountain Reserve. None of these reserves are directly impacted by the project.

The project deviates from the existing Princes Highway corridor in two locations:

- Across Toolijooa Ridge and the Broughton Creek floodplain between Toolijooa Road and east of Austral Park Road.
- To the north of Berry, where a northern bypass of Berry is proposed between the ridgeline to the east of Woodhill Mountain Road and the south of Berry, where it would rejoin the existing route south-west of Kangaroo Valley Road.

Remaining portions of the project follow the existing route of the Princes Highway.

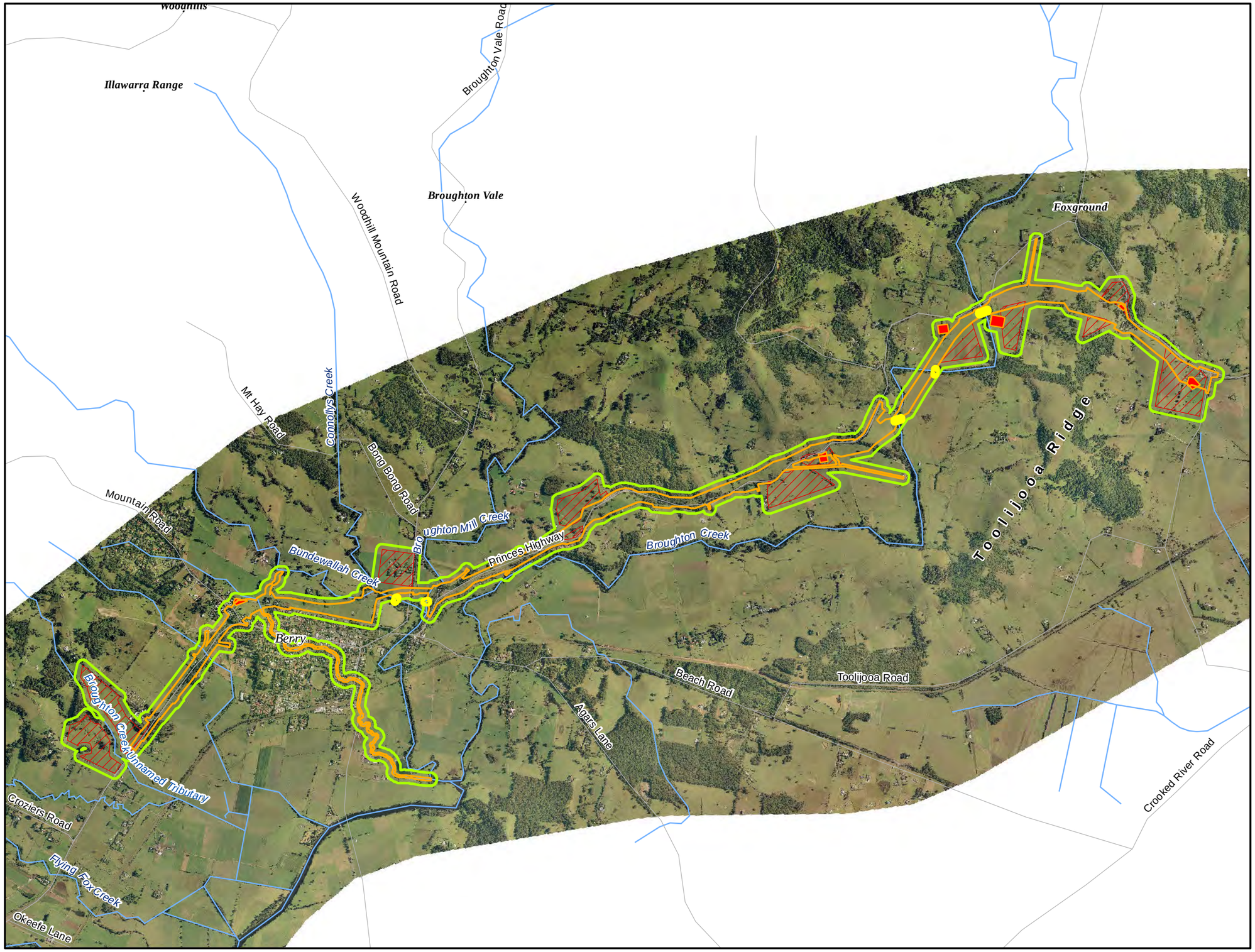
1.4.3 Extent of the study area

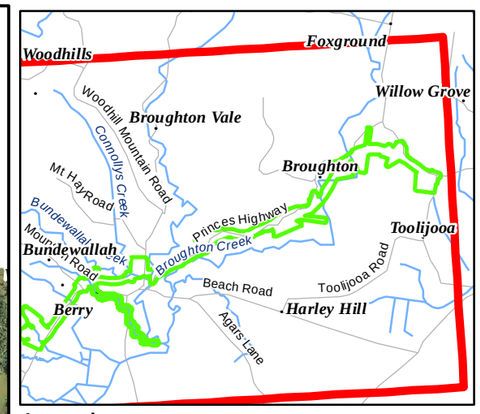
The study area is defined by the extent of direct and indirect impacts on flora and fauna that are likely to occur as a result of the project. Potential impacts on flora and fauna may occur during the construction and/or the subsequent operation of the project. Direct impacts are likely to be limited to the subject site. The proposed location and land take for ancillary facilities such as construction compounds, site offices and stockpile areas (shown in **Figure 1.2**), and land downstream of the proposed Town Creek diversion point, have been considered as part of the subject site in addition to the highway footprint.

Areas that may be indirectly affected by the project include adjoining flora and fauna habitats within 50 metres of either side of the subject site. The subject site and the 50 metre buffer area make up the study area for the project. A distance of 50 metres was chosen for the buffer as this is the average distance that edge effects are likely to be seen and recorded from the edge of a road (Biosis Research 2000, Bali 2005). Although edge effects (indirect impacts) can extend much further than 50 metres, native vegetation patches immediately surrounding the project are already subject to edge effects, and therefore, a relatively small study area was chosen. Edge effects associated with road developments can be summarised as the degradation of adjacent habitat through:

- Changes in microclimate, hydrology or floristics (flora species mix).
- Alteration to the pattern and frequency of fire.
- Invasion by exotic flora and fauna species.
- Increase in sedimentation, tree death or rubbish and water pollution.
- Improved access for predators (Bali 2000).

Further discussion of the potential direct and indirect impacts relating to the project including impacts on wildlife corridors is included in Section 4.1. While the study area includes the subject site and a 50 metre buffer, extensive surveys were carried out within the locality as part of the route options investigations for the project. Surveys carried out within the locality provide important contextual information in relation to the potential impacts of the preferred route.





Legend

- Study Area
- Subject Site - Footprint
- Subject Site - Temporary Creek Crossings

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile

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Figure 1.2 Ancillary Facilities

Date: 16 July 2012	Drawn by: RS/JS/ANP
File: 13194	Checked by: JC
Location:P:\15000s\15039\Mapping\Variaition 1\Variation 1 Figures\13194_S2_F1-2_Ancillary Facilties_Overview_130712.mxd	

Acknowledgements:
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0 350 700 1,050 1,400 1,750
Metres

Scale: 1:35,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 1.2

2 Methods

2.1 Approach

The location and extent of the study area is shown on **Figure 1.1**. The study involved three key stages including a desktop examination, field surveys, and impact assessment reporting. The desktop study involved gathering and reviewing existing information regarding the flora and fauna of the study area. Field surveys were undertaken for the purpose of ground-truthing information obtained during the desktop examination and to gather additional data from parts of the study area selected for further investigation. The combined information from field and desktop studies was then used to assess the impacts of the upgrade on terrestrial flora and fauna values within the study area.

2.2 Desktop study

Existing information regarding the flora and fauna of the study area was obtained from a range of sources, including: databases; aerial photographs and maps; previous studies carried out in the vicinity of the study area; and consultation with experts, government agencies, land owners and land managers, local volunteer organisations and natural heritage clubs. A list of documents cited in this report is located in Chapter 8.

Database records were obtained for the study area and the landscape within a 10 kilometre radius of the perimeter of the study area. Database searches were conducted in April 2011 and included:

- Records of threatened flora and fauna species listed on the schedules of the TSC and EPBC Acts obtained from the NSW Office of Environment and Heritage (OEH) NSW National Parks and Wildlife Service (NPWS) Atlas of NSW Wildlife.
- Records of MNES listed under the provisions of the EPBC Act obtained from the Commonwealth Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) Protected Matters Database.
- Records of threatened and migratory bird species obtained from the Birds Australia New Atlas of Australian Birds.
- Records of threatened flora and fauna species and plant communities from the OEH Illawarra sub-region database.

Spatial information from previous studies carried out in the vicinity of the study area that was examined included:

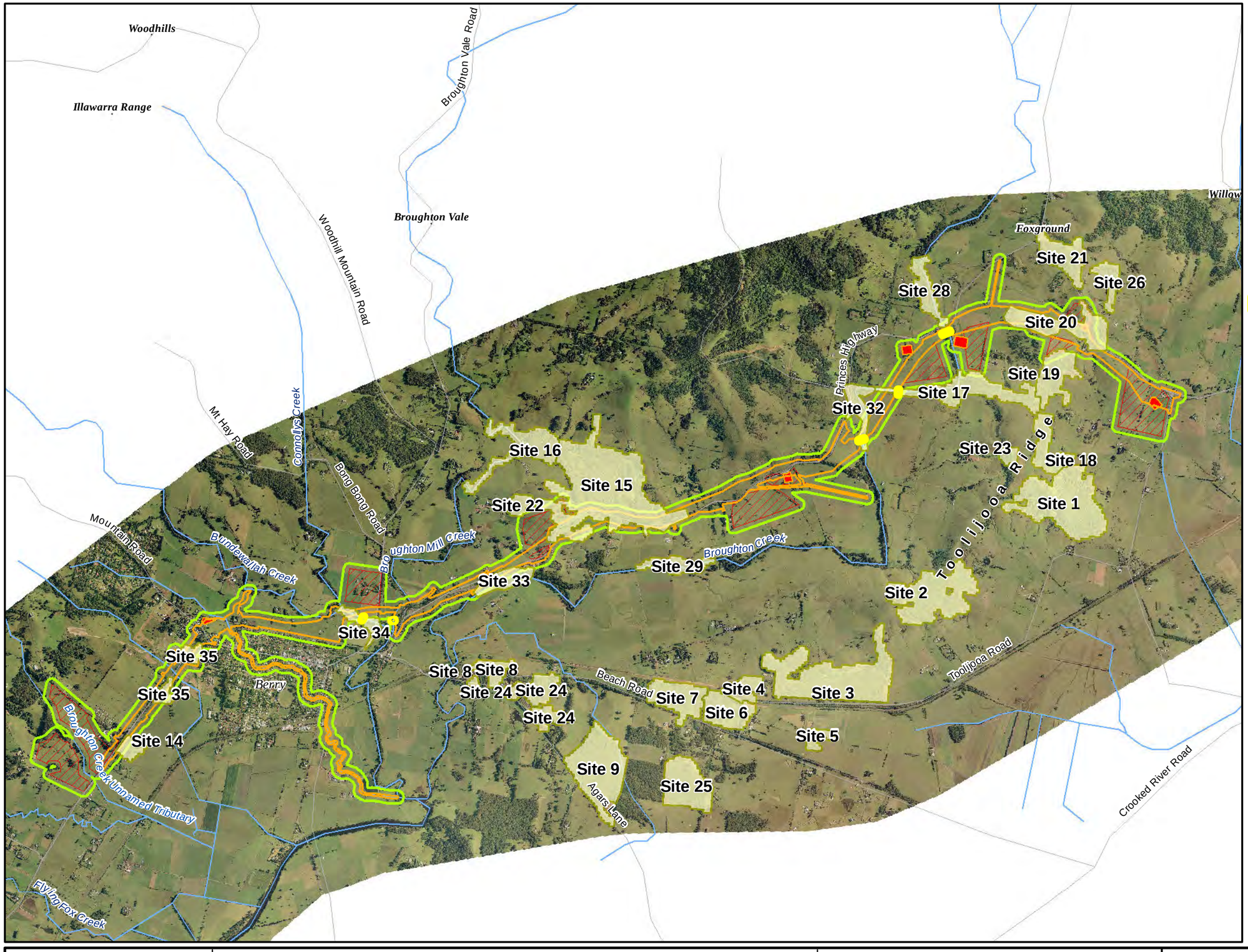
- Aerial photographs of the study area and surrounds, sourced by AECOM.
- Topographic and orthophoto maps (Land and Property Management Authority, (formerly Department of Lands), 1:25,000 maps of Gerroa and Kiama).
- Cadastral information, sourced by AECOM.
- Native Vegetation Map Report Series. No. 4 (DEC 2005o).
- *South Coast Regional Conservation Plan* (NSW Department of Environment, Climate Change and Water (DECCW) 2010).
- Shoalhaven City Council on-line vegetation maps (Shoalhaven City Council 2004).
- Vegetation and Fauna Survey and Assessment prepared for the 1991 Gerringong to Berry route selection study (Muston and Associates 1991).
- *Kiama Municipal Council Local Environment Plan 1996*.
- *Illawarra Regional Environment Plan No 1*.
- *The Natural Vegetation in the Municipality of Kiama New South Wales* (Mills 2006b).
- *Threatened Fauna of the Shoalhaven* (NPWS and Shoalhaven Catchment Management Committee 2000).
- *Mammal Survey of Seven Mile Beach National Park and Comerong Island Nature Reserve on the South Coast of New South Wales* (Murphy 1998).
- *Bats of the Illawarra Region* (Robinson 1985).

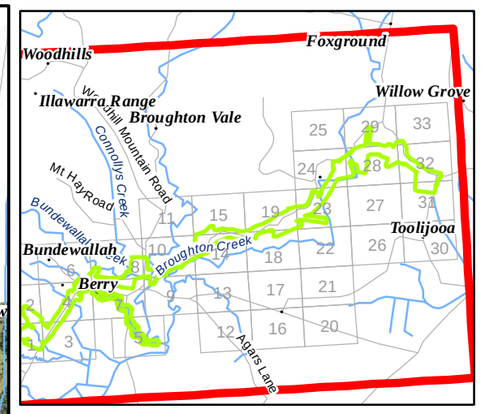
Additional data or information was provided by Mark Tozer (vegetation community expert - DSEWPaC), Ann Goeth (local bird expert – OEH), the Native Animal Network Association, the Berry and District Historical Society Inc., Kerry Withers, Dr Arthur White (frog expert – Frog and Tadpole Study Group) and Garry Daly (herpetologist – NSW National Parks and Wildlife Service (NPWS)).

2.3 Site selection

Sites within the study area were selected for field investigation following roadside reconnaissance and an examination of aerial photographs, topographic maps, existing vegetation maps and threatened species records. Survey sites within the study area included locations containing stands of native vegetation and riparian vegetation along creeks and farm dams. Survey effort previously conducted outside the study area but within the locality as part of the route options assessment has been included for contextual purposes.

Seasonal surveys along the entire upgrade route were conducted in February 2007, November 2008 and May 2009. There were 28 survey sites in the locality of the project (sites 1-9, 14-26, 28-29 and 32-35). The location of survey sites is shown on **Figure 2.1** with survey types shown in **Figure 2.2** and **Figure 2.3** (see Appendix J for mapbooks of these figures at a 1:4000 scale). It should be noted that survey effort was more intensive in areas identified as being of higher conservation significance (Biosis Research 2007). On this basis, survey effort within cleared and disturbed agricultural lands within the study area was limited. Flora surveys and plant community assessments were carried out by one botanist on 28 June 2011 to identify suitable locations for temporary creek crossings during construction. Flora and fauna habitat surveys and plant community assessments were carried out by a botanist and zoologist on 8 November 2011 to assess the proposed diversion of Town Creek.





Legend

- Survey sites
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.1: Survey sites

Date:13 July 2011	Drawn by: RS/JS/ANP
File: 13194	Checked by: JC
Location:P:\15000s\15039\Mapping\Variaition 1\Variation 1 Figures\13194_S2_F2-1_Sites_Overview_130712.mxd	

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0 500 1,000 1,500 2,000
Metres

Scale: 1:35,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.1

2.4 Flora surveys

2.4.1 Survey techniques

Flora surveys were carried out by two botanists over a total of 22 days during three split survey periods conducted between 12 to 23 February 2007; 4 to 12 November 2008, and 18 to 22 May 2009. Flora surveys and plant community assessments were carried out by one botanist on 28 June 2011 to identify suitable locations for temporary creek crossings during construction. These surveys were carried out on Bundewallah Creek, Broughton Mill Creek and Broughton Creek. Surveys involved targeted searches for threatened flora species using random meander techniques and ground-truthing of the plant communities mapped by DEC (2005o) using plot-based surveys. An assessment of plant community condition was conducted at all survey sites. Flora surveys and plant community assessments involving random meanders were carried out by one botanist on 8 November 2011 to determine the potential for threatened flora species and populations to occur, and the presence or absence of EECs, within the area potentially affected by the proposed diversion of Town Creek into Bundewallah Creek.

Surveys were conducted in accordance with the draft publication, *Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities* (DEC 2004a). Survey effort was most rigorous within areas identified as known or potential habitat for threatened flora species and areas identified as EEC. A description of each of the survey methods is provided below.

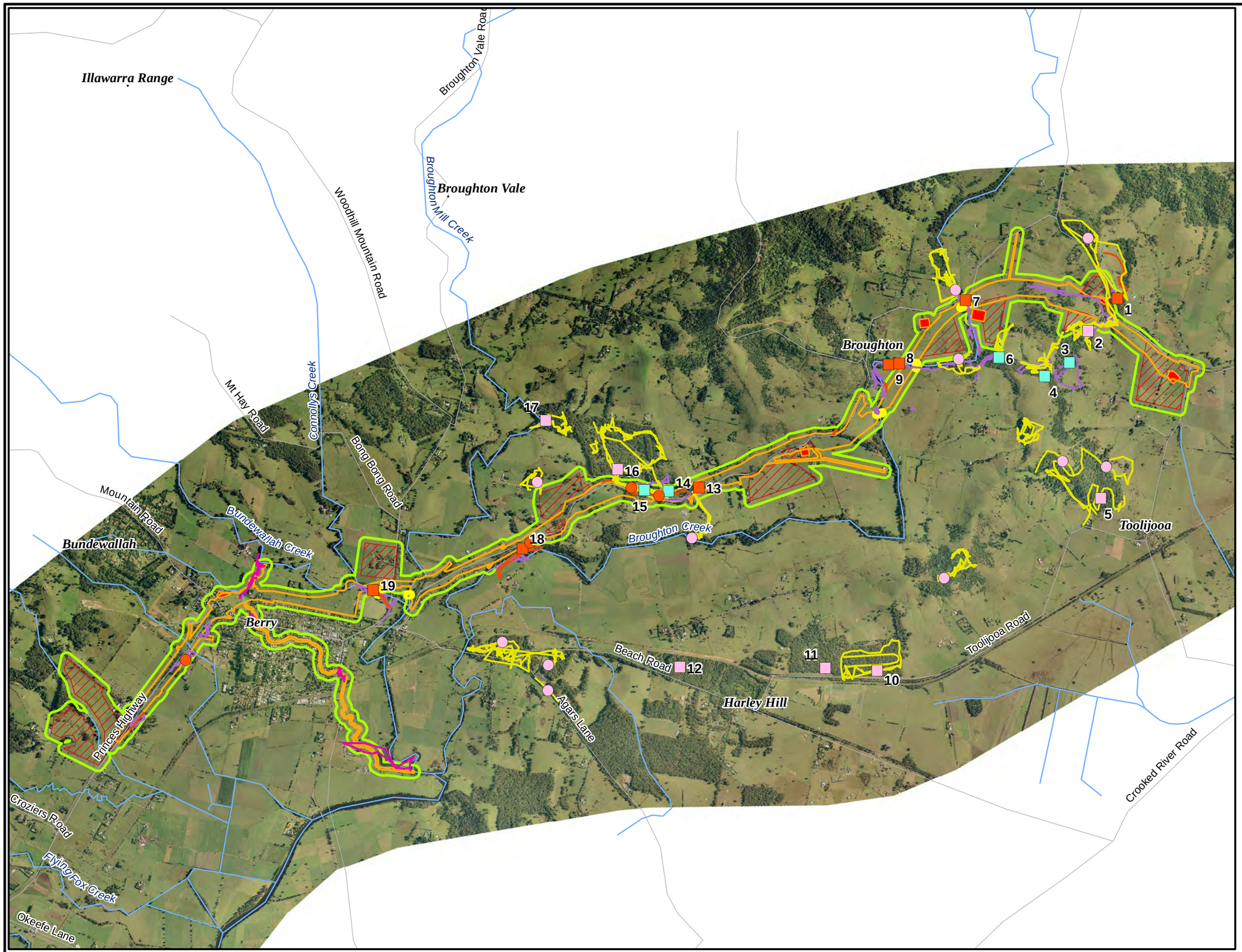
2.4.2 Targeted searches

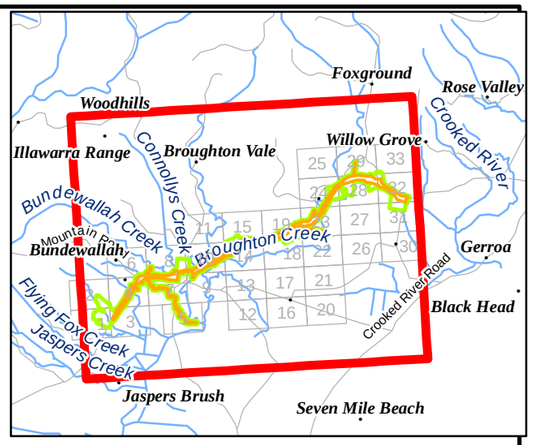
Targeted searches for threatened flora species involved random meander transects as described by Cropper (1993) were carried out in selected areas of known or potential habitat. Random meander transects were undertaken by one or two botanists traversing each site. The locations of random meander transects are shown on **Figure 2.2** (see Appendix J for mapbook at a 1:4000 scale).

During the random meander surveys, an inventory of all observed flora species was recorded at each site (Appendix A). Where threatened flora were detected, the number of individuals present was counted and the extent and geographic location of each population recorded using a hand-held non differential Global Positioning System (GPS). Where flora species could not be identified in the field, a representative sample was collected and preserved for later identification by the Royal Botanic Gardens, Sydney Herbarium.

2.4.3 Plot based surveys (quadrats)

In order to comprehensively describe the structure and floristics of each sampled plant community, plot-based surveys were used. Plot-based surveys also provided a concentrated search area for the detection of inconspicuous flora species that may be present at a particular site. The structure and floristics exhibited by each plant community present in the study area was sampled using one or more 400 square metre quadrats (20 metre x 20 metre). A modified Braun-Blanquet cover abundance scale (Moore 1955) was assigned to each of the species collected within any one quadrat. For this assessment a seven-division cover abundance scale was used (**Table 2.1**).





Legend

Survey period/type

(No. Refers to Quadrats listed in Appendix A)

- Summer 2007 - Habitat condition assessment
- Summer 2007 - Quadrat
- Spring 2008 - Quadrat
- Autumn 2009 - Habitat condition assessment
- Autumn 2009 - Quadrat
- Summer 2007 - Random meander transect
- Spring 2008 - Random meander transect
- Autumn 2009 - Random meander transect
- Spring 2011 - Town Creek Random meander transect
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.2: Location of flora survey effort

Date: 1 August 2012	Drawn by: RS/JMS
File: 13194	Checked by: JC
Location:P:\15000s\15039\Mapping\Variation 2\Variation 2 figures\15039_S2_F2-2_SurveyFlora_Overview_010812.mxd	

Acknowledgements:
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0 490 980 1,470 1,960

Metres

Scale: 1:35,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.2

Table 2.1: Modified Braun Blanquet cover abundance scale (Moore 1955)

Cover abundance score	Cover abundance estimate (per cent cover of any species within each quadrat)
1	Species cover less than five per cent – three or less individuals
2	Species cover less than five per cent – more than three individuals but sparsely scattered consistent throughout plot
3	Species cover less than five per cent – many individuals throughout plot and any number less than five per cent cover abundance
4	Species covers between five per cent and 25 per cent of the plot
5	Species covers between 25 per cent and 50 per cent of the plot
6	Species covers between 50 per cent and 75 per cent of the plot
7	Species covers between 75 per cent and 100 per cent of the plot

Survey data was compared with existing vegetation maps of the study area DEC (2005o) in order to confirm the identification and extent of plant communities, particularly those that correspond to EECs. Any inconsistencies identified in the DEC (2005o) vegetation mapping were checked using the results of both random meander transects and plot-based surveys.

2.4.4 Condition assessments

Habitat condition assessments involved the collection of data regarding the plant communities present at each survey site, including the dominant species within each stratum, the degree of cover and the relative quality or condition of the plant community. The condition of the vegetation was assessed according to the degree to which it resembled relatively natural, undisturbed vegetation using the following criteria:

a) Species composition (species richness, extent of weed invasion).

b) Structure (representation of each of the original layers of vegetation).

Plant community condition was categorised as follows:

Good: containing a high number of indigenous species; no weeds present or weed invasion restricted to edges and track margins; vegetation community containing original layers of vegetation; vegetation layers (ground, shrub, canopy etc) intact.

Moderate: containing a moderate number of indigenous species; moderate level of weed invasion; weeds occurring in isolated patches or scattered throughout; one or more of original layers of vegetation modified; vegetation layers (ground, shrub, canopy etc) largely intact.

Poor: containing a low number of indigenous species; high level of weed invasion; weeds occurring in dense patches or scattered throughout; one or more of the original layers of vegetation highly modified; one or more original vegetation layers (ground, shrub, canopy etc) modified or missing.

Unnatural landscape: highly modified landscape containing few or no indigenous species; exotic species dominant; original native vegetation layers removed; natural soil profile disturbed; unable to be regenerated to natural condition; high input intervention required to revegetate.

2.4.5 Flora survey effort

The details of the flora survey effort for the project are shown in **Table 2.2** and **Table 2.3**. Time invested in each survey technique is based on on-site person hours and does not include travel between locations or flora specimen identification conducted post survey.

Table 2.2: Flora survey details – targeted searches and habitat condition assessments

Task	Details
Aim: to determine presence of threatened flora species and assess habitat condition	
Targeted subject species	Species listed in Appendix C with potential habitat
Survey technique	Random meanders and random meander transects
Time invested in survey technique	138 person hours
Dates of surveys	13 February 2007 to 16 February 2007 19 February 2007 to 23 February 2007 4 November 2008 to 7 November 2008 10 November 2008 to 12 November 2008 18 May 2009 to 22 May 2009 28 June 2011 8 November 2011
Survey point of transect marked on a map	See **Figure 2.2** and Appendix J
Size, orientation and dimensions of quadrat or length of transect for each survey technique	Targeted searches (random meanders) carried out within the study area. This included two persons walking in parallel lines about 20 metres apart and traversing the sample site during field surveys carried out between February 2007 and May 2009. Random meanders during the June and November 2011 surveys were carried out by one botanist and meandering over the potential temporary creek crossing sites and Town Creek.
Survey start times and finish times	Between 8 am and 6 pm

Table 2.3: Flora survey details – plot based sampling

Task	Details
Aim: to describe structure and floristics of each plant community, identify EECs and search for inconspicuous flora species	
Targeted subject species	All flora species and communities
Survey technique	Quadrats
Time invested in survey technique	14.25 person hours
Dates of surveys	13 February 2007 to 16 February 2007 19 February 2007 to 23 February 2007 4 November 2008 to 7 November 2008 10 November 2008 to 12 November 2008 18 May 2009 to 22 May 2009
Description of site location	Stratified within each of the different plant communities
Survey point of transect marked on a map	See **Figure 2.2** and Appendix J
Size, orientation and dimensions of quadrat or length of transect for each survey technique	17 quadrats each measuring 20 metre x 20 metre or 30 metre x 10 metre (400 square metres).
Survey start times and finish times	Between 8.30 am and 4.30 pm

2.5 Fauna surveys

The locations of fauna survey sites are shown in **Figure 2.3** (see Appendix J for mapbook at a 1:4000 scale). Targeted surveys were conducted as described below.

2.5.1 Elliott traps

Elliott traps targeting small, ground-dwelling mammals were deployed at four sites (sites 1, 3, 15 and 19). Both small (size A) and large (size B) traps were used. In 2007 traps were placed along transects with Elliot A and Elliot B traps alternating every five metres (thus, the distance between traps of the same size was about 10 metres). In 2008, pairs of Elliott A and Elliott B traps were placed along a transect every 20 metres (site 19) or 30 metres (site 15). Alternate baits (dog food and a mixture of rolled oats, peanut butter, honey and vanilla essence) were used for both trap sizes. Traps were opened before dusk each night for four consecutive nights and checked each following morning.

2.5.2 Cage traps

Cage traps targeting medium-sized ground-dwelling mammals were deployed at six sites (sites 1, 3, 15, 17, 19 and 20). Traps were placed along a transect and were spaced between 20 metres and 50 metres apart. Traps were baited with chicken necks and a mixture of rolled oats, peanut butter, honey and vanilla essence. Traps were opened before dusk each night for four consecutive nights and checked each following morning.

2.5.3 Hair tubes

Hair tubes targeting small to medium-sized ground-dwelling mammals were deployed at site 15. The hair tubes were placed along a transect and were spaced about 30 metres apart. The hair tubes were baited with a mixture of rolled oats, peanut butter, honey and vanilla essence. The hair tubes were collected after seven consecutive nights.

2.5.4 Harp traps

Harp traps targeting microchiropteran bats were deployed at two sites (sites 3 and 15). Traps were set along potential “flyways” for a maximum of two consecutive nights and checked each following morning.

2.5.5 Ultrasonic call recording

Ultrasonic call detectors (ie Anabats) targeting microchiropteran bats were deployed at eight of the forest remnants (sites 3, 15, 17, just north of 17, 19, 20, 28 and 32). Within site 15, an Anabat unit was deployed at three different locations. Ultrasonic call detectors were left recording for one to two nights at each location.

2.5.6 Diurnal bird survey

Diurnal bird surveys were carried out at 22 sites throughout the study area in patches of native vegetation and also at numerous farm dams (**Figure 2.3** and Appendix J). Surveys involved one or two zoologists traversing forest or woodland patches or scanning an area from a fixed point with binoculars. Birds were identified by direct observation or by call.

2.5.7 Spotlighting

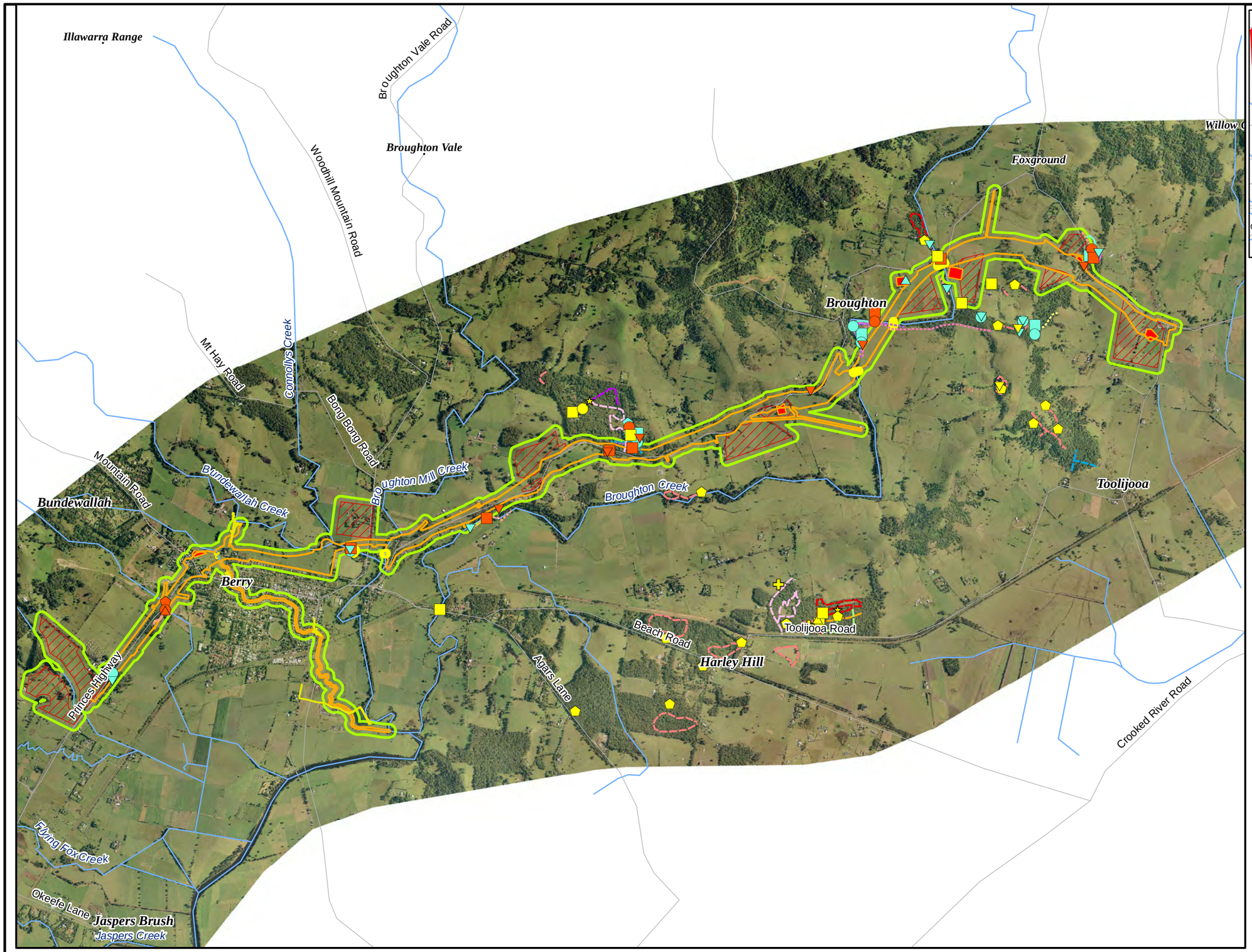
Spotlighting for nocturnal mammals and birds was carried out at six sites (sites 3, 15, 17, 20, 28 and 32) with repeated surveys carried out at three sites (sites 3, 15 and 17). Spotlighting was either undertaken by two zoologists traversing through a site on foot or by driving slowly along tracks and examining the vegetation using a 50-watt spotlight. Spotlighting from a vehicle was also carried out in roadside vegetation along several minor roads and tracks within the study area.

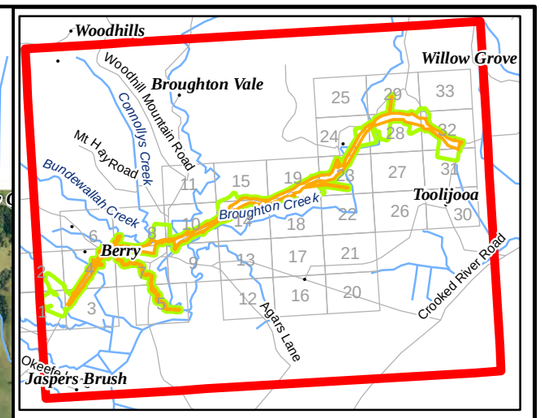
2.5.8 Call playback

Call playback techniques were used to survey for frogs, mammals and/or owls at six sites (sites 3, 15, 17, 20, 28 and 35). Call playback involved repeating recorded calls of target species through a 10 watt TOA megaphone for a period of at least three minutes per call. The playing of each call was followed by a five minute listening period. This process was repeated until each target species’ call had been played. Spotlighting (using hand-held 50-watt spotlights) was conducted following the final listening period.

2.5.9 Nocturnal frog survey

In addition to call playback, frogs were surveyed by spotlight searches and aural surveys, which were conducted at night within three to four hours of dusk. Nocturnal frog surveys targeted waterbodies such as creeks, dams and wetlands (sites 17, 32, north of 32 and 35) and were undertaken in spring, summer and autumn (meeting seasonal requirements for target species). Second replicate surveys were conducted at all four sites. Aural surveys involved quietly listening for calling frogs for a period of five minutes at each site. Aural surveys were followed by a spotlight search using hand-held 50-watt spotlights. Spotlight searches were also carried out after rain at numerous dams and creeks adjacent to the Princes Highway, south of Berry and Toolijooa, and Beach Road east of Berry. Call playback for the threatened Green and Golden Bell Frog (*Litoria aurea*) was also undertaken at sites that were considered to provide potential habitat for the species.





Legend

Survey points
- Summer 2007, Anabat
- Summer 2007, Anabat/Harp Trap
- Summer 2007, Anabat/Owl Call Playback
- Summer 2007, Bird Survey
- Summer 2007, Habitat Assessment
- Summer 2007, Harp Trap
- Summer 2007, Owl Call Playback
- Summer 2007, Spotlighting
- Spring 2008, Anabat
- Spring 2008, Bird Survey
- Spring 2008, Frog Spotlight
- Spring 2008, Habitat Assessment
- Spring 2008, Owl Call Playback
- Autumn 2009, Bird Survey
- Autumn 2009, Call Playback
- Autumn 2009, Frog Spotlight
- Autumn 2009, Habitat Assessment
- Autumn 2009, Spotlighting

Survey transects
- Summer 2007 - Bird Survey
- Summer 2007 - Elliot Trap
- Summer 2007 - Cage Trap
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey/Spotlighting
- Summer 2007 - Spotlighting
- Summer 2007 - Spotlighting/Nocturnal Bird Survey
- Spring 2008 - Bird survey
- Spring 2008 - Elliot Trap/Cage Trap
- Spring 2008 - Elliot Trap/Cage Trap/Hair Tube
- Spring 2008 - Spotlighting
- Spring 2008 - Spotlighting/Nocturnal Bird Survey
- Autumn 2009 - Bird survey
- Autumn 2009 - Cage Trap
- Autumn 2009 - Spotlighting
- Spring 2011 - Town Creek general survey and habitat assessments
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites
- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.3: Location of fauna survey effort

Date:1 August 2012	Drawn by: RS/JMS
File: 13194	Checked by: JC
Location: P:\15000s\15039\Mapping\Variation 2\Variation 2 figures\15039_S2_F2-3_survey_fauna_Overview_010812.mxd	

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0 400 800 1,200 1,600 2,000
Metres

Scale: 1:150,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.3

2.5.10 Reptile survey

Habitat for threatened reptile species is not present within the study area and consequently, no systematic searches for reptiles were carried out as part of this study. Reptiles were recorded by opportunistic identification when observed during other surveys or by occasional hand searches under rocks or fallen timber where suitable habitat was present.

2.5.11 Incidental observations

Both indirect and direct evidence of fauna was recorded and used to identify species presence. Direct evidence of fauna species included actual sightings or identification of the species by calls (eg birds, frogs and some nocturnal mammals). Indirect evidence of fauna species included remains (eg skin), scats, diggings or burrows and feeding scars.

Incidental fauna observations were recorded each day over the entire length of the study area.

2.5.12 Fauna habitat assessment

Fauna habitats within the study area were assessed on the presence of one or more of the following features:

- Vegetation cover.
- Size range and abundance of tree hollows.
- Rocky outcrops, overhangs or crevices.
- Abundance of leaf litter and fallen woody debris.
- Freestanding water bodies, ephemeral drainage or seepage areas.
- Disturbances, including weed invasion, clearing, rubbish dumping or fire.
- Potential foraging, nesting or roosting resources.
- Connectivity to off site habitats.
- Surrounding habitat.

The three categories used to evaluate habitat value were Good, Moderate or Poor, as detailed below:

Good: ground flora containing a high number of indigenous species; plant community structure, ground, log and litter layer intact and undisturbed; a high level of breeding, nesting, feeding and roosting resources available; a high richness and diversity of native fauna species.

Moderate: ground flora containing a moderate number of indigenous species; plant community structure, ground log and litter layer moderately intact and undisturbed; a moderate level of breeding, nesting, feeding and roosting resources available; a moderate richness and diversity of native fauna.

Poor: ground flora containing a low number of indigenous species, plant community structure, ground log and litter layer disturbed and modified; a low level of breeding, nesting, feeding and roosting resources available; a low richness and diversity of native fauna species.

Other habitat features, such as the value of the study area as a habitat corridor, the presence of remnant communities or unusual ecological plant community structures were also used to assess habitat quality.

2.6 Fauna survey effort

Fauna surveys were carried out by two zoologists for a total of 22 days from 12 to 21 February 2007 (inclusive), 3 to 11 November 2008 (excluding weekend), and from 18 to 22 May 2009 (inclusive). Fauna habitat surveys (including incidental observations) were carried out by one zoologist over one day on 8 November 2011 within parts of the study area potentially affected by the full diversion of Town Creek. **Table 2.4** and **Table 2.5** show the total survey effort (excluding incidental observations) conducted for the Foxground and Berry bypass project. The locations of fauna survey sites are shown in **Figure 2.3** and **Appendix J**.

Table 2.4: Trapping survey effort

Technique	No. of trap nights
Elliott A traps	360
Elliott B traps	320
Cage traps	176
Hair tubes	175
Harp traps	7
Anabat detectors	21

Table 2.5: Fauna survey effort other than trapping

Survey technique	No. of sites (No. of surveys)	Total transect length in metres	Total person hours
Diurnal bird survey	22 (31)	8317	13.0
Spotlighting (mammals and birds)	6 (13)	8636	15.0
Nocturnal frog survey	4 (7)	1258	7.0
Call playback (owls and mammals)	5 (15)	n/a	9.5
Call playback (frogs)	3 (4)	n/a	0.75
Habitat assessment	34 (34)	n/a	n/a

2.7 Ancillary facility assessment

The locations for ancillary sites were unknown at the time of field survey and therefore have not all been directly surveyed in the field. Consequently, a methodology for assessing the ancillary sites was developed and approved by the RMS. This methodology is based on using agreed criteria as the primary assessment tool to confirm 'no-go' areas and to identify worst case and representative potential impacts on the receiving environment to ensure sufficient flexibility for the future construction contractor.

The criteria for terrestrial ecology were:

- No substantial vegetation clearing (unless required for project alignment) with sites to have low conservation significance for flora and fauna.
- No removal of EEC, unless area is to be cleared for the highway footprint.

No physical disturbance would occur outside the boundaries of the proposed ancillary sites. Further, buffers and temporary fencing would be used if directly adjacent to EECs or areas of medium-high conservation significance to protect 'no-go' areas (in accordance with the RMS 'Biodiversity Guidelines: Guide 2 – Exclusion Zones' (RTA 2011)).

Low conservation significance is defined as:

- An area with no EEC and no native vegetation (although disturbed, poor quality native vegetation may be considered to have low conservation significance in some situations).
- No threatened (or migratory) flora or fauna records/occurrences.
- No (or very poor quality) potential habitat for threatened (or migratory) species.
- No water source.

Generally, within the study area, areas of low conservation significance are considered to be built-up areas, mown lawns and heavily grazed (ie short grass) exotic pastures (with no shrub layer, no trees, no rocks, no logs, no water).

Medium-high conservation significance is defined as:

- An area with native vegetation which may be EEC or not.
- Threatened (or migratory) flora or fauna records/occurrences.
- Moderate to good potential habitat for threatened (or migratory) species including intact soil profile, intact structural layers, mature fruiting trees, hollow-bearing trees and fallen woody debris.
- Water source.

2.8 Threatened and migratory species likelihood of occurrence criteria

The likelihood of occurrence assessment for threatened flora and fauna and migratory species was based on previous records collated from database searches, data collected during the field survey, the current (known) distribution range of these species, and the presence and condition of suitable habitat in the locality. The criteria to assess the likelihood of threatened flora and fauna or migratory fauna species to occur within the locality is presented in **Table 2.6**.

Table 2.6: Criteria used to assess likelihood of occurrence

Likelihood of occurrence	Assessment criteria
Low	Species considered to have a low likelihood of occurrence include species not recorded in the field surveys that fit one or more of the following criteria: • Have not been recorded previously in the study area or locality and the study area is beyond the known distribution or range. • Are dependent on a narrow range or specific habitats that do not or are not likely to occur in the study area. • Are considered locally extinct. • Are a non-cryptic perennial flora species that were targeted during field surveys. • Are flora species that have a very limited range and highly specific dispersal mechanisms.
Moderate	Species considered to have a moderate likelihood of occurrence include species not recorded in the field surveys that fit one or more of the following criteria: • There are infrequent records for the species in the study area and locality. • Preferential habitats of the species are present in the study area but these are mainly in a poor or modified condition. • May use or occur in habitats within the study area opportunistically during seasonal migration but are unlikely to be present on permanent basis as a populations or vagrant individuals. • Are cryptic flowering flora species that were not seasonally targeted during surveys.
High	Species considered to have a high likelihood of occurrence include species recorded during the field surveys or species not recorded that fit one or more of the following criteria: • Have a high incidence of previous records in the study area and locality. • Preferentially use habitats that are present in the study area which are abundant and/or in good condition. • Resident populations are known in the study area or locality. • Are known to regularly use habitats of the site or locality or are highly likely to visit the site during seasonal dispersal or migration.

2.9 Taxonomy

The flora taxonomy (classification) used in this report follows the most recent *Flora of New South Wales* (Harden 1990, Harden 1991, Harden 1992, Harden 1993, Harden 2002). All doubtful species names were verified with the on-line Australian Plant Name Index (Australian National Botanic Gardens 2007). In the text of this report, flora species are generally referred to by their scientific names only. However, threatened species and introduced flora species are referred to by both their common and scientific names when first mentioned. Flora common names where available have been included in threatened species tables and the complete flora list in Appendix A.

Names of vertebrates follow the 'Census of Australian Vertebrates' maintained by the Commonwealth DSEWPaC (DEWHA 2009a). In the body of this report vertebrates are referred to by both their common and scientific names when first mentioned. Subsequent references to these species cite the common name only. Common and scientific names are included in the Appendix B.

2.10 Limitations

Some flora species that occur in the local area are annuals (completing their life cycle within a single season) and are present only in the seed bank for much of the year. While seasonal surveys were undertaken, some species do not appear or flower consistently each season or from one year to the next. Other flora species are perennial, but are inconspicuous unless flowering or in fruit. Furthermore, some fauna species are only detectable at certain times of the year. Therefore, despite seasonal surveys it is likely that some species that are present in the study area were not detected. Despite these limitations, the assessment of impact is based on the presence or absence of suitable habitat for threatened flora and fauna, and as such, species are taken into account during the assessment even though they may not have been detected during the survey.

This assessment has relied on the regional vegetation survey and mapping project *Native vegetation of southeast NSW: a revised classification and map for the coast and eastern tablelands* and as such the limitations of the surveys and mapping by Tozer *et al* (2010) and (DEC 2005o) apply to some extent to this survey and assessment.

This assessment has relied on threatened species data provided for the project by the OEH and publicly available data from the DSEWPaC. The limitations of the collection, processing, management and distribution of the data sourced from these parties are relevant to the current assessment.

Other limitations to the field investigations include site access. Whilst the majority of land owners able to be contacted assisted the field investigations and the study was able to apply recognised sampling techniques to most of the habitat types present within the study area, surveys of some sites were limited by various constraints. These included limitations imposed by land owners on survey techniques or survey times and duration or, in some cases, a refusal of access. Furthermore, a small number of sites were inaccessible as they presented a significant occupational health and safety risk due to steep and unstable terrain.

Based on an assessment of aerial photography and road side reconnaissance, areas subject to access constraints were determined to be of low conservation significance and therefore, access limitation to some parts of the current study area was not a major limitation.

In addition, the proposed locations for construction compounds, site offices and stockpile areas became available after the targeted field surveys were conducted and as a result, not all of these areas have been investigated in the field. However these sites have been assessed according to the RMS assessment methodology for ancillary facilities (see Section 2.7).

Deviations from recommended fauna survey guidelines and/or effort include:

- Targeted frog survey effort did not entirely meet the Department of Environment and Climate Change (DECC) 'Threatened species survey and assessment guidelines: field survey methods for fauna – Amphibians' (DECC, 2009) as these guidelines were issued in April 2009, after the February 2007 and November 2008 surveys were completed. Whilst another field trip was undertaken in May 2009, after the frog guidelines were released, this was outside the seasonal requirements of the target frogs. The Department of the Environment, Water, Heritage and the Arts (DEWHA) 'Survey guidelines for Australia's threatened frogs' (DEWHA, 2010b) was also released after field surveys were completed. However, the survey effort employed during field surveys was consistent with the survey effort recommended for the target frog species in these guidelines.
- Mapping of den sites and feed trees for the Yellow-bellied Glider was not undertaken (although general habitat assessments took note of the presence of such features). Also, mapping the location and size of the areas occupied by Yellow-bellied Glider family groups in the locality was not undertaken. Such a task would be an enormous undertaking and was considered unnecessary for assessing the potential impacts on this species for the current project.
- Cage trapping for Spotted-tailed Quoll was undertaken in May but not March as well. March surveys were considered unnecessary as this species was considered to occur within the study area despite not being recorded during targeted surveys. Mitigation measures specifically targeting the Spotted-tailed Quoll have been included.
- Pit-fall trapping was not undertaken for the Eastern Pygmy-possum or White-footed Dunnart. Ground Elliott trapping and hair tube surveys were undertaken.
- Stag-watching and a detailed hollow-bearing tree survey would be undertaken post-approval to assess the number and type of nest boxes required for the project.
- Habitat-based surveys were undertaken within the Town Creek part of the study area; no targeted surveys such as trapping or spotlighting were carried out.

Systematic flora surveys using evenly spaced transects was not undertaken. Surveys were conducted in accordance with the *Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities* (DEC 2004) using random meander techniques and ground-truthing of the plant communities mapped by DECCW (DEC 2005) using plot-based surveys.

In relation to the amount of field survey effort and its timing, a reasonable sample of the spectrum of flora and fauna, their habitats and assessment of the ecological processes that are likely to occur in the locality have been made. The desktop and field survey effort and methods have compiled adequate information to provide a reliable assessment of the presence or absence of threatened species, populations and ecological communities or their habitats that potentially occur in the locality.

3 Results

A list of the flora and fauna recorded during surveys within the Foxground and Berry bypass project study area are provided in Appendix A and Appendix B respectively.

3.1 Geology and soils

The study area encompasses the foothills of the escarpment slopes around Berry and the floodplains associated with Broughton Creek and Shoalhaven River. In more detail the study area consists of the following two main topographic groups:

- The undulating hills and foothills extending north-west from the South Coast Railway Line.
- The Shoalhaven lowland plain, extending south-east of the foothills towards the Shoalhaven Bight.

The elevated north-western portion of the project area is influenced by the Cambewarra Mountain Range (north-west of Berry) which is a narrow low range that runs roughly parallel with the coastline. The lower slopes of this range extend into the project area as the ridge lines approach Berry. Harley Hill and Toolijooa Ridge are situated towards the eastern part of the project area and are disjointed from the Cambewarra Range.

A ridge of moderate elevation, from Foxground to Toolijooa Ridge, and a flatter ridge to the south-west of Toolijooa Ridge, separate the Broughton Creek floodplain from the Crooked River floodplain.

The geology of the study area corresponds to the Permian Shoalhaven Group, which may be divided into the Volcanic Sandstones sub-group (also referred to as the Budgong Sandstone), the Volcanics Facies sub-group and Berry Siltstone formation sub-group.

The *Soil Landscapes of the Kiama 1:100,000 Sheet* (Hazelton, 1992) identifies the presence of the following soil landscape units within the study area:

- Kiama landscape unit, occurring in areas close to Toolijooa Road. The Kiama landscape unit is characterised by sandy clay loams and stiff to hard clays.
- Wattamalla Road landscape unit, occurring in steeper areas around Toolijooa Ridge. The Wattamalla Road landscape unit is characterised by shallow soils consisting of sandy and silt loams, very stiff to hard clays and extremely weathered rock developed in units associated with the underlying rock materials.
- Shoalhaven landscape unit, which corresponds to creeks and floodplain areas at Broughton Creek and Berry. This landscape unit consists of alluvial soils, comprised of gravel, sand, silt and clay derived mainly from sandstone and shale and overlying buried estuarine sediments. The erosion hazard is rated as slight to low.
- Coolongatta landscape unit, which largely corresponds to the undulating hills between Austral Park Road and north of Berry. Coolongatta landscape unit consists of sands, and stiff to hard clays.

In summary soil types of the study area typically support tall open forests and closed forests, most of which have been cleared to make way for agricultural land use.

3.2 Plant communities

3.2.1 Vegetation mapping

The following section provides descriptions of each plant community recorded within the study area as well as a discussion of their conservation status, location and extent. Existing vegetation mapping (DEC 2005o) provided the background and assisted with the planning of field sampling and subsequent analysis; however, occasional inconsistencies with the DEC maps arose in the type and extent of vegetation within the study area. Plant communities as mapped by DEC (2005o) have been amended following ground-truthing during the surveys. All amendments to the DEC mapping are identified within the text in Section 3.2.2 and illustrated in **Figure 3.1** (see Appendix J for mapbook at a 1:4000 scale).

A description of the condition of plant communities and fauna habitats present within the study area is provided in Section 3.3.

3.2.2 Identification of plant communities

The majority of the study area is covered by cleared areas and grazed paddocks that contain little native vegetation and have not been mapped or described as a native plant community. Native plant communities that do occur within the study area have been named in accordance with the plant community descriptions provided by DEC (2005o) as part of the NSW native vegetation mapping program. Plant communities conforming to listed EECs were sampled, identified according to their floristic composition and compared to the DEC profiles and relevant scientific committee determinations. The area of each native plant community occurring within the subject site, study area and locality is shown in **Table 3.1**.

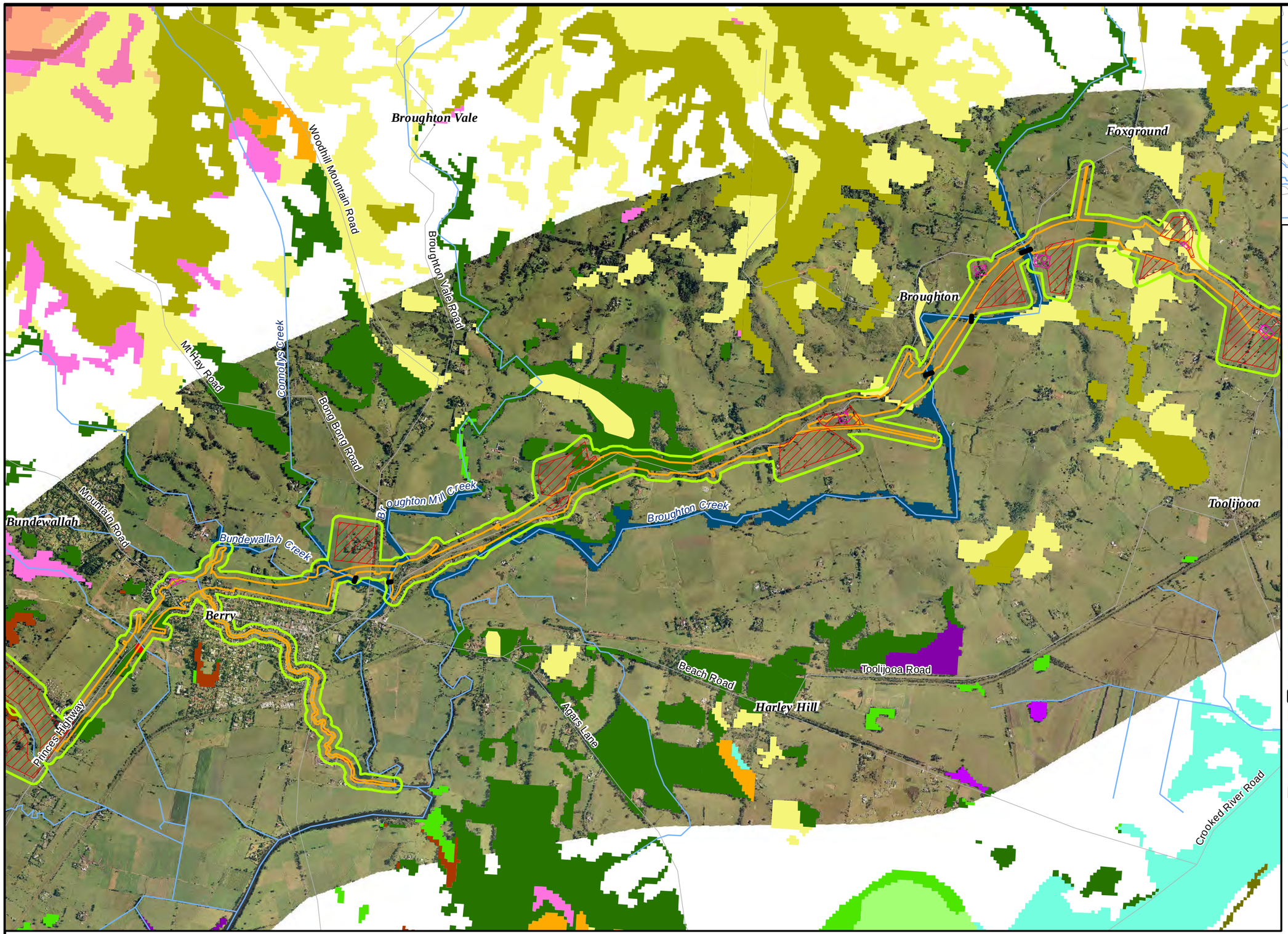
Twenty-five separate plant communities have been mapped as occurring within the locality (five kilometre radius of the study area) (**Figure 3.1** and **Table 3.1**. Twelve of these plant communities are likely to form part of an EEC as listed on the TSC Act (**Table 3.1**).

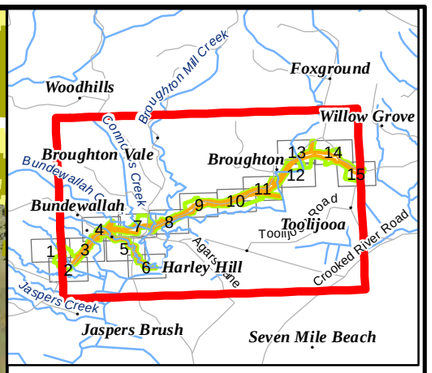
Eight mapped plant communities occur within the study area including Illawarra gully wet forest, Currambene-Batemans lowlands forest, Riverbank forest, warm temperate layered forest, constructed wetland, closed grassland, closed grassland/sedgeland and riparian open woodland. Another community, subtropical complex rainforest, was mapped about 0.25 kilometres from the study area and occurs in association with warm temperate layered forest. A brief description of vegetation occurring within the study area and adjoining areas is provided below.

Illawarra gully wet forest

Illawarra gully wet forest is a tall eucalypt forest with a moist open understorey. This community is scattered along coastal lowlands south from the Hacking River catchment, including areas near Berry, Nowra and Batemans Bay (DEC 2005o). Illawarra gully wet forest occurs on sheltered slopes and gullies with loamy soils. In areas of increased fertility and soil moisture the community grades into warm temperate layered forest. More than a third of its original range has been cleared, mainly in the Illawarra lowlands.

A total of 25.5 hectares of this community was mapped within the study area (**Table 3.1**). The most significant stand occurs to the north-east of Berry adjacent to Tindalls Lane and the Princes Highway (site 15) (**Figure 2.1**, **Figure 3.1** and Appendix J). Small stands were recorded within the study area immediately south-west of Berry, adjacent to the Princes Highway. Large remnants of Illawarra gully wet forest were surveyed within the locality and include remnants adjacent to Agars Lane and Beach Road (sites 6, 7, 9 and 25).





Legend

Vegetation communities

- Budderoo Temperate Rainforest
- Budderoo-Morton Plateau Forest
- Closed Grassland
- Closed Grassland/Sedgeland
- Coastal Foredune Scrub
- Coastal Freshwater Lagoon
- Coastal Sand Forest
- Coastal Sand Swamp Forest
- Coastal Warm Temperate Rainforest
- Constructed Wetland
- Currambene-Batemans Lowlands Forest
- Disturbed Riparian Open Woodland
- Escarpment Foothills Wet Forest
- Estuarine Creekflat Scrub
- Estuarine Mangrove Forest
- Floodplain Swamp Forest
- Illawarra Gully Wet Forest
- Illawarra Lowland Swamp Woodland
- Intermediate Temperate Rainforest
- Riverbank Forest
- South Coast Grassy Woodland
- Subtropical Complex Rainforest
- Subtropical Dry Rainforest
- Warm Temperate Layered Forest
- Yarrawarra Temperate Rainforest
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

Biosis Research Pty. Ltd.
18-20 Mandible Street
Alexandria
NEW SOUTH WALES
2015

Figure 3.1: Vegetation mapping of the study area (modified from DECCW, 2005)

Date: 16 July 2012	Drawn by: RS/JMS/ANP
File: 13194	Checked by: JC
Location: P:\15000s\15039\Mapping\Variaition 1\Variation 1 Figures\13194_S2_F3-1_Veg_Overview_160712.mxd	

Acknowledgements:
Vegetation mapping from DECCW
Aerial imagery provided by ARUP
This product incorporates Data which is copyright to the Commonwealth of Australia (c.2003)

0 430 860 1,290 1,720

Metres

Scale: 1:250,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 3.1

Flora species identified during the field survey were consistent with the diagnostic flora species described for this community (DEC 2005o). Dominant species included a canopy of *Eucalyptus pilularis*, *E. paniculata, E. saligna* X *botryoides* and *Syncarpia glomulifera* with an understorey of *Acacia binervata*, *Pittosporum undulatum, Breynia oblongifolia*, *Persoonia linearis* and a ground layer including *Tylophora barbata*, *Pteridium esculentum*, *Carex longebrachiata* and *Poa labillardieri*.

Currambene-Batemans lowlands forest

Currambene-Batemans lowlands forest is a eucalypt forest with an open shrub layer and a dense grassy groundcover, found on coastal lowlands on sandstones and shales below 100 metres above sea level (ASL). Its distribution is primarily between Bomaderry and Cudmirrah, with the largest stands around Currambene State Forest between Nowra and Culburra. Small woodlots and remnant trees suggest the distribution may have extended northward along the extensively cleared footslopes between Bomaderry and Berry and on the lower slopes of Kangaroo Valley. There are isolated records to the south, from Tabourie and Termeil Lakes, Batemans Bay and Mogo areas (DEC 2005o).

There are several stands of the community mapped in the locality on the south western outskirts of Berry township (**Figure 3.1** and Appendix J). This includes a total of 2.4 hectares within the study area, of which 0.0002 hectares occurs within the subject site (**Table 3.1**). No field surveys were carried out in areas mapped as Currambene-Batemans lowlands forest of the study area for the current assessments (see limitations section 2.10).

Riverbank forest

Riverbank forest is a tall *Casuarina cunninghamiana* forest with an open shrub layer and dense to patchy groundcover of grass species. This community is found on sand and gravel alluvium often with cobbles. The community has a wide distribution and occurs along major creeks and rivers including the Coxs, Abercrombie, Wollondilly, Shoalhaven and Deua Rivers (DEC 2005o). During the current surveys of the study area, this community was identified along the riparian corridors of freshwater creeks including Broughton Creek (sites 17, 28 and 29) and Bundewallah Creek (**Figure 2.1** and Appendix J).

DEC (2005t) did not map Riverbank forest within the study area and mapped this community as floodplain swamp forest, part of the EEC *swamp oak floodplain forest of the NSW North Coast, Sydney Basin and South East Corner bioregions*. Floodplain swamp forest occurs in areas with brackish groundwater and is dominated by *Casuarina glauca*. Vegetation mapping by Shoalhaven City Council (Shoalhaven City Council, 2004) and discussions with one of the authors of the DEC (2005t) vegetation mapping (M. Tozer, pers. comm. 2007) support the interpretation of the area as maintaining Riverbank forest.

A total of 10 hectares (**Table 3.1**) of this community is mapped within the study area (**Figure 3.1** and Appendix J). Native flora species identified during the field survey were consistent with the diagnostic flora species described for Riverbank forest (DEC 2005o). Dominant flora species include a largely monospecific canopy of *Casuarina cunninghamiana* within understorey species including *Hymenanthera dentata* and ground layer of *Sigesbeckia orientalis*, *Lomandra longifolia*, *Microlaena stipoides*, *Dichondra repens* and *Commelina cyanea*. This community is frequently highly disturbed and weed species are often dominant in the understorey.

Despite difficulties categorising this community due to the highly altered species composition and structure, it is considered that Riverbank forest within the study area is consistent with the EEC *River-flat eucalypt forest on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions*.

Warm temperate layered forest

Warm temperate layered forest is a tall eucalypt forest characterised by an open emergent canopy and dense small tree layer with a moist shrubby understorey (DEC 2005o). The distribution ranges from the Hacking River along the Illawarra escarpment to Nowra and within Kangaroo Valley. A total of 12.2 hectares of this community was mapped within the study area (**Table 3.1**), where it occurs on sheltered slopes, low ridges (including Toolijooa Ridge) and gullies scattered between Berry and Toolijooa Road (sites 8, 16, 17, 20 and 21) (**Figure 2.1** and Appendix J). Significant stands of the community have been mapped by DEC (2005o) within the locality between Broughton Vale and Gerringong (**Figure 3.1** and Appendix J).

This community occurs in association with the EEC subtropical complex rainforest (as described below) and intergrades between the two communities are likely to be present within the locality. Each of these intergrading communities contain a similar suite of rainforest species (DEC 2005o). Areas where eucalypt species were the dominant canopy have been attributed to warm temperate layered forest following ground surveys.

Flora species identified during the field survey were consistent with the diagnostic flora species described for this community (DEC 2005o). Dominant species included a canopy of *Eucalyptus botryoides* X *saligna*, *E. quadrangulata* with a mid storey tree layer co-dominated by *Acmena smithii*, *Cryptocarya glaucescens*, *Pittosporum undulatum* and *Livistona australis*, and a shrub layer of *Notelaea venosa*, *Clerodendrum tomentosum*, *Eupomatia laurina* with climbers and ground cover species including *Adiantum formosum, Pandorea pandorana*, *Eustrephus latifolius*, *Tylophora barbata*, *Stephania japonica*, *Doodia aspera*, *Oplismenus imbecilis, Pseuderanthemum variable*, *Gymnostachys anceps* and *Blechnum cartilagineum*.

Subtropical complex rainforest

This community is characterised as a closed forest with a dense and diverse tree canopy supporting a variety of lianas, a sub-canopy layer of small trees, a sparse shrub layer and ground layer dominated by ferns (DEC 2005o). Subtropical complex rainforest is distributed between Scarborough and Cambewarra with an outlying patch to the south at Milton. The community is restricted to volcanic soils on slopes and benches of the Illawarra escarpment. Subtropical complex rainforest is included within the *Illawarra subtropical rainforest in the Sydney Basin bioregion*, an EEC listed under the TSC Act.

This community does not occur within the study area, but was identified in surveys of the locality as part of the route options assessment and is largely restricted to a band of scattered fragments along and near Toolijooa Ridge (sites 1, 2, 17, 18, 23) (**Figure 2.1** and Appendix J). DEC (2005s) has also mapped a significant stand of subtropical complex rainforest at Barren Grounds Nature Reserve within the locality to the north of Berry (**Figure 3.1** and Appendix J). Further isolated fragments have been mapped in the locality between Foxground Road and Gerringong.

Flora species identified during the field survey were consistent with the diagnostic flora species described for this community (DEC 2005q). Dominant species included a canopy of *Doryphora sassafras*, *Dendrocnide excelsa*, *Ficus* spp., *Alectryon subcinereus* and *Toona ciliata*, a small tree layer of *Cassine australis*, *Eupomatia laurina*, *Acronychia oblongifolia*, shrub layer of *Pittosporum multiflorum* with climbers and ground covers including *Arthropteris tenella*, *Piper novae-hollandiae, Marsdenia rostrata*, *Pandorea pandorana*, *Gymnostachys anceps* and *Doodia aspera*.

Constructed wetland

A constructed wetland is mapped at the western end of the project and near the southern end of Town Creek (**Figure 3.1** and Appendix J). Aquatic and semi-aquatic vegetation has established following the construction of the western waterbody and following the construction of the access track causeway of the Berry sewage treatment works, adjacent to Town Creek. Constructed wetland habitats cover 0.7 hectares within the study area (**Table 3.1**). At the time of survey the constructed wetland in the west was dominated by *Typha orientialis* with groundcovers of the banks dominated by pasture grasses such as *Pennisetum clandestinum* and *Paspalum dilatatum*. A stand of regenerating shrubs and trees consisting of *Acacia* and *Eucalyptus* species occurs on the southern margin. The constructed wetland near the southern end of Town Creek is characterised by patches of *Typha orientialis* and sparse cover of other emergent macrophytes. The banks are dominated by pasture grasses such as *Pennisetum clandestinum* and *Paspalum dilatatum* and patches of *Persicaria strigosa*. Exotic trees and shrubs around the banks include *Erythrina crista-galli*, *Lantana camara*, *Ligustrum sinense* and *Solanum mauritianum*.

Closed grassland/closed sedgeland

Closed grassland, closed sedgeland and intergrades of these communities dominate the channel of Town Creek on the northern and southern margins of Berry township (**Figure 3.1** and Appendix J). The closed grassland between Town Creek north to Bundewallah Creek over the alignment of the proposed constructed channel covers 0.9 hectares (**Table 3.1**) and is dominated by *Pennisetum clandestinum*, other introduced pasture species such as *Trifolium repens* and *Paspalum dilatatum* and colonising weeds including *Cirsium vulgare* and *Rumex crispus*. Native herbs and rushes include scattered occurrences of *Ludwigia peploides* ssp *montevidensis* and *Persicaria strigosa*.

Intergrades of the closed grassland and closed sedgeland are present in Town Creek between North and George Streets and from the South Coast Rail Line to the confluence with Broughton Mill Creek adjacent to the Berry sewage treatment works (**Figure 3.1** and Appendix J). These intergrades cover a total area of 2.5 hectares (**Table 3.1**). Structure and floristic composition are similar to that described above for the closed grassland with *Cyperus eragrostis*, *Pennisetum clandestinum* and *Trifolium repens* dominating the suite of exotic species and native *Persicaria* spp and patches of *Typha orientalis* common in the lower channel terraces. The closed grassland and closed sedgeland plant communities represent an unnatural landscape and have established as a result of the substantial clearing of native vegetation and a long history of agriculture.

Riparian open woodland

A disturbed riparian open woodland occurs along Town Creek through the Berry urban area (**Figure 3.1** and Appendix J), covering 3.8 hectares (**Table 3.1**). This plant community is characterised by areas of revegetation, regrowth native vegetation, planted exotic trees with invasive woody weeds and areas of managed open space in public and private land tenure. The canopy consists of local and non-locally occurring native trees and exotic tree species occurring mainly as landscape plantings. Common native and exotic trees include *Araucaria heterophylla*, *Casuarina cunninghamiana* ssp *cunninghamiana*, *Cinnamomum camphora*, *Eucalyptus robusta*, *Grevillea robusta* and *Syncarpia glomulifera* ssp *glomulifera*. Other native and introduced trees present as a sparse midstorey/understorey are *Callistemon viminalis*, *Jacaranda mimosifolia*, *Melaleuca quinquenervia*, *Salix babylonica* and *Tristaniopsis laurina*. The groundcover and aquatic/semi-aquatic vegetation is dominated by exotic herbs and grasses with native species present as minor occurrences or plantings in revegetation areas. Common exotic species are *Anagallis arvensis*, *Bromus catharticus*, *Cyperus eragrostis*, *Myriophyllum* sp, *Rumex crispus* and *Tradescantia fluminensis*. Common native species recorded include *Commelina cyanea*, *Lomandra longifolia*, *Ludwigia peploides* ssp *montevidensis* and *Persicaria strigosa*.

Other areas of the riparian open woodland on the northern and southern sections of Town Creek are primarily stands of exotic shrubs and trees such as, *Erythrina sykesii*, *Ligustrum sinense* and *Salix babylonica* with the groundcovers dominated by introduced pasture species.

The riparian open woodland is a derived plant community that has been subject to clearing of native vegetation, management of urban stormwater and weed invasion. This is an unnatural landscape with resilience in a depleted state.

Cleared land and paddocks

Cleared paddocks dominate the foothills, slopes and floodplains throughout the study area. The majority of the cleared land and paddock areas are considered an unnatural landscape, with limited or no capacity for regeneration to a native plant community.

The cleared land and paddocks are typically comprised of grasslands dominated by exotic pasture species, including Prairie Grass *(Bromus catharticus),* Yorkshire Fog *(Holcus lanatus),* Kikuyu Grass *(Pennisetum clandestinum)*, Panic Veldtgrass *(Ehrharta erecta)* and Paspalum and Vasey Grass *(Paspalum* spp). Introduced annual and perennial herbs and shrubs are also a typical feature of this community, including Curled Dock *(Rumex crispus),* Paddy's Lucerne *(Sida rhombifolia),* Mistflower *(Ageratina riparia),* Fireweed *(Senecio madagascariensis),* Lamb's Tingues *(Plantago lanceolata)* and White clover *(Trifolium repens)*. Large patches of woody weeds including Lantana *(Lantana camara)* and Weeping Willow *(Salix babylonica)* are present along the cleared and disturbed drainage lines and at the interface of bushland remnants.

Scattered trees occur in varying densities across the landscape and include a range of remnant native trees and exotic plantings. Some of the older trees are likely to provide habitat (such as tree hollows or perch sites) for native fauna and, as such, are an important feature within an otherwise denuded landscape.

Native plant communities of the subject site, study area and locality are detailed in **Table 3.1.**

Table 3.1: Native and derived plant communities of the subject site, study area and locality

Plant community (DEC 2005o)	Conservation status		Equivalent EEC	Area within subject site (hectare)	Area within study area, excluding subject site (hectare)	Area within locality (hectare)
	TSC Act	EPBC Act				
Budderoo temperate rainforest	-	-	-	-	-	17.9
Budderoo-Morton plateau forest	-	-	-	-	-	26.4
Closed grassland*	-	-	-	0.4	0.5	1.0
Closed grassland/sedgeland	-	-	-	2.2	0.3	2.5
Coastal foredune scrub	-	-	-	-	-	8.5
Coastal freshwater lagoon	V	-	Freshwater wetlands on coastal floodplains of the NSW North Coast, Sydney Basin and south-east corner bioregions	-	-	124.4
Coastal sand forest	V	-	Bangalay sand forest, Sydney Basin and south-east corner bioregions	-	-	419.1
Coastal sand swamp forest	V	-	Swamp sclerophyll forest on coastal floodplains of the NSW North Coast, Sydney Basin and south-east corner bioregions	-	-	17.1
Coastal warm temperate rainforest	V	-		-	-	87.3
Constructed wetland	-	-	-	0.4	0.3	0.7
Currambene-Batemans lowlands forest	-	-	-	0.0002	2.4	27.7
Disturbed riparian open woodland	-	-	-	2.6	1.2	3.8
Escarpment foothills wet forest	-	-	-	-	-	42.6
Estuarine creekflat scrub	V	-	Swamp oak floodplain forest of the NSW North Coast, Sydney Basin and south-east corner bioregions	-	-	0.2
Estuarine mangrove forest	-	-	-	-	-	1.1
Floodplain swamp forest	V	-	Swamp oak floodplain forest of the NSW North Coast,	-	-	47.7

Plant community (DEC 2005o)	Conservation status		Equivalent EEC	Area within subject site (hectare)	Area within study area, excluding subject site (hectare)	Area within locality (hectare)
	TSC Act	EPBC Act				
			Sydney Basin and south-east corner bioregions			
Illawarra gully wet forest	-	-	-	15.4	10.05	583.6
Illawarra lowland swamp woodland	V	-	Illawarra lowlands grassy woodland in the Sydney Basin bioregion	-	-	9.7
Intermediate temperate rainforest	-	-	-	-	-	62.7
Riverbank forest	V	-	River-flat eucalypt forest of the NSW North Coast, Sydney Basin and south-east corner bioregions	2.9	7.1	65.7
South coast grassy woodland	V	-	Illawarra lowlands grassy woodland in the Sydney Basin bioregion	-	-	37.9
Subtropical complex rainforest	V	-	Illawarra subtropical rainforest in the Sydney Basin bioregion	-	-	914.0
Subtropical dry rainforest	V	-	Illawarra subtropical rainforest in the Sydney Basin bioregion	-	-	0.5
Warm temperate layered forest	-	-	-	6.9	5.3	1278.7
Yarrawarra temperate rainforest	V	-	Robertson rainforest in the Sydney Basin bioregion	-	-	24.5
Totals (hectare)				**30.8**	**27.2**	**3805.3**

** Not considered to be a native plant or derived native plant community.*

3.3 Flora and fauna habitats

The following section provides a description of the condition of flora and fauna habitats within the study area (reference to survey sites outside the study area have been made where they provide important contextual information, such as being part of a potential local wildlife corridor). The following habitat descriptions are largely unchanged from those in the preliminary biological report (Biosis Research 2007). Updates to the descriptions provided in the Biosis Research (2007) report include specific reference to sites that are subject to potential impacts (those within the study area), additional information based on seasonal survey effort conducted since the 2007 surveys, and additional information based on the November 2011 surveys of Town Creek.

3.3.1 Toolijooa Ridge and Harley Hill (sites 1-4, 6-7, 9, 17-21, 23 and 25-26)

Native vegetation along Toolijooa Ridge (sites 1-2, 17-21, 23 and 26) and Harley Hill (sites 3-4, 6-7, 9 and 25) is now confined to about 12 discontinuous patches of remnant and regrowth vegetation from the uppermost hilltops and steep rocky and inaccessible slopes (Toolijooa Ridge) down to the plateau (Harley Hill). Vegetation communities along Toolijooa Ridge include subtropical complex rainforest which grades into warm temperate layered forest further down slope and along edges. Isolated stands of Illawarra gully wet forest are also present, sometimes represented by scattered remnant trees only. The dominant vegetation community at Harley Hill includes Illawarra gully wet forest. Ongoing disturbances such as grazing and a high degree of weed invasion continue to threaten the integrity of flora and fauna habitats at each of these sites.

Study area

Native vegetation at site 20 (**Figure 2.1** and Appendix J) would be impacted by the project. Vegetation at site 20 is represented by disturbed stands of warm temperate layered forest. The condition of vegetation at site 20 was considered to be in poor condition along edges where large infestations of the noxious weed Lantana *(Lantana camara)* are present and have displaced most native species. These edges are likely to have little or no capacity for the regeneration of natural vegetation without significant resources allocated to weed control and revegetation. Patches of Lantana *(L. camara)* were also dispersed within the native remnants, especially where disturbances have created gaps in the remnant canopy. Isolated small pockets of warm temperate layered forest at site 20 were considered to be in moderate condition and included a dense native canopy which excluded Lantana invasion.

Some large hollow-bearing trees were present and provide potential nesting and roosting resources for birds, arboreal mammals and microchiropteran bats.

Down slope to the east of site 20, native vegetation is represented by a sparse stand of mature *Eucalyptus pilularis* with a heavily grazed and cleared understorey. Prior to clearing and grazing, this area was probably represented by Illawarra wet gully forest and is now in poor condition.

Adjoining areas

Vegetation condition outside the study area across Toolijooa Ridge (sites 1, 18, 19, 21 and 26) is highly variable and ranges from very poor in the cleared exotic pasture to good in areas of highly diverse native vegetation. As with site 20, the condition of vegetation at each site was considered in poor condition along edges and in canopy gaps where large infestations of *L. camara* are present and have displaced most native species. These edges were considered to have little or no capacity for the regeneration of natural vegetation without significant resources allocated to weed control and revegetation.

The core areas of remnant vegetation at sites 1, 17 and 18 contained subtropical complex rainforest, often in good condition. Although evidence of previous disturbances such as logging was evident, the dense canopy layers have helped reduce the dispersal of weeds within each remnant. Subtropical complex rainforest present at each site varied in its structure and diversity. The core of the remnant patch at site 23, although relatively small, was considered to be in good condition with all structural layers intact and a high diversity of native species present. A large proportion of site 1, the largest remnant of this community surveyed in the study area covering about 20 hectares, is also in good condition.

The condition of fauna habitats at each of these sites was also highly variable from poor to good condition. Although many sites were in poor condition, a variety of feeding and sheltering resources were observed. A large proportion of surface rock and outcropping is present at each of these sites, particularly under the sheltered rainforest canopy at site 1. Such rock outcrops are likely to provide shelter for a variety of native mammals including the Bush Rat (*Rattus fuscipes)* and Brown Antechinus (*Antechinus stuartii)*. Hollow-bearing trees were scarce, but were present and may provide nesting and roosting habitat for various birds, bats and small mammals. Flora species within the warm temperate layered forest and subtropical complex rainforest remnants are also likely to provide feeding resources. Myrtaceaeous trees (mostly *Eucalyptus* species) within the warm temperate layer forest canopy, provide direct (foliage, nectar, exudates) and indirect (arthropods) food for a range of vertebrates, particularly birds and arboreal mammals. Flowering and fruiting trees such as Figs *(Ficus* spp.) and Cabbage Palm *(Livistona australis)* are common at each site and are likely to provide important feeding resources for a range of insects and nectivorous and frugivorous vertebrates.

3.3.2 Broughton Creek (sites 17, 28-29, and 32-33)

Native vegetation along Broughton Creek is now largely restricted to a thin riparian corridor with patches of remnant and regrowth. Ongoing disturbances such as grazing, erosion and a high degree of weed invasion have had a major impact on habitat condition at each of these sites.

Study area

The project crosses Broughton Creek at sites 17, 28 and 32 and is located upslope in the study area of site 33. Vegetation alongside Broughton Creek at each of these four sites is represented by Riverbank forest in poor condition. Each site has a tall native canopy of *Casuarina cunninghamiana* and an understorey completely dominated by a high density weed infestation. Natural structural layers are no longer intact and in most areas the mid storey and ground layers are completely dominated by weed species including *Ligustrum sinense, Lantana camara, Solanum mauritianum, Ageratina riparia* and *Tradescantia fluminescens*.

These weed-infested areas were considered to have little capacity for the regeneration of natural vegetation without significant resources allocated to weed control and revegetation. Obvious disturbances at each of these sites include heavy grazing and erosion.

Vegetation located on the steep slopes along the existing Princes Highway at site 33 ranges from warm temperate layered forest in protected areas lower down the steep slope, up to Illawarra gully wet forest at the top along the roadside edge. Warm temperate layered forest along the lower stopes is dominated by an extensive infestation of *Ligustrum lucidum* and other woody weed species. Illawarra gully wet forest along the roadside edge was in a moderate to good condition with most natural structural layers of vegetation remaining intact and scattered areas of weed infestation. At least six large hollow-bearing *Casuarina cunninghamiana* (site 17 and 32) and six large hollow-bearing *Eucalyptus pilularis* (site 33) are located within the study area.

Adjoining areas

Adjoining vegetation to the north of the study area at site 28 is similarly impacted by weed infestations in addition to some areas where grazing and trampling by stock has left the creek bank bare and eroded. Vegetation upslope and to the western side of site 28 was identified as the EEC subtropical complex rainforest and warm temperate layered forest. These remnants were also in poor condition and subject to disturbances and a high degree of weed infestation. As with the adjacent riparian vegetation, these areas have little capacity for the regeneration of natural vegetation without significant resources allocated to weed control and revegetation.

Adjoining vegetation to the east of the study area at site 17 is in moderate condition and, despite competition from weeds, the natural layers of vegetation appear relatively intact. A suite of native rainforest species are present on the site and vegetation upslope and to the east of Broughton Creek is represented by warm temperate layered forest and the EEC, subtropical complex rainforest, which is in moderate to good condition away from its disturbed edges.

Regardless of the degraded nature of much of the area observed along Broughton Creek, many sites contained mature casuarinas with small hollows. These trees provide potential roost sites for fauna, particularly microchiropteran bats.

3.3.3 Princes Highway at Tindalls Lane (sites 15-16 and 22)

Adjacent to Tindalls Lane and on the north and south sides of the Princes Highway is an area of remnant vegetation that covers about 60 hectares (sites 15 and 16) and is one of the largest contiguous areas of native vegetation present in the study area. Historic disturbances such as logging have altered the structure of these communities and weed infestations are scattered across each site.

Study area

The project impacts upon vegetation on both the north and south of the existing Princes Highway at site 15. Native vegetation at site 15 is represented by Illawarra gully wet forest in a moderate to good condition with a largely intact native tree, shrub and ground layer and along with infestations of woody weeds such as *Lantana camara*. Where dense patches of lantana were absent, the native shrub layer remains intact.

The fauna habitats at this site were varied. Hollow-bearing trees were scarce, but those present (large eucalypts) may provide nesting and roosting habitat for various birds, bats and arboreal mammals. Small scale habitat features such as logs, dense undergrowth and leaf litter were also present, offering further habitat opportunities to a range of species. Flora species within the remnant are also likely to provide feeding resources.

Myrtaceaeous trees (mostly eucalypt species) dominate the canopy, providing direct (foliage, nectar, exudates) and indirect (arthropods) food for a range of vertebrates, particularly birds and arboreal mammals.

Adjoining areas

Native vegetation adjoining the study area at site 15 is largely dominated by Illawarra gully wet forest in moderate condition due to dense infestations of *Lantana camara* scattered throughout. Where dense patches of lantana were absent the native shrub layer remains intact. Despite lantana infestation, this vegetation exhibited a reasonable capacity for the regeneration of natural vegetation provided weed control practices are implemented.

A small drainage line runs along the south-west of site 15 and vegetation along this portion of the site is represented by warm temperate layered forest in moderate condition. Warm temperate layered forest is also present to the north-west on site 16. Vegetation on site 16 is in a moderate to good condition with patchy infestations of *Lantana camara* and *Tradescantia fluminensis*. Despite these weed infestations the vegetation across site 16 exhibited a reasonable capacity for the regeneration of natural vegetation, provided weed control practices are implemented. The northern and eastern edges of site 16 grade into Illawarra gully wet forest which is also in moderate condition.

3.3.4 Broughton Mill and Bundewallah creeks (site 34)

Immediately north-east of Berry township, the project crosses Broughton Mill and Bundewallah Creeks. Native vegetation along these creeks is now largely restricted to a highly disturbed riparian corridor.

Study area

Vegetation in the study area at site 34 is represented by Riverbank forest in a highly disturbed, poor condition. Site 34 has a tall native canopy of *Casuarina cunninghamiana* and an understorey completely dominated by a high density weed infestation. Natural structural layers are no longer intact and in most areas the mid storey and ground layers are completely dominated by weed species including *Ligustrum lucidum, L. sinense, Solanum nigrum, Ehrharta erecta* and *Tradescantia fluminescens*. These weed infested areas were considered to have little capacity for the regeneration of natural vegetation without significant resources allocated to weed control and revegetation. Obvious disturbances at each of these sites includes clearing, nutrient enrichment, sedimentation and erosion.

Regardless of the degraded nature of much of the area observed along each creek, many sites contain mature casuarinas with hollows.

3.3.5 Bundewallah Creek (proposed receiving point for Town Creek diversion)

Bundewallah Creek at the northern end of Rawlings Lane, is proposed as the receiving water for the full diversion of Town Creek from where it crosses North Street, Berry.

Study area

Native flora species identified during the field survey were consistent with the diagnostic flora species described for Riverbank forest (Tozer 2010). Dominant flora species include a canopy of *Casuarina cunninghamiana* ssp *cunninghamiana* with understorey species including *Hymenanthera dentata* and ground layer of *Commelina cyanea, Dichondra repens, Lomandra longifolia, Microlaena stipoides* and *Sigesbeckia orientalis*. This community is frequently highly disturbed and weed species are often dominant in the understorey (Tozer 2010). Riverbank forest at the proposed receiving location on Bundewallah Creek includes a sparse canopy between 15 and 25 metres of *Casuarina cunninghamiana* ssp *cunninghamiana*, *Cinnamomum camphora* and *Erythrina sykesii*. The woody weeds *Lantana camara* and *Ligustrum sinense* form dense understorey thickets in places. Elsewhere the understorey is absent or characterised by scattered woody weeds. The groundcover stratum is dominated by exotic annual and perennial grasses and herbs with minor patches and occasional occurrences of native groundcovers. Common exotic species are *Anagallis arvensis*, *Bromus catharticus*, *Pennisetum clandestinum*, *Rumex crispus*, *Senecio madagascariensis* and *Trifolium repens*. Native groundcovers include *Dichondra repens*, *Geranium homeanum*, *Sigesbeckia orientalis* ssp *orientalis*, *Persicaria strigosa* and *Urtica incisa*.

Bundewallah Creek at the proposed receiving point varies in width from approximately 3 metres to 10 metres. The creek was slow-flowing at the time of survey and supported wide pools and rocky riffle areas. Fringing vegetation consisted largely of weedy grasses. Common frogs and ducks are likely to utilise these habitats. Deposited concrete slabs provide basking and shelter habitat for common reptiles such as Eastern Water Dragon (*Physignathus lesueurii*) and Eastern Water Skink (*Eulamprus quoyii*). Small tree hollows provide potential roosting habitat for microbats. Fauna habitats at this location range from poor to moderate in condition.

Adjoining areas

A farm dam is present just north-west of the proposed receiving location on Bundewallah Creek and provides habitat for waterbirds and common frogs, such as Pacific Black Duck (*Anas superciliosa*) and Striped Marsh Frog (*Limnodynastes peronii*). No emergent or fringing sedges were present at the time of survey, with the bank dominated by weedy grasses. A few large stags are present on the edge of the dam providing perch sites for waterbirds and raptors.

3.3.6 Town Creek diversion

Where Town Creek meets North Street, heading downstream, it is proposed to be diverted across land adjacent to Rawlings Lane and into Bundewallah Creek. See Section 3.3.5 for description of Bundewallah Creek.

Study area

Closed grassland occurs between Town Creek north to Bundewallah Creek over the alignment of the proposed constructed channel and is dominated by *Pennisetum clandestinum*, other introduced pasture species such as *Trifolium repens* and *Paspalum dilatatum* and colonising weeds including *Cirsium vulgare* and *Rumex crispus*. Native herbs and rushes include scattered occurrences of *Ludwigia peploides* ssp *montevidensis* and *Persicaria strigosa*. The closed grassland represents an unnatural landscape and has established as a result of the substantial clearing of native vegetation and a long history of agriculture.

Fauna habitat is limited within the closed grassland. However, the land is prone to flooding and small, shallow wetlands were present at the time of survey. Common frogs, common and migratory waterbirds may utilise this resource from time to time. Fauna habitat is subject to trampling by cattle, observed drinking from the wetlands during the survey.

Town Creek south of the proposed diversion point on North Street consists of intergrades of closed grassland and closed sedgeland, and disturbed riparian open woodland. Further south, shortly before the confluence with Broughton Mill Creek, a constructed wetland occurs on Town Creek. Structure and floristic composition of the closed grassland/sedgeland are similar to that described above for the closed grassland with *Cyperus eragrostis*, *Pennisetum clandestinum* and *Trifolium repens* dominating the suite of exotic species and native *Persicaria* spp and patches of *Typha orientalis* common in the lower channel terraces. The disturbed riparian open woodland occurs along Town Creek through the Berry urban area. This plant community is characterised by areas of revegetation, regrowth native vegetation, planted exotic trees with invasive woody weeds and areas of managed open space in public and private land tenure. The canopy consists of local and non-locally occurring native trees and exotic tree species occurring mainly as landscape plantings. The constructed wetland has formed as a result of aquatic and semi-aquatic vegetation becoming established following the construction of the access track causeway of the Berry sewage treatment works.

The constructed wetland is characterised by patches of *Typha orientialis* and sparse cover of other emergent macrophytes. The banks are dominated by pasture grasses such as *Pennisetum clandestinum* and *Paspalum dilatatum* and patches of *Persicaria strigosa*. Exotic trees and shrubs around the banks include *Erythrina crista-galli*, *Lantana camara*, *Ligustrum sinense* and *Solanum mauritianum*. These plant communities represent an unnatural landscape.

Fauna habitats along Town Creek south of the proposed diversion point on North Street are reasonably disturbed however provide foraging and breeding resources for a range of common birds, frogs, reptiles and mammals. The creekline itself and constructed wetland provide habitat for threatened and migratory birds such as Black Bittern (*Ixobrychus flavicollis*) and Latham's Snipe (*Gallinago hardwickii*). The constructed wetland, with fringing Typha and emergent rushes, may provide limited potential habitat for the threatened Green and Golden Bell Frog however, was shallow and stagnant at the time of survey. Whilst a number of preferred Koala (*Phascolarctos cinereus*) feed trees occur, they are planted individuals, occurring in low numbers, and provide less than 15 per cent canopy cover. Therefore, these trees are unlikely to provide core habitat for Koalas. Fauna habitats along Town Creek range from poor to moderate in condition.

3.3.7 Broughton Mill Creek (confluence with Town Creek)

Town Creek discharges into Broughton Mill Creek about 1.5 kilometres south-east of the intersection of Queen Street and Prince Alfred Street, Berry. Broughton Mill Creek is tidal-influenced at this location.

Study area

Broughton Mill Creek at the confluence with Town Creek consists of riparian open woodland containing stands of exotic shrubs and trees such as, *Erythrina sykesii*, *Ligustrum sinense* and *Salix babylonica* with the groundcovers dominated by introduced pasture species. Fauna habitats are disturbed and subject to trampling by cattle (observed at time of survey). No sedges are present but patches of the reed *Phragmites australis* provide potential habitat for common frogs and birds. Instream habitats such as logs are largely absent; exposed and fringing rocks occur infrequently.

Adjoining areas

A large effluent storage pond occurs within the Berry sewage treatment plant property. This pond is the last step in the filtration process before the water discharges into Broughton Mill Creek. The pond is predominantly surrounded by weedy grasses and does not contain fringing or emergent sedges, rushes or reeds. The pond provides habitat for waterbirds such as Australasian Grebe (*Tachybaptus novaehollandiae*), Great Cormorant (*Phalacrocorax carbo*) and Pied Cormorant (*Phalacrocorax varius*).

3.3.8 Hitchcocks Lane (site 35)

Two separate stands of vegetation occur on the south side of the existing Princes Highway within site 35, one opposite Hitchcocks Lane and the second within a small reserve at the western end of Victoria Street.

Study area

Vegetation at site 35, opposite Hitchcocks Lane is represented by Illawarra gully wet forest and includes mature hollow-bearing *Eucalyptus saligna* X *botryoides* and *E. pilularis* with a patchy understorey including both native shrubs and groundcovers along with large patches of weed species including *Tecoma capensis* and *Lantana camara.* The condition of Illawarra gully wet forest at the Hitchcocks Lane site was considered to be moderate. Native vegetation within this portion of site 35 exhibited good capacity for natural regeneration, provided competing weed species are removed.

A small drainage line crosses under the existing Princes Highway at site 35 and flows into a constructed wetland supporting native rushes such as *Typha orientialis*. The drainage line and wetland provide habitat for common frogs and birds.

Vegetation at site 35, at the western end of Victoria Street is represented by isolated remnant trees with a mown grassy understorey. This area was considered highly modified and in poor condition. The native canopy layer is all that remains intact.

3.3.9 Schofields Lane (site 14)

South-west of Berry township and directly opposite Schofields Lane occurs a stand of native vegetation. The stand would be largely unaffected directly by the Foxground and Berry bypass project however indirect impacts are possible.

Study area

Vegetation at site 14 is represented by Illawarra gully wet forest and includes mature hollow-bearing *Eucalyptus pilularis* and *E. saligna X botryoides* with a degraded understorey. The native understorey was sparse with *Pteridium esculentum* dominating. Large patches of weed species including *Rubus fruticosus, Senecio madagascariensis*, and *Onopordum acanthium* were scattered throughout the site. The condition of Illawarra gully wet forest at the site 14 was considered to be moderate, based on the amount of mature eucalypt trees present.

No drainage lines or water bodies were present at the site.

There were few logs and scattered stags (dead trees) with hollows on the site. There is potential for microbat breeding and roosting habitat.

3.4 Flora species

A total of 513 vascular flora species were recorded within the study area and adjoining areas, comprising 402 (78 per cent) locally indigenous species and 111 (22 per cent) exotic weed species. A list of flora species recorded is provided in Appendix A. Weeds and significant flora species are discussed below.

3.4.1 Noxious weeds

Seven exotic weed species recorded in the study area and surrounds are listed as noxious weeds in the Shoalhaven LGA with three of these listed as noxious in the Kiama LGA as identified in **Table 3.2**.

Table 3.2 Noxious weeds recorded in the study area

Weed species	Common name	Noxious weed class
Ageratina riparia	Mistflower	4
Lantana camara[#]	Lantana	4
Ligustrum lucidum	Large-leaved privet	4
Ligustrum sinense	Small-leaved privet	4
Lycium ferocissimum[#]	African boxthorn	4
Rubus fruiticosus[#]	Blackberry complex	4
Senecio madagascariensis	Fireweed	4

[#] *Listed as noxious in Kiama LGA*

The legal requirements of these noxious weed classes include:

a) Class 4 - The growth and spread of the flora must be controlled according to the measures specified in a management plan published by the local control authority.

b) Class 5 - The requirements in the *Noxious Weeds Act 1993* for a notifiable weed must be complied with.

Given that survey effort was focussed within areas of native vegetation, it is considered highly likely that further noxious weed species would occur within cleared and disturbed portions of the study area.

3.4.2 Weeds of national significance

Twenty Weeds of National Significance (WONS) have been identified by Australian governments because of their invasiveness, impacts on primary production and the environment, potential for spread and socioeconomic impacts. Two WONS, *Lantana camara* and *Rubus fruiticosus* were recorded in the study area during the current surveys. Other than the requirements of the NSW *Noxious Weeds Act 1993* there are no additional legal obligations to control WONS.

3.4.3 Environmental weeds

Environmental weeds are present in all areas of native vegetation and dominate cleared and disturbed areas throughout the study area. The environmental weed suite includes annual and perennial grasses and herbs such as *Bidens pilosa*, *Cirsium vulgare*, *Ehrharta erecta*, *Pennisetum clandestinum*, *Sida rhombifolia* and *Rumex crispus* in cleared and disturbed paddocks and along the edges of native plant communities. Perennial species such as *Protasparagus aethiopicus* and *Solanum pseudocapsicum* have invaded areas under canopy with dense patches of groundcover species such as *Ranunculus repens* and *Tradescantia fluminensis* present in damp areas and riparian zones.

Woody environmental weeds such as *Cinnamomum camphora* and *Solanum mauritianum* generally occur on the edges of native vegetation with cleared and disturbed areas as small stands or scattered individuals. Exotic vines including *Araujia hortorum*, *Delairea odorata* and *Passiflora subpeltata* occur on disturbed edges and under the canopy of patches of native vegetation.

3.4.4 Significant flora

A total of 17 vascular flora species listed on the TSC Act and/or the EPBC Act, or their habitat have been previously recorded within a 10 kilometre radius of the study area. Threatened flora records extracted from the OEH Atlas of NSW Wildlife within the 10 kilometre radius of the study area are mapped in **Figure 3.2**. An additional 14 species are recorded from the OEH Atlas of NSW Wildlife Illawarra sub region search with a further four species specified for consideration in correspondence from OEH (Appendix C).

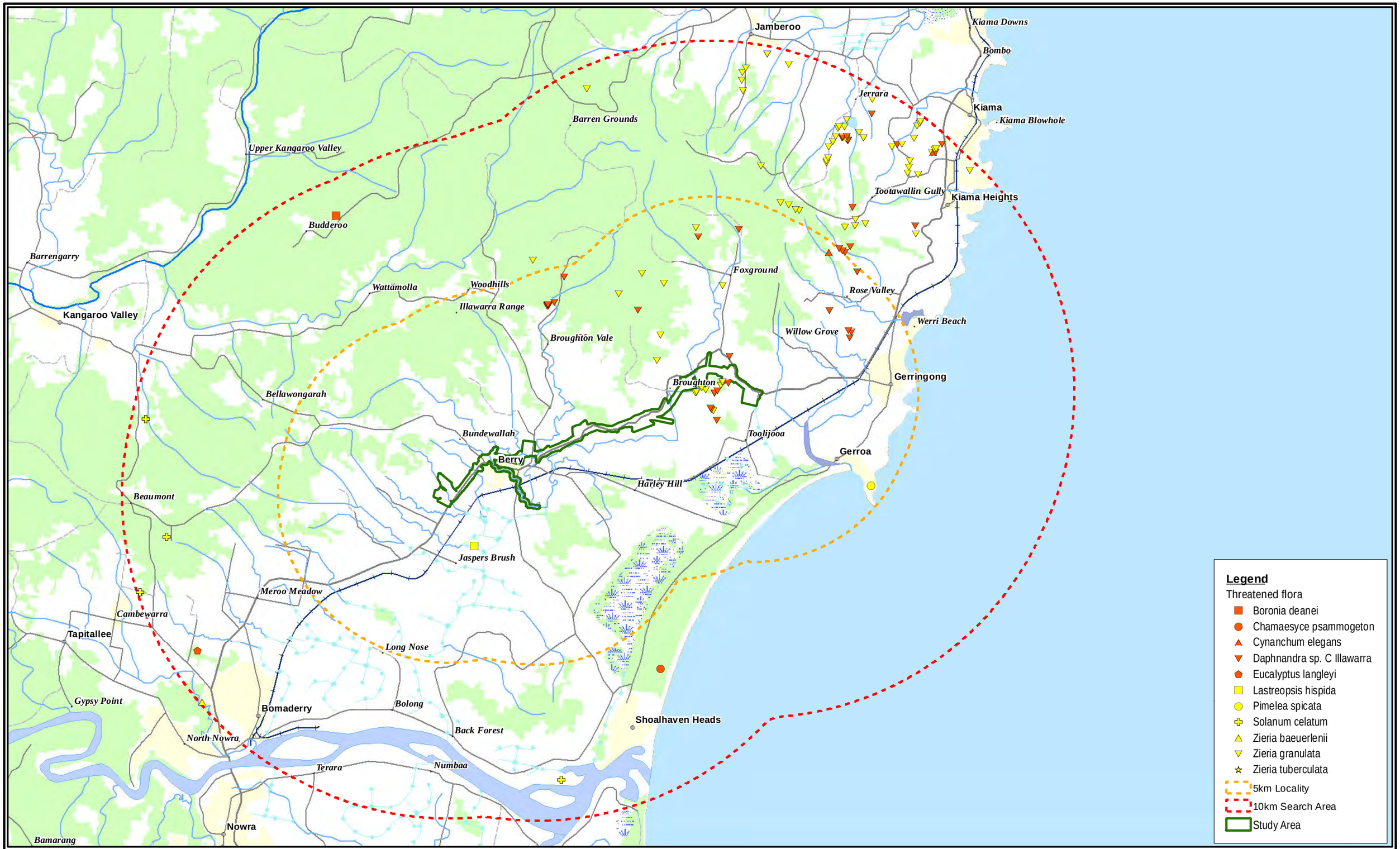
No threatened flora species were recorded in the study area during the survey. Two threatened species, *Daphnandra* sp. 'Illawarra' and *Zieria granulata* were recorded in adjoining areas. *Daphnandra* sp. 'Illawarra' occurred in warm temperate layered forest and subtropical complex rainforest in sites 17, 19 and 23, with the closest record about 600 metres south of the study area. *Zieria granulata* occurred in and adjoining subtropical complex rainforest and warm temperate layered forest, associated with rocky outcrops, in sites 17, 19 and 23. The closest record of *Zieria granulata* to the study area was about 200 metres to the south.

Due to the proximity of previous records and/or the presence of identified habitat preferences, potential habitat may exist within the study area for four threatened flora species: *Cynanchum elegans, Daphnandra* sp. 'Illawarra', *Irenepharsus trypherus* and *Zieria granulata*. Letter correspondence from OEH (then DECCW), dated 31 January 2011 which accompanied the DGRs has specified five flora species to be assessed as subject species for the project including two of the species cited above (*Daphnandra sp. '*Illawarra' *and Zieria granulata*) and an additional three species (Appendix C).

The additional three flora subject species are:

- *Pterostylis gibbosa.*
- *Cryptostylis hunteriana*.
- *Genoplesium baueri*.

All subject species listed in Appendix C and highlighted above have been considered further in Chapter 6 (assessment of impacts) of this report.



Biosis Research Pty. Ltd.
18-20 Mandible Street
Alexandria
NEW SOUTH WALES
2015

Figure 3.2: Threatened flora, listed on the TSC and EPBC Acts, recorded within 5 and 10km of the Study Area

Date: 16 July 2012	Drawn by: RS/JMS/ANP
File: 13194	Checked by: JER
Location: P:\15000s\15039\Mapping\Variaition 1\Variation 1 Figures\13194 S2_F6 flora.mxd	

Acknowledgements:
Species data from DECCW and Biosis Research Pty. Ltd.
This product contains Data which is copyright to the Commonwealth of Australia (c. 2003)

0 1 2 3 4
Kilometers

Scale: 1:110,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 3.2

3.5 Fauna species

A list of fauna recorded within the study area is provided in Appendix B and includes 125 species of bird (including nine introduced species), 34 species of mammal (including five introduced species), nine species of frog and nine species of reptile.

The fauna surveys generally focused on habitats with a greater potential to contain native species, eg remnant native forest/rainforest, waterbodies (wetlands, creeks, farm dams) and rocky outcrops. Highly modified areas such as grazing paddocks and cropped pastures were routinely observed throughout the course of the field work.

3.5.1 Significant fauna

A total of 114 threatened, migratory and/or preliminarily listed fauna species or their habitat have been previously recorded within a 10 kilometre radius of the study area (OEH Atlas of NSW Wildlife and DSEWPaC Online EPBC Database) or the Illawarra sub-region of the Southern Rivers Catchment Management Authority (CMA) (Appendix D). Of these, 73 fauna species are listed under the TSC Act and 69 fauna species are listed (or nominated for listing) under the EPBC Act (20 threatened species and 51 migratory species)[1]. Eighty-nine threatened and/or migratory species have been previously recorded within 10 kilometres of the study area (**Figure 3.3**). Marine and pelagic species have been excluded (except those that may forage on land).

Nine threatened species and six migratory species were recorded during the field surveys for the project:

Threatened species present were:

- Gang-gang Cockatoo (*Callocephalon fimbriatum*).
- Powerful Owl (*Ninox strenua*).
- Yellow-bellied Sheathtail bat (*Saccolaimus flaviventris*).
- Eastern Freetail Bat (*Mormopterus norfolkensis*).
- Grey-headed Flying-fox (*Pteropus poliocephalus*).
- Eastern Bentwing-bat (*Miniopterus schreibersii oceanensis*).
- Eastern False Pipistrelle (*Falsistrellus tasmaniensis*).
- Southern Myotis (*Myotis macropus*).
- Greater Broad-nosed Bat (*Scoteanax rueppellii*).

Migratory species present were:

- White-bellied Sea-eagle (Haliaeetus leucogaster).
- Fork-tailed Swift (Apus pacificus).
- Cattle Egret (Ardea ibis).
- Black-faced Monarch (Monarcha melanopsis).
- Rufous Fantail (Rhipidura rufifrons).
- Australian Reed-warbler (Acrocephalus stentoreus).

[1] An individual species may be listed under one or both Acts and may be listed as threatened and/or migratory.

Jamberoo
Kiama Downs
Bombo
Jerrara
Kiama
Kiama Blowhole
Barren Grounds
Upper Kangaroo Valley
Tootawallin Gully
Kiama Heights
Budderoo
Foxground
Wattamolla
Woodhills
Illawarra Range
Rose Valley
Broughton Vale
Werri Beach
Willow Grove
Gerringong
Broughton
Bellawongarah
Bundewallah
Toolijooa
Berry
Gerroa
Harley Hill
Beaumont
Jaspers Brush
Meroo Meadow
Cambewarra
Long Nose
Bomaderry
Bolong
Shoalhaven Heads
Back Forest
North Nowra
Terara
Numbaa
Nowra

Legend

Threatened and migratory fauna

- Australasian Bittern
- Australian Reed-Warbler
- Bar-tailed Godwit
- Barking Owl
- Beach Stone-curlew
- Black Bittern
- Black-faced Monarch
- Black-necked Stork
- Black-tailed Godwit
- Blue-billed Duck
- Broad-billed Sandpiper
- Broad-headed Snake
- Bush Stone-curlew
- Caspian Tern
- Cattle Egret
- Common Greenshank
- Common Noddy
- Common Sandpiper
- Common Tern
- Curlew Sandpiper
- Double-banded Plover
- Eastern Bentwing-bat
- Eastern Bristlebird
- Eastern Curlew
- Eastern False Pipistrelle
- Eastern Freetail-bat
- Eastern Ground Parrot
- Eastern Pygmy-possum
- Eastern Reef Egret
- Flame Robin
- Fork-tailed Swift
- Gang-gang Cockatoo
- Giant Burrowing Frog
- Glossy Black-Cockatoo
- Glossy Ibis
- Great Egret
- Great Knot
- Greater Broad-nosed Bat
- Greater Sand-plover
- Green and Golden Bell Frog
- Grey Plover
- Grey-headed Flying-fox
- Hooded Plover
- Koala
- Large-eared Pied Bat
- Latham's Snipe
- Lesser Sand-plover
- Little Eagle
- Little Lorikeet
- Little Tern
- Littlejohn's Tree Frog
- Long-nosed Potoroo
- Marsh Sandpiper
- Masked Owl
- Olive Whistler
- Orange-bellied Parrot
- Osprey
- Oriental Cuckoo
- Pacific Golden Plover
- Pied Oystercatcher
- Powerful Owl
- Rainbow Bee-eater
- Red Knot
- Red-necked Stint
- Regent Honeyeater
- Ruddy Turnstone
- Rufous Fantail
- Sanderling
- Satin Flycatcher
- Scarlet Robin
- Sharp-tailed Sandpiper
- Sooty Owl
- Sooty Oystercatcher
- Southern Myotis
- Spectacled Monarch
- Spotted Harrier
- Spotted-tailed Quoll
- Square-tailed Kite
- Superb Fruit-Dove
- Swift Parrot
- Terek Sandpiper
- Turquoise Parrot
- Varied Sittella
- Whimbrel
- White-bellied Sea-Eagle
- White-fronted Chat
- White-throated Needletail
- Yellow-bellied Glider
- Yellow-bellied Sheathtail-bat

5km Locality
10km Search Area
Study Area

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Figure 3.3: Threatened and migratory fauna, listed on the TSC and EPBC Acts, previously recorded within 5 and 10km of the Study Area

Date: 16 July 2012	Drawn by: RS/JMS/ANP
File: 13194	Checked by: JC
Location: P:\15000s\15039\Mapping\Variaition 1\Variation 1 Figures\13194_S2_F3-3_Fauna_160712.mxd	

Acknowledgements:
Species data from DECCW, Birds Australia
and Biosis Research Pty. Ltd.
This product contains Data which is copyright to the
Commonwealth of Australia (c. 2003)

0 1 2 3 4
Kilometers

Scale: 1:110,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 3.3

A letter from the OEH (then DECCW), dated 31 January 2011 which accompanied the DGRs, has specified 18 threatened fauna species to be assessed as subject species for the project (seven of which were recorded during the current surveys). An additional 33 threatened fauna species (two of which were recorded during the current surveys) have been assessed as subject species due to the presence of known and/or potential habitat and/or previous records (Appendix D). All subject species listed in Appendix D have been considered further in Chapter 6 (assessment of impacts) of this report. Further, 29 migratory species with known and/or potential habitat in the study area are also considered further in Chapter 6.

3.6 Endangered populations

Part 2 of Schedule 1 of the TSC Act lists endangered populations of flora and fauna. There are no endangered fauna or flora populations listed that occur within the project study area.

3.7 Critical habitat

Critical habitat can be declared under both the EPBC Act and the TSC Act. Under the EPBC Act, it is an offence for a person to take an action that the person knows will significantly damage the critical habitat of a listed threatened species. Under the TSC Act, the declaration of critical habitat serves primarily as a guide for planning under Part 3 of the EP&A Act and a trigger which ensures a rigorous environmental assessment of all activities and development proposals and any other action that has the potential to damage the species or its habitat (NPWS 2002).

No areas of critical habitat for flora or fauna have been declared within the project study area under either the EPBC Act or the TSC Act (DECC 2008a, DEWHA 2009d). The NPWS has prepared a recommendation for the identification of critical habitat for the Bomaderry Zieria (*Zieria baeuerlenii*), listed under both the TSC Act and EPBC Act, within the Bomaderry bushland (NPWS 2002). A final declaration has not yet been made for this proposed area of critical habitat. This area lies about 10 kilometres to the south-west of the project. It would not be impacted by the project.

3.8 Corridors

3.8.1 Introduction

Wildlife corridors can be best defined as “retained and/or restored systems of (linear) habitat which, at a minimum, enhance connectivity of wildlife populations and may help them overcome the main consequences of habitat fragmentation” (Wilson and Lindenmayer 1995). Alternatively, they can be defined as “linear habitats that differ from a more extensive surrounding matrix; frequently they link one or more patches of habitat in the landscape, but they may also occur as isolated lines of habitat” (Bennett 1990).

A corridor serves a number of different functions in terms of wildlife conservation:

- Providing increased foraging area for wide-ranging species.
- Providing cover for movement between habitat patches, and enhancing the movement of fauna through sub-optimal habitats.
- Reducing genetic isolation.
- Facilitating access to a mix of habitats and successional stages to those species which require them for different activities (eg foraging or breeding).
- Providing refuge from disturbances such as fire.
- Providing habitat in itself.
- Linking wildlife populations and helping to maintain immigration and recolonisation between otherwise isolated patches. This in turn may help reduce the risk of population extinction (Wilson and Lindenmayer 1995).

Vegetation cover in a corridor may not always be continuous. Corridors may include smaller remnants, wetlands, roadside vegetation, groups of trees, and even individual trees. Corridors may be broken, or fragmented, by currently degraded or cleared areas but still contribute to landscape connectivity. Discontinuous corridors can provide important stepping-stone links (Scotts *et al*. 2000).

The functioning of a corridor can be best described in terms of its connectivity, of which there are two components:

- Structural connectivity. This is the mappable spatial continuity of the corridor. This can include the distance over which the corridor extends, the width, the number of gaps and the presence of habitat nodes.
- Functional connectivity. This is a measure of the ability of a species to move between two habitats. The functional connectivity of a corridor depends not only on its spatial continuity, but also on factors such as behaviour of the species, the scale of the species' movements, and its response to the width and quality of habitat in the corridor (Bennett 1990).

3.8.2 Corridors in the region

Large corridors in the Shoalhaven link national parks, nature reserves and other large areas of natural vegetation. These corridors have a high value for conservation purposes as they consist of large tracts of relatively undisturbed vegetation linking coastal areas with the escarpment of the Budawang Range and extending west into the Southern Tablelands. These include the Jervis Bay – Morton National Parks corridor, the Conjola – Morton National Parks corridor, the Five Lakes – Morton National Parks corridor and the Murramarang – Morton National Parks corridor. These corridors are primarily protected through their tenure as national park or other crown reserves, although there is some freehold land and land managed by State Forests (Shoalhaven City Council 2005).

Corridors with cleared sections exist also in the Shoalhaven. These corridors link protected national parks and nature reserves. Cleared sections occur mainly on freehold land and therefore management of existing and re-established vegetation within these corridors relies primarily on private landholders. Of particular concern for this project is the Seven Mile Beach National Park – Barren Grounds Nature Reserve wildlife corridor. Remnant bushland in the Seven Mile Beach and Coomonderry Swamp area is isolated by several kilometres of cleared land from the escarpment forests to the north of Berry. Scattered patches of bushland exist between these two areas, including Toolijooa Ridge, Harley Hill, Moeyan Hill, along Broughton Creek and along public roads (Shoalhaven City Council 2005).

A broader wildlife corridor has been identified by the Southern Rivers CMA. This corridor represents a long term restoration goal which would see a revegetated corridor extending east from the escarpment to the coast. It represents areas of interest for the Southern Rivers CMA and the Berry Landcare group in which efforts towards restoring the native landscape and improving connectivity should be focused. Within the study area, this corridor includes the section of the project between the proposed embankment at Broughton Creek bridge 1 and just east of Tindalls Lane interchange. It is mostly made up of cleared agricultural land and includes most of the wildlife corridors as shown in **Figure 3.4**. The assessment concentrates on connectivity impacts associated with the project. Therefore it focusses on the most vulnerable areas within this corridor which are located along creeks and ridgelines, and which have existing remnant vegetation.

The *Illawarra Regional Environmental Plan No. 1* (as of July 2009) a deemed State Environmental Planning Policy - SEPP also identifies the above wildlife corridors. Under the SEPP, the consent authority must not grant development consent to an application to carry out development on land shown on the map as a wildlife corridor that, in the opinion of the consent authority, will involve significant tree felling or vegetation clearance unless it is satisfied that: (a) the development will be managed so as to not have any long-term detrimental impact on opportunities for wildlife movement; or (b) the development is designed to enhance the retention and augmentation of vegetation native to the area (NSW legislation website 2009). The project crosses the Seven Mile Beach National Park – Barren Grounds Nature Reserve wildlife corridor, which is mapped as a wildlife corridor under the deemed SEPP (discussed in section 3.8.3) and as such, the SEPP applies.

3.8.3 Corridors in the study area

The majority of the study area is covered by cleared areas and grazed paddocks that contain little native vegetation and have not been mapped or described as a native plant community. Therefore, wildlife corridors in the study area are limited, however the Princes Highway does cross the Seven Mile Beach National Park – Barren Grounds Nature Reserve wildlife corridor discussed in section 3.8.2. Vegetation remnants at Toolijooa Ridge, Broughton Creek, Site 15, Broughton Mill Creek and Bundewallah Creek are discontinuous parts of this corridor and are thus important to wildlife in the area. Creeks provide dispersal habitat for aquatic fauna and vegetation along creeks (such as Town Creek) and some road reserves within the study area would also provide limited value as local corridors for some species. These smaller corridors are important in linking the larger corridors, and also provide the added values of protecting riverbanks, improving water quality and flows, controlling soil erosion and increasing land productivity through shelterbelts, windbreaks and screens (Shoalhaven City Council 2005). Fauna can use road reserves as habitat in which to live as well as movement corridors facilitating local movements, dispersal and migration (Bennett 1990). Within highly modified landscapes, remnant patches and strips of vegetation within road reserves are often the only remaining vegetation links. A number of studies have indicated the importance of such roadside vegetation (Breckwoldt 1990, Middleton 1980). Corridors in the study area are shown in **Figure 3.4**.

3.8.4 SEPP 14 wetlands

The nearest SEPP 14 wetland to the project area is Coomonderry Swamp in the southern section of the locality (**Figure 3.4**). The majority of Coomonderry Swamp occurs in private land tenure with some areas included in the boundary of Seven Mile Beach National Park. Drainage of the study area is ultimately to Broughton Creek which is part of the Coomonderry Swamp catchment. Coomonderry Swamp is about five kilometres southeast of Berry.

3.8.5 SEPP 44 Koala habitat protection

SEPP 44 aims to encourage the proper conservation and management of areas of natural vegetation that provide habitat for Koalas, ensuring a permanent free living population over their present range and attempting to reverse the current trend of Koala population decline. Under this policy the distinction is made between 'potential' and 'core' Koala habitat.

"Potential Koala habitat" means areas of native vegetation where the trees of the types listed in Schedule 2 of the Policy constitute at least 15 per cent of the total number of trees in the upper or lower strata of the tree component. "Core Koala habitat" means an area of land with a resident population of Koalas, evidenced by attributes such as breeding females (that is, females with young) and recent sightings of and historical records of a population.

The Koala has been previously recorded north and south of the study area. Although some SEPP 44-listed feed tree species were recorded during the field surveys (eg *Eucalyptus microcorys, E. racemosa, E. robusta and E. tereticornis*), none were dominant within the forest/woodland patches of the study area. Based on the low density of preferred feed trees (ie less than 15 per cent of the total number of trees in the upper or lower strata of the tree component) and the absence of records of this conspicuous species within the study area, the study area does not constitute "potential" or "core" Koala habitat as defined under the SEPP. However, it is possible that the species moves through the study area on occasion between areas of potential habitat. Potential impacts to the Koala have been further assessed in Chapter 6 (assessment of impacts).

3.8.6 Groundwater-dependent ecosystems

Groundwater-dependant ecosystems (GDEs) have been defined by the Department of Land and Water Conservation (DLWC 2002) as ecosystems which have their species composition and natural ecological processes determined by groundwater. GDEs vary in the degree of their dependency on groundwater from having no apparent dependence to being entirely dependent on it.

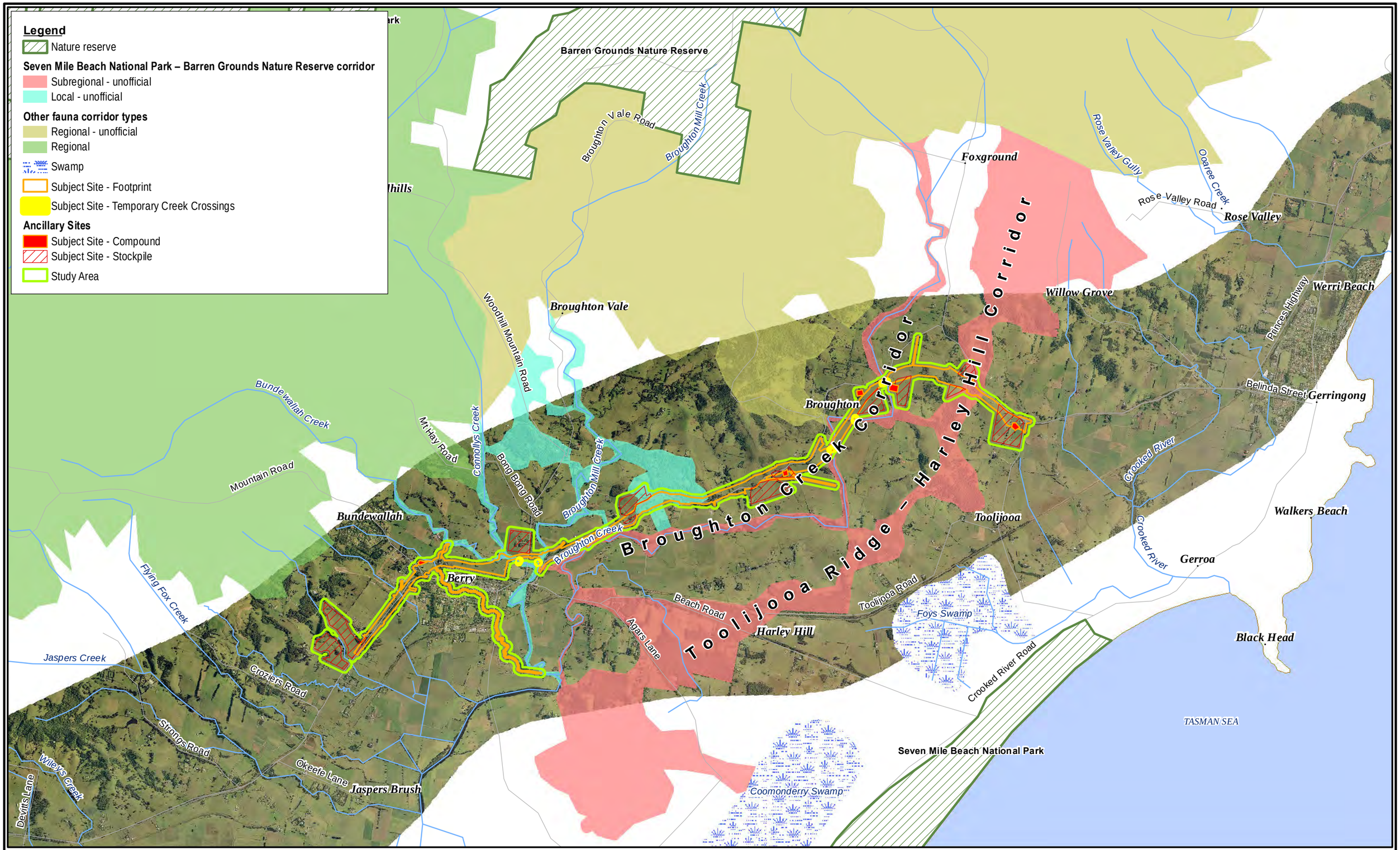
Terrestrial vegetation such as native plant communities including forests, woodlands and wetlands in riparian zones and on coastal floodplains may be dependent on shallow groundwater either permanently or seasonally. River or stream flow is often maintained by groundwater which provides base flow emerging as springs or diffusely from sediments and rock strata underlying a stream and stream banks. Base flow groundwater can be crucial in maintaining in-stream and near-stream ecosystems such as native plant communities (DLWC, 2002).

The NSW *State Groundwater Dependant Ecosystems Policy* (DLWC, 2002) defines five main types of groundwater systems in NSW. Shallow Alluvial Groundwater Systems are associated with coastal rivers and are often in direct connection with surface water bodies such as rivers and wetlands. This type of groundwater system is likely to support base flows and associated terrestrial ecosystems such as riparian forests, riparian woodlands and wetlands. Based on a review of the topographic and physiographic features of the locality the fluvial landscapes of the locality are likely to be characterised by Shallow Alluvial Groundwater Systems.

Riverbank forest occurs in the study area and locality (**Figure 3.1** and Appendix J) and this is discussed in Section 3.2.2. As described by Tozer *et al* (2010) the community is found on sand/gravel alluvium strewn with cobbles along swift-flowing reaches of streams, at elevations from 20-800 metres ASL. Riverbank forest in the current assessment is considered to be part of the EEC River-flat eucalypt forest. The Final Determination for River-flat eucalypt forest (NSW Scientific Committee, 2004) states that the EEC:

- Is associated with silts, clay-loams and sandy loams, on periodically inundated alluvial flats, drainage lines and river terraces associated with coastal floodplains.
- Generally occurs below 50 metres elevation.
- Forms mosaics with other floodplain forest communities and treeless wetlands.
- Floristic composition is primarily determined by the frequency and duration of waterlogging and the texture, nutrient and moisture content of the soil.

Impacts to River-flat eucalypt forest are discussed in Chapter 4. Details on groundwater issues within the study area in general can be found in the technical paper *Princes Highway upgrade - Foxground and Berry bypass - Surface water, groundwater and flooding assessment* by AECOM (August 2012).



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Figure 3.4: Wildlife corridors

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Acknowledgements:
Habitat corridors based on 2008 aerial photography and the Illawarra Regional Environmental Plan (April 1982)
Aerial imagery provided by ARUP
This product incorporates Data which is copyright to the Commonwealth of Australia (c.2003)

0 0.6 1.2 1.8 2.4 3
Kilometres

Scale: 1:50,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 3.4

4 Potential impacts

This chapter assesses the types of impacts that may result as a consequence of the construction and operation of a road, with specific reference to the Princes Highway between about the junction of Toolijooa Road and the Princes Highway and about the junction of Schofield's Lane and the Princes Highway. The assessment focuses on the most likely or representative scenarios based on the current project design, terrestrial flora and fauna field survey and desktop analysis. The impacts estimated from representative scenarios can be mitigated, greatly reducing or eliminating the impacts, thereby avoiding the worst case scenario where no mitigation would be implemented possible leading to local extinctions.

Worst case scenarios have been addressed by adopting a conservative approach in the terrestrial biodiversity assessments. In addition, worst case scenarios have been considered by proceeding with assessments of significance on the basis of potential habitats for threatened terrestrial biodiversity and which is required by impact assessment guidelines. However despite the definition of the construction footprint and ancillary facilities areas, project management systems, operational controls and work methods during construction, potential exists for impacts on native vegetation and terrestrial flora and fauna habitats. Potential worst case scenarios and possible impacts have been addressed in the following sections.

4.1 Potential impacts

Potential impacts resulting from road developments on terrestrial ecological values include the following:

- Vegetation clearance and habitat loss.
- Increased fragmentation including edge effects.
- Increased mortality.
- Weed invasion.

Each of these potential impacts is discussed below.

4.1.1 Vegetation clearance and habitat loss

Impacts of vegetation clearing and the proposed full diversion of Town Creek can result in the loss of flora species and fauna habitat features that occur in the area. In the study area, this would include nesting habitat and roosting hollows, watery habitats, as well as feeding and shelter resources.

Direct impacts would occur for the construction and operation of the project including the roadway, temporary creek crossings, Town Creek diversion and areas for ancillary facilities. The indirect impacts are calculated based on the 50 metres average extent of edge effects, calculated by buffering the area that would be directly impacted by construction of the project by 50 metres (see Section 1.4). Overall, eight different plant communities (including the predominantly exotic 'closed grassland') would be impacted by the project, including fragmentation of linear patches. Such fragmentation would result in new edges being created by the project. The impacts of this vegetation clearing on threatened species habitat are discussed in Section 6.1 and Section 6.2.

The full range of potential impacts due to the diversion of Town Creek into Bundewallah Creek are described in *Princes Highway upgrade - Foxground and Berry bypass Surface water, groundwater and flooding assessment* (AECOM 2012). Potential impacts to flora and fauna habitats as a result of diverting Town Creek into Bundewallah Creek include:

- Increased frequency, volume and velocity of flows in Bundewallah Creek from the receiving point, leading to erosion.
- Increased flows in Bundewallah, Connollys and Broughton Mill Creeks.
- Bundewallah Creek, Connollys Creek and Broughton Mill Creek will have less than 5 per cent change in catchment area due to the proposed diversion.
- Reduced flows in Town Creek south of the project alignment leading to loss of vegetation and fauna habitat (including both native and exotic vegetation).
- Town Creek's catchment would be reduced by 100 per cent at the diversion point and by 47 per cent at the downstream end before the confluence with Broughton Mill Creek.
- The proposed diversion could lead to sediment accumulating in Town Creek downstream of the diversion as a result of reduced flushing efficiency.

Despite the comprehensive assessment methodology the potential exists for a greater level of impact to vegetation and habitats than has been assessed. In this instance a worst case scenario may arise as a result of:

- Accidental clearing of native and derived plant communities and associated habitat for threatened and non-threatened terrestrial biodiversity.
- Project modifications resulting in additional vegetation clearing and habitat loss that fail to adequately further assess impacts that are discrete to the project and at a broader cumulative scale.
- Additional vegetation clearing either approved or accidental that results in residual loss of threatened biodiversity or its potential habitat and which is not compensated for by an offset.

Table 4.1 shows the area of each plant community recorded in the subject site and study area that would be impacted by the project.

Table 4.1: Area of each plant community potentially impacted by the project

Plant community	Impacted area (hectare)					Total impacted area (hectare)
	Direct				Indirect (edge effects)	
	Roadway	Ancillary facilities	Temporary crossings	Town Creek diversion		
Closed grassland*	-	-	-	0.4	0.5	0.9
Closed grassland/ sedgeland	0.1	-	-	2.1	0.3	2.5
Constructed wetland	0.2	-	-	0.2	0.3	0.7
Currambene-Batemans lowlands forest	-	0.0002	-	-	2.4	2.4
Disturbed riparian open woodland	-	-	-	2.6	1.2	3.8
Illawarra gully wet forest	13.7	1.7	-	-	10.05	25.5
Riverbank forest**	2.6	-	0.2	0.1	7.1	10.0
Warm temperate layered forest	5.0	1.9	-	-	5.3	12.2
Total	**21.6**	**3.6**	**0.2**	**5.4**	**27.2**	**58.0**

**Not considered to be a native plant or derived native plant community*
***Equivalent to EEC River-flat eucalypt forest*

4.1.2 Fragmentation

Habitat fragmentation is the division of a single area of habitat into two or more smaller areas, with a new habitat type occurring in the area between the fragments. This new dividing habitat type is often artificial and inhospitable to the fauna species remaining within the fragments (MacNally 1999) and can provide suitable conditions for weed species to establish, which may out-compete native flora species. Although the newly created habitat would be used by some species, they are usually generalist species and are often considered aggressive (eg noisy miners *Manorina melanocephala* (Loyn *et al*. 1983), further decreasing population levels of the species remaining in the fragments.

In addition to the loss of total habitat area, the process of fragmentation can impact on the species within the newly created fragments in a number of ways (eg barrier effects, genetic isolation and edge effects). The degree to which these potential impacts affect the flora and fauna within the newly created fragments depends on a number of variables including distance between fragments, local environmental conditions, the species present and mitigation measures implemented (Chapter 5).

The project without mitigation measures could result in a significant impact to some threatened fauna species (eg Spotted-tailed Quoll and Long-nosed Potoroo) due to the fragmentation of wildlife corridors (worst case scenario). However, given that the mitigation measures detailed in Chapter 5 (ie fauna crossing structures and vegetation corridor enhancement) would be implemented, fragmentation of habitat is unlikely to result in a significant impact to threatened biota. The specific impacts of habitat fragmentation on threatened species are discussed in Section 6.1, Section 6.2 and associated assessments of significance which are provided in Appendices 3 and 4 to this report.

Barrier effects

Barrier effects occur where particular species are either unable or are unwilling to move between suitable areas of fragmented habitat. This could result in either a complete halt to movement or a reduced level of movement between fragments. Roads through areas of native vegetation can act as barriers, with barrier effects greater for some species than others (Goosem 2002). Species most vulnerable to barrier effects include rare species (even a small reduction in movements can reduce genetic continuity within the population hence reducing the effective population size), smaller ground-dwelling species and species with low mobility. Species most likely to be impacted include small birds, terrestrial and arboreal mammals, and reptiles. Species least vulnerable to barrier effects tend to be those that are highly mobile (eg birds and bats), although even these species can vary in their response to barriers.

The project without mitigation measures could result in a significant impact to some threatened fauna species (eg Spotted-tailed Quoll and Long-nosed Potoroo) due to the creation and/or exacerbation of barrier effects (worst case scenario). However, given that the mitigation measures detailed in Chapter 5 (ie underpasses, overpasses and vegetation corridor enhancement) would be implemented, barrier effects are unlikely to result in a significant impact to threatened biota. The specific impacts of barrier effects on threatened species are discussed in Section 6.1, Section 6.2 and associated assessments of significance which are provided in Appendices 3 and 4 of this report).

Corridors and connectivity

As discussed in Section 3.8 the project would cause some impact on local and regional wildlife corridors, particularly where the project crosses Toolijooa Ridge (once) and Broughton Creek (three times), despite the existing degree of clearing and fragmentation.

The project would potentially impact upon habitat connectivity/wildlife corridors in two ways:

1. The barrier to fauna movement across the existing road would increase from two lanes (average width 12.5 metres) to four lanes with a median separation (average width 25 metres). In addition, both the existing and proposed highway would act as barriers to fauna movement where the new highway deviates from the existing alignment for a total of about 6.6 kilometres.
2. Habitat connectivity such as riparian vegetation would be impacted by removal of vegetation, or loss of vegetation due to reduced flow within Town Creek. The removal and/or loss of such vegetation would also create barriers to fauna movement between the fragmented patches.

Currently the existing Princes Highway crosses Toolijooa Ridge once, however the project would widen the existing highway as well as deviate to the west, resulting in a wider and an additional barrier to fauna movement along the ridge. Currently the existing Princes Highway crosses Broughton Creek once with a bridge. The project would cross Broughton Creek just south of the current crossing, also with a bridge. The two new crossings of Broughton Creek and single crossings of Broughton Mill Creek and Bundewallah Creek, on the northern fringe of Berry would also have bridge crossings. In addition, five temporary creek crossings would be required for the construction phase of the project. Vegetation removal for the creek crossings would fragment riparian connectivity along Broughton Creek, Broughton Mill Creek and Bundewallah Creek.

Most threatened species that have been recorded in the study area and/or locality are highly mobile, and would not be averse to crossing cleared areas. These include owls, parrots, cockatoos, raptors and bats. However, the project would create new barriers and exacerbate existing barriers to other threatened species with the potential to occur in the study area, such as the Black Bittern, Bush Stone-curlew, Eastern Pygmy-possum, Spotted-tailed Quoll, Yellow-bellied Glider, Koala and Long-nosed Potoroo.

Non-threatened terrestrial and arboreal mammals recorded in the study area whose movements are limited by the presence of the Princes Highway include Brown Antechinus, Bush Rat, Eastern Grey Kangaroo, Swamp Wallaby, Sugar Glider, Common Ringtail Possum, Common Brushtail Possum, Short-beaked Echidna and Common Wombat. Non-threatened birds whose movements may be limited include small birds such as thornbills, gerygones, treecreepers, scrubwrens and robins. Reptiles such as snakes and lizards would also have their movements limited.

The project without mitigation measures could result in a significant impact to corridors and connectivity (worst case scenario). However, given that the mitigation measures detailed in Chapter 5 (ie underpasses, overpasses and vegetation corridor enhancement) would be implemented, the project is unlikely to significantly impact corridors and connectivity overall. The specific impacts to wildlife corridors and habitat connectivity are discussed in Section 6.1, Section 6.2 and associated species assessments of significance (Appendices F and H).

Edge effects

Edge effects are zones of changed environmental conditions (ie altered light levels, wind speed, temperature) occurring along the edges of habitat fragments. These new environmental conditions along the edges can promote the growth of different vegetation types (including weeds) and allow invasion by pest fauna species specialising in edge habitats. Edge zones can be subject to higher levels of predation by introduced mammalian predators and native avian predators (Berry 2002). This new zone of habitat inside the edge of a fragment can also exacerbate barrier effects.

Biosis Research (2000) noted that there are limitations to edge effect studies, with a study by Murcia (1995) noting that it is unrealistic to expect all variables to vary equally with distance from the edge. As edge effects varied between community types and abiotic effects were the most consistent indicator of edge effects (measuring less than or equal to 50 metres in most studies), Biosis Research (2000) concluded that average edge effects generally occur up to 50 metres away from the road edge.

Specifically, edge effects associated with roads can include the degradation of adjacent habitat through:

- Changes in microclimate (eg temperature, wind, light humidity).
- Changes in hydrology (eg surface and sub-surface water flows).
- Changes in floristics (eg species composition and abundance).
- Alteration to the pattern and frequency of fire.
- Invasion by exotic flora and fauna species.
- Increase in sedimentation.
- Increase in tree death (eg dieback, impact on root zone).
- Increase in rubbish and water pollution.
- Improved access for predators (Bali 2000).

Edge effects may not affect both sides of the road equally and may be greater if they are downslope, downwind or surrounded by more suitable habitat (Biosis Research 2000).

Using the estimate of edge effects of 50 metres proposed by Biosis Research (2000), the subject site was buffered by 50 metres to calculate new edge effects from the project. It is calculated that the project including the permanent roadway, ancillary facilities required during construction, and diversion of Town Creek would directly impact 30.4 hectares of native vegetation (**Table 4.1**). An additional 26.7 hectares of native vegetation would be indirectly impacted by new edge effects. No OEH estates, crown land or State forests would be impacted by edge effects from the project.

4.1.3 Mortality

Fauna injury or death can occur as a result of highway construction and operation in two ways:

- During the break-out phase of construction (when all vegetation is removed to expose a natural earth substrate).

  Habitat clearance may result in the injury or death of resident or visiting fauna. Some species can more readily evade injury by flying (birds) or 'running' away (eg the larger mammals). Many species, however, are unlikely to move quickly enough to avoid being caught. For example, many nocturnal species (possums, gliders, bats) shelter during the day and smaller ground-dwelling species, such as lizards and snakes, are unable to move rapidly and over large distances.

- Road kills.

  Mortality due to road kill during operation of the project has the potential to affect local fauna species at the sub-population level. In general, rates of road kill mortality are likely to be directly proportional to the distance of native vegetation/fauna habitat crossed by the highway (Forman and Sperling 2002). However, other factors such as the design of the road (eg raised or not, presence of walls and fences) also influence road kill mortality. Generally, the effects of road kill mortality on sub-populations cannot be accurately predicted without more detailed demographic data than is available for species in the local area.

The RMS has policies and guidelines in place to manage the risk of fauna mortality during both construction and operation of the highway (Chapter 5). Despite the inclusion of mortality mitigation measures (eg staged habitat clearance during construction, and underpasses with fencing to funnel fauna under the road during operation), road kill may still occur. However, these mitigation measures would reduce the likelihood of road kill causing a significant impact on a species.

A comprehensive assessment has been carried out to determine the potential impacts of the project on native fauna including the likelihood of fauna mortality during the construction phase and ongoing operation. Despite measures to avoid, mitigate and manage the predicted direct and indirect impacts other potential sources of impact may occur as the project progresses. A worst case scenario for fauna mortality may evolve if one or a combination of the following occurs:

- Accidental clearing of native and derived plant communities and associated habitat for threatened and non-threatened terrestrial fauna resulting in additional fauna mortalities during construction.
- Project modifications resulting in additional vegetation clearing and habitat loss for threatened and general fauna that fail to adequately further assess impacts that are discrete to the project and at a broader cumulative scale.
- Project modifications resulting in elimination of some of the proposed fauna friendly crossing structures.
- Improvements in corridor connectivity and habitat quality as a result of mitigation works and biodiversity offset arrangements that expose a greater number and range of threatened or non-threatened fauna to mortality on the roadway.

4.1.4 Weed invasion

Weed invasion can be a significant problem along the edges of habitat fragments. Along these boundaries there are changes in the environment (edge effects) including altered light levels, wind speed, temperature, humidity and runoff. These altered conditions allow the colonisation and growth of weeds which would themselves result in further environmental changes that promote the colonisation and growth of weed species within the area. Due to these environmental changes, weeds may be able to out-compete native flora species and (at worst) could result in the loss of the native plant community in that area.

All areas of native vegetation recorded in the study area had existing weed infestation, with the weediest areas adjoining Broughton and Bundewallah Creeks, where the understorey of Riverbank forest was completely dominated by weed species including *Ligustrum sinense, Lantana camara, Solanum mauritianum, Ageratina riparia* and *Tradescantia fluminescens*.

Given the small size, fragmentation and poor condition of vegetation that would be impacted, the project is not likely to increase the impact of weed invasion in the study area. Although mitigation measures are recommended to reduce the existing weed infestation and the likelihood of increased weed invasion in the impacted patches and manage the potential for introduction of additional weed species (Chapter 5), there remains some potential for a worst case scenario arising as a result of:

- The accidental introduction of a WONS or noxious weed species not currently known from the locality on construction plant and equipment. In particular the introduction of a Class 1 or Class 2 noxious species.
- Project modifications resulting in additional vegetation clearing and habitat loss for threatened and general fauna that fail to adequately further assess impacts that are discrete to the project and at a broader cumulative scale.

4.2 Cumulative impacts

Assessment of the potential cumulative effects on threatened species values arising from the project includes consideration of the following:

- Impacts of other existing or proposed development projects in the locality.
- Impacts of the entire upgrade of the highway between Mount Pleasant and Bomaderry (about 30 kilometres in total), which is the last remaining two lane section of the Princes Highway between Sydney and Nowra (Section 1.4).

4.2.1 Existing and proposed development projects

The project occurs in a largely rural landscape. Consequently, much of the native vegetation in the local area has been cleared and many of the remaining remnants are small, isolated and fragmented. Furthermore, a large proportion of land in the locality is located on the floodplain, which largely precludes further development.

Existing and proposed development projects are predominately located on already cleared land within or adjacent to existing development, such as near Berry township and in the north of Bomaderry. Recent residential development within the study area at Berry includes the Arbor Retirement Village and Huntingdale Park, both of which are located in previously cleared areas. Further temporary housing and tourist park development applications have recently been submitted to Kiama Municipal Council and Shoalhaven City Council, for areas such as Toolijooa and Gerringong, however, the majority are largely within cleared areas with little impacts upon threatened species values.

Approved development in the locality includes expansion of an existing sand quarry at Gerroa (Land & Environment Court 2008), about five kilometres east of the project, adjacent to Seven Mile Beach National Park. Based on the flora and fauna assessment undertaken for the quarry expansion (Mills 2006a), a total of about 4.2 hectares of native coastal vegetation would be cleared including 1.7 hectares of Blackbutt Banksia forest, 1.6 hectares of disturbed Bangalay sand forest and 0.9 hectare of littoral rainforest. No cumulative impacts on these vegetation types are considered likely given that these coastal vegetation types are unlikely to be impacted by the project. Given the lack of habitat connectivity and distance between the quarry and the project, the magnitude of cumulative impacts on threatened fauna populations is considered to be low. Further proposed development adjoining the quarry site, including a tourist resort and golf course, have not received approval.

Approximately 20 kilometres south-west (via the Princes Highway) of Schofields Lane begins the South Nowra project: Princes Highway upgrade, Kinghorne Street to Warra Warra Road, to Forest Road, South Nowra. The South Nowra project involves approximately 6.3 kilometres of Princes Highway upgrades including the construction of a four lane divided carriageway (RTA 2009a; RTA 2009b). Based on the flora and fauna assessments undertaken for the Kinghorne Street to Warra Warra Road section (NGH 2009) and Warra Warra Road to Forest Road section (Hayes Environmental cited in RTA 2009a), the following native vegetation would be cleared: 2.2 hectares of Currambene-Batemans lowlands forest, 2.6 hectares of Southern lowland wet forest, 0.05 hectares of Floodplain swamp forest (EEC), 0.08 hectares of South Coast lowland swamp woodland (EEC), 1.3 hectares of Disturbed edge vegetation, and 9 hectares of Open eucalypt forest. Minor cumulative impacts would occur for Currambene-Batemans lowlands forest only.

Currambene-Batemans lowlands forest is not an EEC however provides potential habitat for three threatened flora species: *Cryptostylis hunteriana*, *Caladenia tessellata* and *Thesium australe*. Only 0.0002 hectares of Currambene-Batemans lowland forest would be directly impacted by the proposed Foxground and Berry bypass project, which equates to less than 0.01 per cent of the total to be cleared by both projects. Known habitat for the Green and Golden Bell Frog occurs within the South Nowra project (Currambene-Batemans lowland forest) and potential habitat occurs for this species within the proposed Foxground and Berry bypass project (constructed wetlands). Only 0.4 hectares of potential habitat would be directly impacted by the proposed Foxground and Berry bypass project, which equates to 15.0 per cent of the total to be directly affected by both projects. The total area to be directly impacted by both projects (2.6 hectares) equates to approximately 0.02 per cent of the same plant communities available with 30 kilometres (16,336.00 hectares) of the Foxground and Berry bypass project (which includes all of the South Nowra Project). Given the lack of habitat connectivity and distance between the proposed Foxground and Berry bypass project and the South Nowra project, the magnitude of cumulative impacts on threatened fauna populations is considered to be low.

4.2.2 Princes Highway upgrade between Gerringong and Bomaderry

A detailed options and constraints analysis process was used to inform the selection of the preferred option for the project and impacts have largely been avoided where possible by following the existing highway alignment or previously cleared land.

However, the project is one of a series of upgrades to sections of the Princes Highway which aims to provide a four lane divided highway between Waterfall and Jervis Bay Road, Falls Creek to improve road safety and traffic efficiency, including for freight, on the NSW south coast and needs to be considered in this context.

An assessment of the cumulative impacts associated with the project requires consideration of the proposed overall upgrade of the highway between Mount Pleasant and Bomaderry (about 30 kilometres in total) which, with the recent opening of the Oak Flats to Dunmore upgrade, remains the only two lane section of the Princes Highway between Sydney and Nowra. The highway between Mount Pleasant and Bomaderry would be upgraded in three sections.

Table 4.2 provides a summary of impacts to vegetation (including fauna habitat) within the subject site (area of direct impacts) and study area (area of direct impacts plus areas subject to potential indirect impacts) for each of the three remaining sections of the Princes Highway still to be upgraded as part of the RMS's overall upgrade of the Princes Highway. The remaining sections include the recently determined Gerringong upgrade project, the Foxground and Berry bypass project (this project) and the proposed Berry to Bomaderry upgrade project to the south, which is currently in the planning phase. About 80 per cent of direct impacts on plant communities and fauna habitats associated with the upgrade of these three sections of highway are attributable to this project (as shown in **Table 4.2**).

Consideration of the cumulative impacts on vegetation and fauna habitat for the three remaining sections of the Princes Highway still to be upgraded does not change the conclusions of impact assessments (Section 6.1.4 and Section 6.2.4) undertaken for threatened biota either occurring or potentially occurring in the study area. Impact mitigation measures that have been proposed in Chapter 5 are specific to the Foxground and Berry bypass project and these will maintain or improve biodiversity values for the threatened flora and fauna (or potential habitats) that may be affected by the project. Despite avoidance and mitigation measures, the project would result in a residual impact through the permanent loss of about 2.9 hectares of the EEC River-flat eucalypt forest. The preparation and implementation of an Offset Package based on the Offset Strategy in Appendix E would address the residual impact on River-flat eucalypt forest to achieve a maintain or improve outcome. The Offset Strategy in Appendix E has not considered cumulative impacts to River-flat eucalypt forest for the other two Princes Hwy upgrades.

Table 4.2: Area (hectares) of each plant community impacted by the upgrade of the three remaining two lane sections of the highway between Mount Pleasant and Bomaderry

Plant community	EEC	Gerringong upgrade		Foxground and Berry bypass		Berry to Bomaderry upgrade		Cumulative total (direct and indirect)
		Direct impact	Indirect impact	Direct impact	Indirect impact	Direct impact	Indirect impact	
Closed grassland				0.4	0.5			**0.900**
Closed grassland/sedgeland				2.2	0.3			**2.500**
Coastal saltmarsh	Yes		1.06					**1.062**
Coastal warm temperate rainforest	Yes						0.20	**0.196**
Constructed wetland				0.4	0.3			**0.700**
Currambene-Batemans lowlands forest				0.0002	2.44	3.19	6.87	**12.500**
Disturbed riparian open woodland				2.6	1.2			**3.800**
Illawarra gully wet forest				15.4	10.1	0.24	0.92	**26.66**
Revegetation							0.56	**0.563**
Riverbank forest	Yes			2.9	7.1	0.03	0.44	**10.470**
Subtropical dry rainforest	Yes	0.01	0.52					**0.521**
Warm temperate layered forest				6.9	5.3			**12.200**
Totals (hectare)		**0.01**	**1.58**	**30.80**	**27.24**	**3.46**	**8.99**	**72.080**
% of cumulative total (direct and indirect)		**0.01**	**2.21**	**42.75**	**37.79**	**4.83**	**12.56**	**-**

5 Management and mitigation

The RMS' road development and impact on habitat amelioration policy states that "in principle, the planning and construction of roads should, in order of consideration endeavour to:

1. Avoid impacts on habitat though the planning process.
2. Minimise impacts on habitat through the planning process.
3. Mitigate impacts on habitat, through the use of a range of amelioration measures (RTA 2001)".
4. Offset unavoidable residual impacts.

After implementing the above amelioration policy, any residual impacts would be offset.

Where possible, important ecological features identified in the local area have been **avoided** during the options and route selection stage, such as patches of Illawarra subtropical rainforest. The project has been designed, where feasible, to **minimise** impacts on habitat. In areas where significant vegetation is located, the land area of the subject site incorporating the road footprint and construction access requirements has been reduced to minimise potential impacts.

A number of measures to **mitigate** the potential impacts on biodiversity resulting from the project have been investigated during the preliminary phases of this assessment including construction of fauna overpasses (including a land bridge, glider poles and canopy bridges) and fauna underpasses (including road bridges and fauna-friendly culverts) with fauna exclusion fencing.

The resulting management, mitigation and **offset** measures (discussed in detail below) have been developed to maintain and/or improve biodiversity.

5.1 Vegetation clearing and habitat loss

In order to mitigate the removal or modification of 30.4 hectares of native vegetation in the subject site, including 2.9 hectares of EEC, and potential disturbance to 26.7 hectares, including 7.1 hectares of EEC, in the study area it is recommended that:

- The existing corridor along Broughton Creek would be enhanced through revegetation including connection to Toolijooa Ridge vegetation.
- Department of Primary Industries, Fisheries to be consulted for input, in relation to matters relevant to Fisheries, into relocation of Town Creek.
- The flow along the current Town Creek alignment should be maintained through appropriate design.
- Vegetation clearing is restricted to those areas where it is necessary and opportunities to minimise clearing would be part of the detailed design. Where possible, effort would be made to retain habitat trees within the subject site. In addition, vegetation in proximity to rope bridges would be retained and protected during construction to encourage arboreal fauna to use the rope bridges (see Section 5.3.5).
- Where clearing does occur, the area would be fenced with highly visible temporary fencing to ensure that clearing does not extend beyond the area necessary, in accordance with Guide 2 Exclusion zones of the RMS 'Biodiversity Guidelines' (RTA 2011).

- Clearing of vegetation would comply with RMS 'Biodiversity Guidelines: Guide 1 The pre-clearing process' (RTA 2011). The guidelines cover the felling of both non-habitat and habitat trees and the rescue and relocation of fauna.
- Prior to construction, a hollow-bearing tree/stag survey and stag-watching would be carried out in order to identify the number and type of nest boxes required and where to install them. Installation of bat roost and nest boxes would take place at least one month prior to the commencement of construction. The optimal season for stag-watching is spring; a hollow-bearing tree/stag survey however, can be conducted any time of year. Bat roost and nest boxes would be installed at a ratio of 1:1 for each hollow removed by the project. Prior to construction, a survey of any bridges or culverts scheduled for removal would be carried out in order to detect roosting microbats. If detected, a Bat Management Plan would be prepared.
- Vegetation within the road reserve and adjacent to areas of vegetation clearing would be managed to reduce invasion of noxious weed species; this may include controlling weeds at their point of source (ie the area of clearing) and in accordance with Guide 6 Weed management and Guide 10 Aquatic habitats and riparian zones of the RMS 'Biodiversity Guidelines' (RTA 2011).
- A VMP would be prepared prior to construction, detailing restoration, regeneration and rehabilitation of areas of native vegetation in the vicinity of the project. The VMP would also detail appropriate management for the potential habitat of threatened flora species in the vicinity of the project, including monitoring during and after construction works to ensure impacts are minimised. Appropriate management may include fencing the habitat; signage and educating contractors on the presence of habitats, their significance and no-go zones. In addition sugar cane mulch would not be used for revegetation and/or landscaping works (to minimise risk of cane toad introduction/spread). The VMP would be integrated with the landscape plan for the project and its preparation should involve consultation with local Landcare groups and the CMA. The VMP should recommend the input of these stakeholders to ensure the use of local expertise and resources such as local provenance seed sources.
- Residual impacts resulting from the mitigated removal or modification of vegetation and habitats would be compensated for through the implementation of a biodiversity offset strategy (see Section 5.7).
- During detailed design, refinements may be made to the design features and construction methods to further minimise vegetation clearing.

5.2 Edge effects

Mitigation measures related to edge effects relate generally to reducing impacts outside of the direct development zone, controlling possible impacts at their source within the road reserve and reducing the hardness of the edge between the extent of earthworks and native vegetation. Measures that are relevant to the project include:

- Minimising disturbance to habitat adjacent to construction (eg the use of visible temporary fencing).
- Minimising disturbance wherever possible to stream banks and streambeds through avoidance of the use of instream structures. This would be achieved in the case of permanent and temporary creek crossings (ie bridges with no instream structures will be used), however would be impossible in the case of culverts.
- Locating all ancillary building and works in cleared or otherwise disturbed areas away from waterways and other sensitive areas.
- Avoiding stockpiling materials on adjacent vegetation. Adjacent vegetation would be designated as an 'environmentally sensitive area', and fenced off (in accordance with the RMS 'Biodiversity Guidelines: Guide 2 – Exclusion Zones' (RTA 2011)).
- Managing general construction activities to appropriately store waste material and/or contaminants away from adjacent habitats.
- Implementing soil erosion and sedimentation control measures.
- Implementing a weed management strategy within the road reserve, to be incorporated into the VMP and that references Guide 6 Weed management and Guide 10 Aquatic habitats and riparian zones of the RMS 'Biodiversity Guidelines' (RTA 2011).
- Using locally indigenous (local provenance) species for revegetation and restoration (non-native species would only be used for landscaping where culturally appropriate and in locations identified within the urban and landscape design strategy).

5.3 Corridors and connectivity

In order to minimise and mitigate the potential impacts of habitat/corridor fragmentation, it is proposed to enhance the existing riparian corridor along Broughton Creek through revegetation and connect the Broughton Creek corridor to Toolijooa Ridge through additional revegetation. The preparation of a VMP would detail restoration methods, performance measures and a monitoring programme to ensure restoration works achieve objectives. Optimally the VMP would integrate with the landscape plan for the project and be prepared in consultation with local Landcare groups and the CMA committing to input local expertise and resources during implementation. Residual impacts resulting from the loss of riparian vegetation are discussed in the offset strategy (Appendix E).

In addition, underpasses (eg bridges and culverts) and overpasses (eg rope bridges) will be designed to assist the safe passage of fauna underneath and/or over the highway. Although the inclusion of a land bridge was considered, it was decided in consultation with the former DECCW (now OEH), that the proposed mitigation measures (ie underpasses and rope bridges) and strategic revegetation would have a better long term outcome for biodiversity in the locality.

The following sections provide a description of the various fauna mitigation structures and their ability to mitigate the impacts of roads. They also describe in detail the proposed design and location of these structures in relation to the project.

5.3.1 Background on fauna-friendly crossing structures

Generally fauna underpasses have been found to work well (Bond and Jones 2008, Goosem 2005, AMBS 2002, AMBS 1997). Species that have been found to use underpasses include a range of terrestrial mammals including dasyurids, macropods (mostly large span bridges), rodents, bandicoots and bats as well as reptiles and amphibians (Bond and Jones 2008, AMBS 2002). Monitoring of rope bridges has shown that a range of possum species will utilise these structures (Goosem *et al.* 2005). Gliding mammals are largely dependent on tree cover to traverse a landscape (Ball and Goldingay 2008) and are particularly sensitive to habitat fragmentation (Goldingay and Taylor 2009). Ball and Goldingay (2008) found that wooden poles (ie glider poles) installed across a gap in tree cover (eg highway) have the potential to connect habitat patches for gliding mammals and allow dispersal through a fragmented landscape. Fauna fencing, to funnel animals towards under and over passes (and away from the road), has been found to be extremely effective in preventing most road-kill, except following human-related breaches in the fence (Bond and Jones 2008).

Various studies, within Australia and internationally, looking at the effectiveness of fauna-friendly crossing structures have found different periods of acclimatisation were required before a species utilised an underpass or overpass to make a full crossing. Factors such as the subject species, local environment, size and length of the crossing and proximity to habitat may affect the length of time a species takes to become accustomed to a new crossing structure. A number of studies undertaken within Australia (particularly NSW and QLD) have found that a reasonable diversity of fauna will utilise crossing structures within months of construction, with the number of species (or species groups) utilising a crossing structure increasing over time (Fitzgerald 2005, Veage and Jones 2007, Bond and Jones 2008).

5.3.2 Underpasses

Underpasses (eg bridges and culverts) can be either constructed solely for the purpose of fauna movements or can be modified from existing structures such as box culverts (AMBS 2002). Suitability of the structures as fauna underpasses depends on a number of factors including:

- The regional continuity of habitat in the area.
- Habitat directly on either side of the structure.
- Proximity to vegetation cover either side of the structure.
- Unimpeded view of habitat on the other side of the structure.
- Road width, traffic volume and associated noise.
- The dimensions of the structure (width, height and length).
- The species in the local area.

Ideally, fauna crossing structures should be located where regular crossing and/or migration pathways are identified (Veage and Jones 2007). Structures such as exclusion fences and fauna ‘furniture’ can also increase the effectiveness of underpasses (Bond and Jones 2008) (Goosem *et al.* 2005).

A bridge for each of the three creek crossings at Broughton Creek and one each for Broughton Mill Creek and Bundewallah Creek would provide incidental fauna underpasses. These bridges would help to facilitate fauna movement along the Broughton Creek corridor and other local riparian corridors.

The bridges would be of sufficient height (ranging from 8 to 20 metres) to allow light to filter underneath the bridge for vegetation growth and to provide a suitable environment for fauna crossing. Each bridge would also be of sufficient length (ranging from 80 to 600 metres) to enable a width of at least 10 metres between the embankment and the creek edge. Where appropriate, fauna fencing would be installed at the western end of the bridge at Berry. Due to the reasonable height of the Broughton Creek crossings above the existing riparian vegetation, and that each creek will be crossed perpendicularly within a predominantly cleared area, fauna fencing is not recommended at these crossings. However, should road kill become an issue during the operational phase of the highway upgrade at these locations, fauna fencing may be required.

In addition to the incidental bridge crossings, four dedicated fauna underpasses would be included. As shown in **Table 5.1** dedicated box culvert underpasses would be installed on Toolijooa Ridge and about 300 metres east of Tindalls Lane. A dual use box culvert with dedicated fauna passage would be installed about 600 metres and 1200 metres east of Tindalls Lane. These dedicated box culverts would be designed to serve as fauna underpasses by ensuring sufficient dry passage and clearance. Fauna 'furniture' such as rocks, piping, raised log railings and refuge poles would be included within the dedicated dry passage part of the culverts. Refuge poles are timber poles erected within and/or at the entrances to fauna underpasses to allow arboreal mammals a place to seek refuge should they encounter a terrestrial predator whilst attempting to make a crossing. Fauna fencing would be used on all four dedicated fauna underpasses and extend at least 200 metres either side of the underpass to funnel fauna toward the crossing structure.

The Southern Rivers CMA and Berry Landcare group have been consulted as part of this environmental assessment. The dual use box culvert to be installed about 1200 metres east of Tindalls Lane was included in the design of the project as part of this consultation. The fauna mitigation structures proposed for the project would ensure that the project would support the Southern Rivers CMA and Berry Landcare's long term goal of restoring the 'escarpment to sea' corridor.

5.3.3 Rope bridges

Aerial overpasses (rope/canopy bridges) have been recommended for Australian roads (Goosem and Marsh 1997, QDMR 2000, QDMR 1997, QDMR 1998, AMBS 2001a, Bax 2006). These may comprise simple rope bridges, rope 'ladders' or more elaborate tunnel-like structures, which span the full road width. Recent studies have found that arboreal mammals will use all types of rope bridges however they tend to cross tunnel-like structures across the top surface (Goosem *et al.* 2005 and Bax 2006).

Bax (2006) monitored one of five rope tunnel canopy bridges at the Karuah Bypass (about three hours north of Sydney). During the study (lasting 244 days), an infrared camera recorded 50 crossings, 46 from brushtail possums and four from squirrel gliders, proving that arboreal mammals would cross a road (in this case a distance of 70 metres) using aerial overpasses (Bax 2006). During a study of rope bridges at two locations along the Hume Highway, Victoria, infrared cameras recorded Squirrel Gliders, Brush-tailed Phascogales, Common Brushtail Possums and Common Ringtail Possums all using the rope bridges (in this case a distance of 70 metres). The cameras confirmed complete crossings by both the Squirrel Glider and Common Ringtail Possum (Soanes and Van der Ree).

A number of rope bridges would be included in the design as show in **Table 5.1**. Rope bridges would be located at all creek crossings, on Toolijooa Ridge and east of Tindalls Lane. At Broughton Creek Bridges 1 and 2, rope bridges would extend both over and under each of the bridges.

5.3.4 Glider poles

Glider poles (different to refuge poles discussed above) may assist with the movement of some arboreal mammals across large forest gaps, such as road corridors (eg where existing vegetation is of insufficient height to permit successful and safe gliding across the road corridor). Glider poles consist of a simple timber pole located in a position that allows gliders to breach large gaps or increases the functional take-off height in forest that is insufficient in height to allow safe crossing. Other features may include a 'predator shield' and horizontal cross members to assist launching (Goldingay 2010) or instead of a single pole, an array of poles might be more effective. Glider poles have been installed in a number of road projects in NSW to provide connectivity for gliders. A study of glider poles across a paddock (five 12 metre poles across a 70 metre gap) showed regular usage by Squirrel Gliders (Ball and Goldingay 2008). A recent review of glider pole locations for the Oxley Highway Deviation (about five hours north of Sydney) found that poles 30 metres in height (or 25 metre high poles situated closer to the road) were required for successful glides across distances of up to 56 meters (Goldingay 2010).

Due to the extreme height of glider poles that would be required for successful gliding over the new highway (50 metre tall poles), and the structure-free-median design of the new highway, glider poles are not recommended. Instead additional rope bridges (rope bridges under bridges) have been included in the design. The only glider previously recorded within the study area, the Sugar Glider, is known to successfully utilise rope bridges (RTA 2009c). It is important that barbed wire fencing is not installed within the vicinity of rope bridges and associated poles ("crossing zones") as gliders crossing at these locations can be caught in the wire and killed.

5.3.5 Maintaining connectivity

The functional efficiency of the proposed fauna-friendly bridges and culverts can be improved by retaining roadside vegetation that is in the immediate vicinity with these structures. This would require the retention of vegetation 'fingers' at strategic points along the road corridor that correspond to identified movement corridors. To provide an immediate functional movement corridor across the road corridor it is essential that the vegetation at these points is maintained and allowed to encroach or remain up to the road edge. However, it is also important that fauna have an unimpeded view of underpasses and the habitat or horizon on the other side (Veage and Jones 2007). At crossing structure entrances, fauna fencing must have a wide opening and be directly joined to the crossing structure to encourage usage by fauna (ERM Mitchell McCotter 1999, Abigroup 2007). Given the obvious hazards to traffic from the close proximity of vegetation, it is recommended that fauna exclusion fencing be modified to incorporate a crash barrier component at these points.

Riparian vegetation under bridges, at temporary creek crossing sites, adjacent to ancillary sites and in the vicinity of rope bridges should be retained and protected during construction to maintain access to these structures. Similarly, roadside vegetation in the vicinity of rope bridges should be retained and protected. These areas should be designated as an 'environmentally sensitive area', fenced off and marked up on construction maps, in accordance with the RMS 'Biodiversity Guidelines: Guide 2 – Exclusion Zones' (RTA 2011).

Where vegetation clearance within the subject site is unavoidable, revegetation under bridges, at temporary creek crossings, at ancillary sites and in the vicinity of rope bridges should be undertaken to maintain connectivity.

5.3.6 Site selection

The following combination of bridges and culverts (underpasses), and rope bridges would be installed in order to retain connectivity in vegetated areas that form part of local or regional corridors (corridors discussed in Section 3.8). **Table 5.1** below provides the nominated locations for these structures. These locations are shown in **Figure 5.1** to **Figure 5.4**.

Table 5.1: Fauna mitigation structures

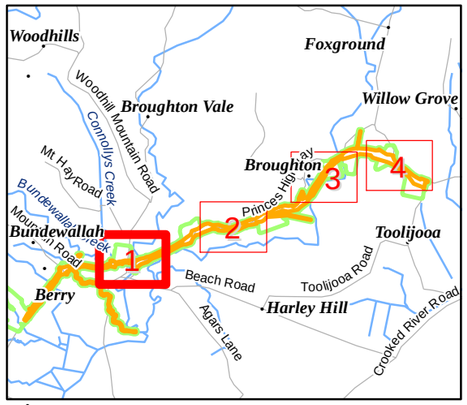
Location	Design chainage (m)	Recommended structures	Target species (* threatened species)
Toolijooa Ridge	8450	• Dedicated fauna underpass (separate to local traffic underpass at chainage 8400) • Fauna fencing • Fauna furniture within underpass	Spotted-tailed Quoll* Long-nosed Potoroo* Bush Stone-curlew* Koala* Brown Antechinus Bush Rat Eastern Grey Kangaroo Swamp Wallaby Short-beaked Echidna Common Wombat
Toolijooa Ridge	8500	• Minimum of three connecting rope bridges: one over existing highway, one over new highway, at least one on south-western side of new highway to nearby stand of vegetation • Exclusion zone fencing during construction to retain and protect existing trees and vegetation in vicinity of rope bridges	Yellow-bellied Glider* Sugar Glider Common Brushtail Possum Common Ringtail Possum
Broughton Creek crossings x 3	9950, 10700, 11200	• Bridge (underpass) at each crossing • Scattered hollow logs sourced from approved clearing zones within the subject site, and supplementary metal pipe tunnels (to provide fauna refuge and shelter opportunities)	Spotted-tailed Quoll* Black Bittern* Long-nosed Potoroo* Bush Stone-curlew* Koala* Brown Antechinus Bush Rat Eastern Grey Kangaroo Swamp Wallaby Short-beaked Echidna Common Wombat reptiles amphibians
Broughton Creek bridge 1	9990	• Three connecting rope bridges: one over existing highway, one over new bridge and one under new bridge • Exclusion zone fencing during construction to retain and protect existing riparian vegetation in vicinity of rope bridges	Yellow-bellied Glider* Sugar Glider Common Brushtail Possum Common Ringtail Possum

Location	Design chainage (m)	Recommended structures	Target species (* threatened species)
Broughton Creek bridge 2	10700	• Two rope bridges: one over new bridge and one under new bridge • Exclusion zone fencing during construction to retain and protect existing riparian vegetation in vicinity of rope bridges	Yellow-bellied Glider* Sugar Glider Common Brushtail Possum Common Ringtail Possum
Broughton Creek bridge 3	11200	• Three rope bridges: two under new bridge (one to each side of creek) and one adjacent to new bridge (crossing the creek) • Exclusion zone fencing during construction to retain and protect existing riparian vegetation in vicinity of rope bridges	Yellow-bellied Glider* Sugar Glider Common Brushtail Possum Common Ringtail Possum
Princes Highway about 1200 metres east of Tindalls Lane	12770	• Dual use box culvert underpass (one side raised and dry for dedicated fauna passage) • Fauna fencing • Fauna furniture within underpass	Spotted-tailed Quoll* Long-nosed Potoroo* Bush Stone-curlew* Koala* Brown Antechinus Bush Rat Eastern Grey Kangaroo Swamp Wallaby Short-beaked Echidna Common Wombat Reptiles Amphibians
Princes Highway about 600 metres east of Tindalls Lane	13320	• Dual use box culvert underpass (one side raised and dry for dedicated fauna passage) • Fauna fencing • Fauna furniture within underpass	Spotted-tailed Quoll* Long-nosed Potoroo* Bush Stone-curlew* Koala* Brown Antechinus Bush Rat Eastern Grey Kangaroo Swamp Wallaby Short-beaked Echidna Common Wombat Reptiles Amphibians

Location	Design chainage (m)	Recommended structures	Target species (* threatened species)
Princes Highway about 600 metres east of Tindalls Lane	13360	• One rope bridge over new highway • Exclusion zone fencing during construction to retain and protect existing trees and vegetation in vicinity of the rope bridge	Yellow-bellied Glider* Sugar Glider Common Brushtail Possum Common Ringtail Possum
Princes Highway about 300 metres east of Tindalls Lane	13680	• Dedicated fauna underpass • Fauna fencing • Fauna furniture within underpass	Spotted-tailed Quoll* Long-nosed Potoroo* Bush Stone-curlew* Koala* Brown Antechinus Bush Rat Eastern Grey Kangaroo Swamp Wallaby Short-beaked Echidna Common Wombat Reptiles Amphibians
Princes Highway about 300 metres east of Tindalls Lane	13700	• Minimum of two connecting rope bridges: one over new highway and at least one on northern side of highway to nearby vegetation • Exclusion zone fencing during construction to retain and protect existing trees and vegetation in vicinity of rope bridges	Yellow-bellied Glider* Sugar Glider Common Brushtail Possum Common Ringtail Possum
Broughton Mill Creek	15900	• One rope bridge joining riparian vegetation under new bridge at Berry • Exclusion zone fencing during construction to retain and protect existing riparian vegetation in vicinity of the rope bridge	Yellow-bellied Glider* Sugar Glider Common Brushtail Possum Common Ringtail Possum

Location	Design chainage (m)	Recommended structures	Target species (* threatened species)
Bridge at Berry	16000	• Bridge (underpass) over Broughton Mill Creek & Bundewallah Creek (Connollys Creek) • Scattered hollow logs sourced from approved clearing zones within the subject site, and supplementary metal pipe tunnels (to provide fauna refuge and shelter opportunities) • Fauna fencing (western end of bridge, northern side of bridge only)	Spotted-tailed Quoll* Long-nosed Potoroo* Bush Stone-curlew* Koala* Brown Antechinus Bush Rat Eastern Grey Kangaroo Swamp Wallaby Short-beaked Echidna Common Wombat Reptiles Amphibians
Bundewallah Creek (Connollys Creek)	16250	• Two rope bridges under the new bridge (Bridge at Berry) • Exclusion zone fencing during construction to retain and protect existing riparian vegetation in vicinity of rope bridges	Yellow-bellied Glider* Sugar Glider Common Brushtail Possum Common Ringtail Possum





Legend

- Bridge (underpass)
- Dedicated Fauna Underpass
- Dual Use Underpass
- Fauna Fencing
- Rope Bridge Adjacent to Bridge
- Rope Bridge Over Road
- Rope Bridge Under Bridge
- Rope Bridge Over and Under Bridge
- Subject Site - Footprint
- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 5.1: Fauna Mitigation Structures

Date: 11 January 2012	Drawn by: RS/JS
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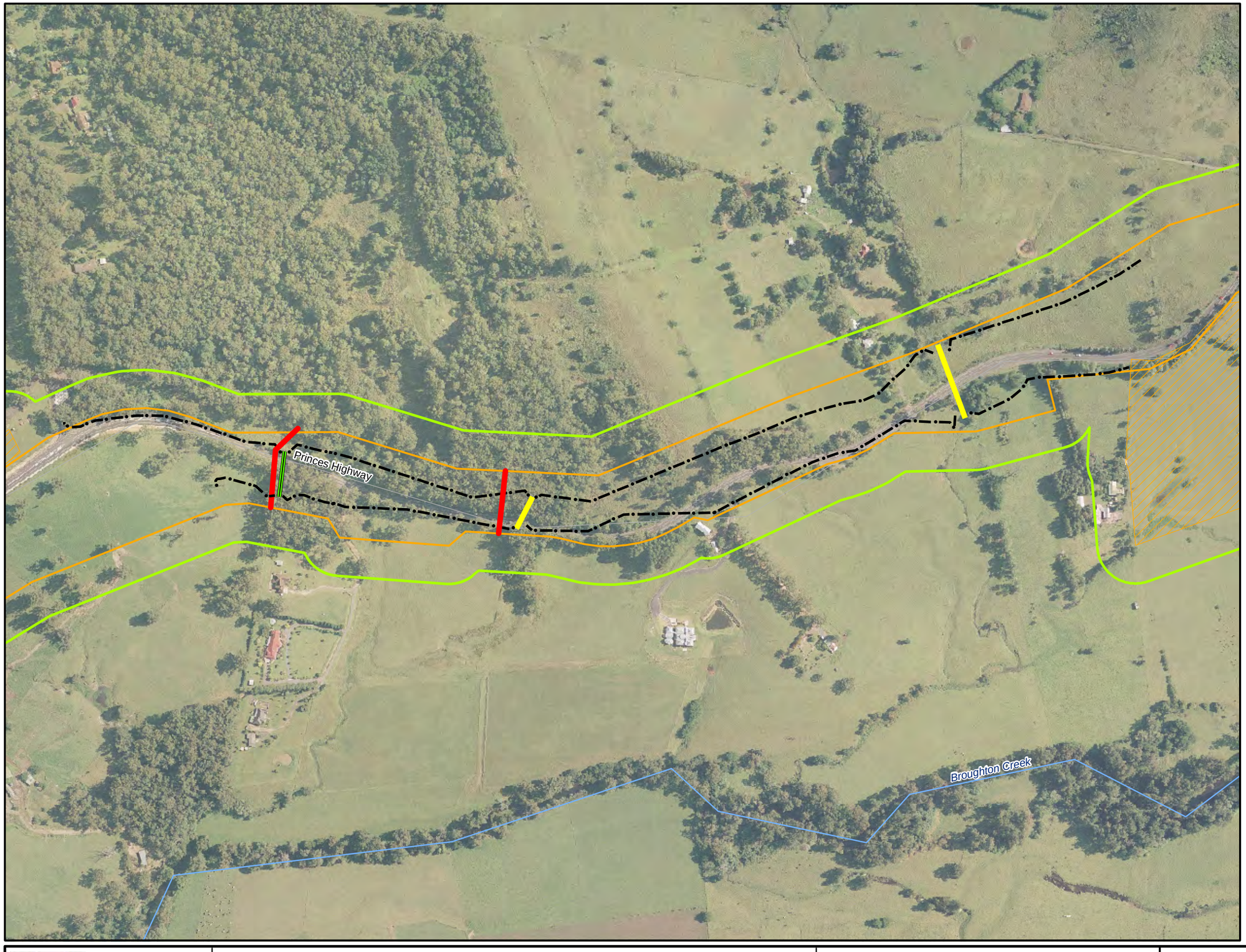
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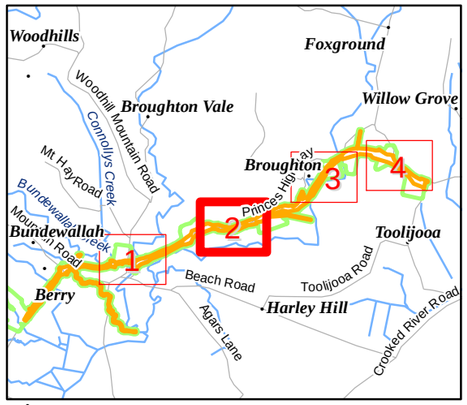
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Scale: 1:5,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 55

N

Figure 5.1





Legend

- Bridge (underpass)
- Dedicated Fauna Underpass
- Dual Use Underpass
- Fauna Fencing
- Rope Bridge Adjacent to Bridge
- Rope Bridge Over Road
- Rope Bridge Under Bridge
- Rope Bridge Over and Under Bridge
- Subject Site - Footprint
- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 5.2: Fauna Mitigation Structures

Date: 11 January 2012	Drawn by: RS/JS
File: 13194	Checked by: JC
Location:P:\13100s\13194\Mapping\Draft 7\13194_S2_F5-1_Fauna_Migitgation_Structures_100112.mxd	

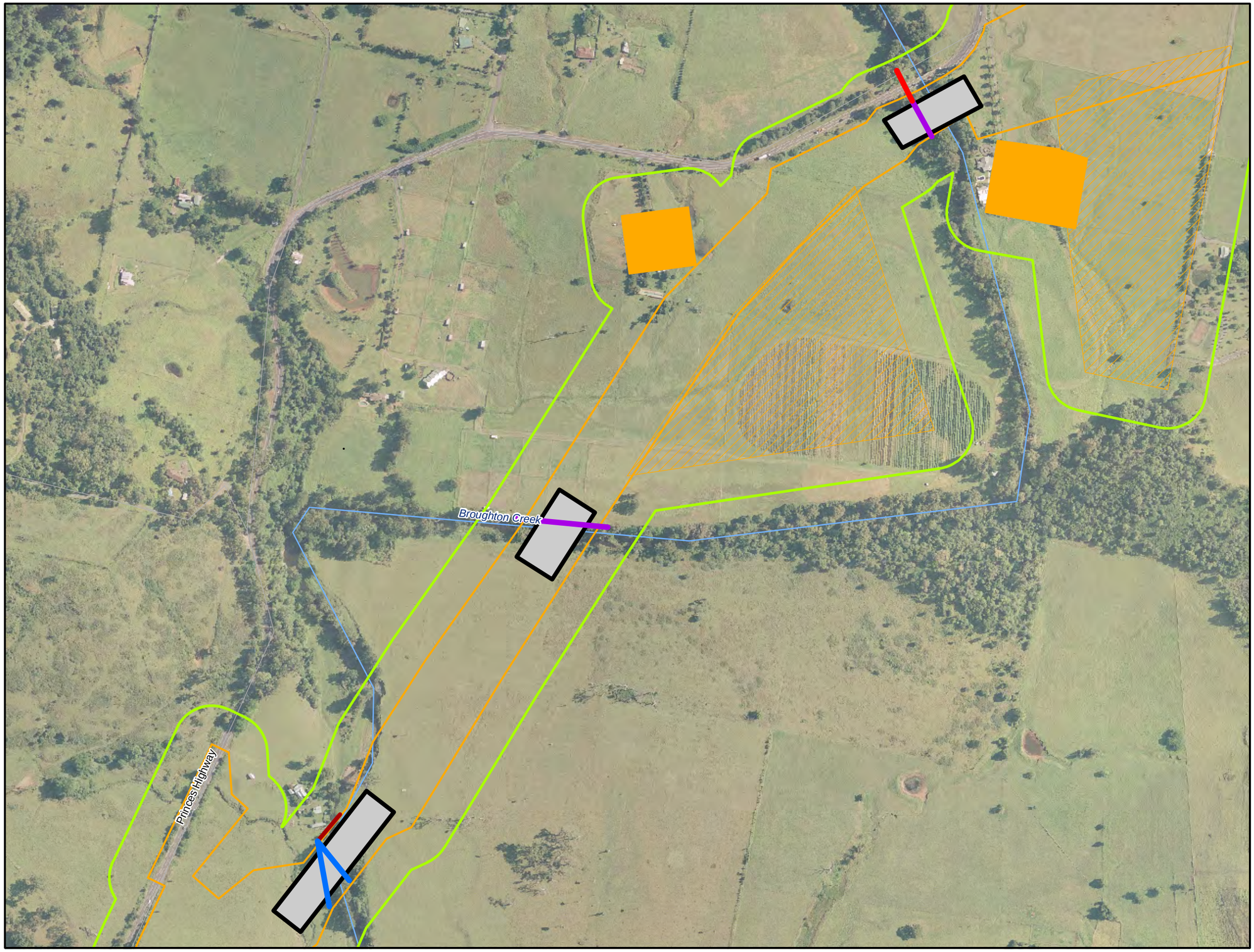
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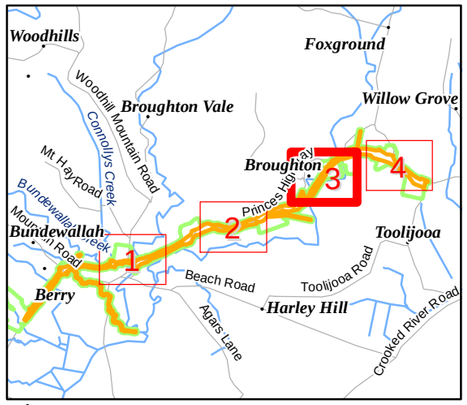
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Metres

Scale: 1:5,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 55

N

Figure 5.2





Legend

- Bridge (underpass)
- Dedicated Fauna Underpass
- Dual Use Underpass
- Fauna Fencing
- Rope Bridge Adjacent to Bridge
- Rope Bridge Over Road
- Rope Bridge Under Bridge
- Rope Bridge Over and Under Bridge
- Subject Site - Footprint
- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 5.3: Fauna Mitigation Structures

Date: 11 January 2012	Drawn by: RS/JS
File: 13194	Checked by: JC
Location:P:\13100s\13194\Mapping\Draft 7\13194_S2_F5-1_Fauna_Migitgation_Structures_100112.mxd	

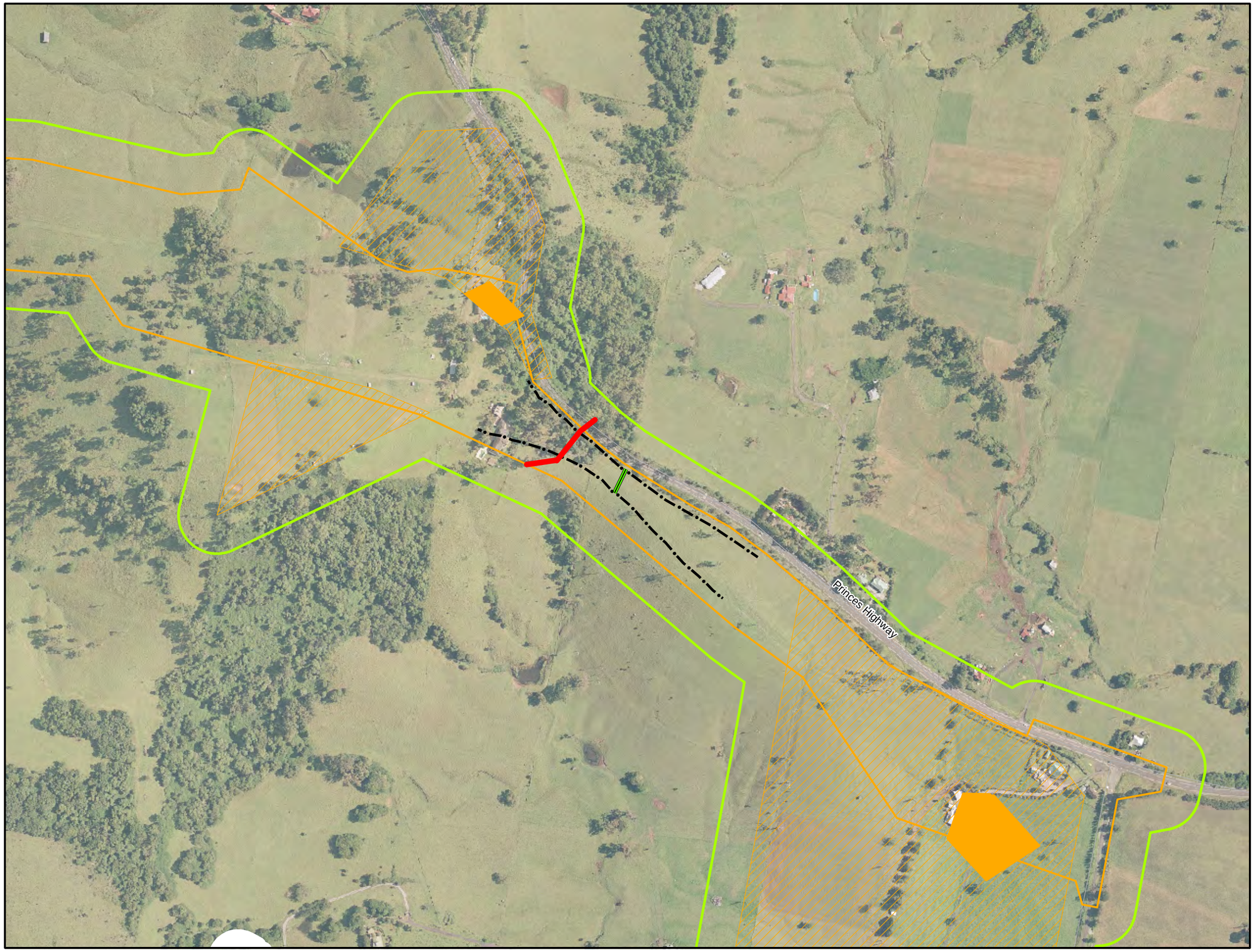
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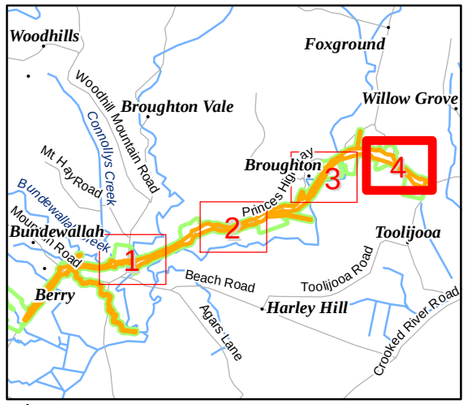
0 30 60 120 180 240
Metres

Scale: 1:5,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 55

N

Figure 5.3





Legend

- Bridge (underpass)
- Dedicated Fauna Underpass
- Dual Use Underpass
- Fauna Fencing
- Rope Bridge Adjacent to Bridge
- Rope Bridge Over Road
- Rope Bridge Under Bridge
- Rope Bridge Over and Under Bridge
- Subject Site - Footprint
- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 5.4: Fauna Mitigation Structures

Date: 11 January 2012	Drawn by: RS/JS
File: 13194	Checked by: JC
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0 30 60 120 180 240
Metres

Scale: 1:5,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 55

N

Figure 5.4

5.4 Mortality

It is recommended that the following management measures be implemented to reduce the risk of mortality.

Prior to and during construction

- Minimise clearance and disturbance of fauna habitat, particularly hollow-bearing trees and other habitat features where fauna may be sheltering. Although this may be difficult to achieve in areas where earthworks are to proceed, it should be particularly noted within the road reserve where temporary sites such as stockpiles may be placed.
- Clearing of vegetation would be undertaken in accordance with Guide 1 Pre-clearing process and Guide 4 Clearing of vegetation and removal of bushrock of the RMS 'Biodiversity Guidelines' (RTA 2011). These guides include procedures for clearing of non-habitat and habitat trees, the relocation of rescued fauna and the inclusion of wildlife specialists in the process.

To reduce the risk of roadkill once the highway is operational

- Implementation of fauna fencing as described in Section 5.3 to encourage fauna to cross the road under bridges and/or through culverts as opposed to the across the highway's surface.
- Avoid vegetation overhanging fauna fences that may encourage fauna crossing into the road reserve.
- Carefully consider the location and type of flora species for the verges and median strip so that they do not attract fauna species.
- Avoid the use of barbed wire fencing at glider crossing zones.

The above management measures would be included within the Construction Environmental Management Plan developed for the project.

5.5 Weeds

Management of weeds is outlined in Guide 6 Weed management of the RMS 'Biodiversity Guidelines' (RTA 2011). The objective of the weed management guide is to prevent or minimise the spread of noxious and environmental weed species on all RMS project sites and during maintenance works. In summary the RMS 'Biodiversity Guidelines' outline requirements for management of terrestrial and aquatic environmental and noxious weeds during construction and suggests best practice methods for weed management during maintenance works (RTA 2011).

In addition to the measures and management practices recommended in the RMS 'Biodiversity Guidelines' (RTA, 2011) the following actions should be implemented to reduce the impact of weed invasion on native plant communities:

- Restrict the area of native vegetation disturbed during construction works.
- Restrict stockpiling to areas already cleared of vegetation.
- Control drainage that may contain weed seeds or high levels of nutrients.
- Use weed-free topsoil in landscaping and revegetate disturbed sites with locally indigenous species (local provenance). Revegetation using stockpiled soil would also include planting local native species to stabilise the soil as well as ongoing weed control. Non-native species would only be used for landscaping where culturally appropriate and in locations identified within the urban and landscape design strategy.
- Monitor and control weed populations that establish in disturbed areas, with particular attention to eradication of noxious weeds. Weed invasions would be monitored and controlled by a person experienced in weed management.
- Weed management strategies would be incorporated into the VMP, detailing necessary weed control works, particularly in areas where the weeds may impact on threatened species and/or their habitats.
- Development and implementation of the VMP would be the responsibility of the RMS during the construction phase of the project. The party responsible for the implementation of the VMP during the operational phase of the project (RMS or Council) would be decided prior to commencement of the project.

Further detail on the methods to implement the actions recommended above are suggested in the RMS 'Biodiversity Guidelines' including a reference list of supporting documents and specific detailed weed management guides (RTA 2011).

5.6 Monitoring

Monitoring is an important part of any environmental management/mitigation strategy as there is generally not just one technique that can be applied to achieve any particular ecological goal. Therefore, an iterative and adaptive approach to monitoring provides the basis for updating and fine-tuning any management or mitigation strategy.

Monitoring the effectiveness of mitigation measures in order to evaluate the impact of road construction and operation on target species and their local populations is recommended. It is recommended that a monitoring program be developed for the project which would likely include the following measures:

- Qualified and licensed ecologist/fauna handler present for staged habitat removal and fauna rescue/relocation (in accordance with the RMS 'Biodiversity Guidelines' (RTA 2011)).
- Where existing culverts may be upgraded or extended, undertake pre-decommission surveys for Eastern Bentwing-bat or Southern Myotis using infra-red cameras and anabat call recording devices to determine if microbats present. If microbats are roosting in these culverts, an exclusion program will be required.
- Monitoring of sediment and erosion control measures during construction (usually part of a sediment and erosion management plan).
- Monitoring of edge effect and weed management measures. A monitoring program would be outlined in the VMP.

- Bi-annual monitoring of nest boxes and bat roost boxes by a qualified and licensed ecologist during construction and annual monitoring for three years post completion of construction.
- Monitoring of dedicated fauna underpasses and rope bridges (eg using remote cameras) by a qualified and licensed ecologist bi-annually during construction then at optimal times for detection of target species for a period of three years post completion of construction. Following three years of post construction monitoring consideration would be given to undertaking a further two years of monitoring in the event a negative impact on species is detected.
- A monitoring program would be produced, dictating the frequency of monitoring, however it is suggested that seasonal monitoring (ie spring, summer, autumn, winter) of dedicated fauna underpasses and rope bridges be undertaken using passive infra-red cameras.
- Regular checks of fauna fencing to identify and fix any damage. A monitoring program would be produced, delegating responsibility of fauna fence monitoring and outlining the frequency of monitoring.
- Road kill monitoring. This should occur during operation of the upgrade over a 12 month period at weekly intervals. The monitoring should include a record of the species (if possible) and the GPS location. The local council road cleansing teams may be contracted to undertake the monitoring or alternatively RMS southern region would undertake the monitoring.

5.7 Residual impacts

Residual impacts have been defined in this assessment as 'impacts that remain following actions to avoid and mitigate direct and indirect impacts'. Direct impacts however, are usually permanent and irreversible and mostly result in quantifiable residual impacts. The subject site of the current assessment has been considered as the area to be directly affected by the project (ie the development “footprint”). In addition the subject site is the area most likely to be affected by residual impacts, some of which can be managed by measures to mitigate the adverse effect of the residual impacts. Such mitigation measures are recommended in Section 5.1 - Vegetation clearing and habitat loss.

Indirect impacts occur when project related activities affect species, populations or ecological communities in an inadvertent manner. Indirect impacts can either be permanent or temporary if managed appropriately. This assessment has considered that indirect impacts may occur within the subject site and potentially extending for a 50 metre buffer from the subject site. However this assessment has considered that indirect impacts can be managed through avoidance and mitigation measures to reduce the potential for a residual impact resulting from indirect impacts of the project. These measures are recommended in Section 5.1 Vegetation clearing and habitat loss.

Step 4 of the ‘Guidelines for Threatened Species Assessment under Part 3A of the EP&A Act’ (DEC and DPI 2005) states that 'The extent to which measures avoid, mitigate or offset impacts upon threatened species must reflect the conservation value of the feature including its formal status as a critically endangered, endangered or vulnerable species, population or ecological community.' Therefore based on this statement and in view of the above discussion it is considered that;

- The project would not result in an adverse residual impact on non threatened native plant communities totalling 47.1 hectares inclusive of direct and indirect impacts.
- The project would not result in an adverse residual impact on the 7.1 hectares of the EEC RFEF subject to indirect impacts.
- The project would however, result in an adverse residual impact on the 2.9 hectares of the EEC RFEF subject to direct impacts.

Details of how the adverse residual impact on the 2.9 hectares of the EEC RFEF subject to direct impacts should be addressed is provided in Section 5.8.

5.8 Offsetting

“The most significant impact of the project would be the permanent loss of an estimated 2.9 hectares (direct impact) of River-flat eucalypt forest that despite being in generally poor condition has a high conservation status (ie EEC) (refer Table 4.1). Additionally the project would result in modification of an estimated 7.1 hectares (indirect impact), of River-flat eucalypt forest in similar condition (refer Table 4.1).

As a result of this, a Biodiversity Offset Strategy (to inform the Biodiversity Offset Package) has been prepared (Appendix E) to compensate for unavoidable adverse residual impacts to the EEC and to maintain or improve the long-term viability of the local occurrence of River-flat eucalypt forest and the habitat it may provide for threatened and non-threatened biodiversity.

Investigation of an offset for impacts to River-flat eucalypt forest has included consultation and negotiation with OEH. Offsetting the loss of significant biodiversity would need to consider (but not be limited to) principles such as:

- Ecological sustainability so that the offset measures ensure the long-term viability and functionality of biodiversity. For example commitment to enhancement of existing habitat and securing and managing land of conservation value for biodiversity.
- A net improvement in biodiversity over time.
- Longevity whereby the measures must offset the impact of the development for the period that the impact occurs.
- Agreement of the offset prior to the impact occurring.
- Quantification so that the impacts and benefits can be reliably estimated.
- Offset like-for-like or better. In the first instance it is recommended that all avenues to match the type of biodiversity be investigated. Where there are considerable limitations to this then other options should be considered. For example ecological communities that are of equal or greater conservation status to the type of ecological community lost are used for an offset.

In view of a commitment and subject to a satisfactory agreement of a Biodiversity Offset Package negotiated with the DP&I and OEH, the project could result in an improvement of biodiversity values for River-flat eucalypt forest, fauna subject species and general biodiversity in the locality and region.

6 Assessment of impacts

6.1 NSW Part 3A guidelines for threatened species assessment (EP&A Act)

The impacts of the project on threatened species, populations and ecological communities listed under the TSC Act have been undertaken following the Guidelines for Threatened Species Assessment under Part 3A of the EP&A Act (DEC and DPI 2005). Where threatened species, populations and/or communities are recorded within a study area, an assessment of significance is required under the EP&A Act. When threatened species, populations and/or communities are not recorded during a survey, the presence of potential habitat for a species (or population or community) is used to determine the need to undertake an assessment of significance under the EP&A Act. Where there is no potential habitat in the study area for threatened species, populations and/or communities, there is unlikely to be any impact and therefore these species (or populations or communities) are not required to be considered further.

6.1.1 Endangered ecological communities

One EEC was recorded in the study area (**Table 3.1**): Riverbank forest. Riverbank forest meets the criteria for the EEC *River-flat eucalypt forest on coastal floodplains of the North Coast, Sydney Basin and South East Corner bioregions*.

The project would result in direct impacts to about 2.9 hectares of this community with a further 7.1 hectares potentially subject to indirect impacts (**Figure 3.1** and Appendix J). Areas where River-flat eucalypt forest EEC would be impacted by either direct removal or edge effects for the construction and operation of the project including the permanent roadway, drainage diversions and temporary creek crossings are at:

- Bundewallah Creek north of Rawlings Lane (**Figure 3.1.4**, Appendix J).
- The junction of Bundewallah Creek and Connollys Creek and downstream to Broughton Mill Creek (**Figure 3.1.7**, Appendix J).
- Broughton Creek to the east of Berry on the southern side of the Princes Highway (**Figure 3.1.8**, Appendix J).
- Broughton Creek to the south east and east of the intersection of Tomlins Road and Princes Highway, at Broughton (**Figure 3.1.12**, Appendix J).
- Broughton Creek to the east of the intersection of Thompson Road and Princes Highway, at Broughton (**Figure 3.1.13**, Appendix J).

According to the vegetation mapping a total of 65.7 hectares of this EEC occurs within the locality (**Table 3.1**).

On this basis, an assessment of impact following the Guidelines for Threatened Species Assessment under Part 3A of the EP&A Act has been carried out for this EEC (Appendix G). The assessment of significance for the TSC Act-listed EEC River-flat eucalypt forest concluded that although a significant impact by the project on this EEC would be unlikely (due to the implementation of actions to avoid and mitigate direct and indirect impacts of the project), a residual impact would occur due to the unavoidable loss of/disturbance to the EEC (10 hectares; equivalent to 15.2 per cent of River-flat eucalypt forest in the locality; **Table 3.1**). Therefore, a biodiversity offset strategy (Appendix E) has been prepared to compensate for the unavoidable loss and residual impact on River-flat eucalypt forest from the project.

The project would result in further fragmentation of the riparian vegetation in the study area. However impacts on River-flat eucalypt forest are not considered to be significant, on the basis that:

- River-flat eucalypt forest in the study is highly fragmented.
- River-flat eucalypt forest that will be subject to direct impacts and potential indirect impacts is currently in poor condition.
- Mitigation measures would be implemented to minimise the direct and potential indirect impacts on River-flat eucalypt forest in the study area (see Chapter 5).

A biodiversity Offset Strategy (Appendix E) has been prepared to compensate for the unavoidable loss and residual impact on River-flat eucalypt forest EEC from the project.

6.1.2 Flora

No threatened flora species were recorded in the study area. However, of the 32 threatened flora species considered in Appendix C, five species (*Cynanchum elegans*, *Cryptostylis hunteriana, Daphnandra* sp. 'Illawarra', *Irenepharsus trypherus* and *Zieria granulata*) are considered to have potential habitat in the study area. Based on the number and distribution of previous records of these five species, *Cynanchum elegans*, *Daphnandra* sp. and *Zieria granulata* have a high likelihood of occurring within the study area. Two species, *Cryptostylis hunteriana* and *Irenepharsus trypherus* are considered unlikely to occur in the study area or locality. OEH have specified that *Pterostylis gibbosa*, *Cryptostylis hunteriana* and *Genoplesium baueri* require consideration as subject species.

In view the above, assessments of impact following the' Guidelines for Threatened Species Assessment under Part 3A of the EP&A Act' have been carried out for the seven flora species cited above. These include the four subject species determined by Biosis Research and the additional three species that OEH has required to be specifically considered (OEH correspondence dated 31 January 2011 (Appendix C). The Part 3A threatened species assessments of significance are provided in Appendix G.

Daphnandra (*Daphnandra* sp. 'Illawarra') and Zieria (*Zieria granulata*) were recorded to the south of the study area during broader surveys. The alignment of the project avoids direct and indirect impacts on known records of these species. White-flowered Wax Plant (*Cynanchum elegans*) is recorded in the north eastern sector of the study area about 3.5 kilometres from the eastern end of the project. Delicate Cress (*Irenepharsus trypherus*), Illawarra Greenhood (*Pterostylis gibbosa*), Leafless Tongue-orchid (*Cryptostylis hunteriana*) and Bauer's Midge Orchid (*Genoplesium baueri*) have not been previously recorded within the locality or broader 10 kilometre OEH Atlas of NSW Wildlife searches.

The assessments of significance concluded that the project would have a minimal impact on flora subject species or their potential habitat in the locality based on the following:

- No individuals were recorded in the study area despite targeted surveys, including for those that are considered relatively conspicuous.
- The area of potential habitat impacted within the study area compared to that in the locality is considered small.
- Impacts resulting from the project are largely contained to areas that are already cleared and disturbed and include existing road infrastructure.
- Potential habitat in the study area is currently fragmented and subject to edge effects.
- The project is unlikely to interfere with the pollination and dispersal of native flora species.

6.1.3 Fauna

Where there is potential habitat (foraging or breeding resources) for threatened species in the study area, further consideration must be given to the potential impact of the project on these species. The project may impact on threatened species by causing any of the following:

- Death or injury of individuals.
- Loss or disturbance of limiting foraging resources.
- Loss or disturbance of limiting breeding resources.

Limiting resources are specialised habitat components that species are dependent on for their ongoing survival. Such limiting resources are predominantly associated with specialised breeding habitats (such as tree hollows or suitable nest/maternity roost sites) that occur at low densities, with high levels of competition from a range of species. However, for some species, limiting resources include specialised foraging habitats that have a restricted distribution (eg Koalas feeding only on specific tree species).

Nine threatened species were recorded during the field surveys: Gang-gang Cockatoo, Powerful Owl, Yellow-bellied Sheathtail Bat, Eastern Freetail Bat, Grey-headed Flying-fox, Eastern Bentwing-bat, Eastern False Pipistrelle, Southern Myotis and Greater Broad-nosed Bat. These nine species, along with an additional 42 TSC Act-listed fauna species with potential habitat identified in the study area, have been considered as subject species (Appendix D). Eighteen of the 51 subject species were also specified in correspondence from OEH dated 31 January 2011.

Table 6.1 summarises the possible impacts from the project on the 51 TSC Act-listed threatened fauna with known and/or potential habitat in the study area, and determines the need for Part 3A assessments of significance. Based on the nature of the project (Section 1.4), database interrogation, literature review regarding the ecology of each species, and information gathered during field surveys within the study area, 27 of these species are considered as unlikely to be subject to negative impacts resulting from the project (**Table 6.1**). Accordingly, no Part 3A assessments of significance have been prepared for these species (see Appendix H for more details).

Part 3A assessments of significance have been prepared for the 24 species that may be impacted by the project. These species are: Green and Golden Bell Frog[2], Black Bittern, Bush Stone-curlew, Gang-gang Cockatoo, Glossy Black-cockatoo, Little Lorikeet, Swift Parrot, Turquoise Parrot, Barking Owl, Powerful Owl, Masked Owl, Sooty Owl, Eastern Pygmy-possum, Spotted-tailed Quoll, Yellow-bellied Glider, Koala, Long-nosed Potoroo, Grey-headed Flying-fox, Eastern Bentwing-bat, Southern Myotis, Yellow-bellied Sheathtail-bat, Eastern Freetail Bat, Eastern False Pipistrelle and Greater Broad-nosed Bat (Appendix G).

6.1.4 Conclusions of flora and fauna Part 3A assessments of significance

The assessments of significance (Appendix G) concluded that the project is likely to have minor impacts on threatened flora and fauna species as listed on the TSC Act, provided recommended mitigation measures (Chapter 5) are implemented.

[2] A Part 3A assessment of significance was undertaken for the Green and Golden Bell Frog based on removal/modification of non-limiting dispersal habitat as a precautionary measure given the proximity to the Coomonderry Swamp Key Population.

6.1.5 Key thresholds

The Part 3A Guidelines of the EP&A Act (DEC and DPI 2005) set out a number of key thresholds which need to be addressed to justify the impacts of the project on threatened species, populations and ecological communities. The key thresholds are (DEC and DPI 2005):

- Whether or not the project, including actions to avoid or mitigate impacts or compensate to prevent unavoidable impacts, would maintain or improve biodiversity values.
- Whether or not the project is likely to reduce the long-term viability of a local population of the species, population or ecological community.
- Whether or not the project is likely to accelerate the extinction of the species, population or ecological community or place it at risk of extinction.
- Whether or not the project would adversely affect critical habitat.

Based on the assessments of significance following the Guidelines for Threatened Species Assessment under Part 3A of the EP&A Act (Appendix G), the project is unlikely to reduce the long-term viability of, accelerate the extinction of and/or adversely affect critical habitat for threatened species within the locality.

Maintenance of biodiversity values

Given that 57.1 hectares of native vegetation, including potential habitat for threatened species and an EEC, would be impacted by the project (including 30.4 hectares subject to direct impacts and 26.7 hectares subject to indirect impacts), some biodiversity values of the locality would be lost (**Table 4.1**). The loss of biodiversity values would be minimised by incorporating the mitigation measures detailed in **Chapter 5**, particularly measures to avoid significant habitat features; the provision of fauna under and over passes; rehabilitation of intact native vegetation that would be disturbed by the project; and, revegetation of disturbed areas to improve habitat connectivity. Rehabilitation of disturbed areas is critical to maintaining biodiversity values of the impacted areas.

A biodiversity offset strategy (Appendix E) has been prepared to compensate for the unavoidable loss of and residual impact on River-flat eucalypt forest from the project.

Given the above, the project is considered likely to maintain or improve biodiversity values.

Table 6.1: Potential impact and Part 3A assessment of significance requirements for threatened fauna listed on the TSC Act with potential habitat in the study area.

Common name	EPBC Act	TSC Act	Potential impacts on threatened species			EP&A Act Part 3A assessment of significance required?
			Individual death or injury?	Loss or disturbance of limiting foraging resources?	Loss or disturbance of limiting breeding resources?	
Green and Golden Bell Frog	V	E1	Unlikely	No	No	**Yes – undertaken as a precautionary measure due to the proximity to the Coomonderry Swamp Key Population**
Spotted Harrier	-	V	Unlikely	No	No	No
Little Eagle	-	V	Unlikely	No	No	No
Square-tailed Kite	-	V	Unlikely	No	No	No
Osprey	M	V	Unlikely	No	No	No
Blue-billed Duck Freckled Duck	-	V	Unlikely	No	No	No
Australasian Bittern	-	V	Unlikely	No	No	No
Black Bittern	-	V	Unlikely	No	No	**Yes**
Bush Stone-curlew	-	E1	Unlikely	No	No	**Yes**
Gang-gang cockatoo	-	V	Possible	No	Yes	**Yes**
Glossy Black-cockatoo	-	V	Possible	Yes	Yes	**Yes**
Greater Sand Plover	M	V	Unlikely	No	No	No
Black-necked Stork	-	E1	Unlikely	No	No	No
Wompoo Fruit- dove	-	V	Unlikely	Yes	No	No

Common name	EPBC Act	TSC Act	Potential impacts on threatened species			EP&A Act Part 3A assessment of significance required?
			Individual death or injury?	Loss or disturbance of limiting foraging resources?	Loss or disturbance of limiting breeding resources?	
Rose-crowned Fruit-dove Superb Fruit-dove						
Pied Oystercatcher	-	V	Unlikely	No	No	No
Comb-crested Jacana	-	V	Unlikely	No	No	No
Regent Honeyeater	E	E1	Unlikely	No	No	No
White-fronted Chat	-	V	Unlikely	No	No	No
Varied Sittella	-	V	Unlikely	No	No	No
Olive Whistler	-	V	Unlikely	No	No	No
Eastern Bristlebird	E	E1	Unlikely	No	No	No
Diamond Firetail	-	V	Unlikely	No	No	No
Scarlet Robin	-	V	Unlikely	No	No	No
Flame Robin	-	V	Unlikely	No	No	No
Little Lorikeet	-	V	Possible	No	Yes	**Yes**
Swift Parrot	E	E1	Unlikely	Yes	No	**Yes**
Orange-bellied Parrot	ZM	C1	Unlikely	No	No	No
Turquoise Parrot	-	V	Unlikely	No	Yes	**Yes**
Eastern Ground Parrot	-	V	Unlikely	No	No	No
Australian Painted Snipe	V	E1	Unlikely	No	No	No
Barking Owl Powerful Owl Masked Owl	-	V	Possible	No	Yes	**Yes**

Common name	EPBC Act	TSC Act	Potential impacts on threatened species			EP&A Act Part 3A assessment of significance required?
			Individual death or injury?	Loss or disturbance of limiting foraging resources?	Loss or disturbance of limiting breeding resources?	
Sooty Owl						
Eastern Pygmy-possum	-	V	Unlikely	No	No	**Yes**
Spotted-tailed Quoll	E	V	Unlikely	No	Yes	**Yes**
White-footed Dunnart	-	V	Unlikely	No	No	No
Yellow-bellied Glider	-	V	Unlikely	No	No	**Yes**
Koala	V	V	Unlikely	No	No	**Yes**
Long-nosed Potoroo	V	V	Unlikely	No	No	**Yes**
Grey-headed Flying-fox	V	V	Unlikely	No	No	**Yes**
Large-eared Pied Bat	V	V	Unlikely	No	No	No
Eastern Bentwing-bat Southern Myotis	-	V	Unlikely	No	No	**Yes**
Yellow-bellied Sheathtail Bat Eastern Freetail Bat Eastern False Pipistrelle Greater Broad-nosed Bat	-	V	Possible	No	Yes	**Yes**

6.2 Commonwealth significant impact criteria (EPBC Act)

Under the Commonwealth EPBC Act, if the project has the potential to have an adverse impact on threatened species, populations and/or ecological communities as listed under the Act, the project must be referred to the Commonwealth Minister for Sustainability, Environment, Water, Population and Communities for further consideration. The DSEWPaC publication *EPBC Act Policy Statement 1.1 Significant Impact Guidelines: Matters of National Environmental Significance* (DEWHA 2009) was used to assess the likelihood of impact on EPBC Act-listed species.

6.2.1 Endangered ecological communities

No EECs listed under the EPBC Act were recorded in or adjoining the study area.

6.2.2 Flora

No threatened flora species listed under the EPBC Act were recorded in the study area. However, of the 14 EPBC Act-listed threatened flora species considered in Appendix C, four species (*Cynanchum elegans*, *Daphnandra* sp. 'Illawarra', *Irenepharsus trypherus* and *Zieria granulata*) are considered to have potential habitat within the study area as a result of the field surveys and desktop analysis by Biosis Research. In addition to these four species, the OEH have specified a further two EPBC Act-listed threatened flora species, *Pterostylis gibbosa* and *Cryptostylis hunteriana*, that require consideration as subject species. One of these two additional species, *Cryptostylis hunteriana* is considered to have potential habitat in the study area but is unlikely to be present based on the absence of records within the locality.

The impacts of the project on these six species has been assessed against the relevant significant impact criteria (Appendix I) in accordance with the DSEWPaC publication *EPBC Act Policy Statement* (DEWHA 2009). *1.1 Significant Impact Guidelines: Matters of National Environmental Significance*

The project is unlikely to have a significant impact on the five species listed as Endangered under the EPBC Act (*Cynanchum elegans*, *Daphnandra* sp. 'Illawarra', *Irenepharsus trypherus*, *Zieria granulata* and *Pterostylis gibbosa*) as there is not a real chance or possibility that it would:

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

The project is unlikely to have a significant impact on the one species listed as Vulnerable under the EPBC Act (*Cryptostylis hunteriana*) as there is not a real chance or possibility that it would:

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

6.2.3 Fauna

Threatened species

Five species listed as Endangered or Critically Endangered under the EPBC Act have potential habitat in the study area: Regent Honeyeater, Eastern Bristlebird, Swift Parrot, Orange-bellied Parrot and Spotted-tailed Quoll. As shown above (**Table 6.1**), no limiting breeding habitat or foraging habitat is expected to be impacted for the Regent Honeyeater, Eastern Bristlebird or Orange-bellied Parrot. No assessments have been carried out for the Regent Honeyeater, Eastern Bristlebird or Orange-bellied Parrot, in accordance with the Significant Impact Criteria (DEWHA 2009) as the project is unlikely to:

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

The project may impact limiting foraging habitat for the Swift Parrot and/or impact habitat connectivity for the Spotted-tailed Quoll. Therefore, Significant Impact Criteria assessments have been carried out for these two species (Appendix I). The assessments of significance concluded a significant impact on these species by the project to be unlikely provided the mitigation measures detailed in Chapter 5 are implemented.

Six species listed as Vulnerable under the EPBC Act that have known and/or potential habitat in the study area include the Green and Golden Bell Frog, Australian Painted Snipe, Long-nosed Potoroo, Grey-headed Flying-fox (recorded during field surveys), Koala and Large-eared Pied Bat. As shown above (**Table 6.1**), no limiting breeding habitat or foraging habitat is expected to be impacted for the Green and Golden Bell Frog, Australian Painted Snipe or Large-eared Pied Bat. If present within the study area, individuals of Australian Painted Snipe and Large-eared Pied bat are not considered 'important populations' as they are not likely to be key source populations either for breeding or dispersal; populations that are necessary for maintaining genetic diversity; and/or populations that are near the limit of the species range.

However, the project is not likely to:

- Lead to a long-term decrease in the size of an important population.
- Reduce the area of occupancy of an important population.
- Fragment an existing important population into two or more populations.
- Disrupt the breeding cycle of an important population.
- Adversely affect habitat critical to the survival of any of these species.
- Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that any of these species is likely to decline.
- Result in invasive species that are harmful to any of these vulnerable species becoming established in the vulnerable species' habitat.
- Introduce disease that may cause any of these species to decline.
- Interfere substantially with the recovery of any of these species.

As such, no assessments have been carried out for the Australian Painted Snipe or Large-eared Pied Bat, in accordance with the Significant Impact Criteria (DEWHA 2009). The project may, however, impact habitat connectivity for the Long-nosed Potoroo and/or impact known foraging habitat for the Grey-headed Flying-fox. Although the study area is considered unlikely to support limiting breeding resources for the Green and Golden Bell Frog, individuals of this species occurring in the study area may be from 'important populations' and may be key source individuals for dispersal and maintaining genetic diversity. Therefore, Significant Impact Criteria assessments have been carried out for these three species (Appendix I).

Several species of SEPP 44-listed Koala feed trees (*Eucalyptus microcorys, E. racemosa, E. robusta* and *E. tereticornis*) have been recorded in forest and woodland habitats of the study area. Additionally, primary and secondary food tree species (*Eucalyptus amplifolia* ssp. *amplifolia, E. tereticornis* and *Eucalyptus scias* ssp. *scias*) from Appendix 2 of the Recovery Plan (DECC, 2008) have been recorded in the flora surveys. Although the study area is considered unlikely to support a population of Koala it is possible that the species moves through the study area on occasion between areas of potential habitat. On this basis a Significant Impact Criteria assessment has been carried out for Koala and is included in Appendix I. The assessment has considered the criteria for assessing habitat critical to the survival of the species from the *Interim Koala referral advice for proponents* (DSEWPaC, 2012).

The assessments of significance concluded a significant impact on the Green and Golden Bell Frog, Long-nosed Potoroo, Grey-headed Flying-fox and Koala by the project to be unlikely provided the mitigation measures detailed in Chapter 5 are implemented.

Migratory species

The list of migratory species under the EPBC Act is a compilation of species listed under four international conventions: China-Australia Migratory Bird Agreement (CAMBA), Japan-Australia Migratory Bird Agreement (JAMBA), Republic of Korea-Australia Migratory Bird Agreement (RoKAMBA), and the Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention).

Fifty-one migratory species (or their habitat) have been previously recorded within 10 kilometres of the study area. Six of these species were recorded during the field surveys: White-bellied Sea-eagle, Fork-tailed Swift, Cattle Egret, Black-faced Monarch, Rufous Fantail and Australian Reed-warbler. Potential habitat exists in the study area for an additional 23 migratory species (Appendix D).

Migratory waders are the most common migratory species recorded in the locality. While Coomonderry Swamp, Seven Mile Beach National Park, Crooked River Estuary and Black Head are used on occasion or regularly by these species, individuals of these species that have been or may be recorded in the study area are not considered likely to be an ecologically significant proportion of their populations. Similarly, individuals of other migratory birds (eg forest/woodland birds) that have been or may be recorded in the study area are not considered likely to be an ecologically significant proportion of their populations. Known and/or potential habitat in the study area is not considered important for the migratory species listed in Appendix D. Only previously disturbed and/or edge-affected areas of forest and woodland, as well as farmland, would be removed by the project and indirect impacts are not expected to occur beyond 50 metres from the subject site. Habitat/corridor fragmentation is considered unlikely to significantly impact these mobile species. Given the minimal impact expected on the known and/or potential habitat for these species in the study area, no assessments have been carried out for these species, in accordance with the Significant Impact Criteria (DEWHA 2009).

6.2.4 Conclusions of significant impact criteria assessments

The Significant Impact Criteria Assessments under the EPBC Act (Appendix I) concluded that the project is unlikely to have a significant impact on threatened species, populations and/or ecological communities or their habitats listed under the Act, provided the mitigation measures detailed in Chapter 5 are implemented.

A Referral to the Australian Government Minister of the Department of Sustainability, Environment, Water, Population and Communities is not considered necessary.

7 Conclusion

This report assesses the ecological significance of threatened flora and fauna species, endangered populations and EECs that occur, or have the potential to occur, within the area affected by the project, in accordance with the EP&A Act, the TSC Act and the EPBC Act.

Four naturally occurring native plant communities and four derived native plant communities totalling 58 hectares are mapped in the study area. It is estimated the project would directly impact on 30.4 hectares of naturally occurring and derived native plant communities and up to 26.7 hectares may be indirectly impacted.

One EEC was recorded in the study area and would be impacted by the project. About 10 hectares of the EEC River-flat eucalypt forest would be impacted by the project (some 2.9 hectares directly and 7.1 hectares indirectly). This EEC was considered to be in poor condition within the study area, with an understorey completely dominated by invasive weed species. An assessment of significance undertaken for this vegetation community according to the Part 3A Guidelines (DEC and DPI 2005) concluded the project is unlikely to have a significant impact on this EEC, provided the mitigation measures outlined in Chapter 5, and an adequate Offset Package, are implemented.

A further two EECs are present in the locality that have been identified by OEH as EECs to be addressed as subject ecological communities. The EECs Illawarra subtropical rainforest and Illawarra lowlands grassy woodland are mapped in the locality but not on the subject site (DEC 2005o). Neither of these vegetation communities has been recorded in the study area during the field surveys. Assessments of significance according to Part 3A Guidelines (DEC and DPI 2005) concluded the project is unlikely to have a significant impact on these EECs.

No threatened flora species were recorded in the study area, however potential habitat exists for four threatened flora species (all listed under both the TSC Act and the EPBC Act): *Cynanchum elegans*, *Daphnandra* sp. 'Illawarra', *Irenepharsus trypherus* and *Zieria granulata*. Assessments of significance undertaken for each threatened flora species concluded the project was unlikely to have a significant impact on these species.

Although not recorded in the study area in the current surveys or in the locality from database records, an additional three threatened flora species have been assessed as subject species as specified by the former DECCW. Assessments of significance undertaken for *Pterostylis gibbosa*, *Cryptostylis hunteriana* and *Genoplesium baueri* concluded the project is unlikely to have a significant impact on these three flora species.

Nine threatened and six migratory fauna species were recorded during the field surveys. Based on the proximity of current and previous records and the presence of identified habitat preferences, known and/or potential habitat exists within the study area for 51 threatened and 29 migratory fauna species. Impacts to the known/potential habitat of 27 threatened species were considered negligible and therefore, assessments of significance were not conducted for these species. Assessments of significance were carried out for the remaining 24 threatened fauna species (24 listed on the TSC Act and four listed on the EPBC Act). The assessments concluded the project is unlikely to have a significant impact on any TSC or EPBC Act-listed species, provided the mitigation measures outlined in Chapter 5 are implemented.

A referral to the Australian Government Environment Minister is not required for the project.

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Terms and acronyms used in this EA

Term	Definition
ACT	Australian Capital Territory
CAMBA	China-Australia Migratory Bird Agreement
CEMP	Construction Environmental Management Plan
DEC	NSW Department of Environment and Conservation (became DECCW and now OEH)
DECCW	NSW Department of Environment, Climate Change and Water (formerly DEC and now OEH)
DEWHA	Commonwealth Department of Environment, Water, Heritage and the Arts (now DSEWPaC)
DPC	NSW Department of Premier and Cabinet
DSEWPaC	Commonwealth Department of Sustainability, Environment, Water, Population and Communities (formerly DEWHA)
EEC	Endangered ecological community
EP&A Act	*Environmental Planning and Assessment Act 1979* (NSW)
EP&A Regulation	*Environmental Planning and Assessment Regulation 2000* (NSW)
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth).
Fauna	Animal life occurring in a particular region
Flora	Plant life occurring in a particular region
GPS	Global positioning system
ILGW	Illawarra lowlands grassy woodland in the Sydney basin bioregion
ISR	Illawarra subtropical rainforest in the Sydney basin bioregion
Infrastructure SEPP	State Environmental Planning Policy (Infrastructure) 2007
Intergrade	The way in which two distinct species are connected via areas where ecological communities are found that have characteristics of both.
JAMBA	Japan Australia Migratory Bird Agreement
Lerp	Structure of crystallised honeydew produced by the larvae of psyllid insects as a protective cover.
LGA	Local government area
MNES	Matters of national environmental significance. Refers to the seven matters
Noxious Weeds Act	*Noxious Weeds Act 1993* (NSW)
NPWS	NSW National Park and Wildlife Service
NSW	New South Wales
OBPRT	Orange–bellied Parrot Recovery Team
OEH	NSW Office of Environment and Heritage (formerly DECCW)
RFEF	River-flat eucalypt forest on coastal floodplains of the NSW North Coast, Sydney Basin and south east corner bioregions

Term	Definition
RoKAMBA	Republic of Korea-Australia Migratory Bird Agreement
RMS	NSW Roads and Maritime Services (formally RTA)
RTA	NSW Roads and Traffic Authority (now RMS)
SEPP	State Environmental Planning Policy. A type of planning instrument made under Part 3 of the EP&A Act.
SEPP 14	State Environmental Planning Policy No.14 – Coastal Wetlands
SEPP 44	State Environmental Planning Policy No.44 – Koala Habitat Protection
Stag	Dead tree (often provide habitat for fauna)
TSC Act	*Threatened Species Conservation Act 1995* (NSW)
VMP	Vegetation management plan

Appendix A

Flora results recorded within the Foxground and Berry bypass study area

Flora results

Flora species recorded in Foxground and Berry bypass study area (quadrat locations shown on **Figure 2.2** and in Appendix J):

Scientific name	Common name	Exotic	Quadrat number and cover abundance																			T	A
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19		
Abrophyllum ornans	Native Hydrangea																						+
Abutilon oxycarpum	Flannel Weed																						+
Acacia binervata	Two-veined Hickory														1		3					+	+
Acacia decurrens	Black Wattle																						+
Acacia falcata	Acacia																						+
Acacia irrorata ssp. irrorata	Green Wattle										1												+
Acacia longifolia	Coast/Sallow Wattle																						+
Acacia maidenii	Maiden's Wattle			3	4	2		1										1					+
Acacia mearnsii	Black Wattle																						+
Acacia melanoxylon	Blackwood																						+
Acacia myrtifolia	Red-stemmed Wattle																						+
Acacia parramattensis	Parramatta Wattle																						+
Acacia spp.	Acacia																						+
Acacia suaveolens	Sweet Wattle																						+
Acacia terminalis	Sunshine Wattle																						+
Acacia terminalis ssp. angustifolia	Acacia																						+
Acacia ulicifolia	Prickly Moses																						+
Acetosella vulgaris	Sheep Sorrel	*																					+
Acmena smithii	Lilly Pilly		2																3				+

Scientific name	Common name	Exotic	Quadrat number and cover abundance																			T	A
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19		
Acronychia oblongifolia	Common Acronychia						5																+
Adiantum aethiopicum	Common Maidenhair											3	3				2						+
Adiantum formosum	Giant Maidenhair		3	3		2																	+
Adiantum hispidulum var. hispidulum	Rough Maidenhair										1								2	3			+
Agapanthus praecox	Agapanthus	*																					+
Ageratina adenophora	Crofton Weed	*			2						1									1			+
Ageratina riparia	Mistflower	*	1	1	3				4	2	5								2	3			+
Aira spp.	Aira	*																					+
Alectryon subcinereus	Wild Quince		1			1																	+
Allocasuarina littoralis	Black Sheoak																						+
Alocasia brisbanensis	Cunjevoi																						+
Alphitonia excelsa	Red Ash			1				4				1											+
Alpinia caerulea	Native Ginger																						+
Amyema gaudichaudii	Amyema																						+
Amyema spp.	Amyema																						+
Amylotheca dictyophleba	Amylotheca																						+
Anagallis arvensis	Scarlet/Blue Pimpernel	*																				+	+
Andropogon virginicus	Whisky Grass	*																					+
Aneilema acuminatum	Aneilema		1						1										2				+
Angophora floribunda	Rough-barked Apple													2									+
Anisopogon avenaceus	Oat Speargrass																						+

Scientific name	Common name	Exotic	Quadrat number and cover abundance																			T	A
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19		
Anredera cordifolia	Madeira Vine	*																					+
Aphanopetalum resinosum	Gum Vine																						+
Apium prostratum ssp. prostratum	Sea Celery	*																					+
Araucaria spp.	Araucaria																						+
Araucaria heterophylla	Norfolk Island Pine																					+	
Araujia hortorum	Araujia	*				2		2	2	1	1												+
Aristida ramosa var. ramosa	Aristida																						+
Aristida vagans	Threeawn Speargrass																						+
Arthropodium milleflorum	Vanilla Lily																						+
Arthropteris tenella	Arthropteris						5																+
Asparagus densiflorus	Sprengeri Fern	*																					+
Asperula conferta	Common Woodruff																						+
Asplenium australasicum	Asplenium																						+
Asplenium flabellifolium	Necklace Fern																						+
Atriplex cinerea	Grey Saltbush																						+
Atriplex prostrata	Hastate Orache	*																					+
Atriplex spp.	Atriplex																						+
Austrodanthonia spp.	Austrodanthonia																2						+
Austrodanthonia tenuior	Purplish Wallaby-grass																						+

Scientific name	Common name	Exotic	Quadrat number and cover abundance																			T	A
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19		
Austrostipa pubescens	Austrostipa																						+
Austrostipa ramosissima	Stout Bamboo Grass																						+
Austrostipa spp.	Austrostipa							1															+
Austrostipa verticillata	Austrostipa																						+
Avena fatua	Wild Oats	*																					+
Axonopus affinis	Narrow-leaved Carpet Grass	*								2	3										2		+
Backhousia myrtifolia	Grey Myrtle																						+
Baloghia inophylla	Brush Bloodwood																						+
Banksia spinulosa var. collina	Banksia																						+
Banksia spinulosa var. spinulosa	Hairpin Banksia																						+
Baumea spp.	Baumea																			1			+
Bidens pilosa	Cobbler's Pegs	*			1			1	1														+
Billardiera scandens var. scandens	Common Apple-berry													1	2		1						+
Blechnum cartilagineum	Gristle Fern											2	3		1			2					+
Blechnum patersonii ssp. patersonii	Strap Water-fern																		2				+
Blechnum spp.	Blechnum																						+
Bossiaea heterophylla	Variable Bossiaea																						+
Botrychium australe	Parsley Fern																						+
Brachychiton acerifolius	Illawarra Flame Tree						2		1														+
Brassica rapa	White Turnip	*																					+

Scientific name	Common name	Exotic	Quadrat number and cover abundance																			T	A
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19		
Brassica spp.	Brassica																						+
Breynia oblongifolia	Coffee Bush			1				2						2		1	1	1					+
Briza maxima	Quaking Grass	*															1						+
Bromus catharticus	Prairie Grass	*									1										2	+	+
Brunoniella pumilio	Dwarf Blue Trumpet																						+
Bursaria spinosa ssp. spinosa	Sweet Bursaria																						+
Callistemon rigidus	Stiff Bottlebrush																						+
Callistemon salignus	Willow Bottlebrush																						+
Callistemon viminalis	Weeping Bottlebrush																					+	
Calochlaena dubia	Common Ground Fern																	3	2	2			+
Calystegia sepium	Large Bindweed																1						+
Calystegia silvatica	Greater Bindweed	*																					+
Canna indica	Tous-les-mois Arrowroot	*																				+	
Carex appressa	Tall Sedge											3				2							+
Carex fascicularis	Tassel Sedge															3	2						+
Carex longebrachiata	Bergalia Tussock		2	2	3					2	2		3		1			4					+
Carex spp.	Carex																						+
Carronia multisepalea	Carronia																						+
Cassine australis var. australis	Red Olive-berry		4			2		5															+
Cassinia spp.	Cassinia																						+
Cassytha glabella forma glabella	Slender Dodder-laurel																						+

Scientific name	Common name	Exotic	Quadrat number and cover abundance																			T	A
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19		
Casuarina cunninghamiana ssp. cunninghamiana	River Oak								4	3	4										5	+	+
Casuarina glauca	Swamp Oak																						+
Cayratia clematidea	Slender Grape																						+
Celastrus australis	Staff VIne																						+
Celastrus spp.	Celastrus																						+
Celastrus subspicata	Celastrus																						+
Centaurium tenuiflorum	Slender Centaury	*																					+
Centella asiatica	Pennywort											2	1		1								+
Cephalaralia cephalobotrys	Climbing Panax																						+
Cestrum elegans	Elegant Poison-berry	*																					+
Cheilanthes sieberi ssp. sieberi	Narrow Rock-fern																						+
Chlorophytum comosum	Spider Plant	*																					+
Christella dentata	Binung																		2				+
Chrysocephalum apiculatum	Common Everlasting																						+
Cinnamomum camphora	Camphor Laurel	*							2	1											2	+	+
Cirsium vulgare	Spear Thistle	*			1					2	1											+	+
Cissus antarctica	Water Vine																						+
Cissus hypoglauca	Giant Water Vine																						+
Citrus limonia	Rough Lemon	*																					+
Claoxylon australe	Brittlewood																						+

Scientific name	Common name	Exotic	Quadrat number and cover abundance																			T	A
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19		
Clematis aristata	Mountain Clematis																						+
Clerodendrum tomentosum	Hairy Clerodendrum		1			2	1	2											2	1			+
Colocasia esculenta	Taro	*								1	2									1			+
Commelina cyanea	Commelina												2				1					+	+
Commersonia fraseri	Brush Kurrajong																						+
Convolvulus erubescens	Convolvulus																						+
Conyza albida	Tall Fleabane	*																					+
Conyza spp.	Conyza	*			1																	+	+
Coreopsis lanceolata	Coreopsis	*																					+
Correa reflexa var. reflexa	Native Fuschia																						+
Corymbia gummifera	Red Bloodwood																						+
Corymbia maculata	Spotted Gum																					+	+
Cotula coronopifolia	Water Buttons	*																					+
Croton acronychioides	Thick-leaved Croton																						+
Croton verreauxii	Native Cascarilla					3													2				+
Cryptocarya glaucescens	Jackwood																						+
Cryptocarya microneura	Murrogun						3												2				+
Cryptocarya spp.	Cryptocarya							1															+
Cryptostylis erecta	Tartan Tongue Orchid																2						+
Cryptostylis spp.	Cryptostylis											1	1										+
Cryptostylis subulata	Large Tongue Orchid																1						+

Scientific name	Common name	Exotic	Quadrat number and cover abundance																			T	A
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19		
Cyathea australis	Rough Treefern		1																1				+
Cyathochaeta diandra	Sheath Sedge																						+
Cymbidium suave	Snake Orchid																						+
Cymbopogon refractus	Barbed Wire Grass																						+
Cynodon dactylon	Common Couch									2											1		+
Cyperus brevifolius	Mullumbimby Couch										2												+
Cyperus eragrostis	Umbrella Sedge	*								2	2									1	2	+	+
Cyperus imbecillis	Cyperus																						+
Cyperus spp.	Cyperus							1												1			+
Daphnandra sp. 'Illawarra' (Schodde)	Daphnandra					5																	+
Daviesia ulicifolia ssp. aridicola	Daviesia																						+
Daviesia ulicifolia ssp. stenophylla	Daviesia																						+
Daviesia ulicifolia ssp. ulicifolia	Gorse Bitter-pea																						+
Deeringia amaranthoides	Deeringia																						+
Delairea odorata	Cape Ivy	*			3	3		2												1			+
Dendrobium speciosum	Rock Lily																						+
Dendrocnide excelsa	Giant Stinging Tree																						+
Desmodium rhytidophyllum	Desmodium														3								+
Desmodium varians	Slender Tick-trefoil																						+

Scientific name	Common name	Exotic	Quadrat number and cover abundance																			T	A
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19		
Dianella caerulea var. caerulea	Paroo Lily																						+
Dianella caerulea var. producta	Blue Flax-lily												1	3			2					+	+
Dianella longifolia var. longifolia	Pale Flax-lily																						+
Dichelachne micrantha	Shorthair Plumegrass																						+
Dichondra repens	Kidney Weed			2	2			2					2		2	2	3	3				+	+
Dicksonia antarctica	Soft Treefern															1							+
Dillwynia retorta (J.C.Wendl.) Druce species complex	Dillwynia																						+
Dillwynia spp.	Dillwynia																						+
Dioscorea transversa	Native Yam																						+
Diospyros australis	Black Plum																						+
Diploglottis australis	Native Tamarind							1															+
Dipodium punctatum	Hyacinth Orchid																						+
Dodonaea triquetra	Large-leaf Hop-bush																						+
Doodia aspera	Prickly Rasp Fern		2		2		3					1	3			4		3	4	3			+
Doryphora sassafras	Sassafras						2												6				+
Duboisia myoporoides	Corkwood													3									+
Echinopogon ovatus	Forest Hedgehog Grass																2						+
Echium plantagineum	Patterson's Curse	*																					+
Ehretia acuminata var. acuminata	Koda																						+

Scientific name	Common name	Exotic	Quadrat number and cover abundance																			T	A
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19		
Ehrharta erecta	Panic Veldtgrass	*			1			2	2		3										5		+
Ehrharta longiflora	Annual Veldtgrass	*																					+
Einadia hastata	Berry Saltbush																						+
Elaeocarpus kirtonii	Silver Quandong																						+
Elaeocarpus reticulatus	Blueberry Ash												1										+
Eleusine indica	Crowsfoot Grass	*																			2		+
Endiandra sieberi	Hard Corkwood																						+
Entolasia marginata	Bordered Panic						1					3	3	4	2	2	2	3	3				+
Entolasia stricta	Wiry Panic																						+
Epacris microphylla var. microphylla	Coast Coral Heath																						+
Epacris pulchella	Epacris																						+
Eragrostis brownii	Brown's Lovegrass																						+
Eragrostis spp.	Eragrostis																						+
Eriobotrya japonica	Loquat	*																					+
Erythrina crista-galli	Cockspur Coral Tree	*																				+	
Erythrina X sykesii	Coral tree	*																				+	+
Eucalyptus amplifolia ssp. amplifolia	Cabbage Gum																						+
Eucalyptus botryoides	Bangalay												3				1	2	4				+
Eucalyptus eugenioides	Thin-leaved Stringybark																						+
Eucalyptus globoidea	White Stringybark																						+
Eucalyptus microcorys	Tallowwood																					+	+

Scientific name	Common name	Exotic	Quadrat number and cover abundance																			T	A
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19		
Eucalyptus paniculata ssp. paniculata	Grey Ironbark																						+
Eucalyptus pilularis	Blackbutt													5	5	4	5						+
Eucalyptus piperita	Sydney Peppermint																						+
Eucalyptus quadrangulata	White-topped Box																						+
Eucalyptus racemosa	Narrow-leaved Scribbly Gum																						+
Eucalyptus robusta	Swamp Mahogany																					+	+
Eucalyptus saligna	Sydney Blue Gum		4																				+
Eucalyptus scias ssp. scias	Large-fruited Red Mahogany																						+
Eucalyptus sclerophylla	Hard-leaved Scribbly Gum																						+
Eucalyptus spp.	-																						+
Eucalyptus tereticornis	Forest Red Gum																						+
Euphorbia oblongata	Egg-leaf Spurge	*																				+	
Euphorbia peplus	Petty Spurge	*																					+
Eupomatia laurina	Bolwarra		1																4				+
Eustrephus latifolius	Wombat Berry		2	1	1	2	1	2								2	1			2			+
Exocarpos cupressiformis	Native Cherry																						+
Ficus coronata	Creek Sandpaper Fig								1										4				+
Ficus macrophylla ssp. macrophylla	Moreton Bay Fig																						+
Ficus obliqua var.	Ficus																						+

Scientific name	Common name	Exotic	Quadrat number and cover abundance																			T	A
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19		
obliqua																							
Ficus rubiginosa	Ficus																						+
Ficus spp.	Ficus																						+
Ficus watkinsiana	Strangling Fig																						+
Foeniculum vulgare	Fennel	*									1												+
Fumaria spp.	Fumaria	*																				+	+
Gahnia aspera	Gahnia																						+
Gahnia clarkei	Tall Saw-sedge																1						+
Gahnia melanocarpa	Black-fruit Saw-sedge											5	4	3				1					+
Galium aparine	Goosegrass	*																			1		+
Galium ciliare	Hairy Bedstraw																						+
Galium propinquum	Maori Bedstraw																						+
Galium spp.	Galium																						+
Geitonoplesium cymosum	Scrambling Lily					2		2					1	3				2					+
Geranium homeanum	Northern Cranesbill										2				1							+	+
Geranium spp.	Geranium																						+
Glochidion ferdinandi var. ferdinandi	Cheese Tree				2						1		4	3	1	5	4	1					+
Glycine clandestina	Twining Glycine				1												2						+
Glycine tabacina	Variable Glycine														3								+
Gnaphalium spp.	Gnaphalium																						+
Gompholobium grandiflorum	Large Wedge Pea																						+

Scientific name	Common name	Exotic	Quadrat number and cover abundance																			T	A
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19		
Gompholobium minus	Dwarf Wedge Pea																						+
Gompholobium pinnatum	Pinnate Wedge Pea																						+
Gonocarpus tetragynus	Common Raspwort																						+
Gonocarpus teucrioides	Germander Raspwort																1						+
Goodenia hederacea ssp. hederacea	Ivy Goodenia																						+
Goodenia heterophylla ssp. eglandulosa	Goodenia																						+
Goodenia spp.	Goodenia																						+
Grevillea linearifolia	Small-flower Grevillea																						+
Grevillea robusta	Silky Oak																					+	+
Guioa semiglauca	Guioa					4																	+
Gymnostachys anceps	Settler's Flax					2	3	2					1					1	2				+
Hakea dactyloides	Finger Hakea																						+
Hakea salicifolia ssp. salicifolia	Hakea																						+
Hakea sericea	Bushy Needlewood																						+
Hardenbergia violacea	False Sarsaparilla														2								+
Hedycarya angustifolia	Native Mulberry																						+
Hedychium gardnerianum	Ginger Lily	*																					+
Helichrysum elatum	Tall Everlasting																						+
Hibbertia aspera ssp. aspera	Hibbertia																						+

Scientific name	Common name	Exotic	Quadrat number and cover abundance																			T	A
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19		
Hibbertia dentata	Twining Guinea Flower													3				2					+
Hibbertia diffusa	Wedge Guinea-flower																						+
Hibbertia scandens	Climbing Guinea Flower													2	2		3						+
Holcus lanatus	Yorkshire Fog	*																				+	+
Hovea linearis	Hovea																						+
Hydrocotyle laxiflora	Stinking Pennywort																						+
Hydrocotyle peduncularis	Pennywort																						+
Hydrocotyle spp.	Hydrocotyle				2											2		2					+
Hymenanthera dentata	Tree Violet					2																	+
Hymenophyllum cupressiforme	Common Filmy Fern																						+
Hypericum gramineum	Small St John's Wort																						+
Hypochaeris radicata	Catsear	*									2												+
Hypolepis muelleri	Harsh Ground Fern											3	4			4							+
Imperata cylindrica var. major	Blady Grass														5	1	4						+
Indigofera australis	Austral Indigo																						+
Isolepis prolifera	Proliferous Club-sedge	*																					+
Jacaranda mimosifolia	Jacaranda	*																				+	+
Juncus kraussii ssp. australiensis	Sea Rush																						+
Juncus spp.	Juncus																						+

Scientific name	Common name	Exotic	Quadrat number and cover abundance																			T	A
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19		
Juncus tenuis	Slender Rush	*																					+
Juncus usitatus	Billabong Rush								2	4	1										2		+
Kennedia rubicunda	Red Kennedy Pea														2		1						+
Kunzea ambigua	Tick Bush																						+
Lagenifera stipitata	Blue Bottle-daisy																						+
Lambertia formosa	Mountain Devil																						+
Lantana camara	Lantana	*	2	1	3	4		3	2	2	2	1	3	4	3	2	3	4	3	2		+	+
Lastreopsis acuminata	Shiny Shield Fern																						+
Lastreopsis decomposita	Trim Shield Fern																						+
Lastreopsis microsora ssp. microsora	Creeping Shield-fern																						+
Lastreopsis spp.	Lastreopsis																						+
Laxmannia gracilis	Slender Wire-lily																						+
Legnephora moorei	Round-leaf Vine		1																				+
Lepidosperma laterale	Variable Sword-sedge													5			1						+
Leptinella longipes	Coast Cotula																						+
Leptomeria acida	Sour Currant Bush																						+
Leptospermum continentale	Prickly Teatree																						+
Leptospermum polygalifolium ssp. polygalifolium	Tantoon													2									+
Leptospermum spp.	Leptospermum																						+
Leptospermum	Paperbark Tea-tree																						+

Scientific name	Common name	Exotic	Quadrat number and cover abundance																			T	A
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19		
trinervium																							
Leucopogon juniperinus	Long-flower Beard-heath																						+
Leucopogon lanceolatus var. lanceolatus	Lance Beard-heath													2									+
Libertia paniculata	Branching Grass-flag																		1				+
Ligustrum lucidum	Large-leaved Privet	*	1						1											6	1	+	+
Ligustrum sinense	Small-leaved Privet	*						1	3	3	4				1	2	1	2	1	1	2	+	+
Lindsaea linearis	Screw Fern																						+
Litsea reticulata	Bolly Gum																						+
Livistona australis	Cabbage Palm		1				1							1				1	3	1			+
Lolium perenne	Perennial Ryegrass	*																					+
Lomandra filiformis ssp. filiformis	Wattle Mat-rush																						+
Lomandra glauca	Pale Mat-rush																						+
Lomandra longifolia	Spiny-headed Mat-rush									2	3		1		3	1	2				1	+	+
Lomandra multiflora ssp. multiflora	Many-flowered Mat-rush																						+
Lomandra obliqua	Lomandra																						+
Lomatia ilicifolia	Holly Lomatia																						+
Lonicera japonica	Japanese Honeysuckle	*																					+
Ludwigia peploides ssp montevidensis	Water Primrose																					+	
Lycium ferocissimum	African Boxthorn	*																					+

Scientific name	Common name	Exotic	Quadrat number and cover abundance																			T	A
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19		
Maclura cochinchinensis	Cockspur Thorn					2		2							1								+
Macrozamia spp.	Macrozamia																						+
Malus spp.	Malus	*																					+
Marsdenia flavescens	Hairy Milk Vine						1																+
Marsdenia rostrata	Common Milk Vine		2	1	2			2	1			2	1		2	2	1	2	2	1			+
Maytenus silvestris	Narrow-leaved Orangebark																						+
Melaleuca decora	-																					+	
Melaleuca linariifolia	Budjur											5	2										+
Melaleuca quinquenervia	Broad-leaved Paperbark																					+	
Melaleuca styphelioides	Prickly-leaved Tea Tree																						+
Melia azedarach	White Cedar							2															+
Melicope micrococca	Hairy-leaved Doughwood							1															+
Micrantheum ericoides	Micrantheum																						+
Microlaena stipoides var. stipoides	Weeping Grass				1						4				3		2			2	3		+
Microsorum scandens	Fragrant Fern																						+
Mirbelia rubiifolia	Heathy Mirbelia																						+
Morinda jasminoides	Jasmine Morinda			1		1		1				4	4					3	3	2			+
Modiola caroliniana	Red-flowered Mallow	*																				+	
Myriophyllum sp		*																				+	
Myoporum acuminatum	Myoporum																						+

Scientific name	Common name	Exotic	Quadrat number and cover abundance																			T	A
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19		
Nephrolepis cordifolia	Fishbone Fern																						+
Notelaea longifolia	Large Mock-olive																						+
Notelaea spp.	Notelaea																						+
Notelaea venosa	Veined Mock-olive						1	2				3	3	2						1			+
Ochna serrulata	Mickey Mouse Plant	*																					+
Olea europaea	Common Olive	*																					+
Olea europaea ssp. cuspidata	Olea	*													1								+
Olearia viscidula	Wallaby Weed																						+
Omalanthus populifolius	Omalanthus																						+
Opercularia diphylla	Stinkweed																						+
Oplismenus aemulus	Basket Grass		1								3									1			+
Oplismenus imbecillis	Oplismenus		2	1	3	2		2				3	2	3	2	2	2	3	2				+
Oxalis perennans	Grassland Wood-sorrel																						+
Oxalis spp.	Oxalis									1	1												+
Ozothamnus diosmifolius	White Dogwood																						+
Palmeria scandens	Anchor Vine		1																				+
Pandorea pandorana ssp. pandorana	Wonga Vine		3	2	3	2		1			1		2			1	1	3	2	1			+
Panicum simile	Two-colour Panic																						+
Panicum spp.	Panicum																						+

Scientific name	Common name	Exotic	Quadrat number and cover abundance																			T	A
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19		
Pararchidendron pruinosum var. pruinosum	Snow Wood					4	2																+
Parsonsia straminea	Common Silkpod			2		2			1	1		2	2	3	2			3					+
Paspalum dilatatum	Paspalum	*								2	3										1	+	+
Paspalum urvillei	Vasey Grass	*																					+
Passiflora edulis	Common Passionfruit	*																					+
Passiflora herbertiana ssp. herbertiana	Native Passionfruit																						+
Passiflora subpeltata	White Passionflower	*																					+
Patersonia glabrata	Leafy Purple-flag																						+
Patersonia sericea	Silky Purple-flag																						+
Pellaea falcata	Sickle Fern		2	2	2			1															+
Pennantia cunninghamii	Brown Beech																						+
Pennisetum clandestinum	Kikuyu Grass	*							2						1							+	+
Persicaria decipiens	Slender Knotweed																					+	+
Persicaria praetermissa	Spotted Knotweed									3	1									1			+
Persicaria spp.	Persicaria									3												+	+
Persicaria strigosa	-																					+	
Persoonia levis	Broad-leaved Geebung																						+
Persoonia linearis	Narrow-leaved Geebung													2									+
Persoonia mollis ssp. leptophylla	Persoonia																						+

Scientific name	Common name	Exotic	Quadrat number and cover abundance																			T	A
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19		
Petrophile pulchella	Petrophile																						+
Petrophile sessilis	Petrophile																						+
Phragmites australis	Common Reed																						+
Phytolacca octandra	Inkweed	*			1																		+
Pimelea linifolia ssp. linifolia	Slender Rice-flower																						+
Pinus radiata	Radiata Pine	*																					+
Pinus spp.	Pine	*																					+
Piper novae-hollandiae	Giant Pepper Vine						2																+
Pittosporum multiflorum	Orange Thorn		1	2	1		3	2															+
Pittosporum revolutum	Rough Fruit Pittosporum											1		2	1			1					+
Pittosporum undulatum	Sweet Pittosporum		4	6	6	4		1							4					2			+
Planchonella australis	Black Apple																						+
Plantago lanceolata	Lamb's Tongues	*									1												+
Platylobium formosum ssp. formosum	Handsome Flat-pea													3									+
Platysace linearifolia	Platysace																						+
Plectranthus parviflorus	Cockspur Flower																						+
Poa labillardierei var. labillardierei	Tussock																	2					+
Poa spp.	Poa																						+
Podocarpus elatus	Plum Pine						1																+
Polyosma cunninghamii	Featherwood																						+
Polyscias elegans	Celery Wood																						+

Scientific name	Common name	Exotic	Quadrat number and cover abundance																			T	A
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19		
Polyscias murrayi	Pencil Cedar																						+
Pomaderris ferruginea	Rusty Pomaderris													2									+
Pomax umbellata	Pomax																						+
Pratia purpurascens	Whiteroot																2						+
Protasparagus aethiopicus	Sprengeri Fern	*																					+
Protasparagus plumosus	Climbing Asparagus Fern	*																					+
Prunella vulgaris	Self-heal	*																					+
Prunus spp.	Prunus																						+
Pseuderanthemum variabile	Pastel Flower		2	3		3		3				2	1			2		3	2				+
Psychotria loniceroides	Hairy Psychotria																						+
Pteridium esculentum	Bracken													3			2						+
Pteris umbrosa	Jungle Brake				1																		+
Pultenaea retusa	Blunt Bush-pea																						+
Pyrrosia rupestris	Rock Felt Fern															1							+
Ranunculus inundatus	River Buttercup									2													+
Ranunculus plebeius	Forest/Hairy Buttercup																						+
Ranunculus repens	Creeping Buttercup	*																					+
Ranunculus sceleratus	Celery Buttercup	*																					+
Ranunculus spp.	Ranunculus																						+
Rapanea howittiana	Brush Muttonwood																		1				+
Rapanea variabilis	Muttonwood				1								1										+

Scientific name	Common name	Exotic	Quadrat number and cover abundance																			T	A
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19		
Rhodamnia rubescens	Scrub Turpentine							1															+
Ricinus communis	Castor Oil Plant	*																					+
Ripogonum album	White Supplejack																						+
Rorippa microphylla	One-rowed Watercress	*								2													+
Rorippa nasturtium-aquaticum	Watercress	*																				+	+
Rorippa spp.	Rorippa																				1		+
Rubus fruiticosus	Blackberry complex	*								1													+
Rubus moluccanus var. trilobus	Molucca Bramble																						+
Rubus parvifolius	Native Raspberry							1								1	2						+
Rubus rosifolius var. rosifolius	Rose-leaf Bramble																						+
Rubus spp.	Rubus																						+
Rumex brownii	Swamp Dock																						+
Rumex crispus	Curled Dock	*							1	2	2									1	2	+	+
Sagittaria graminea	Sagittaria	*																					+
Salix babylonica	Weeping Willow	*																				+	+
Salix spp.	Willow	*									2												+
Sambucus australasica	Native Elderberry																						+
Samolus repens	Creeping Brookweed																						+
Santalum obtusifolium	Sandalwood																						+
Sarcocornia quinqueflora ssp.	Beaded Glasswort																						+

Scientific name	Common name	Exotic	Quadrat number and cover abundance																			T	A
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19		
quinqueflora																							
Sarcomelicope simplicifolia ssp. simplicifolia	Big Yellow Wood							4															+
Sarcopetalum harveyanum	Pearl Vine																		1				+
Schelhammera undulata	Lilac Lily											1		2		2		2	1				+
Schinus areira	Pepper Tree	*																				+	
Scolopia braunii	Flintwood						1																+
Sedum spp.	Sedum																						+
Selliera radicans	Shiny Swamp-mat																						+
Senecio madagascariensis	Fireweed	*								3							1				1	+	+
Senecio spp.	Senecio																						+
Senna pendula var. glabrata	Cassia	*																					+
Setaria gracilis	Slender Pigeon Grass	*																		1	1		+
Setaria italica	Foxtail Millet	*																				+	
Sherardia arvensis	Field Madder	*																					+
Sida rhombifolia	Paddy's Lucerne	*							2	2	3									1	2		+
Sigesbeckia orientalis ssp. orientalis	Indian Weed																			1	1	+	+
Smilax australis	Sarsaparilla		2					1											1				+
Smilax glyciphylla	Sweet Sarsparilla													1									+
Solanum aviculare	Kangaroo Apple																						+

Scientific name	Common name	Exotic	Quadrat number and cover abundance																			T	A
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19		
Solanum jasminoides	Potato Climber	*																					+
Solanum mauritianum	Wild Tobacco Bush	*						1	3		3									1		+	+
Solanum nigrum	Black-berry Nightshade	*						1											1		2		+
Solanum pseudocapsicum	Madeira Winter Cherry	*			2			2													1		+
Solanum pungetium	Eastern Nightshade																						+
Solanum spp.	Solanum																						+
Solanum vescum	Gunyang																						+
Sonchus oleraceus	Common Sowthistle	*								1													+
Spiranthes sinensis ssp. australis	Ladies Tresses																						+
Spirodela spp.	Spirodela									2											1		+
Sporobolus indicus	Parramatta Grass	*									1												+
Sporobolus indicus var. capensis	Parramatta Grass	*																					+
Sporobolus spp.	Sporobolus																						+
Stellaria flaccida	Forest Starwort																						+
Stenocarpus salignus	Scrub Beefwood																						+
Stenotaphrum secundatum	Buffalo Grass	*																					+
Stephania japonica var. discolor	Snake Vine			2		2	1	1				1	1						1				+
Streblus brunonianus	Whalebone Tree		2	2	2	4	3	4											2	1			+
Stylidium productum	Stylidium																						+

Scientific name	Common name	Exotic	Quadrat number and cover abundance																			T	A
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19		
Suaeda australis	Austral Seablite																						+
Symplocos thwaitesii	Buff Hazelwood																						+
Syncarpia glomulifera ssp. glomulifera	Turpentine											5	4					5				+	+
Synoum glandulosum ssp. glandulosum	Bastard Rosewood		1																				+
Syzygium australe	Brush Cherry																			1		+	+
Syzygium spp.	Syzygium																						+
Tagetes minuta	Stinking Roger	*																					+
Taraxacum officinale	Dandelion	*																					+
Tecoma capensis	Cape Honeysuckle	*																					+
Tetragonia tetragonioides	New Zealand Spinach																						+
Thelionema caespitosum	Tufted Lily																						+
Themeda australis	Kangaroo Grass																						+
Thunbergia alata	Black-eyed Susan	*																					+
Thysanotus tuberosus ssp. tuberosus	Common Fringe-lily																						+
Todea barbara	King Fern																						+
Toona ciliata	Red Cedar		1																				+
Tradescantia albiflora	-	*						2															+
Tradescantia fluminensis	-	*							5	3	3								4	2	5	+	+
Trema tomentosa var. viridis	Native Peach																						+

Scientific name	Common name	Exotic	Quadrat number and cover abundance																			T	A
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19		
Trifolium repens	White Clover	*									2											+	+
Triglochin striatum	Streaked Arrowgrass																						+
Tristaniopsis laurina	Kanuka																					+	+
Trophis scandens ssp. scandens	Trophis																						+
Tylophora barbata	Bearded Tylophora		2	1			2								2	2	2	2	1				+
Typha orientalis	Broadleaf Cumbungi																					+	
Typha spp.	Typha																						+
Urtica incisa	Stinging Nettle					1														1	2	+	+
Verbascum virgatum	Twiggy Mullein	*																					+
Verbena bonariensis	Purpletop	*									1											+	+
Verbena rigida	Veined Verbena	*																					+
Vernonia cinerea var. cinerea	Vernonia																						+
Veronica plebeia	Trailing Speedwell																						+
Viola hederacea	Ivy-leaved Violet			1												2							+
Viola spp.	Viola																						+
Wahlenbergia gracilis	Sprawling or Australian Bluebell																						+
Wahlenbergia spp.	Wahlenbergia																						+
Watsonia bulbillifera	Watsonia	*																					+
Wilkiea huegeliana	Veiny Wilkiea					2							2							1			+
Xanthorrhoea spp.	Grass Tree																						+
Zantedeschia aethiopica	Arum Lily	*																					+

Scientific name	Common name	Exotic	Quadrat number and cover abundance																			T	A
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19		
Zieria granulata	Zieria																						+
Zieria smithii	Sandfly Zieria													1									+

* *Denotes exotic species*
T *Recorded during Town Creek surveys*
A *Denotes opportunistic records of all flora species*

Cover abundance scores:

Score	Species cover in Quadrat	Other attributes
1	<5%	3 or less individual of a species
2	<5%	More than 3 individuals of a species
3	<5%	Species common throughout plot
4	5% - 25%	-
5	25% - 50%	-
6	50% - 75%	-
7	75% - 100%	-

Appendix B

Fauna results recorded within the Foxground and Berry bypass study area

Fauna results

Family name	Latin name	Common name	EPBC Act	TSC Act	Obs. type
Amphibians					
Hylidae	*Litoria dentata*	Bleating Tree Frog			W
Hylidae	*Litoria fallax*	Eastern Dwarf Tree Frog			O/W
Hylidae	*Litoria jervisiensis*	Jervis Bay Tree Frog			W
Hylidae	*Litoria lesueuri*	Lesueur's Frog			O
Hylidae	*Litoria nudidigita*	Leaf Green Tree Frog (Southern Call Race)			W
Hylidae	*Litoria peronii*	Peron's Tree Frog			O/W
Hylidae	*Litoria verreauxii*	Verreaux's Frog			O/W
Myobatrachidae	*Crinia signifera*	Common Eastern Froglet			W
Myobatrachidae	*Limnodynastes peronii*	Striped Marsh Frog			O/W
Birds					
Alaudidae	*Alauda arvensis*	Skylark		U	W
Anatidae	*Anas platyrhynchos*	Mallard		U	O
Columbidae	*Streptopelia chinensis*	Spotted Turtle-Dove		U	W
Fringillidae	*Carduelis carduelis*	European Goldfinch		U	O
Muscicapidae	*Turdus merula*	Common Blackbird		U	O
Passeridae	*Passer domesticus*	House Sparrow		U	O
Pycnonotidae	*Pycnonotus jocosus*	Red-whiskered Bulbul		U	O/W
Sturnidae	*Acridotheres tristis*	Common Myna		U	O/W
Sturnidae	*Sturnus vulgaris*	Common Starling		U	O
Accipitridae	*Accipiter cirrhocephalus*	Collared Sparrowhawk			O
Accipitridae	*Accipiter fasciatus*	Brown Goshawk			O
Accipitridae	*Aquila audax*	Wedge-tailed Eagle			O

Family name	Latin name	Common name	EPBC Act	TSC Act	Obs. type
Accipitridae	*Circus approximans*	Swamp Harrier			O
Accipitridae	*Elanus axillaris*	Black-shouldered Kite			O
Accipitridae	*Haliaeetus leucogaster*	White-bellied Sea-eagle	M		O
Anatidae	*Anas castanea*	Chestnut Teal			O
Anatidae	*Anas gracilis*	Grey Teal			O
Anatidae	*Anas superciliosa*	Pacific Black Duck			O/W
Anatidae	*Aythya australis*	Hardhead			O
Anatidae	*Chenonetta jubata*	Australian Wood Duck			O
Apodidae	*Apus pacificus*	Fork-tailed Swift	M		O
Ardeidae	*Ardea ibis*	Cattle Egret	M		O
Ardeidae	*Ardea pacifica*	White-necked Heron			O
Ardeidae	*Egretta novaehollandiae*	White-faced Heron			O/W
Artamidae	*Artamus cyanopterus*	Dusky Woodswallow			O
Artamidae	*Cracticus nigrogularis*	Pied Butcherbird			O
Artamidae	*Cracticus torquatus*	Grey Butcherbird			W
Artamidae	*Grallina cyanoleuca*	Magpie-lark			O/W
Artamidae	*Gymnorhina tibicen*	Australian Magpie			O/W
Artamidae	*Strepera graculina*	Pied Currawong			W
Cacatuidae	*Cacatua galerita*	Sulphur-crested Cockatoo			O/W
Cacatuidae	*Cacatua roseicapilla*	Galah			O/W
Cacatuidae	*Cacatua sanguinea*	Little Corella			O/W
Cacatuidae	*Cacatua tenuirostris*	Long-billed Corella			O/W
Cacatuidae	*Callocephalon fimbriatum*	Gang-gang Cockatoo		V	W
Cacatuidae	*Calyptorhynchus funereus*	Yellow-tailed Black-Cockatoo			O/W
Campephagidae	*Coracina novaehollandiae*	Black-faced Cuckoo-shrike			O/W

Family name	Latin name	Common name	EPBC Act	TSC Act	Obs. type
Campephagidae	*Coracina tenuirostris*	Cicadabird			W
Charadriidae	*Vanellus miles*	Masked Lapwing			O
Cinclosomatidae	*Psophodes olivaceus*	Eastern Whipbird			O/W
Climacteridae	*Cormobates leucophaeus*	White-throated Treecreeper			O/W
Columbidae	*Columba leucomela*	White-headed Pigeon			O/W
Columbidae	*Geopelia humeralis*	Bar-shouldered Dove			O/W
Columbidae	*Leucosarcia melanoleuca*	Wonga Pigeon			W
Columbidae	*Lopholaimus antarcticus*	Topknot Pigeon			O
Columbidae	*Macropygia amboinensis*	Brown Cuckoo-Dove			O/W
Columbidae	*Ocyphaps lophotes*	Crested Pigeon			O/W
Columbidae	*Phaps chalcoptera*	Common Bronzewing			O/W
Coraciidae	*Eurystomus orientalis*	Dollarbird			O/W
Corvidae	*Corvus coronoides*	Australian Raven			O/W
Cuculidae	*Cacomantis flabelliformis*	Fan-tailed Cuckoo			W
Cuculidae	*Cacomantis variolosus*	Brush Cuckoo			W
Cuculidae	*Chrysococcyx lucidus*	Shining Bronze-Cuckoo			W
Cuculidae	*Cuculus pallidus*	Pallid Cuckoo			O
Cuculidae	*Eudynamys scolopacea*	Common Koel			W
Cuculidae	*Scythrops novaehollandiae*	Channel-billed Cuckoo			O/W
Dicaeidae	*Dicaeum hirundinaceum*	Mistletoebird			O/W
Dicruridae	*Monarcha melanopsis*	Black-faced Monarch	M		O/W
Dicruridae	*Myiagra inquieta*	Restless Flycatcher			W
Dicruridae	*Rhipidura albiscapa*	Grey Fantail			O/W
Dicruridae	*Rhipidura leucophrys*	Willie Wagtail			O/W
Dicruridae	*Rhipidura rufifrons*	Rufous Fantail	M		O/W

Family name	Latin name	Common name	EPBC Act	TSC Act	Obs. type
Falconidae	*Falco cenchroides*	Nankeen Kestrel			O
Falconidae	*Falco peregrinus*	Peregrine Falcon			O
Halcyonidae	*Dacelo novaeguineae*	Laughing Kookaburra			O/W
Halcyonidae	*Todiramphus sanctus*	Sacred Kingfisher			O/W
Hirundinidae	*Hirundo neoxena*	Welcome Swallow			O
Hirundinidae	*Hirundo nigricans*	Tree Martin			O
Maluridae	*Malurus cyaneus*	Superb Fairy-wren			O/W
Maluridae	*Malurus lamberti*	Variegated Fairy-wren			O/W
Maluridae	*Stipiturus malachurus*	Southern Emu-wren			O
Meliphagidae	*Acanthorhynchus tenuirostris*	Eastern Spinebill			O/W
Meliphagidae	*Anthochaera carunculata*	Red Wattlebird			W
Meliphagidae	*Anthochaera chrysoptera*	Little Wattlebird			W
Meliphagidae	*Lichenostomus chrysops*	Yellow-faced Honeyeater			O/W
Meliphagidae	*Manorina melanocephala*	Noisy Miner			O/W
Meliphagidae	*Meliphaga lewinii*	Lewin's Honeyeater			O/W
Meliphagidae	*Melithreptus lunatus*	White-naped Honeyeater			W
Meliphagidae	*Myzomela sanguinolenta*	Scarlet Honeyeater			W
Meliphagidae	*Philemon citreogularis*	Little Friarbird			W
Meliphagidae	*Philemon corniculatus*	Noisy Friarbird			W
Meliphagidae	*Phylidonyris novaehollandiae*	New Holland Honeyeater			W
Motacillidae	*Anthus novaeseelandiae*	Richard's Pipit			O
Muscicapidae	*Acrocephalus stentoreus*	Australian Reed-Warbler	M		O
Muscicapidae	*Zoothera lunulata*	Bassian Thrush			W
Oriolidae	*Oriolus sagittatus*	Olive-backed Oriole			O/W
Pachycephalidae	*Colluricincla harmonica*	Grey Shrike-thrush			W

Family name	Latin name	Common name	EPBC Act	TSC Act	Obs. type
Pachycephalidae	*Falcunculus frontatus*	Crested Shrike-tit			O
Pachycephalidae	*Pachycephala pectoralis*	Golden Whistler			O/W
Pachycephalidae	*Pachycephala rufiventris*	Rufous Whistler			O/W
Pardalotidae	*Acanthiza chrysorrhoa*	Yellow-rumped Thornbill			O/W
Pardalotidae	*Acanthiza lineata*	Striated Thornbill			O/W
Pardalotidae	*Acanthiza nana*	Yellow Thornbill			O/W
Pardalotidae	*Acanthiza pusilla*	Brown Thornbill			O/W
Pardalotidae	*Acanthiza reguloides*	Buff-rumped Thornbill			O
Pardalotidae	*Gerygone mouki*	Brown Gerygone			O/W
Pardalotidae	*Pardalotus punctatus*	Spotted Pardalote			W
Pardalotidae	*Sericornis frontalis*	White-browed Scrubwren			O/W
Passeridae	*Neochmia temporalis*	Red-browed Finch			O/W
Passeridae	*Stagonopleura bella*	Beautiful Firetail			O/W
Pelecanidae	*Pelecanus conspicillatus*	Australian Pelican			O
Petroicidae	*Eopsaltria australis*	Eastern Yellow Robin			O/W
Petroicidae	*Microeca fascinans*	Jacky Winter			O
Petroicidae	*Petroica rosea*	Rose Robin			O/W
Phalacrocoracidae	*Phalacrocorax melanoleucos*	Little Pied Cormorant			O
Phalacrocoracidae	*Phalacrocorax varius*	Pied Cormorant			O
Phalacrocoracidae	*Phalacrocorax carbo*	Great Cormorant			O
Podargidae	*Podargus strigoides*	Tawny Frogmouth			O
Podicipedidae	*Tachybaptus novaehollandiae*	Australasian Grebe			O
Psittacidae	*Alisterus scapularis*	Australian King-Parrot			O/W
Psittacidae	*Glossopsitta concinna*	Musk Lorikeet			W
Psittacidae	*Platycercus elegans*	Crimson Rosella			O/W

Family name	Latin name	Common name	EPBC Act	TSC Act	Obs. type
Psittacidae	*Platycercus eximius*	Eastern Rosella			O/W
Psittacidae	*Trichoglossus haematodus*	Rainbow Lorikeet			O/W
Ptilonorhynchidae	*Ailuroedus crassirostris*	Green Catbird			W
Ptilonorhynchidae	*Ptilonorhynchus violaceus*	Satin Bowerbird			O/W
Rallidae	*Gallinula tenebrosa*	Dusky Moorhen			O
Rallidae	*Fulica atra*	Eurasian Coot			O
Rallidae	*Gallirallus philippensis*	Buff-banded Rail			O
Rallidae	*Porphyrio porphyrio*	Purple Swamphen			O
Strigidae	*Ninox strenua*	Powerful Owl		V	W
Threskiornithidae	*Platalea regia*	Royal Spoonbill			O
Threskiornithidae	*Threskiornis molucca*	Australian White Ibis			O
Threskiornithidae	*Threskiornis spinicollis*	Straw-necked Ibis			O
Zosteropidae	*Zosterops lateralis*	Silvereye			O/W
Mammals					
Canidae	*Vulpes vulpes*	Fox		U	P
Cervidae	*Cervus timorensis*	Rusa Deer		U	O
Leporidae	*Lepus capensis*	Brown Hare		U	O
Leporidae	*Oryctolagus cuniculus*	Rabbit		U	O
Muridae	*Rattus rattus*	Black Rat		U	T
Dasyuridae	*Antechinus stuartii*	Brown Antechinus			T
Emballonuridae	*Saccolaimus flaviventris*	Yellow-bellied Sheathtail Bat		V	AD/AP/AM
Macropodidae	*Macropus giganteus*	Eastern Grey Kangaroo			O
Macropodidae	*Wallabia bicolor*	Swamp Wallaby			O/P
Molossidae	*Mormopterus norfolkensis*	Eastern Freetail Bat		V	AD
Molossidae	*Mormopterus sp. (little penis)*	Mormopterus sp. (little penis)			AD

Family name	Latin name	Common name	EPBC Act	TSC Act	Obs. type
Molossidae	*Tadarida australis*	White-striped Freetail Bat			AD/W
Muridae	*Rattus fuscipes*	Bush Rat			T
Petauridae	*Petaurus breviceps*	Sugar Glider			O/W/N
Petauridae	*Pseudocheirus peregrinus*	Common Ringtail Possum			O/W/P
Phalangeridae	*Trichosurus vulpecula*	Common Brushtail Possum			O/R
Pteropodidae	*Pteropus poliocephalus*	Grey-headed Flying-fox	V	V	O
Rhinolophidae	*Rhinolophus megaphyllus*	Eastern Horseshoe-bat			AD
Tachyglossidae	*Tachyglossus aculeatus*	Short-beaked Echidna			O
Vespertilionidae	*Miniopterus schreibersii oceanensis*	Eastern Bentwing-bat		V	AD/AP/AM
Vespertilionidae	*Chalinolobus gouldii*	Gould's Wattled Bat			AD/T
Vespertilionidae	*Chalinolobus morio*	Chocolate Wattled Bat			AD/AP
Vespertilionidae	*Falsistrellus tasmaniensis*	Eastern False Pipistrelle		V	AP/AM
Vespertilionidae	*Myotis macropus*	Southern Myotis		V	AD/AP
Vespertilionidae	*Nyctophilus geoffroyi*	Lesser Long-eared Bat			T
Vespertilionidae	*Nyctophilus gouldi*	Gould's Long-eared Bat			T
Vespertilionidae	*Nyctophilus sp.*	Long-eared bat sp.			AD/AP
Vespertilionidae	*Scoteanax rueppellii*	Greater Broad-nosed Bat		V	T/AP/AM
Vespertilionidae	*Scotorepens orion*	Eastern Broad-nosed Bat			T/AD/AP
Vespertilionidae	*Vespadelus darlingtoni*	Large Forest Bat			AD/AP
Vespertilionidae	*Vespadelus pumilus*	Eastern Forest Bat			AD/AP/AM
Vespertilionidae	*Vespadelus regulus*	Southern Forest Bat			AP
Vespertilionidae	*Vespadelus vulturnus*	Little Forest Bat			T/AD
Vombatidae	*Vombatus ursinus*	Common Wombat			P
Reptiles					
Agamidae	*Physignathus lesueurii*	Eastern Water Dragon			O

Family name	Latin name	Common name	EPBC Act	TSC Act	Obs. type
Boidae	*Morelia spilota spilota*	Diamond Python			O
Chelidae	*Chelodina longicollis*	Eastern Long-necked Tortoise			R
Elapidae	*Pseudechis porphyriacus*	Red-bellied Black Snake			O
Scincidae	*Ctenotus robustus*	Striped Skink			O
Scincidae	*Eulamprus quoyii*	Eastern Water Skink			O
Scincidae	*Lampropholis delicata*	Grass Skink			O
Scincidae	*Lampropholis guichenoti*	Garden Skink			O
Scincidae	*Tiliqua scincoides*	Eastern Blue-tongued Lizard			O

Act listing: *V = Vulnerable, M = Migratory, U = Unprotected/introduced*
Observation type: *W = heard, O = seen, T = trapped, P = scat, N = glider notches/scratches, R = roadkill, AD = anabat recording (definite), AP = Anabat recording (probable), AM = Anabat recording (possible)*

Appendix C

Threatened flora potentially occurring in the local area

Terrestrial flora listed on the TSC Act and/or the EPBC Act that may occur in the local area

Key: 1) Listed on the EPBC Act as Endangered (E), Critically Endangered (Z) or Vulnerable (V)
2) Listed on the TSC Act as Endangered (E1), Vulnerable (V) or Preliminary Determination (PD)
*) Subject species considered further in Chapter 6

Latin name/common name	EPBC Act[1]	TSC Act[2]	Habitat	Potential habitat in the study area?	Likelihood of occurrence in the locality?
Acacia baueri ssp. *aspera*	-	V	Occurs in the Hawkesbury/Nepean, Southern Rivers, and Sydney Metropolitan Catchment Authority Regions. More specifically it occurs on the Kings Tableland in the central Blue Mountains and with sporadic occurrences on the Woronora Plateau in the Royal National Park, Mt. Keira district and at Wedderburn. May also occur on the escarpment/Woronora Plateau in the Flat Rock Junction and Stanwell Tops area of the Illawarra (DEC 2005a). Occurs in low, damp heathlands, often on exposed rocky outcrops over a wide range of climatic and topographical conditions (DEC 2005a). For instance, at Kings Tableland *A. baueri* subsp. *aspera* occurs on Narrabeen Group Sandstones. The soil landscape is Mount Sinai comprising narrow, rocky crests with steep-sided slopes and rocky benches(NPWS 2000). At Woronora Plateau *A. baueri* subsp. *aspera* occurs in dry to damp heath associated with more open areas within Sandstone Woodland (Keith 1994) dominated by *Eucalyptus sieberi*, *E. rossii* and *Allocasuarina distyla - Banksia ericifolia* scrub-heath. The geology is Hawkesbury Sandstone and soil landscapes include Maddens Plains, Bundeena and Lucas Heights (NPWS 2000). Appears to prefer open conditions; rarely observed where there is any shrub or tree canopy development; and many of the observations of this species have been made following fire, suggesting the species prefers early successional habitats. Peak flowering occurs December to March. Pods have been observed to remain on the plants for several months, maturing October to December (DEC 2005a).	No	Low

Latin name/common name	EPBC Act[1]	TSC Act[2]	Habitat	Potential habitat in the study area?	Likelihood of occurrence in the locality?
Arthropteris palisotii Lesser Creeping Fern	-	E1	May be extinct in NSW. Found in rainforest where it usually grows on tree trunks (Harden and Murray 2000).	Yes. Illawarra Wet Gully Forest and Warm Temperate Layered Forest provide marginal habitat for the species.	Low. There are no records of the species in the locality. There are only two records of the species in NSW. Habitat is marginal and the nearest record of the species is 140 kilometres north of the study area recorded in 1996.
Boronia deanei Deane's Boronia	V	V	Occurs in Hawkesbury/Nepean and Southern Rivers catchments. There are scattered populations of Deane's Boronia between the far south-east of NSW and the Blue Mountains (DEC 2005d). The species grows on the margins of high altitude swamps (Ollerenshaw 1979), in wet heath and in drier open forest on low nutrient, poorly drained peaty soils on sandstone or granite (Benson and McDougall 2001). The distribution of this species overlaps with the following *EPBC Act*-listed threatened ecological communities: White Box-Yellow Box-Blakely's Red Gum grassy woodland and derived native grassland, natural temperate grassland of the Southern Tablelands of NSW and ACT, and temperate highland peat swamps on sandstone (DEC 2005d).	No	Low

Latin name/common name	EPBC Act[1]	TSC Act[2]	Habitat	Potential habitat in the study area?	Likelihood of occurrence in the locality?
Caladenia tessellata Tessellated Spider Orchid	V	E1	*Caladenia tessellata* is found in the Sydney Metropolitan, Southern Rivers, Hawkesbury/Nepean, and Hunter/Central Rivers Catchment Management Regions. Currently known from three disjunct areas: Braidwood on southern tablelands, Ulladulla on the south coast and three populations in Wyong area on the Central Coast (DEC 2005d). It is generally found in grassy, dry sclerophyll forests/woodland, particularly those associated with clay loam, or sandy soils. However, there is one population at Braidwood in lowland on stony soil (DEC 2005d). This species only grows in very dense shrubbery in coastal areas (Bishop 1996). Flowers appear between September and November, but generally late September or early October in extant southern populations (DEC 2005d).	Yes. Currambene-Batemans Lowlands Forest provides marginal habitat for the species.	Low. There are no records of the species in the locality. The potential habitat is marginal and is small in area. The nearest record of the species is a single observation made in 1931 30 kilometres south of the study area. The majority of remaining records are from the Sydney Metropolitan and Central Coast areas.
Callistemon linearifolius	-	V	Occurs chiefly from Georges River to the Hawkesbury River where it grows in dry sclerophyll forest (Harden 2002), open forest, scrubland (Fairley and Moore 2000) or woodland on sandstone. Found in damp places, usually in gullies (Robinson 1994). Flowers in Spring.	No	Low
Chamaesyce psammogeton Sand Spurge	-	E1	Found sparsely along the coast from south of Jervis Bay to Queensland, in the following catchment regions – Hunter/Central Rivers, Hawkesbury/Nepean, Northern Rivers, Southern Rivers and Sydney Metropolitan. Populations have been recorded in Wamberal Lagoon Nature Reserve, Myall Lakes National Park and Bundjalung National Park. Grows on fore-dunes and exposed headlands, often with *Spinifex sericeus.* Flowering occurs in summer, with plant growth occurring in spring and summer (DEC 2005g).	No	Low

Latin name/common name	EPBC Act[1]	TSC Act[2]	Habitat	Potential habitat in the study area?	Likelihood of occurrence in the locality?
*Cryptostylis hunteriana** Leafless Tongue Orchid	V	V	This species typically grows in swamp-heath on sandy soils chiefly in coastal districts (Harden 1993) but has also been recorded on steep bare hillsides (Bishop 1996). This species does not appear to have well defined habitat preferences and is known from a range of communities, including swamp-heath and woodland. The larger populations typically occur in woodland dominated by *Eucalyptus sclerophylla, E. sieberi, Corymbia gummifera* and *Allocasuarina littoralis;* appears to prefer open areas in the understorey of this community and is often found in association with *Cryptostylis subulata* (DEC 2005h).	Yes. Potential habitat considered to be associated with Currambene-Batemans lowlands forest.	Low. The potential habitat is marginal and is small in area. The nearest record of the species is 15 kilometres southwest of the study area recorded in 2005.
*Cynanchum elegans** White-flowered Wax Plant	E	E1	Restricted to eastern NSW where it is distributed from Brunswick Heads on the north coast to Gerroa in the Illawarra region. The species has been recorded as far west as Merriwa in the Upper Hunter River Valley. Catchment management regions include Hawkesbury/Nepean, Hunter/Central Rivers, Northern Rivers, Southern Rivers and Sydney Metropolitan (DEC 2005‰). *Cynanchum elegans* usually occurs on the edge of dry rainforest vegetation. Other associated vegetation types include littoral rainforest; *Leptospermum laevigatum, Banksia integrifolia* subsp. *integrifolia; Eucalyptus tereticornis* open forest and woodland; *Eucalyptus maculata* open forest and woodland; and *Melaleuca armillaris* scrub to open scrub (DEC 2005‰). Flowering occurs between August and May, with a peak in November. Flower abundance on individual plants varies from sparse to prolific (DEC 2005‰).	Yes. Potential habitat considered to be associated with subtropical complex rainforest and warm temperate layered forest.	High. Records in the eastern area of the locality.
Daphnandra sp. "Illawarra'* Illawarra Socketwood	E	E1	Occupies the rocky hillsides and gullies of the Illawarra lowlands, occasionally extending onto the upper escarpment slopes. Associated vegetation includes rainforest and moist eucalypt forest (DEC 2005j).	Yes. Potential habitat considered to be associated with subtropical complex rainforest and warm temperate layered forest.	High. Multiple records in the eastern area of the locality.

Latin name/common name	EPBC Act[1]	TSC Act[2]	Habitat	Potential habitat in the study area?	Likelihood of occurrence in the locality?
Distichlis distichophylla Australian Saltgrass	-	E1	This grass is common in Victoria and Tasmania, and extends to South Australia and Western Australia. In Victoria it is found inland as well, but in its limited NSW range it grows only in coastal situations, except for one existing population at Lake Cargelligo. Scattered records are from the areas of Jervis Bay, Bermagui, Wonboyn, Narooma, Bodalla and Nadgee Nature Reserve (at Womboyn). A coloniser of damp saline soils; found at the edges of salt marshes and on low dunes. Flowers and sets seed in late spring and summer (DEC 2005f).	No	Low
Eucalyptus langleyi Albatross Mallee	V	V	The main occurrence of the Albatross Mallee is to the south-west of Nowra as far as Yarramunmun Creek. It is also found to a limited extent north of the Shoalhaven River in the vicinity of Bomaderry Creek. Found in mallee shrubland on poorly-drained, shallow, sandy soils on sandstone. The species regenerates from rootstock after fire (DEC 2005o).	No	Low
Eucalyptus sturgissiana Ettrema Mallee	-	V	The Ettrema Mallee is mostly restricted to the Northern Budawang Range in Morton National Park, with a few occurrences on the nearby coastal plain. Usually grows as an emergent in low shrub-heath. Grows on sandy, swampy soils (DEC 2005h).	No	Low
*Genoplesium baueri** Bauer's Midge Orchid	-	V	This terrestrial orchid species grows in open sclerophyll forest or moss gardens on sandstone. Typically the habitat is a drier heathy forest (Harden 1993; Bishop 1996). The species has been recorded from locations between Nowra and Pittwater and may occur as far north as Port Stephens. About half the records were made before 1960 with most of the older records being from Sydney suburbs including Asquith, Cowan, Gladesville, Longueville and Wahroonga. No collections have been made from those sites in recent years. Flowers December to March (DEC 2005i).	No	Low
Genoplesium superbum	-	E1	*Genoplesium superbum* is restricted to the southern tablelands of NSW where it has been recorded from two locations near Nerriga, c. 20 km apart. Some plants fall within the boundary of Morton National Park. Occurs predominantly in wet heathland on shallow soils above a sandstone cap but has also been found in open woodland interspersed with heath (DEC 2005j).	No	Low

Latin name/common name	EPBC Act[1]	TSC Act[2]	Habitat	Potential habitat in the study area?	Likelihood of occurrence in the locality?
Haloragis exalata ssp *exalata* Square Raspwort	-	V	Square Raspwort occurs in four widely scattered localities in eastern NSW. These disjunct populations occur on the central coast, south coast and north-western slopes of NSW. This species prefers protected and shaded damp habitat in riparian communities. Flowering has been recorded throughout November to January (DEC 2005l).	Yes. Riverbank forest provides habitat for the species.	Low. Habitat for the species in the study area is highly degraded and subject to continuing impacts such as weed invasion and grazing. There are no records of the species in the locality and nearest record of the species is 140 kilometres north of the study area recorded in 1996.
*Irenepharsus trypherus** Delicate Cress	E	E1	Occurs on coast and escarpment between Wollongong and the Shoalhaven River (Harden 1990). Typically inhabits steep rocky slopes near cliff lines and ridge tops. The species is less typically found growing out of rock crevices or on narrow benches along cliff lines. The vast majority of sites are recorded from the upper slopes of the ridge systems that extend south and east of the Illawarra escarpment, although the species has also been recorded from the deep sandstone gorges of the Shoalhaven River. Associated vegetation includes moist sclerophyll forest, Ironwood *Backhousia myrtifolia* thicket, and rainforest (DEC 2005u).	Yes. Potential habitat considered to be associated with subtropical complex rainforest, Illawarra gully wet forest and warm temperate layered forest.	Low. Although there are no records of the species in the locality there are multiple records of the species approximately 15 kilometres to the west in the vicinity of Kangaroo Valley.

Latin name/common name	EPBC Act[1]	TSC Act[2]	Habitat	Potential habitat in the study area?	Likelihood of occurrence in the locality?
Lastreopsis hispida Bristly Shield Fern	-	E1	In NSW, occurs in the Blue Mountains. Also occurs in Southern Victoria and Tasmania. Grows in wet forests, frequently under *Nothofagus antarcticus* and often rotting on logs (DEC 2005x).	Yes. Illawarra Wet Gully Forest and Warm Temperate Layered Forest provide marginal habitat for the species.	Low. Habitat is marginal and there are only five records of the species in NSW. The single record in the southeast area of the locality dates from 1884. The remaining records are from the Blue Mountains between 1914 and 1979.
Melaleuca biconvexa Biconvex Paperbark	V	V	*Melaleuca biconvexa* is only found in NSW, with scattered and dispersed populations found in the Jervis Bay area in the south and the Gosford-Wyong area in the north. Catchment regions include: Hunter/Central Rivers, Hawkesbury/Nepean, Southern Rivers, and Northern River catchments (DEC 2005{). *Melaleuca biconvexa* generally grows in damp places, often near streams or low-lying areas on alluvial soils of low slopes or sheltered aspects. Flowering occurs over just three to four weeks in September and October (DEC 2005{).	No	Low

Latin name/common name	EPBC Act[1]	TSC Act[2]	Habitat	Potential habitat in the study area?	Likelihood of occurrence in the locality?
Pimelea spicata Spiked Rice-flower	E	E1	Once widespread on the Cumberland Plain, *Pimelea spicata* occurs in two disjunct areas, the Cumberland Plain and the Illawarra. Catchment areas are Hawkesbury/Nepean, Southern Rivers, and Sydney Metropolitan catchment (NPWS 2000). In the Illawarra region, *P. spicata* is found in open woodland and also in coastal grassland communities with emergent shrubs. Dominant species within the woodland habitat include *Eucalyptus tereticornis, E. eugenioides, Themeda australis,* and *Lomandra longifolia*. In the Coastal Illawarra it occurs commonly in Coast Banksia open woodland with a well developed shrub and grass understorey (NPWS 2004). *Pimelea spicata* flowers sporadically throughout the year, with flowering likely to depend upon climatic conditions, particularly rainfall. Flowering times recorded for *P. spicata* vary. Benson and McDougall (2001) noted peak flowering period as March/April (NPWS 2000).	No	High. One record at Black Head at the eastern extent of the locality.
Pomaderris adnata Sublime Point Pomaderris	-	E1	Ridgetop vegetation often with *Eucalyptus sieberi* and *Corymbia gummifera* (NSW Scientific Committee 2001). Occurs near the edge of the plateau behind the Illawarra escarpment. Known only from one site at Sublime Point, north of Wollongong (DEC 2005p).	No	Low
*Pterostylis gibbosa** Illawarra Greenhood	E	E1	Known from a small number of populations in the Hunter region, the Illawarra region and the Shoalhaven region. It is apparently extinct in Western Sydney which is the area where it was first collected (1803) (DEC 2005€). All known populations grow in open forest or woodland, on flat or gently sloping land with poor drainage. In the Illawarra region, the species grows in woodland dominated by *Eucalyptus tereticornis, E. longifolia and Melaleuca decora*. Near Nowra, the species grows in an open forest of *Corymbia maculata, E. tereticornis* and *E. paniculata*. In the Hunter region, the species grows in open woodland dominated by *E. crebra, Forest Red Gum* and *Callitris endlicherii* (DEC 2005€). The Illawarra Greenhood is a deciduous orchid that is only visible above the ground between late summer and spring, and only when soil moisture levels can sustain its growth. The leaf rosette grows from an underground tuber in late summer, followed by the flower stem in winter (DEC 2005€).	No	Low

Latin name/common name	EPBC Act[1]	TSC Act[2]	Habitat	Potential habitat in the study area?	Likelihood of occurrence in the locality?
Pterostylis pulchella Waterfall Greenhood	V	V	The Waterfall Greenhood is found only at Fitzroy Falls, Belmore Falls, upper Bundanoon Creek (Meryla) and Minnamurra Falls (DEC 2005‹). Usually favours creek banks and mossy rocks very close to running water (Bishop 1996). Flowers appear from February to May (DEC 2005‹).	No	Low
Pultenaea aristata Prickly Bush-pea	V	V	Restricted to the Woronora Plateau, a small area between Helensburgh, south of Sydney, and Mt Keira above Wollongong. The species occurs in either dry sclerophyll woodland or wet heath on sandstone. Flowering has been recorded in winter and spring (DEC 2005s).	No	Low
Rulingia prostrata Dwarf Kerrawang	E	E1	*Rulingia prostata* occurs on the Southern Tablelands, and on the North Coast, in the Hawkesbury/Nepean, Hunter/Central Rivers, Murrumbidgee and Southern Rivers Catchments. Occurs on sandy, sometimes peaty soils in a wide variety of habitats: *Eucalyptus pauciflora* Woodland at Rose Lagoon; *E. agglomerata* Open Forest at Tallong; and in *E. mannifera* Low Open Woodland at Penrose; *Eucalyptus haemostoma*/*E. robusta* Ecotonal Forest at Tomago (DEC 2005v). Associated native species may include *Imperata cylindrica*, *Empodisma minus* and *Leptospermum continentale*. Appears to respond positively to some forms of disturbance (DEC 2005v).	No	Low
Senna acclinis Rainforest Cassia	-	E1	Found in coastal districts and adjacent tablelands of NSW from the Illawarra in NSW to Queensland. Grows in or on the edges of subtropical and dry rainforest (DEC 2005w).	Yes. Illawarra Wet Gully Forest and Warm Temperate Layered Forest provide marginal habitat for the species.	Low. There are no records of the species in the locality and the nearest record of the species is 40 kilometres north of the study area recorded in 1998.

Latin name/common name	EPBC Act[1]	TSC Act[2]	Habitat	Potential habitat in the study area?	Likelihood of occurrence in the locality?
Solanum celatum	-	E1	Restricted to an area from Wollongong to just south of Nowra, and west to Bungonia. Majority of records are prior to 1960 and the majority of populations are likely to have been lost to clearing. Grows in rainforest clearings, or in wet sclerophyll forests. Flowers August to October and produces fruit December to January (DEC 2005x).	Yes. Illawarra Wet Gully Forest and Warm Temperate Layered Forest provide marginal habitat for the species.	Low. There are no records of the species in the locality and the habitat is marginal. The majority of records in the region are on the higher slopes of the Cambewarra and Illawarra Ranges.
Syzygium paniculatum Magenta Lilly Pilly	V	V	Subtropical and littoral rainforest on sandy soils or stabilised dunes near the sea (Harden 1991). Found only in NSW, in a narrow, linear coastal strip from Bulahdelah to Conjola State Forest. On the south coast the Magenta Lilly Pilly occurs on grey soils over sandstone, restricted mainly to remnant stands of littoral (coastal) rainforest. On the central coast Magenta Lilly Pilly occurs on gravels, sands, silts and clays in riverside gallery rainforests and remnant littoral rainforest communities (DEC 2005{). The species occurs in the Hunter/Central Rivers, Hawkesbury/Nepean, Sydney Metropolitan, and Southern Rivers Catchment Authority Regions	Yes. Illawarra Wet Gully Forest and Warm Temperate Layered Forest provide marginal habitat for the species.	Low. There are no records of the species in the locality. The nearest record of the species is from 2004, 17 kilometres to the south in an urban area.
Thelymitra sp. Kangaloon Kangaloon Sun-orchid	Z	PD E1	*Thelymitra* sp. Kangaloon is a terrestrial orchid endemic to NSW, and is known from three locations near Robertson in the Southern Highlands. The swamp habitat in which the species occurs has an extent of occurrence of 300 square kilometres and an area of occupancy of 10 square kilometres. The three swamps are Butlers Swamp, Stockyard Swamp and Wildes Meadow Swamp, and are all located above what is known as the Kangaloon aquifer. It flowers in late October and early November. The species grows amongst tall sedges and rushes in seasonally swampy sedgeland on grey silty clay loam at 600 metres to 700 metres above sea level (Threatened Species Listing Advice 2008).	No	Low

Latin name/common name	EPBC Act[1]	TSC Act[2]	Habitat	Potential habitat in the study area?	Likelihood of occurrence in the locality?
Thesium australe Austral Toad-flax	V	V	Found in very small to large populations scattered across eastern NSW, along the coast, and from the Northern to Southern Tablelands. *Thesium australe* is a root parasite that takes water and some nutrient from other plants, especially Kangaroo Grass (DEC 2005ˆ). It is often found in damp sites in association with *Themeda australis*, but also found on other grass species at inland sites (G. Leonard pers. obs.). Occurs on clay soils in grassy woodlands or coastal headlands (James *et al.* 1999).	Yes. Potential habitat considered to be associated with Currambene-Batemans lowlands forest.	Low. The potential habitat is small in area. The nearest record of the species is 67 kilometres south of the study area recorded in 1911.
Triplarina nowraensis Nowra Heath-myrtle	E	E1	There are five known populations of *Triplarina nowraensis.* Three of these form a cluster to the immediate west of Nowra. A fourth, much smaller population is found 18 kilometres south-west of Nowra in the Boolijong Creek Valley. The fifth population is located north of the Shoalhaven River on the plateau above Bundanon. *Triplarina nowraensis* occurs on poorly drained, gently sloping sandstone shelves or along creek lines underlain by Nowra Sandstone. The sites are often either treeless or have a very open tree canopy due to the impeded drainage (DEC 2005Œ).	No	Low
Wilsonia backhousei Narrow-leafed Wilsonia	-	V	In NSW *Wilsonia backhousei* is found in the Southern Rivers and Sydney Metropolitan Catchment Area, specifically on the coast between Mimosa Rocks National Park and Wamberal north of Sydney (Nelson's Lake, Potato Point, Sussex Inlet, Wowly Gully, Parramatta River at Ermington, Clovelly, Voyager Point, Wollongong and Royal National Park) (DEC 2005}). This is a species of the margins of salt marshes and lakes, both coastal and inland, chiefly in the Sydney district, also common at Jervis Bay (Harden 1992). Flowering occurs in spring and summer (DEC 2005}).	No	Low
Wilsonia rotundifolia Round-leafed Wilsonia	-	E1	Occurs in the Sydney Metropolitan, Hawkesbury/Nepean, Murray and Southern Rivers Catchment Authority Regions. Is known from several sites in the Jervis Bay area, Royal National Park, near Deniliquin and in Lake George and Lake Bathurst (DEC 2005d~). Grows in mud in coastal salt marsh and inland saline lakes. It occurs in mid marsh, mixed with *Sporobolus virginicus* and *Sarcocornia quinqueflora*. Flowers mainly appear in spring and summer (DEC 2005d~).	No	Low

Latin name/common name	EPBC Act[1]	TSC Act[2]	Habitat	Potential habitat in the study area?	Likelihood of occurrence in the locality?
Zieria baeuerleni Bomaderry Zieria	E	E1	The species occurs in only one location north-west of Nowra. The population occurs in a total of 43 colonies in six discrete clusters. These clusters are confined within a 0.5 kilometre x 1.0 kilometre area of the bushland, and are found on both sides of Bomaderry Creek. Bomaderry *Zieria baeuerleni* occurs on skeletal sandy loam overlaying sandstone, on a rocky plateau amongst sandstone boulders in either shrubby open forest, shrubby woodland or closed scrub (DEC 2005).	No	Low
*Zieria granulata** Hill Zieria	E	E1	Occurs in the Kiama district where it grows on dry rocky ridges in sclerophyll forest to rainforest margins (Harden 2002). The species primarily occupies the coastal lowlands between Oak Flats and Toolijooa, in the local government areas of Shellharbour and Kiama. The typical habitat is dry ridge tops and rocky outcrops on shallow volcanic soils. Less frequently found on the moist slopes of the Illawarra escarpment and in low-lying areas on Quaternary sediments. Associated vegetation includes *Melaleuca armillaris* scrub, *Eucalyptus tereticornis* woodland and rainforest margins, although the species has been recorded from a number of other vegetation types (DEC 2005').	Yes. Potential habitat considered to be associated with subtropical complex rainforest and warm temperate layered forest, associated with rocky outcrops.	High. Multiple records in the eastern area of the locality.
Zieria tuberculata Warty Zieria	V	V	Warty Zieria grows in the Mt Dromedary and Tilba Tilba area. The population in the Cambewarra Mountain area near Nowra is now referable to a separate taxon. The Warty Zieria grows in heath amongst rocky outcrops on rain forest edges and in tall forest and shrubland. The flowers appear from late winter to spring (DEC 2005). Now known only from Little Dromedary Mt and the lower eastern slopes of Mt Dromedary in the Central Tilba area on the South Coast of NSW, the species has a geographic range of 6 kilometres. In 1931, it was collected from Good Dog Mountain in the Cambewarra Range, north of Nowra but more recent searches have failed to find the species there. Although this site is now heavily revegetated, the species may have been eliminated from the area as a result of earlier clearing and grazing (DEWHA 2008b). The total known population of about 900 plants grows at eight sites. Four populations are on private property. Three of the smaller populations totalling about 60 plants occur within Gulaga NP and the Little Dromedary Mt population is on crown land (DEWHA 2008b).	No	Low

Appendix D

Threatened and migratory fauna potentially occurring in the local area

Terrestrial fauna listed on the TSC Act and/or the EPBC Act that may occur in the local area

Key: 1) Listed on the EPBC Act as Endangered (E), Critically Endangered (Z), Vulnerable (V) or covered under migratory provisions (M) of the Act
2) Listed on the TSC Act as Endangered (E1), Critically Endangered (CI) or Vulnerable (V)
*) Subject species considered further in Chapter 6
#) Migratory species considered further in Chapter 6

Note: Species which were recorded in the study area during current surveys are presented in bold font.

Latin name/ common name	EPBC Act[1]	TSC Act[2]	Habitat	Potential habitat in study area?	Likelihood of occurrence in the locality?
Amphibians					
*Litoria aurea** Green and Golden Bell Frog	V	E1	Most existing locations for the species occur as small, coastal, or near coastal populations, with records occurring between south of Grafton and northern Victoria (NSW Government 2009). The species is found in marshes, dams and stream sides, particularly those containing bullrushes or spikerushes. Preferred habitat contains water bodies that are unshaded, are free of predatory fish, have a grassy area nearby and have diurnal sheltering sites nearby such as vegetation or rocks (NPWS 1999e; White and Pyke 1996), although the species has also been recorded from highly disturbed areas including disused industrial sites, brick pits, landfill areas and cleared land. Breeding usually occurs in summer. Tadpoles, which take about 10-12 weeks to develop (DECC 2008), feed on algae and other vegetative matter. Adults eat insects as well as other frogs, including juveniles of their own species (DEC2005k).	Yes, but limited.	High. Previously recorded south of the study area within Foys and Coomonderry swamps.
Litoria littlejohni Littlejohn's Tree Frog	V	V	The species is distributed along the eastern slopes of the Great Dividing Range from Watagan State Forest near Wyong, south to Buchan in north-eastern Victoria. It is not known from coastal habitats (DEH 2005). Occurs in wet and dry sclerophyll forests and heath communities associated with sandstone outcrops between 280 metres and 1000 metres (Barker *et al.* 1995). Littlejohn's Tree Frog prefers permanent and semi-permanent rocky flowing streams, but individuals have also been collected from semi-permanent dams with some emergent vegetation (Barker *et al.* 1995). Forages both in the tree canopy and on the ground, and has been observed sheltering under rocks on high exposed ridges during summer. The species breeds in autumn but will also breed after heavy rainfall in spring and summer (NSW Scientific Committee 2000). The species has been recorded calling in all seasons with variously reported peak calling periods (DEH 2005). Eggs are laid in loose gelatinous masses attached to submerged twigs; eggs and tadpoles are most often recorded in slow-flowing pools that receive extended exposure to sunlight (DSEWPC 2010).	No	Low. Previously recorded north and north-west of the locality. Not a coastal species.

Latin name/ common name	EPBC Act[1]	TSC Act[2]	Habitat	Potential habitat in study area?	Likelihood of occurrence in the locality?
Heleioporus australiacus Giant Burrowing Frog	V	V	Prefers hanging swamps on sandstone shelves adjacent to perennial non-flooding creeks (Daly 1996; Recsei 1996). Can also occur within shale outcrops within sandstone formations. Known from wet and dry forests and montane woodland in the southern part range (Daly 1006). Individuals can be found around sandy creek banks or foraging along ridge-tops during or directly after heavy rain. Males often call from burrows located in sandy banks next to water (Barker *et al.* 1995). Spends the majority of its time in non-breeding habitat 20-250 metres from breeding sites (Penman *et al.* 2008).	No	Low. Previously recorded 10 kilometres west and south-west of the study area.
Mixophyes balbus Stuttering Frog	V	E1	This species is usually associated with mountain streams, wet mountain forests and rainforests (Barker *et al.* 1995). It rarely moves very far from the banks of permanent forest streams, although it will forage on nearby forest floors. Eggs are deposited in leaf litter on the banks of streams and are washed into the water during heavy rains (Barker *et al.* 1995).	No	Low. Not previously recorded within 10 kilometres of the study area.
Pseudophryne australis Red-crowned Toadlet	-	V	Occurs on wetter ridge tops and upper slopes of sandstone formations on which the predominant vegetation is dry open forests and heaths. This species typically breeds within small ephemeral creeks characterised by a series of shallow pools that feed into larger semi-perennial streams (Thumm and Mahony 1997). Breeds all year round (Thumm and Mahony 1997).	No	Low. Not previously recorded within 10 kilometres of the study area.
Birds					
*Circus assimilis** Spotted Harrier	-	V	The Spotted Harrier is found throughout Australia but rarely in densely forested and wooded habitat of the escarpment and coast (NSW Scientific Committee 2010b). Preferred habitat consists of open and wooded country with grassland nearby for hunting. Habitat types include open grasslands, acacia and mallee remnants, spinifex, open shrublands, saltbush, very open woodlands, crops and similar low vegetation (NSW Scientific Committee 2010b). The Spotted Harrier is more common in drier inland areas, nomadic part migratory and dispersive, with movements linked to the abundance of prey species. Nesting occurs in open or remnant woodland and unlike other harriers, the Spotted Harrier nests in trees (Marchant and Higgins 1993).	Yes	High. Previously recorded just south of the study area within Berry and north of the study area.
***Haliaeetus leucogaster*[#] White-bellied Sea-eagle**	**M**	**-**	**A migratory species that is generally sedentary in Australia, although immature individuals and some adults are dispersive** (Marchant and Higgins 1993)**. Found in terrestrial and coastal wetlands; favouring deep freshwater swamps, lakes and reservoirs; shallow coastal lagoons and saltmarshes. It hunts over open terrestrial habitats. Feeds on birds, reptiles, fish, mammals, crustaceans and carrion. Roosts and makes nest in trees** (Marchant and Higgins 1993)**.**	**Yes**	**High. Recorded during field surveys at the western end of the study area. Also previously recorded north, south, east and west of the study area.**

Latin name/ common name	EPBC Act[1]	TSC Act[2]	Habitat	Potential habitat in study area?	Likelihood of occurrence in the locality?
*Hieraaetus morphnoides** Little Eagle	-	V	The Little Eagle is most abundant in lightly timbered areas with open areas nearby providing an abundance of prey species (NSW Scientific Committee 2009b). It has often been recorded foraging in grasslands, crops, treeless dune fields, and recently logged areas. The Little Eagle nests in tall living trees within farmland, woodland and forests (Marchant and Higgins 1993).	Yes	High. Previously recorded east of the study area at Crooked River. Also previously recorded north and south-west of the study area.
*Lophoictinia isura** Square-tailed Kite	-	V	Typically inhabits coastal forested and wooded lands of tropical and temperate Australia (Marchant and Higgins 1993). In NSW it is often associated with ridge and gully forests dominated by *Eucalyptus longifolia, Corymbia maculata, E. elata*, or *E. smithii* (NPWS 1999i). Individuals appear to occupy large hunting ranges of more than 100 square kilometres. They require large living trees for breeding, particularly near water with surrounding woodland/forest close by for foraging habitat. Nest sites are generally located along or near watercourses, in a tree fork or on large horizontal limbs (Marchant and Higgins 1993).	Yes	High. Previously recorded south of the study area at Coomonderry Swamp and 10 kilometres to the south-west.
*Pandion haliaetus** Osprey	M	V	Found in coastal waters, inlets, estuaries and offshore islands. Occasionally found 100 kilometres inland along larger rivers (Pizzey and Knight 1997). It is water-dependent, hunting for fish in clear, open water. The Osprey occurs in terrestrial wetlands, coastal lands and offshore islands. It is a predominantly coastal species, generally using marine cliffs as nesting and roosting sites. Nests can also be made high up in dead trees or in dead crowns of live trees, usually within one kilometre of the sea (Marchant and Higgins 1993).	Yes	Moderate. Previously recorded once, south of the study area at Seven Mile Beach National Park.
*Oxyura australis** Blue-billed Duck	-	V	Almost wholly aquatic, preferring deep water in large, permanent wetlands with an abundant aquatic flora (Marchant and Higgins 1990).	Yes, but limited.	Low. Habitat is marginal and the closest records occur 10 kilometres southeast of the study area recorded over 25 years ago in 1985.
*Stictonetta naevosa** Freckled Duck	-	V	The Freckled Duck breeds in permanent fresh swamps that are heavily vegetated. Found in fresh or salty permanent open lakes, especially during drought. Often seen in groups on fallen trees and sand spits (Simpson and Day 1996).	Yes, but limited.	Low. Habitat is marginal and the closest record occurs 11 kilometres southwest of the study area recorded 30 years ago in 1981.

Latin name/ common name	EPBC Act[1]	TSC Act[2]	Habitat	Potential habitat in study area?	Likelihood of occurrence in the locality?
***Apus pacificus*[#]** **Fork-tailed Swift**	**M**	**-**	**Almost exclusively aerial. The Fork-tailed Swift breeds in Asia but migrates to Australia from September to April (Higgins 1999). Individuals or flocks can be observed hawking for insects at varying heights from only a few metres from the ground and up to 300 metres high (Boehm 1944).**	**Yes**	**High. Recorded during field surveys (site 7). Likely to fly high over the study area.**
Hirundapus caudacutus[#] White-throated Needletail	M	-	An aerial species found in feeding concentrations over cities, hilltops and timbered ranges. Breeds in Asia (Pizzey and Knight 1997).	Yes	High. Likely to fly high over the study area.
Ardea alba[#] Great Egret	M	-	Terrestrial wetlands, estuarine and littoral habitats and moist grasslands. Inland, prefer permanent waterbodies on floodplains; shallows of deep permanent lakes (either open or vegetated), semi-permanent swamps with tall emergent vegetation and herb dominated seasonal swamps with abundant aquatic flora. Also regularly use saline habitats including mangrove forests, estuarine mudflats, saltmarshes, bare saltpans, shallows of salt lakes, salt fields and offshore reefs. Breeding requires wetlands with fringing trees in which to build nests including mangrove forest, freshwater lakes or swamps and rivers (Marchant and Higgins 1990).	Yes	High. Previously recorded within Broughton Creek (site 32) as well as south of the study area.
***Ardea ibis*[#]** **Cattle Egret**	**M**	**-**	**Occurs in tropical and temperate grasslands, wooded lands and terrestrial wetlands** (Marchant and Higgins 1990)**.**	**Yes**	**High. Recorded during field surveys. Also previously recorded north, south, east and west of the study area.**
*Botaurus poiciloptilus** Australasian Bittern	E	E1	The Australasian Bittern is distributed across south-eastern Australia. Often found in terrestrial and estuarine wetlands, generally where there is permanent water with tall, dense vegetation including Typha spp. and Eleoacharis spp. (DECC 2005; NPWS 1999a). Typically this bird forages at night on frogs, fish and invertebrates, and remains inconspicuous during the day. The breeding season extends from October to January with nests being built amongst dense vegetation on a flattened platform of reeds (DECC 2005).	Yes	High. Previously recorded north-east, south-east and south of the study area (including within Coomonderry Swamp).
Egretta sacra Eastern Reef Egret	M	-	Widely distributed throughout a range of maritime littoral and estuarine habitats on mainland, islands and atolls. Prefers rocky shorelines. Roosts within close proximity to water, on dead or living trees, sand spits, banks, and artificial structures, such as wharfs (Marchant and Higgins 1990).	No	High. Previously recorded south-east of the study area at Crooked River and Black Head.

Latin name/ common name	EPBC Act[1]	TSC Act[2]	Habitat	Potential habitat in study area?	Likelihood of occurrence in the locality?
*Ixobrychus flavicollis** Black Bittern	-	V	The Black Bittern is found along the coastal plains within NSW, although individuals have rarely being recorded south of Sydney or inland. It inhabits terrestrial and estuarine wetlands such as flooded grasslands, forests, woodlands, rainforests and mangroves with permanent water and dense waterside vegetation (DEC 2005c). The Black Bittern typically roosts on the ground or in trees during the day and forages at night on frogs, reptiles, fish and invertebrates (DEC 2005c). The breeding season extends from December to March. Nests are constructed of reeds and sticks in branches overhanging the water.	Yes	High. Previously recorded on the edge of the study area adjacent to Town Creek (south of Berry) and south-east of the study area at Black Head.
*Burhinus grallarius** Bush Stone-curlew	-	E1	Lightly timbered open forest and woodland, or partly cleared farmland with remnants of woodland, with a ground cover of short sparse grass and few or no shrubs where fallen branches and leaf litter are present (Marchant and Higgins 1993).	Yes	Moderate. Previously recorded once, about 9 kilometres south of the study area.
Esacus neglectus Beach Stone-curlew	-	C1	Occurs on open, undisturbed beaches, islands, reefs and estuarine intertidal sand and mudflats (Marchant and Higgins 1993).	No	Moderate. Previously recorded once, about 10 kilometres south of the study area.
Callocephalon fimbriatum* **Gang-gang Cockatoo**	**-**	**V**	**In summer, occupies tall montane forests and woodlands, particularly in heavily timbered and mature wet sclerophyll forests** (Higgins 1999)**. Also occur in subalpine Snow Gum woodland and occasionally in temperate or regenerating forest (Forshaw and Cooper 1981). In winter, occurs at lower altitudes in drier, more open eucalypt forests and woodlands, particularly in box-ironbark assemblages, or in dry forest in coastal areas (Shields and Crome 1992). It requires tree hollows in which to breed (Gibbons and Lindenmayer 1997).**	**Yes**	**High. Recorded during field surveys (site 8). Also previously recorded north, south, east and west of the study area.**
*Calyptorhynchus lathami** Glossy Black-cockatoo	-	V	Inhabits forest with low nutrients, characteristically with key Allocasuarina species. Tends to prefer drier forest types (NPWS 1999c). Often confined to remnant patches in hills and gullies. Breed in hollows stumps or limbs, either living or dead (Higgins 1999).	Yes	High. Recorded during field surveys within the Berry to Bomaderry upgrade study area. Also previously recorded north, south, east and west of the current study area.
Charadrius bicinctus[#] Double-banded Plover	M	-	Tidal mudflats, beaches, exposed reefs, salt marshes, freshwater wetlands, inland salt lakes, short grass on golf courses, airfields (Morcombe 2003).	Yes	High. Previously recorded south of the study area at Seven Mile Beach National Park and Coomonderry Swamp.

Latin name/ common name	EPBC Act[1]	TSC Act[2]	Habitat	Potential habitat in study area?	Likelihood of occurrence in the locality?
*Charadrius leschenaultia** Greater Sand Plover	M	V	Entirely coastal in NSW, foraging on intertidal sand and mudflats in estuaries and roosting during high tide on sandy beaches or rocky shores. Individuals have been recorded on inshore reefs, rock platforms, small rocky islands and sand cays on coral reefs, within Australia. Occasional sightings have also occurred on near-coast saltlakes, brackish swamps, shallow freshwater wetlands and grassed paddocks (NPWS 1999d).	Yes	Moderate. Previously recorded once, south-east of the study area at Seven Mile Beach National Park.
Charadrius mongolus Lesser Sand Plover	M	V	In Australia, the species is known to favour coastal environs including beaches, mudflats and mangroves. Within NSW, individuals have been observed on intertidal sand and mudflats in estuaries or roosting on sandy beaches or rocky shores at high tide (NPWS 1999f).	No	Moderate. Previously recorded south of the study area at Coomonderry Swamp.
Charadrius ruficapillus Red-capped Plover	M	-	Large numbers occur on inland salt lakes, salty edges of waterways, brackish pools and claypans. Commonly found within sheltered estuaries and salt marsh lagoons (Morcombe 2003).	No	Low. Not previously recorded within 10 kilometres of the study area.
Charadrius veredus[#] Oriental Plover	M	-	Generally inland; open grasslands in arid and semi-arid zones; less often in estuarine or littoral environments. Prefers flat inland plains, sparsely vegetated with short grass, and with much hard bare ground, including claypans, playing fields, lawns and cattle camps. At onset of wet season, may move to lightly wooded grasslands (Marchant and Higgins 1993).	Yes	Low. Not previously recorded within 10 kilometres of the study area.
Pluvialis fulva[#] Pacific Golden Plover	M	-	Migratory species that visits estuaries mudflats, saltmarshes and ocean shores as well as paddocks, grasslands and swamps near the coast (Pizzey and Knight 1997).	Yes	High. Previously recorded south of the study area at Coomonderry Swamp.
Pluvialis squatarola Grey Plover	M	-	Almost entirely coastal, but occasionally recorded on inland wetlands. Mainly on marine shores, inlets, estuaries and lagoons where there are nearby large tidal mudflats or sandflats for feeding and sandy beaches for roosting (Marchant and Higgins 1993).	No	Low. Previously recorded once, south of the study area at Shoalhaven Heads.
Thinornis rubricollis Hooded Plover	-	C1	Prefers sandy ocean beaches, especially those that are broad and flat (Marchant and Higgins 1993).	No	Low. Previously recorded once about 10 kilometres south of the study area at Shoalhaven River mouth.

Latin name/ common name	EPBC Act[1]	TSC Act[2]	Habitat	Potential habitat in study area?	Likelihood of occurrence in the locality?
*Ephippiorhynchus asiaticus** Black-necked Stork	-	E1	Found in swamps, mangroves and mudflats. Can also occur in dry floodplains and irrigated lands and occasionally forages in open grassy woodland. Nests in live or dead trees usually near water (Pizzey and Knight 1997).	Yes	Low. Previously recorded south-east of the study area at Crooked River and south of the study area at Coomonderry Swamp (records over 30 years old).
*Ptilinopus magnificus** Wompoo Fruit-dove	-	V	Mainly occurs in large undisturbed patches of tall tropical or subtropical rainforest. Occasionally occurs in patches of monsoon forest, closed gallery forest, wet sclerophyll forest, tall open forest, open woodland or vine thickets near rainforest (Higgins and Davies 1996).	Yes, but limited.	Low. Not previously recorded within 10 kilometres of the study area.
*Ptilinopus regina** Rose-crowned Fruit-dove	-	V	Occurs in tall tropical and subtropical, evergreen or semi-deciduous rainforest, especially with dense growth of vines. Prefers large patches of rainforest, but sometimes occurs in remnant patches surrounded by suboptimal habitat including farmlands (Higgins and Davies 1996).	Yes, but limited.	Low. Not previously recorded within 10 kilometres of the study area.
*Ptilinopus superbus** Superb Fruit-Dove	-	V	The Superb Fruit Dove's NSW distribution ranges from northern NSW to as far south as Moruya (DEC 2005y). It is found in rainforests, closed forests (including mesophyll vine forests) and sometimes in eucalypt and acacia woodlands where there are fruit-bearing trees (Higgins and Davies 1996). It forages in the canopy of fruiting trees such as figs and palms. Nests are constructed high in the canopy throughout September to January (DEC 2005y).	Yes, but limited.	Low. Previously recorded once, north-east of the study area, outside the locality.
Cuculus saturatus[#] Oriental Cuckoo	M	-	Canopy or shrub layer of monsoon rainforest, vine thickets, wet sclerophyll forest, or open casuarina, Acacia or Eucalyptus woodland (Higgins 1999).	Yes	Low. Previously recorded nine kilometres north of the study area.
Monarcha melanopsis[#] **Black-faced Monarch**	**M**	**-**	**A migratory species found during the breeding season in damp gullies in temperate rainforests. Disperses after breeding into more open woodland** (Pizzey and Knight 1997)**.**	**Yes**	**High. Recorded during field surveys (sites 3, 15, 17, 18, 20, 23 and 28). Also previously recorded north, north-east, south and west of the study area.**
Monarcha trivirgatus[#] Spectacled Monarch	M	-	Found in darker parts of mountain and lowland rainforest, adjacent to thickly wooded gullies (Pizzey and Knight 1997).	Yes	Low. Previously recorded eight kilometres and 10 kilometres north of the study area.

Latin name/ common name	EPBC Act[1]	TSC Act[2]	Habitat	Potential habitat in study area?	Likelihood of occurrence in the locality?
Myiagra cyanoleuca[#] Satin Flycatcher	M	-	Migratory species that occurs in coastal forests, woodlands and scrubs during migration. Breeds in heavily vegetated gullies (Pizzey and Knight 1997).	Yes	High. Previously recorded south-east of the study area at Seven Mile Beach National Park and once, 9.5 kilometres to the north.
Rhipidura rufifrons[#] **Rufous Fantail**	**M**	**-**	**Migratory species that prefers dense, moist undergrowth of tropical rainforests and scrubs. During migration it can stray into gardens and more open areas** (Pizzey and Knight 1997)**.**	**Yes**	**High. Recorded during field surveys (sites 3, 15 and 20). Also previously recorded north, south, east and west of the study area.**
Haematopus fuliginosus Sooty Oystercatcher	-	V	The Sooty Oystercatcher is found on undisturbed tidal rocks on ocean shores and islands. Occasionally it is observed on sandspits and mudflats (Pizzey and Knight 1997). It forages on exposed rock or coral at low tide for limpets and mussels. The Sooty Oystercatcher breeds in spring and summer almost exclusively offshore or on isolated promontories (DECCW 2005b).	No	High. Previously recorded east and south-east of the study area along the coast.
*Haematopus longirostris** Pied Oystercatcher	-	E1	An intertidal forager found on undisturbed sandy beaches and spits, tidal mudflats and estuaries. Its food supply (beach macroinvertebrates) have been negatively affected by human impacts (NSW Scientific Committee 2010a). The Pied Oystercatcher is restricted to the littoral zone of beaches and estuaries, nesting on the ground above the tideline. A pair will re-nest in the same spot each year, rarely shifting their territory (NSW Scientific Committee 2010a). Occasionally the Pied Oystercatcher is found in paddocks near the coast (Pizzey and Knight 1997).	Yes	High. Previously recorded south of the study area at Seven Mile Beach National Park and Coomonderry Swamp.
Irediparra gallinacea Comb-crested Jacana	-	V	Occurs in freshwater wetlands, lagoons, Billabongs, swamps, lakes, rivers and reservoirs, generally with abundant floating aquatic vegetation (Marchant and Higgins 1993).	Yes	Low. Not previously recorded within 10 kilometres of the study area.
Anous stolidus Common Noddy	M	-	Pelagic bird, found well offshore except when it is breeding. During these times it is observed in coastal waters close to island breeding colonies (Morcombe 2003).	No	Moderate. Previously recorded south-east of the study area at Black Head.
Sterna albifrons Little Tern	M	E1	The Little Tern favours sheltered coasts, harbours, bays, lakes, inlets, estuaries, coastal lagoons and ocean beaches especially with sand-spits and sand islets (Higgins and Davies 1996; Morcombe 2003). It forages over shallow waters close inshore or over sandbars and reefs (Morcombe 2003).	No	Moderate. Previously recorded south of the study area at Seven Mile Beach National Park and Coomonderry Swamp.

Latin name/ common name	EPBC Act[1]	TSC Act[2]	Habitat	Potential habitat in study area?	Likelihood of occurrence in the locality?
Sterna caspia[#] Caspian Tern	M	-	Usually coastal, with a preference for sheltered estuaries, inlets, bays, harbours, lagoons with muddy or sandy shores. Keeps close inshore, not out beyond reef line. Also extends well inland on fresh or salt lakes, temporary floodwaters, large rivers, reservoirs, sewage ponds (Morcombe 2003).	Yes	High. Previously recorded south of the study area at Seven Mile Beach National Park and Coomonderry Swamp.
Sterna hirundo Common Tern	M	-	Marine, typically well offshore, but also in coastal waters, sheltered bays, estuaries, and on ocean beaches (Morcombe 2003).	No	High. Previously recorded south-east of the study area at Seven Mile Beach National Park and Black Head, as well as 10 kilometres south of the study area.
*Anthochaera Phrygia** Regent Honeyeater	E	C1	A semi-nomadic species occurring in temperate eucalypt woodlands and open forests. Most records are from box-ironbark eucalypt forest associations and wet lowland coastal forests (NPWS 1999g; Pizzey and Knight 1997). Key eucalypt species include Mugga Ironbark, Yellow Box, Blakely's Red Gum, White Box and Swamp Mahogany. Also utilises: *E. microcarpa*, *E. punctata*, *E. polyanthemos*, *E. mollucana*, *Corymbia robusta*, *E. crebra*, *E. caleyi*, *C. maculata*, *E. mckieana*, *E. macrorhyncha*, *E. laevopinea* and *Angophora floribunda*. Nectar and fruit from the mistletoes *A. miquelii, A. pendula, A. cambagei* are also eaten during the breeding season (DEC 2005t). Regent Honeyeaters usually nest in horizontal branches or forks in tall mature eucalypts and sheoaks. Also nest in mistletoe haustoria. An open cup-shaped nest is constructed of bark, grass, twigs and wool by the female (DEC 2005t).	Yes, but limited.	Moderate.,Previously recorded south of the study area at Seven Mile Beach National Park.

Latin name/ common name	EPBC Act[1]	TSC Act[2]	Habitat	Potential habitat in study area?	Likelihood of occurrence in the locality?
*Epthianura albifrons** White-fronted Chat	-	V	The White-fronted Chat occupies foothills and lowlands below 1000 metres above sea level. In NSW it occurs mostly in the southern half of the state, occurring in damp open habitats along the coast, and near waterways in the western part of the state (Higgins *et al* 2001). The White-fronted Chat is found in damp open habitats, particularly wetlands containing saltmarsh areas that are bordered by open grasslands or lightly timbered lands. Along the coastline, they are found in estuarine and marshy grounds with vegetation less than 1 metre tall. The species is also observed in open grasslands and sometimes in low shrubs bordering wetland areas. Inland, the species is often observed in open grassy plains, saltlakes and saltpans that are along the margins of rivers and waterways (Higgins *et al* 2001). In Victoria White-fronted Chats have been observed breeding from late July through to early March. Nests are built in low vegetation and in the Sydney region nests have also been observed in low isolated mangroves (NSW Scientific Committee 2009d). An Endangered Population occurs in the Sydney Metropolitan CMA area, at Newington Nature Reserve near Homebush and at Towra Point Nature Reserve (NSW Scientific Committee 2009e).	Yes, but limited.	Low. Previously recorded south of the study area at Shoalhaven Heads.
Merops ornatus[#] Rainbow Bee-eater	M	-	Usually occurs in open or lightly timbered areas, often near water. Nest in embankments, including banks of creeks and rivers, in sand dunes, in quarries and in roadside cuttings. Breeding occurs from November to January. It has complex migratory movements in Australia. NSW populations migrate north for winter (Higgins 1999).	Yes	Moderate. Previously recorded once, south of the study area at Seven Mile Beach National Park and once, 10 kilometres to the north.
Acrocephalus australis[#] **Australian Reed-Warbler**	**M**	**-**	**This species lives singly or in pairs usually in wetlands with reeds. It feeds on insects (Blakers *et al.* 1984).**	**Yes**	**High. Recorded during field surveys (site 3). Also previously recorded 2 kilometres south-east of Berry at Seven Mile Beach National Park.**

Latin name/ common name	EPBC Act[1]	TSC Act[2]	Habitat	Potential habitat in study area?	Likelihood of occurrence in the locality?
*Daphoenositta chrysoptera** Varied Sittella	-	V	The Varied Sittella is a sedentary species which inhabits a wide variety of dry eucalypt forests and woodlands, usually with either shrubby understorey or grassy ground cover or both, in all climatic zones of Australia. Usually inhabit areas with rough-barked trees, such as stringybarks or ironbarks, but also in mallee and acacia woodlands, paperbarks or mature Eucalypts (Higgins and Peter 2002; NSW Scientific Committee 20010c). The Varied Sittella feeds on arthropods gleaned from bark, small branches and twigs. It builds a cup-shaped nest of plant fibres and cobweb in an upright tree fork high in the living tree canopy, and often re-uses the same fork or tree in successive years (NSW Scientific Committee 2010c).	Yes	High. Previously recorded north and south of the study area.
*Pachycephala olivacea** Olive Whistler	-	V	Found in a range of habitats including alpine thickets, wetter rainforest/woodlands, riparian vegetation and heaths (Pizzey and Knight 1997).	Yes	Moderate. Previously recorded north and south of the study area.
*Dasyornis brachypterus** Eastern Bristlebird	E	E1	Found in coastal woodlands, dense scrub and heathlands, particularly where it borders taller woodlands (Pizzey and Knight 1997).	Yes, but limited	Moderate. Recently recorded less than one kilometre north of the study area in Broughton. Also previously recorded north of the study area at Barren Grounds Nature Reserve.
*Stagonopleura guttata** Diamond Firetail	-	V	Found in a range of habitat types including open eucalypt forest, mallee and acacia scrubs (Pizzey and Knight 1997). Often occur in vegetation along watercourses (Higgins *et al* 2006).	Yes	Low. Not previously recorded within 10 kilometres of the study area. The closest record for this species occurs 18 kilometres west of the study area recorded in 2001.
*Petroica boodang** Scarlet Robin	-	V	During the breeding season the Scarlet Robin is found in eucalypt forests and temperate woodlands, often on ridges and slopes. During autumn and winter it moves to more open and cleared areas. It has dispersive or locally migratory seasonal movements. The Scarlet Robin forages amongst logs and woody debris for insects which make up the majority of its diet (NSW Scientific Committee 2009c). The nest is an open cup of plant fibres and cobwebs, sited in the fork of a tree (often a dead branch in a live tree, or in a dead tree or shrub) which is usually more than two metres above the ground (NSW Scientific Committee 2009c). It is conspicuous in open and suburban habitats (Moorcombe 2003).	Yes	High. Previously recorded north and south of the study area.

Latin name/ common name	EPBC Act[1]	TSC Act[2]	Habitat	Potential habitat in study area?	Likelihood of occurrence in the locality?
*Petroica phoenicea** Flame Robin	-	V	Flame Robins are found in a broad coastal band from southern Queensland to just west of the South Australian border (Australian Museum 2009). The species is also found in Tasmania. The preferred habitat in summer includes moist eucalyptus forests and open woodlands, whilst in winter prefers open woodlands and farmlands (NSW Scientific Committee 2009a). It is considered migratory. The Flame Robin breeds from about August to January (Morcombe 2003).	Yes	Moderate. Previously recorded north of the study area.
Petroica rodinogaster Pink Robin	-	V	The Pink Robin is found in dense, dank forests and treefern gullies (Pizzey and Knight 1997). During the winter months the Pink Robin disperses north (as far up as the central coast of NSW) and west (as far as the ACT area) into more open forests, woodlands and scrublands (DECCW 2005a).	No	Low. Not previously recorded within 10 kilometres of the study area.
*Glossopsitta pusilla** Little Lorikeet	-	V	Distributed in forests and woodlands from the coast to the western slopes of the Great Dividing Range in NSW, extending westwards to the vicinity of Albury, Parkes, Dubbo and Narrabri. Mostly occur in dry, open eucalypt forests and woodlands. They feed primarily on nectar and pollen in the tree canopy. Nest hollows are located at heights of between 2 metres and 15 metres, mostly in living, smooth-barked eucalypts. Most breeding records come from the western slopes (NSW Scientific Committee 2008b).	Yes	High. Previously recorded south of the study area at Seven Mile Beach National Park and Coomonderry Swamp as well as 10 kilometres to the north of the study area.
*Lathamus discolor** Swift Parrot	E	E1	The Swift Parrot occurs in woodlands and forests of NSW from May to August, where it feeds on eucalypt nectar, pollen and associated insects(Forshaw and Cooper 1981). The Swift Parrot is dependent on flowering resources across a wide range of habitats in its wintering grounds in NSW (Shields and Crome 1992). Favoured feed trees include winter flowering species such as Swamp Mahogany *Eucalyptus robusta*, Spotted Gum *Corymbia maculata*, Red Bloodwood *C. gummifera*, Mugga Ironbark *E. sideroxylon*, and White Box *E. albens*. Commonly used lerp infested trees include Grey Box *E. microcarpa*, Grey Box *E. moluccana* and Blackbutt *E. pilularis* (DEC 2005z). This species is migratory, breeding in Tasmania and also nomadic, moving about in response to changing food availability (Pizzey and Knight 1997).	Yes	Moderate. Previously recorded north and south of the study area.

Latin name/ common name	EPBC Act[1]	TSC Act[2]	Habitat	Potential habitat in study area?	Likelihood of occurrence in the locality?
*Neophema chrysogaster** Orange-bellied Parrot	ZM	C1	A single breeding population of fewer than 200 individuals occurs in a narrow coastal strip of south-west Tasmania. Adult birds depart Tasmania for the mainland in February. The first adults begin leaving the mainland for Tasmania in September with the last birds having departed by November. It is a coastal species inhabiting saltmarshes, sedgeplains, coastal dunes, pastures, shrublands and moorlands, generally within 10 kilometres of the coast (OBPRT 1998). Critical winter habitat for the species includes natural saltmarshes dominated by *Sarcocornia quinqueflora* (Beaded Glasswort) and *Sclerostegia arbuscula* (Shrubby Glasswort), as well as the associated grassy or weedy pastures (DECC 2007). Historical records indicate that the Orange-bellied Parrot was formerly more abundant and widespread in NSW than it is now, however the species' distribution continues to extend into south-eastern NSW where suitable habitat is still available (DECC 2007).	Yes	Low. Previously recorded once 9.5 kilometres south of the study area.
*Neophema pulchella** Turquoise Parrot	-	V	Occurs in open woodlands and eucalypt forests with a ground cover of grasses and understorey of low shrubs (Morros 1980). Generally found in the foothills of the Great Divide, including steep rocky ridges and gullies (Higgins 1999). Nest in hollow-bearing trees, either dead or alive; also in hollows in tree stumps. Prefer to breed in open grassy forests and woodlands, and gullies that are moist (Higgins 1999).	Yes	Moderate. Previously recorded north of the study area at Barren Grounds Nature Reserve.
*Pezoporus wallicus wallicus** Eastern Ground Parrot	-	V	Mainly found in heathland, sedgeland or buttongrass plains providing medium to dense cover (Higgins 1999).	Yes, but limited.	Moderate. Recently recorded less than one kilometre north of the study area in Broughton. Also previously recorded north of the study area at Barren Grounds Nature Reserve and once to the south at Seven Mile Beach National Park.
*Rostratula australis** Australian Painted Snipe	VM	E1	Usually found in shallow inland wetlands including farm dams, lakes, rice crops, swamps and waterlogged grassland. They prefer freshwater wetlands, ephemeral or permanent, although they have been recorded in brackish waters (Marchant and Higgins 1993).	Yes	Low. Not previously recorded within 10 kilometres of the study area. The closest record of this species occurs 20 kilometres north of the study area recorded over 40 years ago in 1970.

Latin name/ common name	EPBC Act[1]	TSC Act[2]	Habitat	Potential habitat in study area?	Likelihood of occurrence in the locality?
Actitis hypoleucos Common Sandpiper	M	-	Inhabits a wide range of coastal and inland wetlands, often with muddy or rocky margins. Also known to occur at estuaries, billabongs, dams, pools and lakes, often associated with mangroves (Higgins and Davies 1996).	No	Low. Previously recorded once, 5 kilometres east of the study area at Werri Beach.
Arenaria interpres Ruddy Turnstone	M	-	Inhabits tidal reefs, sandy beaches mudflats and exposed or shallow seaweed beds (Pizzey and Knight 1997).	No	Moderate. Previously recorded south-east of the study area at Black Head and Seven Mile Beach National Park.
Calidris acuminata Sharp-tailed Sandpiper	M	-	Inland waters, coastal (Simpson and Day 1996).	No	Low. Previously recorded once, south of the study area at Seven Mile Beach National Park.
Calidris alba Sanderling	M	V	Occurs on the coast mostly on open sand beaches exposed to open sea-swells (Higgins and Davies 1996).	No	Moderate. Previously recorded south-east and south of the study area at Seven Mile Beach National Park and Coomonderry Swamp.
Calidris canutus Red Knot	M	-	Typically located within intertidal mudflats, sandflats and sandy beaches of sheltered coasts. Occasionally found on sandy open beaches or shallow pools, or in saline wetlands close to the coast (Higgins and Davies 1996).	No	Low. Previously recorded 10 kilometres south of the study area.
Calidris ferruginea Curlew Sandpiper	M	-	Inhabits sheltered intertidal mudflats. Also non-tidal swamps, lagoons and lakes near the coast. Infrequently recorded inland (Higgins and Davies 1996).	No	Moderate. Previously recorded south of the study area at Coomonderry Swamp and Shoalhaven Heads.
Calidris melanotos[#] Pectoral Sandpiper	M	-	Scarce, but regular visitor, usually recorded in summer from November to March (Slater *et al.* 2003). Widespread but scattered records in Australia. Usually found in fresh to saline wetlands, floodplains, swamps, estuaries and lagoons, sometimes with emergent or fringing vegetation such as grass (Higgins and Davies 1996).	Yes, but limited.	Low. Not previously recorded within 10 kilometres of the study area.
Calidris ruficollis[#] Red-necked Stint	M	-	Inhabits mainly coastal environments; saltmarshes, tidal mudflats, saline and freshwater wetlands, sandy or shelly beaches and sewage ponds (Higgins and Davies 1996).	Yes, but limited.	Moderate. Previously recorded south of the study area at Seven Mile Beach National Park and Coomonderry Swamp.

Latin name/ common name	EPBC Act[1]	TSC Act[2]	Habitat	Potential habitat in study area?	Likelihood of occurrence in the locality?
Calidris subminuta Long-toed Stint	M	-	Inhabit coastal and inland shallow wetlands, sewage ponds and tidal mudflats (Pizzey and Knight 2003).	Yes, but limited.	Low. Not previously recorded within 10 kilometres of the study area.
Calidris tenuirostris Great Knot	M	V	Mainly found on intertidal mudflats, sandflats and sandy beaches (Higgins and Davies 1996).	No	Low. Previously recorded south of the study area at Coomonderry Swamp and Shoalhaven Heads.
Gallinago hardwickii[#] Latham's Snipe	M	-	Typically found on wet soft ground or shallow water with good cover of tussocks. Often found in wet paddocks, seepage areas below dams (Pizzey and Knight 1997).	Yes	High. Recorded during field surveys at site 2 of Gerringong upgrade. Also previously recorded south-east of current study area at Seven Mile Beach National Park as well as eight kilometres and nine kilometres to the north.
Heteroscelis brevipes Grey-tailed Tattler	M	-	Found in estuaries, mangroves and tidal mudflats. Also in shallow river margins, both coastal and inland (Pizzey and Knight 1997).	No	Low. Not previously recorded within 10 kilometres of the study area.
Limicola falcinellus Broad-billed Sandpiper	M	V	Occurs in sheltered parts of coasts, such as estuaries, harbours, embayments and lagoons, which have shell or sandbanks nearby (Higgins and Davies 1996).	No	Low. Previously recorded about 10 kilometres south of the study area within Comerong Lagoon.
Limosa lapponica Bar-tailed Godwit	M	-	Coastal species, usually inhabiting intertidal sandflats, spits and banks. Less frequently found in mudflats, estuaries, coastal lagoons and harbours (Higgins and Davies 1996).	No	Moderate. Previously recorded south-east and south of the study area at Seven Mile Beach National Park and Coomonderry Swamp.

Latin name/ common name	EPBC Act[1]	TSC Act[2]	Habitat	Potential habitat in study area?	Likelihood of occurrence in the locality?
Limosa limosa Black-tailed Godwit	M	V	Mainly coastal, usually in sheltered bays, estuaries and lagoons with large intertidal mudflats or sandflats (Higgins and Davies 1996).	No	Moderate. Previously recorded south of the study area in Coomonderry Swamp and south-east of the study area in the Shoalhaven River.
Numenius madagascariensis Eastern Curlew	M	-	Occurs in sheltered coasts, especially estuaries, embayments, harbours, inlets and coastal lagoons with large intertidal mudflats or sandflats often with beds of seagrass (Higgins and Davies 1996).	No	Moderate. Previously recorded east of the study area at Werri Beach as well as south and south-east of the study area.
Numenius minutus Little Curlew	M	-	Short, dry grasslands and sedgelands, including dry floodplains and blacksoil plains, which have scattered, shallow freshwater pools. Mostly feed in dry grassland or sedgeland, either natural or artificial. Foraging sites usually occur within five kilometres of daytime roosting sites (Higgins and Davies 1996).	Yes, but limited.	Low. Not previously recorded within 10 kilometres of the study area.
Numenius phaeopus Whimbrel	M	-	Occurs in intertidal mudflats of sheltered coasts (Higgins and Davies 1996). Also in estuaries, mangroves, coral clays and exposed reefs. Roosts in trees and mangroves (Pizzey and Knight 1997).	No	Low. Previously recorded once, south-east of the study area near Crooked River.
Philomachus pugnax Ruff	M	-	Rare migrant from northern Eurasia (Slater et al. 2003), regularly visits fresh, brackish or saline wetlands with exposed mudflats at edges, usually terrestrial but sometimes found in sheltered coast habitats (Higgins and Davies 1996).	No	Low. Not previously recorded within 10 kilometres of the study area.
Tringa glareola[#] Wood Sandpiper	M	-	Freshwater swamps, lakes, flooded pasture; less frequently on brackish waters, occasionally in mangroves (Morcombe 2003).	Yes	Low. Not previously recorded within 10 kilometres of the study area.
Tringa nebularia[#] Common Greenshank	M	-	Widely distributed throughout a range of inland wetlands and sheltered coastal habitats. Occurs in habitats with varying salinity (Higgins and Davies 1996).	Yes	Low. Previously recorded about 10 kilometres south of the study area within Comerong Lagoon.

Latin name/ common name	EPBC Act[1]	TSC Act[2]	Habitat	Potential habitat in study area?	Likelihood of occurrence in the locality?
Tringa stagnatilis[#] Marsh Sandpiper	M	-	Inhabits permanent or ephemeral wetlands, including swamps, billabongs, lagoons, saltmarshes and estuaries. Forages at the edge of wetlands in shallow water (Higgins and Davies 1996).	Yes	Low. Previously recorded once about 10 kilometres south of the study area within Comerong Lagoon.
Xenus cinereus Terek Sandpiper	M	V	Mainly found on saline intertidal mudflats in sheltered estuaries, embayments, harbours and lagoons (Higgins and Davies 1996).	No	Low. Previously recorded about 10 kilometres south of the study area within Comerong Lagoon.
*Ninox connivens** Barking Owl	-	V	Generally found in open forests, woodlands, swamp woodlands and dense scrub. Can also be found in the foothills and timber along watercourses in otherwise open country (Pizzey and Knight 1997). Territories are typically 2000 hectares in NSW habitats (DEC 2005b).	Yes	Moderate. Previously recorded east of the study area at Werri Beach as well as north and north-west of the study area.
Ninox strenua* **Powerful Owl**	**-**	**V**	**The Powerful Owl occupies wet and dry eucalypt forests and rainforests. It may inhabit both un-logged and lightly logged forests as well as undisturbed forests where it usually roosts on the limbs of dense trees in gully areas (Debus and Chafer 1994b; Debus and Shafer 1994a). Large mature trees with hollows at least 0.5 metres deep are required for nesting (Garnett 1992). Tree hollows are particularly important for the Powerful Owl because a large proportion of the diet is made up of hollow-dependent arboreal marsupials** (Gibbons and Lindenmayer 1997)**. Nest trees for this species are usually emergent with a diameter at breast height of at least 100 centimetres** (Gibbons and Lindenmayer 1997)**. It has a large home range of between 450 and 1450 hectares (DEC 2005q).**	**Yes**	**High. Recorded during field surveys (site 15). Also recorded north, east and south of the study area.**
Plegadis falcinellus[#] Glossy Ibis	M	-	Terrestrial wetlands, and occasionally wet grasslands and sheltered marine habitats. Forage in shallow water over soft substrate or on grassy or muddy verges of wetlands, preferring those providing variety of water depths; avoid dry ground (Marchant and Higgins 1990).	Yes	Low. Previously recorded once eight kilometres south of the study area.

Latin name/ common name	EPBC Act[1]	TSC Act[2]	Habitat	Potential habitat in study area?	Likelihood of occurrence in the locality?
Tyto novaehollandiae Masked Owl	-	V	The Masked Owl may be found across a diverse range of wooded habitat that provide tall or dense mature trees with hollows suitable for nesting and roosting (Higgins 1999). It has mostly been recorded in open forests and woodlands adjacent to cleared lands. They nest in hollows, in trunks and in near vertical spouts or large trees, usually living but sometimes dead (Higgins 1999). The nest hollows are usually located within dense forests or woodlands (Gibbons and Lindenmayer 1997). Masked Owls prey upon hollow-dependent arboreal marsupials, but terrestrial mammals make up the largest proportion of the diet (Gibbons and Lindenmayer 1997; Higgins 1999). It has a large home range of between 500 to 1000 hectares(DEC 2005n).	Yes	Moderate. Previously recorded once, south of the study area at Seven Mile Beach National Park.
*Tyto tenebricosa** Sooty Owl	-	V	The Sooty Owl is often found in tall old-growth forests, including temperate and subtropical rainforests. In NSW it is mostly found on escarpments with a mean altitude less than 500 metres. The Sooty Owl nests and roosts in hollows of tall emergent trees, mainly eucalypts (Higgins 1999) often located in gullies (Gibbons and Lindenmayer 1997). Nests have been located in trees 125 to 161 centimetres in diameter (Gibbons and Lindenmayer 1997).	Yes	High. Previously recorded north of the study area including at Barren Grounds Nature Reserve.
Mammals					
*Cercartetus nanus** Eastern Pygmy-possum	-	V	Patchily distributed from the coast to the Great Dividing Range, and as far as Pillaga, Dubbo, Parkes and Wagga Wagga on the western slopes. Inhabits rainforest through to sclerophyll forest and tree heath. Banksias and myrtaceous shrubs and trees are a favoured food source. Soft fruits are eaten when flowers are unavailable and it also feeds on insects (DEC 1005g; Turner 2008). Will often nest in tree hollows, but can also construct its own nest (Turner and Ward 1995). Because of its small size it is able to utilise a range of hollow sizes including very small hollows (Gibbons and Lindenmayer 1997). Individuals will use a number of different hollows and an individual has been recorded using up to 9 nest sites within a 0.5 hectare area over a 5 month period (Ward 1990). It is mainly solitary, and each individual uses several nests. Home ranges of males are generally less than 0.75 hectares, and those of females are smaller (Ward andn Turner 2008).	Yes	Low. Previously recorded outside the locality between six kilometres and 10 kilometres north of the study area. Previous records occur up on the escarpment and within better connected habitat.

Latin name/ common name	EPBC Act[1]	TSC Act[2]	Habitat	Potential habitat in study area?	Likelihood of occurrence in the locality?
*Dasyurus maculatus maculatus** Spotted-tailed Quoll (south eastern mainland)	E	V	Occurs along the east coast of Australia and the Great Dividing Range (Belcher *et al.* 2008). Uses a range of habitats including sclerophyll forests and woodlands, coastal heathlands and rainforests (Dickman and Read 1992). Occasional sightings have been made in open country, grazing lands, rocky outcrops and other treeless areas (NPWS 1999k). Habitat requirements include suitable den sites, including hollow logs, rock crevices and caves, an abundance of food and an area of intact vegetation in which to forage (Edgar and Belcher 1995). Seventy per cent of the diet is medium-sized mammals, and also feeds on invertebrates, reptiles and birds. Individuals require large areas of relatively intact vegetation through which to forage (NPWS 1999h). The home range of a female is between 180 – 1000 hectares, while males have larger home ranges of between 2000 – 5000 hectares. Breeding occurs from May to August (Belcher *et al.* 2008).	Yes	High. Previously recorded just north of the study area at Broughton (east of site 15) and 0.5 kilometres south-east of the Toolijooa Road and Princes Highway intersection. Records further north and south exist also.
*Sminthopsis leucopus** White-footed Dunnart	-	V	The White-footed Dunnart is found in a range of different habitats across its distribution, including coastal dune vegetation, coastal forest, tussock grassland and sedgeland, heathland, woodland and forest. They shelter in bark nests in hollows under standing or fallen timber, burrows in the ground, piles of logging debris, large grass clumps such as provided by Grass Trees Xanthorrhoea sp. and Macrozamias and rock crevices (DEC 2005|).	Yes, but limited.	Low. Not previously recorded within 10 kilometres of the study area.
Saccolaimus flaviventris* **Yellow-bellied Sheathtail Bat**	**-**	**V**	**Found throughout NSW (Richards 2008). They have been reported from southern Australia between January and June (Churchill 1998). Reported from a wide range of habitats throughout eastern and northern Australia, including wet and dry sclerophyll forest, open woodland, acacia shrubland, mallee, grasslands and desert (Churchill 1998). They roost in tree hollows in colonies of up to 30 (but more usually two to six) and have also been observed roosting in faunal burrows, abandoned Sugar Glider nests, cracks in dry clay, hanging from buildings and under slabs of rock. It is high-flying, making it difficult to detect. It forages above the canopy of eucalypt forests, but comes lower to the ground in mallee or open country (Churchill 2008; Richards 2008).**	**Yes**	**High. Recorded during field surveys (sites 3, 17, 28 and close to 8). Also previously recorded south and south-west of the study area.**
Petrogale penicillata Brush-tailed Rock-wallaby	V	E1	Occurs along the Great Dividing Range south to the Shoalhaven, and also occurs in the Warrumbungles and Mt Kaputar. Habitats range from rainforest to open woodland. It is found in areas with numerous ledges, caves and crevices, particularly where these have a northerly aspect. Individuals defend a specific rock shelter, emerging in the evening to forage on grasses and forbs, as well as browse in drier months. Home sizes range from 2-30 hectares (Eldridge and Close 1995).	No	Low. Not previously recorded within 10 kilometres of the study area.

Latin name/ common name	EPBC Act[1]	TSC Act[2]	Habitat	Potential habitat in study area?	Likelihood of occurrence in the locality?
Mormopterus norfolkensis* **Eastern Freetail Bat**	**-**	**V**	**Distribution extends east of the Great Dividing Range from southern Queensland to south of Sydney (Churchill 1998). Most records are from dry eucalypt forests and woodland. Individuals tend to forage in natural and artificial openings in forests, although it has also been caught foraging low over a rocky river within rainforest and wet sclerophyll forest habitats. The species generally roosts in hollow spouts of large mature eucalypts (including paddock trees), although individuals have been recorded roosting in the roof of a hut, in wall cavities, and under metal caps of telegraph poles. Foraging generally occurs within a few kilometres of roosting sites (Churchill 2008; Hoye *et al.* 2008).**	**Yes**	**High. Recorded during field surveys (sites 3, 17, 28, 32 and close to 8). Also previously recorded south-west of the study area, within the locality.**
Pseudomys fumeus Smoky Mouse	E	E1	Appears to prefer heathy ridgetops and slopes within sclerophyll forests, heathland and open forest from the coast to sub-alpine regions of up to 1800 metres (Lee 1995).	No	Low. Not previously recorded within 10 kilometres of the study area.
Pseudomys novaehollandiae New Holland Mouse	V	-	The New Holland Mouse currently has a disjunct, fragmented distribution across Tasmania, Victoria, New South Wales and Queensland. Across the species' range the New Holland Mouse is known to inhabit open heathlands, open woodlands with a heathland understorey, and vegetated sand dunes. The home range of the New Holland Mouse can range from 0.44 hectares to 1.4 hectares. The New Holland Mouse is a social animal, living predominantly in burrows shared with other individuals. The species is nocturnal and omnivorous, feeding on seeds, insects, leaves, flowers and fungi, and is therefore likely to play an important role in seed dispersal and fungal spore dispersal. It is likely that the species spends considerable time foraging above-ground for food, predisposing it to predation by native predators and introduced species. Breeding typically occurs between August and January, but can extend into autumn (Threatened Species Scientific Committee 2010).	No	Low. Not previously recorded within 10 kilometres of the study area.
Isoodon obesulus obesulus Southern Brown Bandicoot	E	E1	This species prefers sandy soils with scrubby vegetation and/or areas with low ground cover that are burnt from time to time (Braithwaite 1995). A mosaic of post fire vegetation is important for this species (Maxwell *et al.* 1996).	No	Low. Not previously recorded within 10 kilometres of the study area.

Latin name/ common name	EPBC Act[1]	TSC Act[2]	Habitat	Potential habitat in study area?	Likelihood of occurrence in the locality?
*Petaurus australis** Yellow-bellied Glider	-	V	Restricted to tall native forests in regions of high rainfall along the coast of NSW. Preferred habitats are productive, tall open sclerophyll forests where mature trees provide shelter and nesting hollows. Critical elements of habitat include sap-site trees, winter flowering eucalypts, mature trees suitable for den sites and a mosaic of different forest types (NPWS 1999j). Live in family groups of 2-6 individuals which commonly share a number of tree hollows. Family groups are territorial with exclusive home ranges of 30-60 hectares. Very large expanses of forest (more than 15,000 hectares) are required to conserve viable populations (Goldingay 2008).	Yes	Moderate. Previously recorded north and north-west of the study area, within the locality.
Petaurus norfolcensis Squirrel Glider	-	V	Sparsely distributed along the east coast and immediate inland areas as far west as Coonabarabran in the northern part of the state (DEC 1999) and as far west as Tocumwal along the southern border of the state (NSW Government 2009). Generally occurs in dry sclerophyll forests and woodlands but is absent from dense coastal ranges in the southern part of its range. Requires abundant hollow-bearing trees and a mix of eucalypts, banksias and acacias (Van de Ree and Suckling 2008). Within a suitable vegetation community at least one species should flower heavily in winter and one species of eucalypt should be smooth barked (Mnekhorst *et al.* 1988). They live in family groups of 2-10 individuals and maintain home ranges of 0.65 and 10.5 hectares, varying according to habitat quality and food resource availability (Quin 1995; Goldingay and Jackson 2004). Family groups occupy multiple hollows over time (Van de Ree and Suckling 2008).	No	Low. Not previously recorded within 10 kilometres of the study area. Closest records occur 18 kilometres south and 26 kilometres north of the study area.
*Phascolarctos cinereus** Koala	N	V	In NSW the Koala mainly occurs on the central and north coasts with some populations in the western region (DEC 2005m). Koalas feed almost exclusively on eucalypt foliage, and their preferences vary regionally (Martin *et al.* 2008). Primary feed trees include Eucalyptus robusta, E. tereticornis, E. punctata, E. haemostoma and E. signata (DoP 1995). They are solitary with varying home ranges. In high quality habitat home ranges may be one hectare - two hectares and overlap, while in semi-arid country they are usually discrete and around 100 hectares (Martin *et al.* 2008).	Yes, but limited.	Moderate. Previously recorded north and south of the study area.
*Potorous tridactylus** Long-nosed Potoroo	V	V	Occurs from Queensland to Victoria, normally within 50 kilometres of the coast (Claridge *et al.* 2007). Inhabits coastal heath and wet and dry sclerophyll forests. Generally found in areas with rainfall greater than 760 mm. Requires relatively thick ground cover where the soil is light and sandy. Known to eat fungi, arthropods, fleshy fruit, seeds and plant tissue. It is solitary and sedentary, buts tends to aggregate in small groups. It has two breeding seasons, one in late winter-early spring and the other in late summer (Johnston 2008). This species appears to benefit from a lack of recent disturbance (Claridge *et al.* 2007).	Yes, but limited.	Moderate. Previously recorded north and south of the study area.

Latin name/ common name	EPBC Act[1]	TSC Act[2]	Habitat	Potential habitat in study area?	Likelihood of occurrence in the locality?
Pteropus poliocephalus* **Grey-headed Flying-fox**	**V**	**V**	**Occurs along the NSW coast, extending further inland in the north. This species is a canopy-feeding frugivore and nectarivore of rainforests, open forests, woodlands, melaleuca swamps and banksia woodlands. Roosts in large colonies (camps), commonly in dense riparian vegetation. Bats commute daily to foraging areas, usually within 15 kilometres of the day roost (Tideman 1995) although some individuals may travel up to 70 kilometres (Augee and Ford 1999).**	**Yes**	**High. Recorded during field surveys (site 15). Also previously recorded north-east, south and west of the study area. Known camp site within Coomonderry Swamp.**
*Chalinolobus dwyeri** Large-eared Pied Bat	V	V	Occurs from the Queensland border to Ulladulla, with largest numbers from the sandstone escarpment country in the Sydney Basin and Hunter Valley (Van dyck and Strahan 2008). Primarily found in dry sclerophyll forests and woodlands, but also found in rainforest fringes and subalpine woodlands (Churchill 2008; Hoye and Schulz 2008). Forages on small, flying insects below the forest canopy. Roosts in caves in colonies of between three and 80 individuals, Fairy Martin nests and mines, and beneath rock overhangs, but usually less than 10 individuals. Likely that it hibernates during the cooler months (Churchill 2008). The only known existing maternity roost is in a sandstone cave near Coonabarabran (Pennay 2008).	Yes	Moderate. Recorded once during 2007 surveys west of the current study area. One other record 10 kilometres north of the study area.
Falsistrellus tasmaniensis* **Eastern False Pipistrelle**	**-**	**V**	**Distribution extending east of the Great Dividing Range throughout the coastal regions of NSW, from the Queensland border to the Victorian border. Prefers wet high-altitude sclerophyll and coastal mallee habitat, preferring wet forests with a dense understorey but being found in open forests at lower altitudes** (Churchill 2008). **Apparently hibernates in winter. Roosts in tree hollows and sometimes in buildings in colonies of between 3 and 80 individuals. Often change roosts every night. Forages for beetles, bugs and moths below or near the canopy in forests with an open structure, or along trails (Law *et al.* 2008). Has a large foraging range, up to 136 hectares (Churchill 2008; Law *et al.* 2008). Records show movements of up to 12 kilometres between roosting and foraging sites (Menkhorst and Lumsden 1995).**	**Yes**	**High. Recorded during field surveys (site 15). Also previously recorded north-east, south-east and south of the study area.**
Kerivoula papuensis Golden-tipped Bat	-	V	Occurs in a narrow band down the coast from Cape York to Eden, in moist, closed forest that receives high rainfall (Law and Chidel 2004). Important habitat features include forest ecotones, streams and an abundance of vines (Van dyckand Strahan 2008). Primarily feeds on web-building spiders. Most nightly movements occur within 2 kilometres of the roost. Roosts in the nests of Yellow-throated Scrubwren and Brown Gerygone, as well as in tree hollows, foliage and roofs of houses (Van dyckand Strahan 2008.	No	Low. Not previously recorded within 10 kilometres of the study area. No records on entire Kiama 1:100 000 map sheet.

Latin name/ common name	EPBC Act[1]	TSC Act[2]	Habitat	Potential habitat in study area?	Likelihood of occurrence in the locality?
Miniopterus schreibersii oceanensis* **Eastern Bentwing-bat**	**-**	**V**	**Occurs from Victoria to Queensland, on both sides of the Great Dividing Range. Forms large maternity roosts (up to 100,000 individuals) in caves and mines in spring and summer. Individuals may fly several hundred kilometres to their wintering sites, where they roost in caves, culverts, buildings, and bridges. They occur in a broad range of habitats including rainforest, wet and dry sclerophyll forest, paperbark forest and open grasslands. Has a fast, direct flight and forages for flying insects (particularly moths) above the tree canopy and along waterways (Churchill 2008; Hoye and Hall 2008).**	**Yes**	**High. Recorded during field surveys (sites 3, 17, 28, 32 and close to 8). Also previously recorded north, south-east and south-west of the study area.**
Myotis macropus* **Southern Myotis**	**-**	**V**	**Scattered, mainly coastal distribution extending to South Australia along the Murray River. Roosts in caves, mines or tunnels, under bridges, in buildings, tree hollows, and even in dense foliage. Colonies occur close to water bodies, ranging from rainforest streams to large lakes and reservoirs. They catch aquatic insects and small fish with their large hind claws, and also catch flying insects (Richards *et al.* 2008).**	**Yes**	**High. Recorded during field surveys (sites 3, 15, 17, 28, 32 and close to 8). Also previously recorded west and south-west of the study area.**
Scoteanax rueppellii* **Greater Broad-nosed Bat**	**-**	**V**	**Occurs along the Great Dividing Range, generally at an altitude of 500 metres but also up to 1200 metres, and in coastal areas. Occurs in woodland and rainforest, but prefers open habitats or natural or human-made openings in wetter forests. Often hunts along creeks or river corridors. Flies slowly and directly at a height of 30 metres or so to catch beetles and other large, flying insects. Also known to eat other bats and spiders. Roosts in hollow tree trunks and branches (Churchill 2008; Richards *et al.* 2008).**	**Yes**	**High. Recorded during field surveys (sites 3, 15, 18, 32 and close to 8). Also previously recorded north, south and south-west of the study area.**
Reptiles					
Hoplocephalus bungaroides Broad-headed Snake	V	E1	Mainly occurs in association with communities occurring on Triassic sandstone within the Sydney Basin. Typically found among exposed sandstone outcrops with vegetation types ranging from woodland to heath. Within these habitats they generally use rock crevices and exfoliating rock during the cooler months and tree hollows during summer (Webb 1996; Webb and Shine 1998).	No	Low. One record occurs within 10 kilometres of the study area, outside the locality.
Varanus rosenbergi Rosenberg's Goanna	-	V	This species is a Hawkesbury/Narrabeen sandstone outcrop specialist (Wellington and Wells 1085). Occurs in coastal heaths, humid woodlands and both wet and dry sclerophyll forests (Cogger 1992). Termite mounds are a critical habitat component (DEC 2005u).	No	Low. Not previously recorded within 10 kilometres of the study area.

Appendix E

Biodiversity offset strategy

Foxground and Berry bypass

Biodiversity offset strategy

1 Introduction

RMS is seeking approval under Part 3A of the *Environmental Planning and Assessment Act 1979* (EP&A Act) for the upgrade of 11.6 kilometres of the Princes Highway between Toolijooa Road north of Foxground and Schofields Lane south of Berry, in New South Wales (NSW) (the project), to achieve a four lane divided highway (two lanes in each direction) with median separation. The project includes bypasses of Foxground and Berry.

The project is one of a series of upgrades to sections of the Princes Highway which aims to provide a four lane divided highway between Waterfall and Jervis Bay Road, Falls Creek. This would improve road safety and traffic efficiency, including for freight, on the NSW south coast.
The project and the key features of the project are shown in **Figure AE-1**.

The preparation of this Biodiversity Offset Strategy has involved:

- Review by the NSW Office of Environment and Heritage (OEH) and subsequent amendments according to comments received.
- Consultation with the Southern Rivers Catchment Management Authority (CMA) to determine broad scale priority corridors for riparian restoration works.
- Reference to the RMS 'Biodiversity Guidelines - Protecting and managing biodiversity on RTA projects' (RTA 2011).

1.1 Purpose of the strategy

This Biodiversity Offset Strategy has been prepared to address the NSW Department of Planning and Infrastructure (DP&I) Director-General's requirements (DGRs) issued for assessment of the project under Part 3A of the NSW EP&A Act for both terrestrial and aquatic ecology.

1.2 Director-General's requirements

The DGRs require:

> *'an assessment of all project components on flora and fauna and their habitat (both terrestrial and aquatic, as relevant) be prepared according to the Draft Guidelines for Threatened Species Assessment (Department of Environment and Conservation (DEC) & DP&I, 2005) for the Part 3A environmental assessment.'*

The DGRs identify broad focus areas for the terrestrial and aquatic flora and fauna impact assessments. Terrestrial and aquatic flora and fauna surveys consistent with the DEC and DP&I (2005) guidelines have been carried out. These surveys have informed the current project technical working papers and are the basis for the environmental assessment and terrestrial and aquatic ecological investigations.

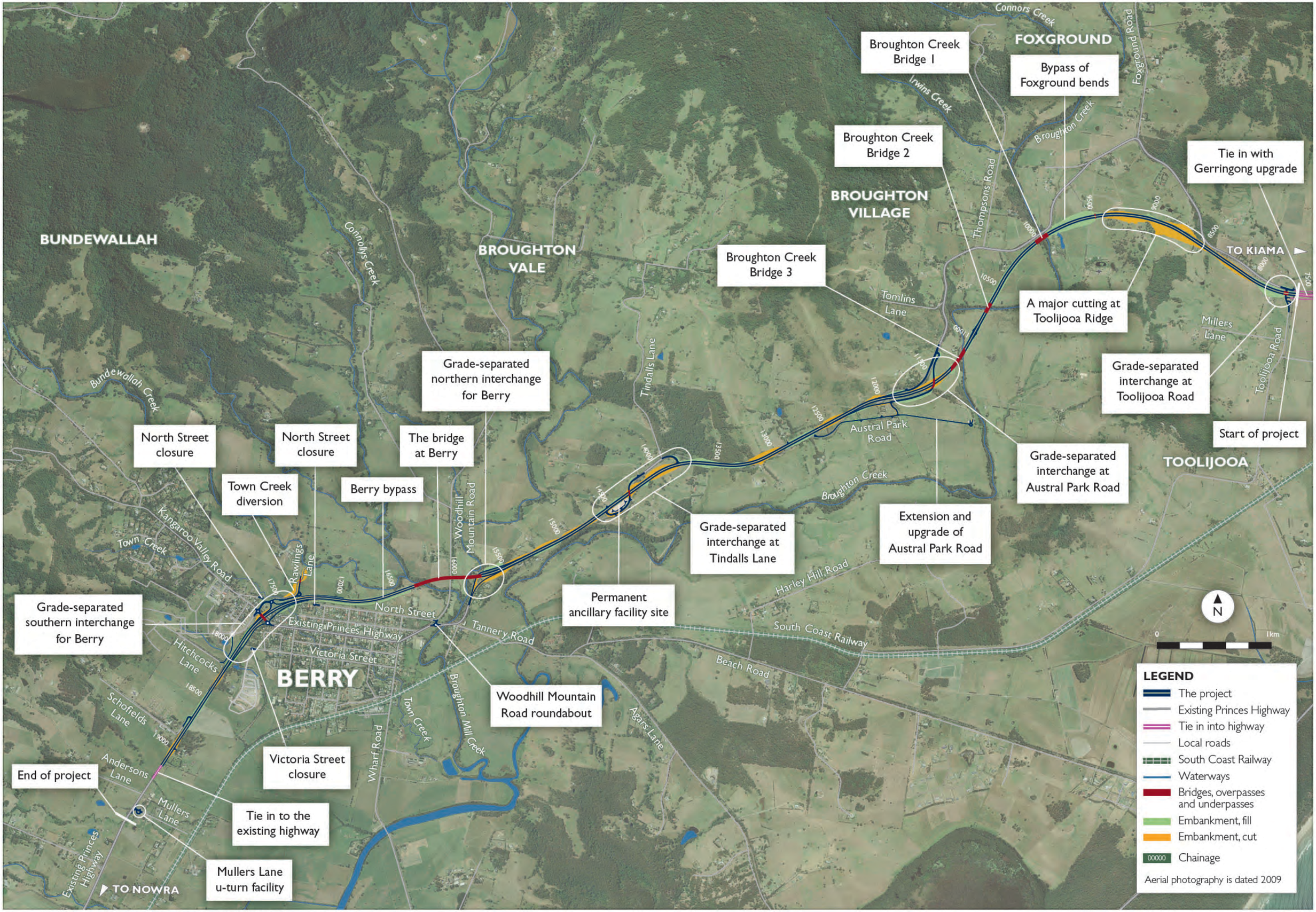


Figure AE-1 – The project and key features of the project

In addition to providing the main scope for terrestrial and aquatic flora and fauna surveys and assessments the DGRs specify that the environmental assessment must:

> *'demonstrate actions to be undertaken to avoid, mitigate or offset impacts associated with the project (all components) consistent with the principles of "improve or maintain". Sufficient details must be provided to demonstrate the availability of viable and achievable options to offset the impacts of the project, where offset measures are proposed to address residual impacts.'*

1.3 Aims

Terrestrial and aquatic ecological assessments determined that biodiversity offsets are required to meet the 'improve or maintain' principle specified in the DGRs as a result of residual impacts on biodiversity values from the project. The aim of this Biodiversity Offset Strategy is to provide the framework, baseline data and options for the development of a Biodiversity Offset Package that will achieve an 'improve or maintain' biodiversity outcome for the region as a result of the project.

1.4 Definitions

This Biodiversity Offset Strategy adopts the definitions of the main *Environmental Assessment – Terrestrial Flora and Fauna Assessment* (Biosis Research 2012) and *Aquatic Ecology and Water Quality Management Assessment* (CEL 2012). Definitions of the terrestrial ecology impact assessments and aquatic ecology impact assessments relevant to the Biodiversity Offset Strategy are summarised below.

1.4.1 Terrestrial

Project – all components of the proposed upgrade of the Princes Highway between about the junction of Toolijooa Road and the Princes Highway and about the junction of Schofields Lane and the Princes Highway on the NSW south coast (Foxground and Berry bypass project).

Subject site – the area to be directly impacted by the project (ie the development "footprint"). The subject site includes the roadway, temporary creek crossings and areas for ancillary facilities.

Study area – the subject site and any additional areas which are likely to be affected by the project, either directly or indirectly. In the case of the project, the study area includes the subject site and a 50 metre buffer to account for any indirect impacts.

Locality – for the purposes of this report, the "locality" is defined as the area within a five kilometre radius of the perimeter of the study area.

Direct impacts – the loss of terrestrial native vegetation and modification of potential terrestrial flora and fauna habitat that will occur for the construction and operation of the project. Project components that will result in direct impacts are the roadway, temporary creek crossings and areas for ancillary facilities. Direct impacts are likely to be limited to the subject site.

Indirect impacts - are calculated by buffering the area that would be directly impacted (subject site) by construction of the project by 50 metres to account for an average extent of edge effects (see Section 4.1 of main *Environmental Assessment – Terrestrial Flora and Fauna Assessment* (Biosis Research 2012) report for details of edge effects). Indirect impacts extend to at least the limits of the study area.

Residual impacts – these are impacts that remain following actions to avoid and mitigate direct and indirect impacts. The unavoidable loss of the endangered ecological community (EEC) River-flat eucalypt forest (RFEF) will be a residual impact of the project.

1.4.2 Aquatic

Riparian vegetation – the plants that occur on the land that adjoins, directly influences or is influenced by bodies of water, such as creeks, rivers, lakes and wetlands on river floodplains.

2 Methods

This Biodiversity Offset Strategy relies on the terrestrial flora and fauna and aquatic ecology field surveys and desktop assessments of the environmental assessment. Methods for the terrestrial flora and fauna assessments are detailed in Section 2 of the *Environmental Assessment – Terrestrial Flora and Fauna Assessment* (Biosis Research 2012). Methods for the aquatic ecology are described in Section 2.2 of the *Aquatic Ecology and Water Quality Management Assessment* (CEL 2012) which is provided at Appendix G of the environmental assessment. Terrestrial and aquatic field survey and desktop assessment methods most relevant to the Biodiversity Offset Strategy are summarised in Sections 2.1 to 2.2 below. Section 2.3 provides an overview of the desktop mapping methods used to identity locations that will be most suitable for further consideration in development of a detailed Biodiversity Offset package.

2.1 Terrestrial

2.1.1 Flora survey

Flora surveys for the terrestrial ecology assessment were conducted in accordance with the draft publication, 'Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities' (DEC 2004). The bulk of flora surveys were carried out over a total of 22 days concentrated in February 2007, November 2008 and 22 May 2009.

2.1.2 Vegetation condition assessment

An assessment of plant community condition was conducted at all survey sites. Vegetation condition was assessed according to the degree to which it resembled relatively natural, undisturbed vegetation and is categorised as follows:

Good: containing a high number of indigenous species; no weeds present or weed invasion restricted to edges and track margins; vegetation community containing original layers of vegetation; vegetation layers (ground, shrub, canopy etc) intact.

Moderate: containing a moderate number of indigenous species; moderate level of weed invasion; weeds occurring in isolated patches or scattered throughout; one or more of original layers of vegetation modified; vegetation layers (ground, shrub, canopy etc) largely intact.

Poor: containing a low number of indigenous species; high level of weed invasion; weeds occurring in dense patches or scattered throughout; one or more of the original layers of vegetation highly modified; one or more original vegetation layers (ground, shrub, canopy etc) modified or missing.

Unnatural landscape: highly modified landscape containing few or no indigenous species; exotic species dominant; original native vegetation layers removed; natural soil profile disturbed; unable to be regenerated to natural condition; high input intervention required to revegetate.

2.1.3 Plant communities

Field survey

Native vegetation ground-truthed in the study area has been classified according to the plant community descriptions in *Native Vegetation of Southeast NSW: A Revised Classification and Map for the Coast and Eastern Tablelands* by DEC (2005). Plot based surveys to sample discrete vegetation communities and ground-truth existing vegetation mapping involved one or more 20 metre x 20 metre (400 square metre) quadrats. Quadrat sampling used a modified Braun-Blanquet cover abundance scale to record floristics and structure. Random meanders targeting threatened flora species were carried out in suitable habitats. Additionally, an inventory of all observed flora species was recorded at each site.

Following field surveys, plant communities mapped by DEC (2005) in some locations have been amended. All amendments to the DEC mapping are identified within the text in Section 3.2.2 of the *Terrestrial Flora and Fauna Assessment* report by Biosis Research (2012). Plant communities conforming to listed EECs were sampled, identified according to their floristic composition and compared to the OEH profiles and relevant scientific committee determinations.

Desktop analysis of impacts to native vegetation and potential terrestrial flora and fauna habitats involved calculation of estimates using the project footprint and data of the *Native Vegetation of Southeast NSW: A Revised Classification and Map for the Coast and Eastern Tablelands* (SCIVI) by DEC (2005). Determination of potential locations for implementing the preferred offset action has also used the DEC (2005) mapping and this has been amended using aerial photo interpretation, topographic data and reference to areas where ground-truthing of vegetation communities has been carried out. Further discussion of the use of vegetation mapping in identifying suitable areas for the preferred offset action is provided in Section 2.3.

2.1.4 Limitations

This assessment has relied on the broad scale regional vegetation survey and mapping project. SCIVI Plant communities as mapped by DEC (2005) have been amended following ground-truthing during the field surveys. All amendments to the DEC (2005) mapping are identified within the text in Section 3.2.2 and illustrated in Figure 3.1 of the main terrestrial ecology assessment report. The limitations of the surveys and mapping by (DEC 2005) and Tozer *et al* (2010) apply to some extent to the desktop vegetation assessments of this Biodiversity Offset Strategy.

2.2 Aquatic

Field surveys of aquatic habitat, biota and water quality were undertaken by Cardno Ecology Lab from 15 to 17 April, with subsequent inspection of potential sites for temporary crossings on 28 June 2011. Water quality parameters recorded, species sampled or observed are likely to be representative of the range of conditions and species that could be recorded using the methodology employed, but should be considered a “snapshot” in nature rather than representing seasonal changes in aquatic assemblage that may occur. Surveys were undertaken following a period of locally significant rainfall which was not considered to have significantly affected the number or type of species recorded.

2.3 Potential offset area mapping

Desktop mapping was carried out to identify areas that would be suitable for restoration and rehabilitation of riparian vegetation. The analysis focused primarily on defining areas where rehabilitation, focusing on revegetation, will improve the current connectivity of areas of riparian EEC’s (adopting a like for like or similar for like approach) and then more broadly over the coastal floodplain and low hills habitat of the riparian EEC’s throughout the locality. The analysis has adopted an investigation area of five kilometres from the project and applied a standardised riparian zone of 50 metres either side of a perennial or permanent drainage line consistent with the RMS ‘Biodiversity Guidelines’ (RTA 2011) and Category 1 – Environmental Corridor according to the *Riparian Corridor Management Study* (RCMS) by DIPNR (2004). In the absence of detailed top of bank mapping the 50 metres has been calculated from the drainage feature centreline.

The mapping adopted a qualitative three category mapping scheme which considers in order of ranked priority the perennial nature of streams, existing vegetation connectivity and existing plant community mapping. Each key theme corresponds to a layer of GIS data with the composite overlay identifying areas potentially suitable for offsets. The scheme ranks the lowest number eg one (1) as the most suitable and the highest numeric value eg three (3) as least suitable. The Priority 1 and 2 classes are further divided into two subclasses (a and b). The key offset suitability criteria are briefly discussed in the following sections and summarised in Table AE.1 below.

Table AE.1 Offset suitability mapping scheme.

Priority		Map colour	Physical attribute	Plant community (current surveys)	Restoration strategy
1	a		50 m riparian zone on perennial drainage with **no native vegetation cover**	-	Revegetation to replicate RFEF
	b		50 m riparian zone on perennial drainage with native vegetation cover	Riparian forest Illawarra wet gully forest	Weed control and supplementary planting
2	a		50 m riparian zone on non - perennial drainage with **no native vegetation cover**	-	Revegetation to replicate RFEF
	b		50 m riparian zone on non - perennial drainage with native vegetation cover	Riparian forest Illawarra wet gully forest	Weed control and supplementary planting
3	3		50 m riparian zone on perennial drainage with native vegetation cover	Floodplain swamp forest	Weed control and supplementary planting

2.3.1 Stream flow characteristics

Perennial streams were given the highest weighting as these provide a composite habitat for both RFEF and aquatic biodiversity values. Although non-perennial streams support RFEF and aquatic habitats, these are assigned lower weighting as these habitats are generally more simplified than perennial waterways. Stream flow characteristic data was sourced from the NSW Land and Property Information Authority (LPIs) digital topographic database, hydro line vector dataset.

2.3.2 Existing vegetation connectivity

Areas where improved connectivity along the riparian zones could be achieved through vegetation restoration were determined by automatic and interactive mapping techniques. These techniques involved the following process:

- A single polygon was created within the five kilometre locality to represent areas without recorded vegetation by creating a ‘negative’ of the SCIVI vegetation polygons which have been modified by Biosis Research through a combination of field survey and aerial image interpretation.
- The negative polygon was then intersected with the 1:25,000 scale stream polyline layer acquired from the NSW LPI to create lines representing sections of creek not covered by vegetation.
- Stream centrelines without vegetation were then buffered to 50 metres to identify possible revegetation areas.

2.3.4 Vegetation mapping

As noted the SCIVI mapping by DEC (2005) has been used as the baseline vegetation mapping in this assessment focusing on communities associated with the coastal floodplain and low foothill areas of the locality. The SCIVI data has been amended using aerial photo interpretation, topographic data and with reference areas where ground-truthing of vegetation communities has been carried out. SCIVI mapping vegetation communities incorporated into the offset suitability analysis are:

- Riverbank forest (corresponding to RFEF in places).
- Floodplain swamp forest (corresponding to Swamp oak floodplain forest (SOFF) in places).
- Illawarra wet gully forest (intergrading with Riverbank forest on perennial and non perennial drainages in areas of increasing elevation)

2.3.5 Southern Rivers CMA mapping

The Southern Rivers CMA provided Biosis Research with vector GIS data representing previously defined preferred corridors for vegetation rehabilitation and previous or current revegetation project locations. Although these map themes have not been included as part of the weighted analysis, they provide a general guide for focusing further investigation of offset areas consistent with current biodiversity planning and improvement strategies and programmes for the locality and region.

2.3.6 Land tenure

Land tenure within the study area is shown on the offset suitability maps. Similar to the Southern Rivers CMA data land tenure has not been included as part of the weighted analysis, however it provides a further guide to preferentially siting offset areas, such as on RMS land or other publically owned property.

2.3.7 Use and limitations

The purpose of the Biodiversity Offset Strategy suitability model is to identify potential locations for rehabilitation works to take place and it is expected that any potential locations which are chosen for rehabilitation will be more thoroughly assessed for suitability prior to finalisation of works being designed and as part of an offset delivery package.

This model has relied on data from a number of sources that has been captured using different techniques at a range of different scales. The model has been applied consistently and automatically within the five kilometre locality around the study area. The resulting suitability layer is therefore indicative only and should not be taken as a 100 per cent accurate representation of the various themed layers at an individual site.

3 Biodiversity impacts of the project

3.1 Terrestrial

The terrestrial ecological field investigations and assessments of the impacts of the project are detailed in the main body of the *Environmental Assessment – Terrestrial Flora and Fauna Assessment* (Biosis Research 2012) and relevant appendices. In summary, following the detailed terrestrial flora and fauna surveys encompassing the study area and impact assessments of the project at a locality scale (Section 4 of the main report), it was determined that the project is unlikely to have a significant impact on flora and fauna species listed under the *Threatened Species Conservation Act 1995)* (TSC Act) and/or the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) provided recommended mitigation measures are implemented (refer Chapter 5 of the terrestrial ecology assessment report).

RFEF which is listed as an EEC under the TSC Act was recorded in the study area during the field surveys for the terrestrial flora and fauna assessment. A detailed description of the community is provided in the main terrestrial ecology assessment report. In summary, RFEF in the study area was dominated by characteristic tree species with the lower strata supporting sparse native shrubs and small trees and dense infestations of woody weeds. The groundcover in most areas was dominated by exotic annual and perennial herbs and grasses. The majority of RFEF in the study area was subject to edge effects with impacts in addition to weed invasion including, grazing and stream bank erosion. The overall condition of RFEF in the study area was considered to be Poor.

Areas where RFEF would be impacted by either direct removal or migrating existing edge effects for the construction and operation of the project including the permanent roadway, temporary creek crossings and other in stream works are at:

- Bundewallah Creek on the northern section of the Town Creek diversion (Figure 3.1.4).
- Below the junction of Bundewallah Creek and Connollys Creek and downstream to Broughton Mill Creek (Figure 3.1.7).
- Broughton Creek to the east of Berry on the southern side of the Princes Highway (Figure 3.1.7).
- Broughton Creek to the southeast and east of the intersection of Tomlins Road and Princes Highway, at Broughton (Figure 3.1.12).
- Broughton Creek to the east of the intersection of Thompson Road and Princes Highway, at Broughton (Figure 3.1.13).

Desktop analysis using geographic information systems (GIS) has determined that the project will likely result in:

- Direct removal of 2.9 hectares of the TSC Act-listed EEC RFEF from the subject site (incorporating the permanent roadway, temporary creek crossings and Town Creek diversion).
- Potential indirect impacts to 7.1 hectares of the TSC Act-listed EEC RFEF in the study area.

The unavoidable loss of the EEC RFEF would be a residual impact of the project. Table AE.2 below identifies the amount of RFEF and riparian habitat that would be affected by project construction activities.

Table AE.2 RFEF and riparian habitat impacted by the project.

Plant community	Impacted area (hectares)				
	Direct				Indirect (edge effects)
	Roadway	Ancillary facilities	Temporary crossings	Town Creek diversion	
Riverbank forest (equivalent to RFEF)	2.6	-	0.2	0.1	7.1

3.2 Aquatic flora and riparian vegetation

The aquatic ecological field investigations and assessments of the impacts of the project are detailed in *Aquatic Ecology and Water Quality Management Assessment* (CEL 2012). In summary, subsequent to the detailed aquatic ecology surveys of the study area and impact assessments of the project, it has been determined that impacts to aquatic ecology would not be significant. No impacts were identified to instream (emergent or submergent) aquatic flora.

The aquatic ecological value of riparian vegetation is outlined in Section 3.3.3 of the *Aquatic Ecology and Water Quality Management Assessment* (CEL 2012). The project would result in an estimated loss of riparian vegetation (Riverbank forest) within the study area of 2.9 hectares (see Table AE.2 above). This vegetation type is considered to be consistent with RFEF and as such meets the Department of Trade and Investment, Regional Infrastructure and Services (DTIRIS) requirements in terms of provision of offset for residual impacts on aquatic ecology.

4 Biodiversity mitigation measures

Detailed discussion of mitigation measures to address impacts to biodiversity spanning the project inception, planning, construction and operation phases is provided in Section 5 of the terrestrial ecology assessment report and Section 5 of the aquatic ecology assessment report. In summary the development of impact mitigation measures has followed RMS policy (RTA 2001) and been consistent with the following key principles:

1. Avoid impacts on habitat though the planning process.
2. Minimise impacts on habitat through the planning process.
3. Mitigate impacts on habitat, through the use of a range of amelioration measures (RTA 2001).

4.1 Terrestrial flora and fauna

4.1.1 Impact avoidance through planning

The project has progressed to its current form through the consideration of multiple route options and these have been investigated as result of consultation with regulatory authorities and the broader community. As part of this process to the current design, important ecological features identified in the local area have been avoided where possible including patches of the EECs Illawarra subtropical rainforest and RFEF.

The project has been designed, where feasible, to minimise impacts on flora and fauna habitat. In areas where significant vegetation such as RFEF EEC cannot be avoided, the land area of the subject site, incorporating the permanent road and associated infrastructure and construction access requirements, has been reduced to minimise impacts.

4.1.2 Impact minimisation during construction

A number of measures have been recommended to minimise impacts on biodiversity during construction. These measures are detailed in the main terrestrial ecology assessment report and include:

- Vegetation clearing is restricted to those areas where it is necessary.
- Defining limits of clearing using temporary exclusion fencing.
- Implementing the RMS 'Biodiversity Guidelines' (RTA, 2011).
- Staged habitat removal.
- Pre-clearing process.
- Siting all ancillary building and works in cleared or otherwise disturbed areas away from waterways (50 metres[3]) and other sensitive areas.

[3] *Refers to the working footprint of the facility. The property on which the site is located may encompass or may extend within the 50 metre buffer to the watercourse.*

- Preparation of a Vegetation Management Plan (VMP) prior to construction that includes vegetation management actions that specifically address the construction phase.
- Installation and maintenance of sediment and erosion controls.

4.1.3 Impact mitigation measures

Terrestrial biodiversity impact mitigation measures proposed in the environmental assessment focus on restoring and improving flora and fauna habitat connectivity and condition following construction of the roadway. The main impact mitigation measures are:

- Restoration and management of the known or potential habitat of threatened flora and fauna species temporarily impacted by project. The preparation of a VMP (VMP) would detail restoration methods, performance measures and a monitoring programme to ensure restoration works achieve objectives. Optimally the VMP would integrate with the landscape plan for the project and be prepared in consultation with local Landcare groups and the CMA committing to input local expertise and resources during implementation.
- Construction of rope bridges for arboreal species and fauna underpasses (including road bridges and fauna dedicated underpasses incorporating fauna furniture). Fauna fencing would be installed as part of the function of these structures. Proposed sites have been selected for these structures as detailed in Table 5.1 of the terrestrial ecology assessment report.

4.2 Aquatic ecology

4.2.1 Impact avoidance through planning

It is recommended that the project design aims to minimise stormwater and disturbed surface runoff entering adjacent waterways by diverting and/or containing it in sediment basins/vegetated swales. Earthworks are recommended to be designed to minimise the risk of mobilising acid sulfate soils (ASS).

Impacts on the natural surface and groundwater flow regime of the study area would be minimised through the redirection of groundwater seepage into aquatic habitats via longitudinal drainage systems. It is recommended that bridge structures be designed to have minimal impact on the natural flow regime and to provide immunity from 100 and 50 year annual recurrence interval (ARI) flood events respectively. It is recommended that no bridge piers or abutments should be positioned within the section of waterway channel (wetted width) that carries median flows. Therefore, bridges are the recommended structures for the three crossings of Broughton Creek and the crossings of Broughton Mill Creek and Bundewallah Creek. It is recommended that bridge piers be placed outside the main channel to avoid formation of turbulence and bed erosion, and abutments placed away from the bank. If placement of bridge piers within waterways is unavoidable, impacts would be minimised through the provision of scour protection during the detailed design phase of the project. Due to their size and classification as fish habitat, culverts are considered adequate crossings for the remaining waterways.

4.2.2 Impact minimisation during construction

Erosion and sediment controls, such as bunding, silt fences/curtains, sediment basins and vegetated swales are recommended to minimise potential impacts to aquatic ecology during the construction phase of the project.

It is recommended that run-off from disturbed areas, stockpile dust suppression/washdown facilities be diverted into sediment basins and erosion controls, and that clean water be diverted around disturbed areas. Areas of exposed earthworks are recommended to be re-vegetated and remediated as soon as possible although erosion controls and sediment traps would remain in place until vegetation cover has been established. It is recommended that project works and ancillary infrastructure not take place within 50 metres of Category 1 (Environmental Corridor) riparian habitat.

The outline of a surface water quality monitoring program consistent with Australian and New Zealand Environment Conservation Council (ANZECC) guidelines has been prepared (*Aquatic Ecology and Water Quality Management Assessment*) and its incorporation into the erosion and sediment control plan is recommended. The measures that are recommended to minimise erosion and sedimentation would also address potential contamination and pollution issues. It is additionally recommended that any hazardous substances should be properly handled, stored, transported and disposed of. Invasive species have been identified within the study area (eg alligator weed). It is therefore recommended that alligator weed or other invasive pests are identified and appropriately disposed of. It is recommended that large woody debris displaced during construction should be relocated within the same reach.

4.2.3 Impact mitigation measures

The main impact mitigation measure is the revegetation and restoration of riparian vegetation, particularly the EEC RFEF along the waterway at strategic locations. This mitigation measure overlaps with that proposed for loss of terrestrial biodiversity.

4.2.4 Residual impacts

Residual impacts on aquatic ecology and water quality that cannot be adequately mitigated and fail to 'improve or maintain' biodiversity include:

- Direct impacts to 2.9 hectares and potential indirect impacts to 7.1 hectares of riparian habitat within the project corridor, ancillary infrastructure and temporary crossing footprint.
- Reduced floodplain storage, productivity and lateral connectivity in the region of Bridge 2 embankment.
- Slight changes to hydrology due to placement of pier structures within the waterway of Bundewallah Creek.
- Potential reduced longitudinal connectivity at temporary crossings during low flows.
- Changes to flood hydrology at Town Creek, Bundewallah Creek and Broughton Creek from installation of transverse drainage structures.

4.3 Offsets

The unavoidable loss of the EEC RFEF would be a residual impact of the project. To meet the 'improve or maintain' outcomes required by the project DGRs, offsetting is required. The following sections discuss general principles for planning and implementing biodiversity offset actions; and, proposes two actions for further consideration to maintain or improve the long-term viability of the local occurrence of RFEF and the habitat it may provide for threatened and non-threatened biodiversity.

The DTIRIS have a policy of 2:1 environmental compensation for direct loss of aquatic or riparian habitat (Smith and Pollard 1999). Compensation for the unavoidable loss of riparian habitat, changes to the natural flow regime and lateral connectivity caused by the project would be addressed by the offsets outlined below.

5 Proposed biodiversity offset actions

5.1 General biodiversity offset principles

Biodiversity offsets are commonly required for major developments under Part 3A of the EP&A Act. Biodiversity offsets are secured under mechanisms such as the BioBanking Scheme, conservation agreements and planning agreements under the EP&A Act. Outcomes for biodiversity offsets for major developments under Part 3A of the EP&A Act must meet the 'improve or maintain' standard (OEH, 2011). A set of general principles have been prepared by OEH (2011) to provide a framework and guidance when formulating biodiversity offsets and these are provided in Appendix F of the main report. Table AE.3 below identifies how the project has considered and is consistent with the OEH (2011) general principles for biodiversity offsetting.

Table AE.3 Compliance of the project with the OEH (2011) principles for the use of biodiversity offsets NSW

Impacts must be avoided first by using prevention and mitigation measures. Measures to prevent and mitigate biodiversity impacts of the project have been guided by the following key principles: 1. "Avoid impacts on habitat though the planning process. 2. Minimise impacts on habitat through the planning process. 3. Mitigate impacts on habitat, through the use of a range of amelioration measures (RTA 2001)". Section 5 of the *Terrestrial Flora and Fauna Assessment* (Biosis 2012) details avoidance, prevention and mitigation measures that have been implemented and are proposed to minimise impacts on terrestrial biodiversity. These are summarised in Section 4 of this Biodiversity Offset Strategy.
All regulatory requirements must be met. This Biodiversity Offset Strategy and the subsequent Biodiversity Offset Package is designed to offset the residual biodiversity impacts from the project and is not designed to satisfy any other legislative approvals. This Biodiversity Offset Strategy has been refined in consultation with OEH and would be finalised on the basis of the NSW Minister for Planning's Conditions of Approval for the project.
Offsets must never reward ongoing poor performance. The efforts that have been made to avoid, minimise and mitigate impacts to biodiversity as a result of the project are consistent with the DGR's and RMS 'Biodiversity Guidelines' (RTA 2011). Riparian habitats that are proposed for offsetting are highly degraded due to a long history of agriculture. Offsetting will aim to improve the condition and management of riparian habitats in the locality.
Offsets will complement other government programs. The preferred Action 1 proposed in this Biodiversity Offset Strategy is to restore riparian habitats in strategic locations with an objective of improving native riparian vegetation connectivity and aquatic habitats at a locality scale. Delivery of a Biodiversity Offset Package that maintains or improves riparian habitats and RFEF may compliment the following: Biodiversity targets of the Southern Rivers Catchment Action Plan (Southern Rivers CMA, 2005). Priority actions of the South Coast Regional Conservation Plan (Department of Environment, Climate Change and Water (DECCW), 2010). Biodiversity actions and targets of the Illawarra Biodiversity Strategy (Wollongong City Council (WCC) et al, 2010). In addition to this, community stakeholders such as the local Landcare groups and other government departments may be involved in the implementation of the Biodiversity Offset Package.

Offsets must be underpinned by sound ecological principles.

This Biodiversity Offset Strategy has been formulated on the basis of detailed field surveys and desktop analysis focusing on threatened terrestrial biodiversity and aquatic ecology. Direct and indirect impacts of the project have been considered on a scale that extends from the roadway footprint to the locality. As a result of the biodiversity impact assessment, the Biodiversity Offset Strategy proposes enhancing existing riparian habitat as the preferred offset action. Should proposed Action 1 become the preferred offset action consultation would occur with local Landcare groups and the Southern Rivers CMA providing input of local expertise and resources. (see section 5.1). Preliminary assessments have been carried out to identify locations that would be most suitable for improving riparian vegetation connectivity using best practice desktop analysis. Additionally this Biodiversity Offset Strategy provides baseline data for use of the BioBanking Assessment Methodology (BBAM) to guide the preparation of a Biodiversity Offsets Package for the project should Action 2 become the preferred offset arrangement.

Offsets should aim to result in a net improvement in biodiversity over time.

This Biodiversity Offset Strategy informs the preparation of a Biodiversity Offset Package that would achieve an 'improve or maintain' biodiversity outcome for the region as a result of the project. This Biodiversity Offset Strategy proposes to use the desktop mapping presented in Figures C1 to C7 or the BBAM to guide an offset that would result in a net improvement to riparian habitats in the locality over time.

Offsets must be enduring - they must offset the impact of the development for the period that the impact occurs.

The biodiversity benefits delivered by the Biodiversity Offset Package would be permanent including further investigation mechanisms to ensure the benefits are maintained and managed.

Offsets should be agreed prior to the impact occurring.

The preparation of this Biodiversity Offset Strategy is acknowledgement that an offset for riparian habitats would be delivered in a Biodiversity Offset Package, consistent with Minister for Planning's Conditions of Approval for the project.

Offsets must be quantifiable - the impacts and benefits must be reliably estimated.

This Biodiversity Offset Strategy has been formulated on the basis of detailed field surveys and desktop analysis focusing on threatened terrestrial biodiversity and aquatic ecology. Quantification of direct and indirect impacts of the project has been considered on a scale that extends from the roadway footprint to the locality. Methods to quantify the type and extent of impacts have referenced current technical information and scientific studies and reports. Preliminary assessments have been carried out as the basis for further investigation of locations most suitable for improving riparian vegetation connectivity or BBAM to guide the preparation of a Biodiversity Offsets Package for the project.

Offsets must be targeted.

Preliminary assessments have been carried out to provide the basis for further investigation of locations most suitable for improving riparian vegetation connectivity or the BBAM to guide the preparation of a Biodiversity Offsets Package for the project. This Biodiversity Offset Strategy proposes offsetting on a like for like basis for both the RFEF vegetation community and aquatic habitats and where this is not feasible then other vegetation types of a similar conservation value incorporating aquatic habitats of a similar quality may be considered in consultation with OEH and DTIRIS.

Offsets must be located appropriately.

This Biodiversity Offset Strategy proposes that:

- The Action 1 offset should be located within a five (5) kilometre radius of the project.
- The Action 2 offset should be located within a 30 kilometre radius of the project.
- There is enhancement of native riparian vegetation connectivity at a locality scale.
- The offset location, land and Action should seek to optimise improvement of threatened terrestrial flora and fauna species or aquatic biodiversity habitat.

Offsets must be supplementary. This Biodiversity Offset Strategy proposes that RMS owned land within the study area be considered for the implementation of the preferred Action 1. This land is not under an existing private agreement for protection or managed by any government agency for the purposes of conservation or open space. Properties where native vegetation restoration works either are or have been carried out in association with the Southern Rivers CMA, are identified in the accompanying mapping Consultation would occur with local Landcare groups and the Southern Rivers CMA with this local expertise ensuring that a Biodiversity Offsets Package results in a supplementary outcome.
Offsets and their actions must be enforceable through development consent conditions, licence conditions, conservation agreements or a contract. Development of this Biodiversity Offset Strategy has involved consultation with OEH and the Southern Rivers CMA. Additionally the development of a Biodiversity Offset Package would be in consultation with OEH, the Sothern Rivers CMA and local Berry Landcare groups. Further investigation of an appropriate agreement or contract to implementation the preferred offset action is to occur. The implementation of a Biodiversity Offset Package that proposes performance measures and includes reporting requirements is likely to be a Condition of Approval for the project.

5.2 Proposed actions

The following offset actions are proposed in order to achieve an 'improve or maintain' biodiversity outcome for the region as a result of the project:

Action 1 Revegetation and rehabilitation of riparian vegetation in strategic locations.

Action 2 Use of an appropriate legal instrument to acquire and/or secure native vegetation to ensure that the land is managed for conservation.

Action 1 is the first priority to achieve the objectives of the Biodiversity Offset Strategy. Action 2 would only be considered if there are residual offset requirements after Action 1 offset measures have been exhausted. Table AE.4 provides a summary of specific agency DGRs relating to terrestrial and aquatic biodiversity issues that would be addressed by Action 1. Further details on the proposed delivery of Actions 1 and 2 are provided in following sections.

Table AE.4 Summary agency DGRs that will be addressed by Action 1

Agency	Summary DGRs	Relevant to	Comment
OEH	The environmental outcomes should be acceptable in terms of the achievement or protection of the River Flow Objectives and Water Quality Objectives.	Aquatic biodiversity	Delivery of Action 1 would contribute to achievement of River Flow and Water Quality objectives.
	Describe the actions that will be taken to avoid or mitigate impacts or compensate to prevent unavoidable impacts of the project on threatened species, populations, ecological communities, or their habitats.	Terrestrial biodiversity	Delivery of Action 1 would compensate for unavoidable impacts to RFEF.
	Offsetting biodiversity and habitat loss would be required as identified in the threatened species guidelines.	Terrestrial biodiversity	Delivery of Action 1 would compensate for unavoidable impacts to RFEF.

Agency	Summary DGRs	Relevant to	Comment
	The development of long-term management strategies shall be considered to protect areas within the study area which are of particular importance for the subject species, populations or ecological communities likely to be affected by the proposal. This may include proposals to restore or improve habitat on site where possible.	Terrestrial biodiversity	Delivery of Action 1 would restore or improve habitat for RFEF either on site or in nearby areas.
	If significant modification of the proposal to minimise impacts on subject species, populations or ecological communities is not possible, then compensatory strategies shall be considered. These may include other off-site or local area proposals that contribute to long term conservation of the subject species, populations or ecological communities. The areas proposed to be used for compensatory strategies must be described in full including a detailed description of their biodiversity, tenure and conservation status. These areas should be assessed in accordance with the Principles for the use of biodiversity offsets in NSW.	Terrestrial biodiversity	Delivery of Action 1 would compensate for unavoidable impacts to RFEF.
NSW Office of Water (NOW)	Provide details of safeguard measures to mitigate impacts, contingency plans for the remediation and rehabilitation of riparian areas in the event of potential adverse impacts and the long term management of the riparian lands.	Terrestrial biodiversity and aquatic biodiversity	The delivery of Action 1 would in part provide a contingency for the long term management of riparian lands.
DTIRIS Fisheries	Proposed measures to mitigate, rehabilitate or compensate for such impacts ensure that there is 'no net loss' of aquatic habitats.	Aquatic biodiversity	Delivery of Action 1 would indirectly ensure that there is no net loss of aquatic habitat by reducing sediment load from creek erosion and providing large woody debris for fish habitat.
	Propose environmental compensation measures to offset the permanent loss of riparian habitats in Broughton Creek, Broughton Mill Creek and Bundewallah Creek.	Aquatic biodiversity	Delivery of Action 1 would offset permanent loss of riparian habitats in Broughton Creek, Broughton Mill Creek and Bundewallah Creek.

5.2.1 Delivery of Action 1 - Revegetation and rehabilitation of riparian vegetation in strategic locations

The optimal delivery of Action 1 would be to invest in the strategic revegetation of RFEF that addresses improvement of both terrestrial and aquatic biodiversity. A key component in the delivery of Action 1 would be to enhance native riparian vegetation connectivity at a locality scale. The recommendations provided below for the restoration or enhancement of riparian and aquatic habitats, focusing on RFEF, other coastal floodplain EECs or closely associated non threatened plant communities, are the main considerations on which Action 1 should be based. Table AE.4 below provides an estimate of the area for each of the offset suitability mapping classes in the five kilometre locality (Figures C1 to C7).

Table AE.4 Offset suitability area calculations.

Priority		Map colour	Physical attribute	Area estimate for 5km locality (hectares*)	Restoration strategy
1	a		50 m riparian zone on perennial drainage with **no native vegetation cover**	591	Revegetation to replicate RFEF
	b		50 m riparian zone on perennial drainage with native vegetation cover	155	Weed control and supplementary planting
2	a		50 m riparian zone on non - perennial drainage with **no native vegetation cover**	3578	Revegetation to replicate RFEF
	b		50 m riparian zone on non - perennial drainage with native vegetation cover	226	Weed control and supplementary planting
3	3		50 m riparian zone on perennial drainage with native vegetation cover	14	Weed control and supplementary planting

** This is an estimate of the potential area (hectares) for each mapping unit that demonstrates the availability of viable and achievable options to offset the impacts of the project.*

Broughton Creek, Broughton Mill Creek and Bundewallah Creek are assessed as Category 1 waterways (Environmental Corridor) based on RCMS classification system (DIPNR 2004). The waterways and their riparian vegetation are significant terrestrial and aquatic environmental corridors and the objective of the RCMS is to provide biodiversity linkages by maintaining unbroken connectivity and habitat for the aquatic organisms along the waterway network. The minimum core riparian zone (CRZ) width either side of Category 1 waterways should be 40 metres of fully vegetated habitat with a 10 metre buffer (DIPNR 2004).

Riparian habitat is significantly degraded at many of the aquatic ecology survey sites. Large woody trees have been removed and the understorey was often dominated by weed species. The degradation of riparian habitat and surrounding agricultural land use has significantly affected aquatic habitat and biota within the study area.

Action 1 should consider the following:

1. Restoration of riparian habitat to Category 1 level creeks on RMS owned land to enhance connectivity for terrestrial and aquatic habitats. The RMS owns land with significant frontages on Broughton Creek, Broughton Mill Creek, Bundewallah Creek and Connollys Creek.
2. Ongoing financial support for existing riparian restoration works within the region (eg programs run by Southern Rivers CMA, Shoalhaven City Council or DTIRIS).
3. The area of restoration would be guided by a simulated assessment of the project impacts and potential offsets using the BBAM with a minimum of 2:1 for riparian vegetation to meet DTIRIS requirements.

Restoration works would be carried out by accredited organisations and include, where appropriate, revegetation of native riparian species, removal of exotic species and restoration/protection of existing riparian habitat (eg fencing protection from livestock).

Restoration and rehabilitation of RFEF in areas other than land owned and managed by the RMS may be considered. These alternate locations have been identified by desktop mapping as described in Section 2.3 and presented in Figures C1 to C7. Finalisation of the exact locations for restoration of riparian vegetation to improve outcomes for both terrestrial and aquatic biodiversity would be guided by the outcomes of:

- Further investigation and specialist advice from OEH and/or the Southern Rivers CMA or other specialist ecologists.
- Consultation with the Berry Landcare Group and consideration of the strategic priorities or actions of *Berry Nature Corridor – Escarpment to Sea* (Berry Landcare Group, in preparation).

If Action 1 were to be further investigated then an appropriate instrument for ongoing management for conservation may consider one of the following legally binding arrangements:

- A Trust Agreement.
- A Conservation Agreement.
- A Property Vegetation Plan.
- A Wildlife Refuge.
- A BioBanking Agreement.

5.2.2 Delivery of Action 2 - Use an appropriate legal instrument to secure native vegetation to ensure that the land is managed for conservation

The relevant general principles outlined in Appendix F for biodiversity offsetting would form the basis for proceeding with delivery of the proposed Action 2. In addition the key aims in the delivery of Action 2 are:

- The offsets would be located within a 30 kilometre radius of the project and within the NSW Sydney Basin Bioregion.
- Offsetting native vegetation on a like for like basis.
- Offset land should comprise land that would improve connectivity between areas of remnant vegetation.
- Offset land must be suitable for ongoing management for conservation through an appropriate legal instrument.
- Where it is not feasible to offset on a like for like basis other vegetation types of a similar conservation value in the offset investigation area would be considered.

In proceeding with Action 2 and to address the 'improve or maintain' outcome, the RMS proposes to use the BBAM to guide the calculation of an appropriate offset amount for the TSC Act-listed EEC, RFEF. The BBAM contains rules to ensure the biodiversity values created on a Biobank site match those lost on a development site including offsetting the same vegetation type or another vegetation type in the same formation that contains the same predicted species; or a more cleared vegetation type that contains the same threatened species (DECC 2009). Additionally the Final Determination for RFEF states that the community may adjoin or intergrade with several other EECs, which collectively cover all remaining native vegetation on the coastal floodplains of NSW. Swamp oak floodplain forest (SOFF) is identified by the NSW Scientific Committee (2005) as a vegetation community that may adjoin or intergrade with RFEF.

Preliminary analysis using the BBAM has been carried out to propose a suitable alternate vegetation type for consideration. Table AE.5 below provides the definition of vegetation types for the Southern Rivers CMA from The Vegetation Types Database (DECCW 2008) against which the RFEF may be assessed and offset.

Table AE.5 Plant communities impacted by the project, Southern Rivers CMA vegetation types and alternative offset EECs.

Plant community (current surveys)	EEC	Southern Rivers CMA vegetation type (DECCW 2008)	Vegetation formation (Keith 2004)
Riparian forest	RFEF	River Oak open forest of major streams, Sydney Basin and South East Corner	Forested Wetlands
Floodplain swamp forest	SOFF	Swamp Oak swamp forest fringing estuaries, Sydney Basin and South East Corner	Forested Wetlands

Figures D1 to D6 highlight the location of Riparian forest and Floodplain swamp forest in a 30 kilometre radius of the project based on the DEC 2005 mapping. Figures C1 to C6 also highlight the location of conservation reserves and state forest falling within and adjacent to the 30 kilometre offset investigation area. In summary, Riparian forest is present close to the project on Broughton Creek (Figure C3). Large stands of the community are present in Kangaroo Valley on the Kangaroo River and Brogers Creek with scattered occurrences on the tributaries of these major drainages (Figure D3). The most extensive stands of Riparian forest in the offset investigation area are on the Shoalhaven River, west of Nowra (Figures D3 and D5). The main areas of Floodplain swamp forest are on the western margin of Lake Illawarra (Figure C2) and to the east and southeast of Nowra (Figure C5). The largest and most contiguous stand of Floodplain swamp forest to the project area is at Coomonderry Swamp, southeast of Berry (Figure C3).

Table AE.6 below details the potential offset vegetation types within 30 kilometres of the project. Potential offset vegetation types have been determined in accordance with the OEH Biometric database.

Table AE.6 Potential offset vegetation types within 30 kilometres of the project.

Southern Rivers CMA vegetation type (DECCW 2008)	Tenure		Total area mapped (hectares) (DECC 2005n)
	Conservation (hectares)	Private (hectares)	
River Oak open forest of major streams, Sydney Basin and South East Corner	25.4	586.4	611.8
Swamp Oak swamp forest fringing estuaries, Sydney Basin and South East Corner	202.5	1026.0	1228.5

The BBAM would be used to guide the selection of proposed offset areas to ensure the potential offset land(s) consist of appropriate vegetation type(s).

If Action 2 were to be further investigated then an appropriate instrument for ongoing management for conservation may consider one of the following legally binding arrangements.

- A Trust Agreement.
- A Conservation Agreement.
- A Property Vegetation Plan.
- A Wildlife Refuge.
- A BioBanking Agreement.

6 Biodiversity offset package

6.1 Decision making framework

Any biodiversity offsets would be located within the NSW Sydney Basin Bioregion and within 30 kilometres of the subject site, with the aim of offsetting on a like for like basis for both the RFEF vegetation community and aquatic habitats. Where it is not feasible to offset vegetation on a like for like basis other vegetation types of a similar conservation value incorporating aquatic habitats of a similar quality will need to be considered in consultation with OEH and DTIRIS.

Potential offset areas would need to be assessed and RMS owned land within the study area has preliminarily been proposed in delivery of Action 1. However it is recognised that the availability and suitability of land and associated aquatic habitat for inclusion in the offset package will be uncertain until the detailed investigation of suitable sites is completed. If the RMS owned land is not suitable to accommodate a dual terrestrial and aquatic offset then negotiations with private landholders may need to occur. Areas of riparian vegetation types that may be suitable for further investigation in the delivery of Actions 1 and 2 are highlighted in Figures C1 to C7.

In addition to the above, and dependant on the final preferred Action, other considerations as part of the decision making framework include:

- Offset should be located within a 30 kilometre radius of the project.
- Using the DTIRIS policy of 2:1 environmental compensation for direct loss of aquatic or riparian habitat as the minimum offset ratio regardless of the outcomes of a simulated BioBanking assessment proposed for further investigation of Actions 1 and 2.
- Enhancement of native riparian vegetation connectivity at locality scale.
- Offset land and Action should seek to optimise improvement of other threatened terrestrial or aquatic biodiversity habitat. For example the development of a planting schedule for Action 1 should include flora species characteristic of RFEF that provide preferred foraging resource for seasonal migratory threatened bird species.
- Commitment of resources to a defined and measurable outcome that at least maintains or ultimately improves terrestrial and aquatic biodiversity for the region.
- Further consideration of the general offset principles highlighted in Appendix F as required in the implementation of the Biodiversity Offsets Package.

6.2 Implementation

Within 12 months of approval of the project, the RMS would submit to the DP&I a Biodiversity Offset Package. The package would be prepared in consultation with OEH and DTIRIS and would include details of the final suite of measures to be implemented based on this strategy and addressing both terrestrial and aquatic biodiversity. The package would identify a timeline for implementation and the detail of measures, including arrangements for ongoing management of offset lands or other actions.

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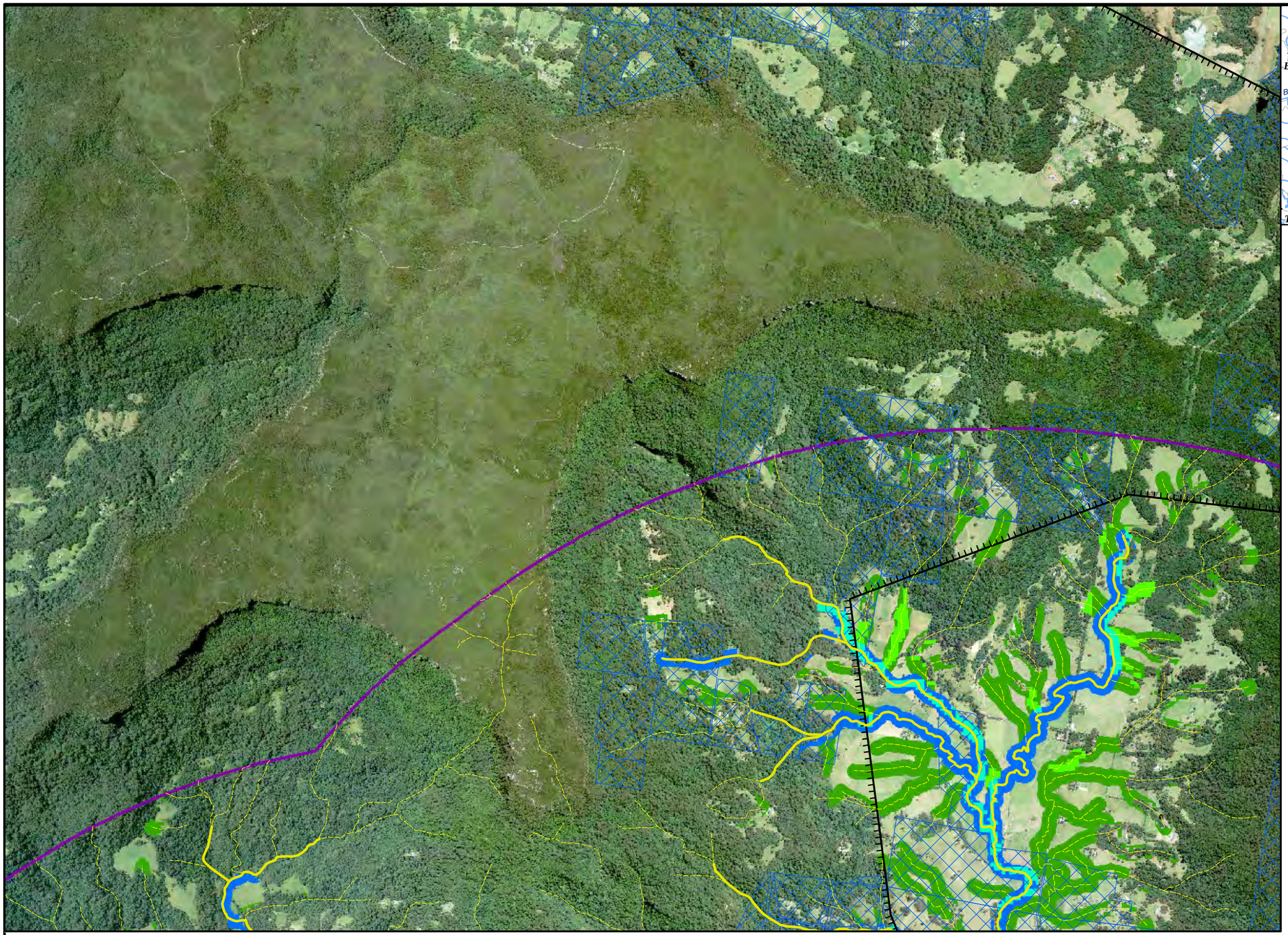
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Legend

Stream Perenniality
- Perennial
- NonPerennial

Offset Suitability

Priority - Ranking
- 1 - 1a
- 1 - 1b
- 2 - 2a
- 2 - 2b
- 3 - 3

- SRCMA Priority Corridor Mapping
- SRCMA Revegetation Project Locations

Land Ownership
- RMS
- Council/Government
- Private / Unknown
- 5km Locality

Ancillary Sites
- Subject Site - Compound
- Subject Site - Stockpile
- Subject Site - Footprint
- Study Area

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18-20 Mandible Street
Alexandria
NEW SOUTH WALES
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Figure C.1: Offset Strategy Model

Date: 24 October 2012	Drawn by: RS/JMS
File: 13194	Checked by: JC
Location: P:\15000s\15039\Mapping\Variation 5\15039_OS_Suitability_231012.mxd	

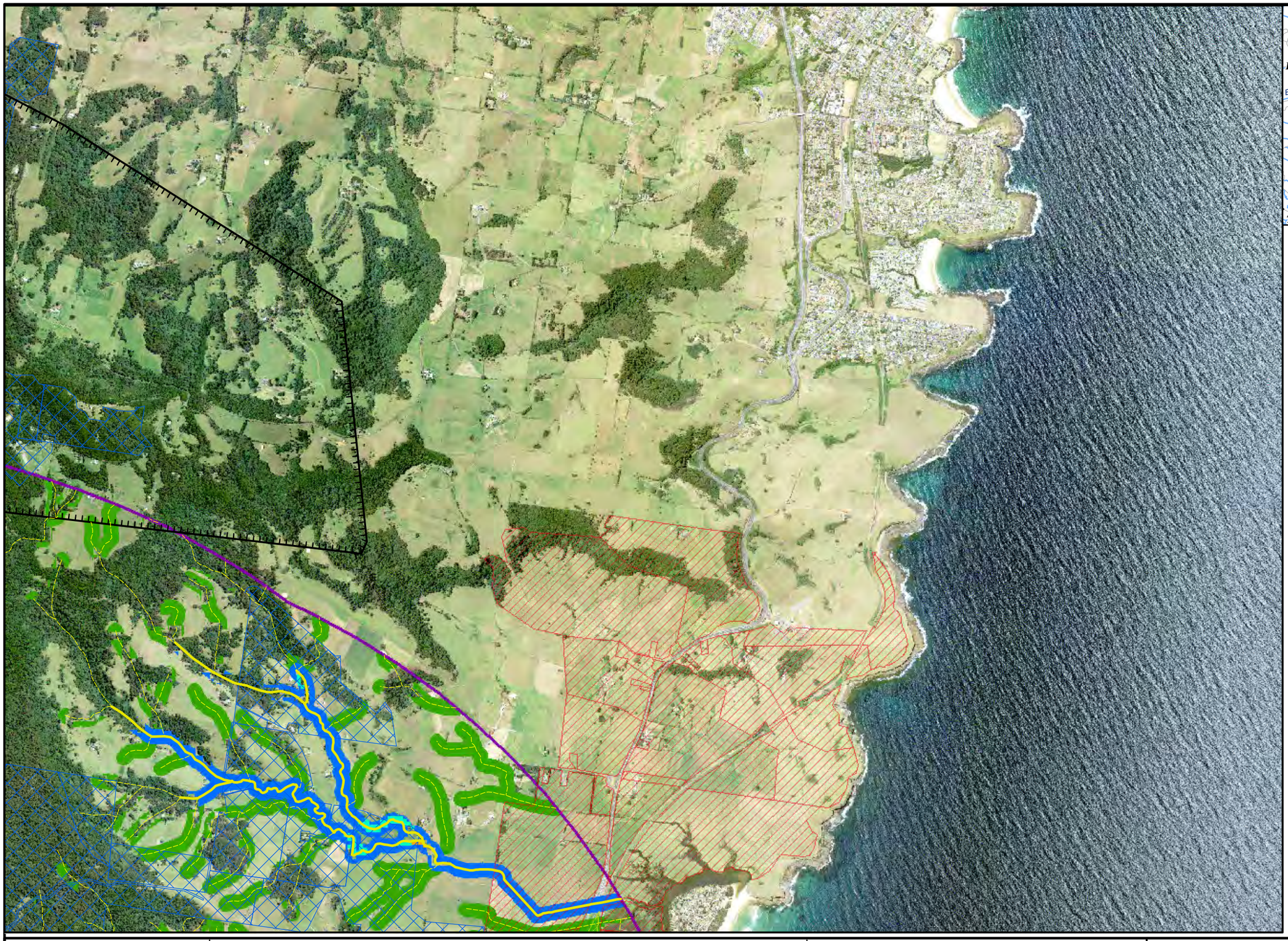
Acknowledgements:
Vegetation mapping from DECCW
Aerial imagery provided by ARUP
This product incorporates Data which is copyright to the Commonwealth of Australia (c.2003)

0 250 500 750 1,000
Metres

Scale: 1:25,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 3



Legend

Stream Perenniality
- Perennial
- NonPerennial

Offset Suitability

Priority - Ranking
- 1 - 1a
- 1 - 1b
- 2 - 2a
- 2 - 2b
- 3 - 3
- SRCMA Priority Corridor Mapping
- SRCMA Revegetation Project Locations

Land Ownership
- RMS
- Council/Government
- Private / Unknown
- 5km Locality

Ancillary Sites
- Subject Site - Compound
- Subject Site - Stockpile
- Subject Site - Footprint
- Study Area

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Figure C.2: Offset Strategy Model

Date: 24 October 2012	Drawn by: RS/JMS
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Location: P:\15000s\15039\Mapping\Variation 5\15039_OS_Suitability_231012.mxd	

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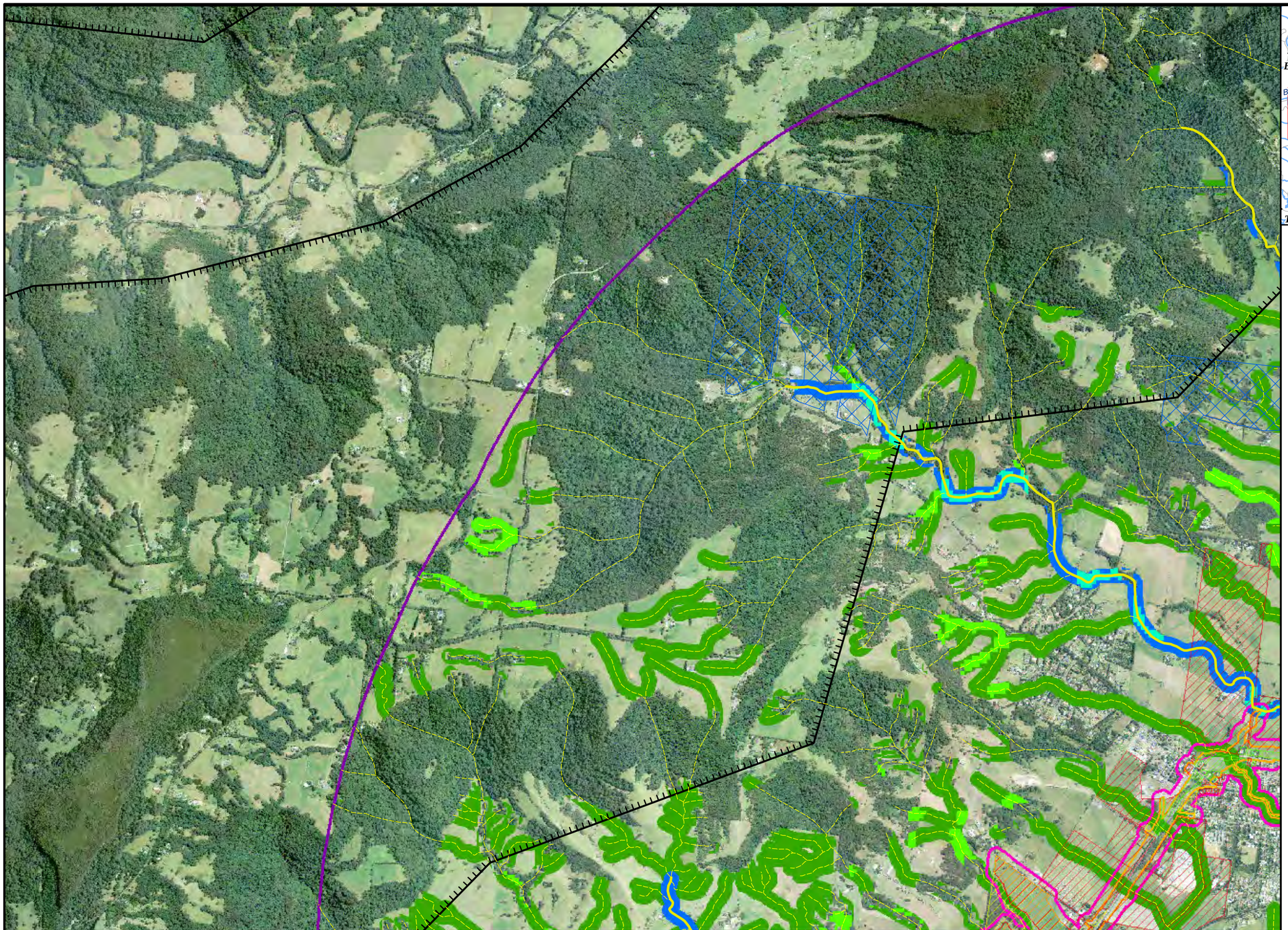
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Metres

Scale: 1:25,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 3



Legend

Stream Perenniality
- Perennial
- NonPerennial

Offset Suitability

Priority - Ranking
- 1 - 1a
- 1 - 1b
- 2 - 2a
- 2 - 2b
- 3 - 3

- SRCMA Priority Corridor Mapping
- SRCMA Revegetation Project Locations

Land Ownership
- RMS
- Council/Government
- Private / Unknown
- 5km Locality

Ancillary Sites
- Subject Site - Compound
- Subject Site - Stockpile
- Subject Site - Footprint
- Study Area

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Figure C.3: Offset Strategy Model

Date: 24 October 2012	Drawn by: RS/JMS
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Location: P:\15000s\15039\Mapping\Variation 5\15039_OS_Suitability_231012.mxd	

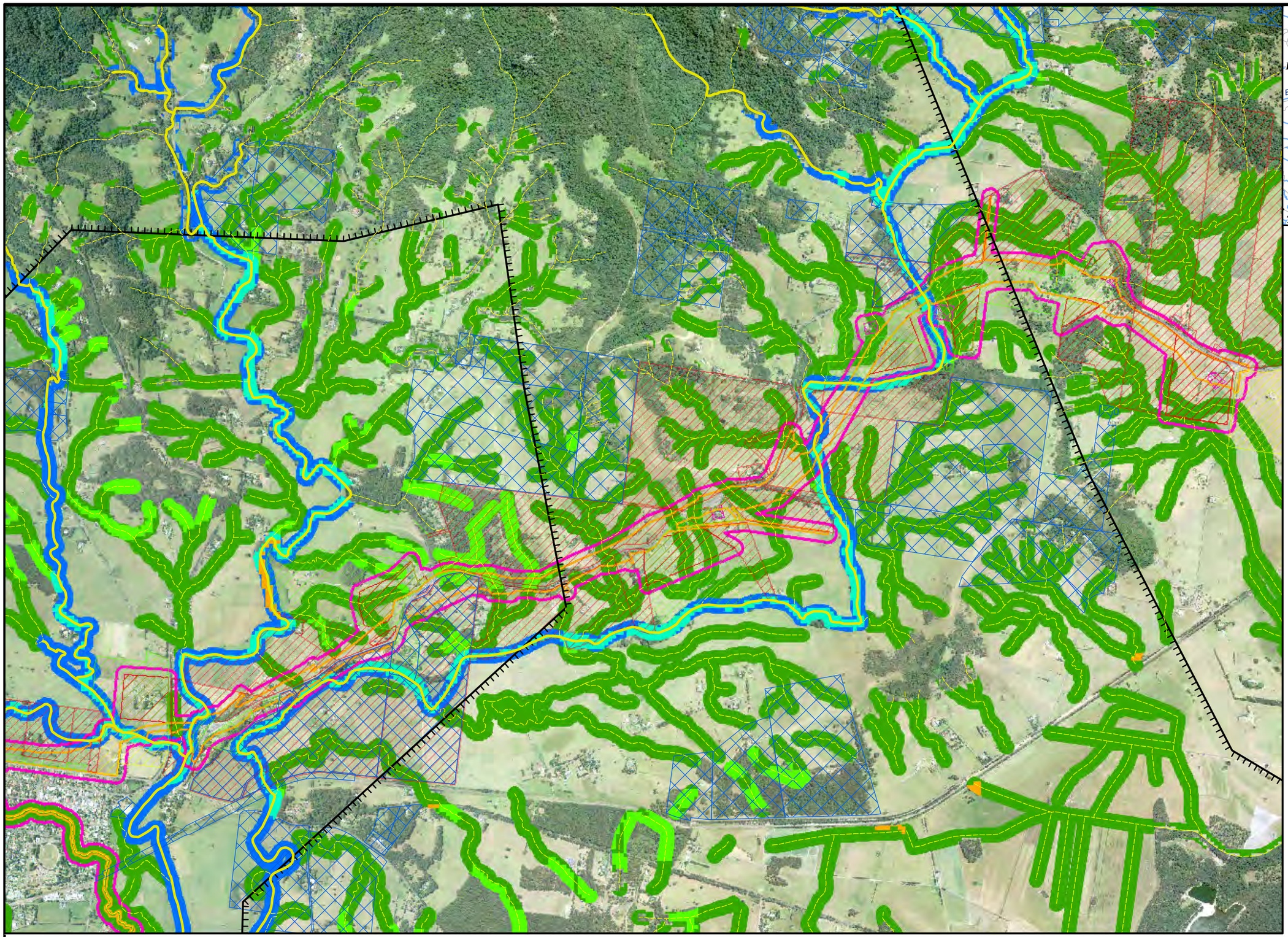
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0 250 500 750 1,000
Metres

Scale: 1:25,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 3



Legend

Stream Perenniality
- Perennial
- NonPerennial

Offset Suitability

Priority - Ranking
- 1 - 1a
- 1 - 1b
- 2 - 2a
- 2 - 2b
- 3 - 3

SRCMA Priority Corridor Mapping

SRCMA Revegetation Project Locations

Land Ownership
- RMS
- Council/Government
- Private / Unknown

5km Locality

Ancillary Sites
- Subject Site - Compound
- Subject Site - Stockpile
- Subject Site - Footprint

Study Area

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Figure C.4: Offset Strategy Model

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0 250 500 750 1,000
Metres

Scale: 1:25,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 3



Legend

Stream Perenniality
- Perennial
- NonPerennial

Offset Suitability

Priority - Ranking
- 1 - 1a
- 1 - 1b
- 2 - 2a
- 2 - 2b
- 3 - 3
- SRCMA Priority Corridor Mapping
- SRCMA Revegetation Project Locations

Land Ownership
- RMS
- Council/Government
- Private / Unknown
- 5km Locality

Ancillary Sites
- Subject Site - Compound
- Subject Site - Stockpile
- Subject Site - Footprint
- Study Area

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Figure C.5: Offset Strategy Model

Date: 24 October 2012	Drawn by: RS/JMS
File: 13194	Checked by: JC
Location: P:\15000s\15039\Mapping\Variation 5\15039_OS_Suitability_231012.mxd	

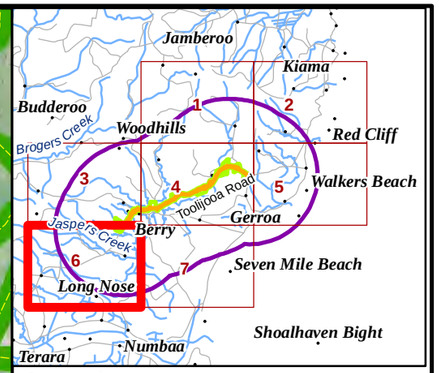
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0 250 500 750 1,000
Metres

Scale: 1:25,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 3



Legend

Stream Perenniality
- Perennial
- NonPerennial

Offset Suitability

Priority - Ranking
- 1 - 1a
- 1 - 1b
- 2 - 2a
- 2 - 2b
- 3 - 3

SRCMA Priority Corridor Mapping

SRCMA Revegetation Project Locations

Land Ownership
- RMS
- Council/Government
- Private / Unknown

5km Locality

Ancillary Sites
- Subject Site - Compound
- Subject Site - Stockpile
- Subject Site - Footprint

Study Area

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Figure C.6: Offset Strategy Model

Date: 24 October 2012	Drawn by: RS/JMS
File: 13194	Checked by: JC
Location: P:\15000s\15039\Mapping\Variation 5\15039_OS_Suitability_231012.mxd	

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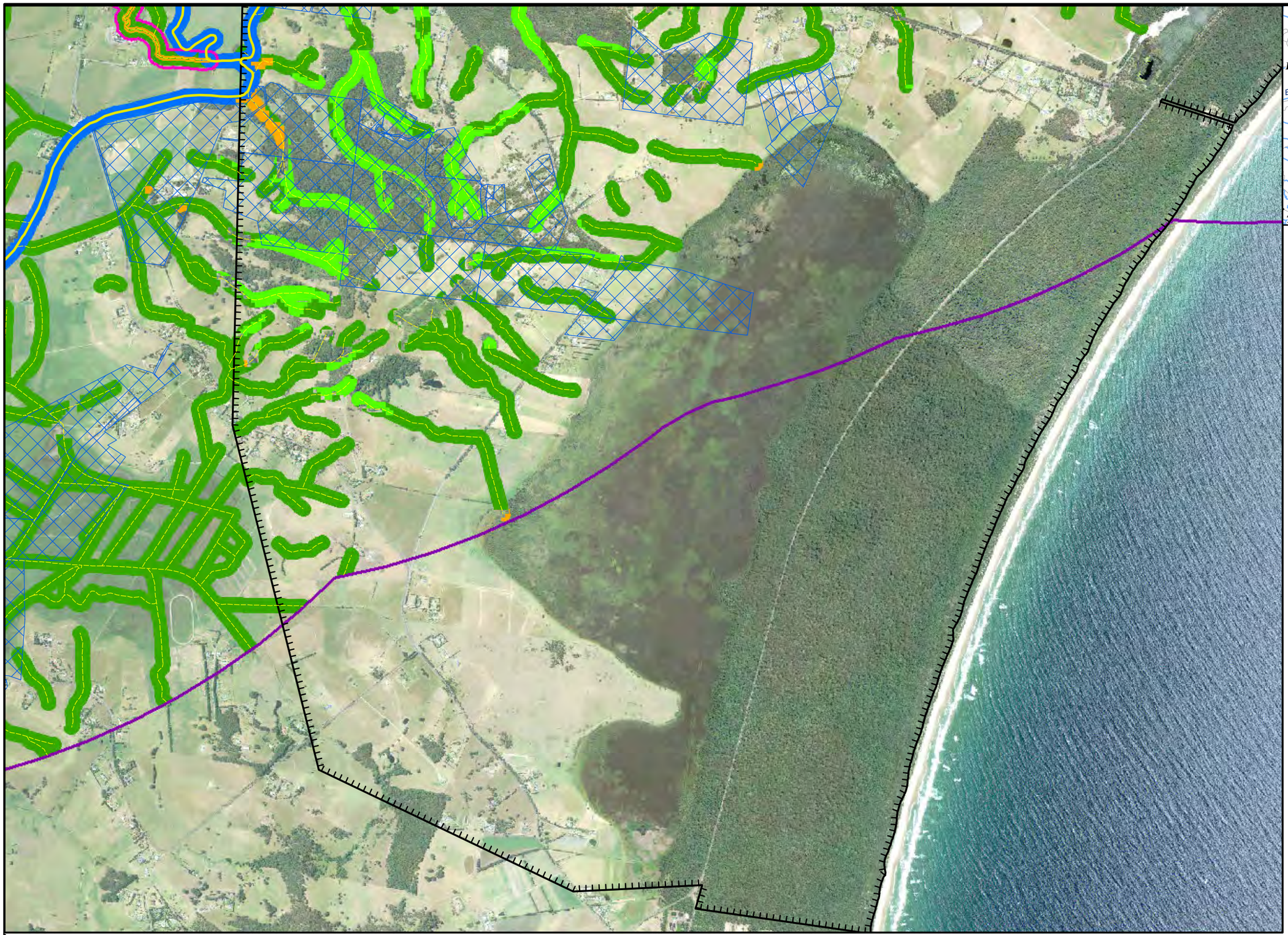
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Scale: 1:25,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 3



Legend

Stream Perenniality
- Perennial
- NonPerennial

Offset Suitability

Priority - Ranking
- 1 - 1a
- 1 - 1b
- 2 - 2a
- 2 - 2b
- 3 - 3

SRCMA Priority Corridor Mapping

SRCMA Revegetation Project Locations

Land Ownership
- RMS
- Council/Government
- Private / Unknown

5km Locality

Ancillary Sites
- Subject Site - Compound
- Subject Site - Stockpile
- Subject Site - Footprint

Study Area

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Figure C.7: Offset Strategy Model

Date: 24 October 2012	Drawn by: RS/JMS
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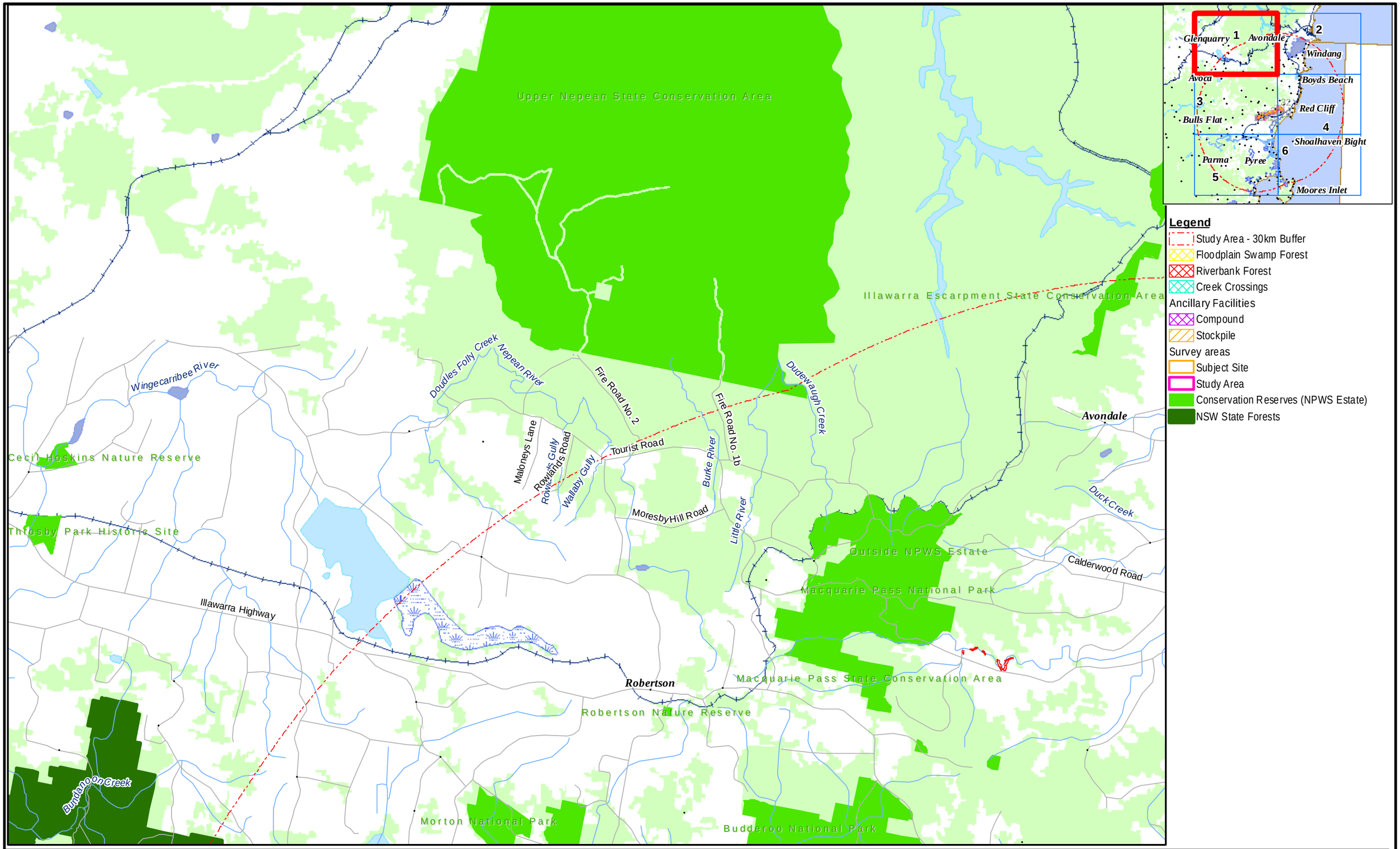
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0 250 500 750 1,000
Metres

Scale: 1:25,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

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Figure 3



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Figure D.1: Riparian and Floodplain Vegetation within 30 km of the Study Area

Date: 14 August 2012	Drawn by: RS/JMS
File: 15039	Checked by: JC
Location: P:\15000s\15039\Mapping\Variation 2\Offset Figures\15039_OS_FB_30kmVeg_20120814.mxd	

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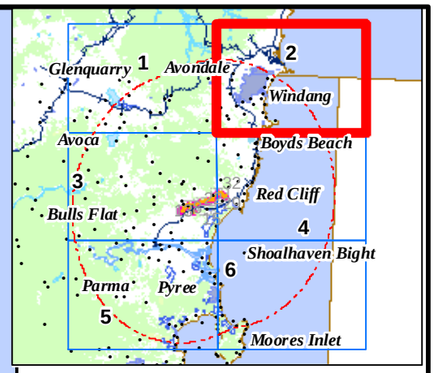
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Metres

Scale: 1:100,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 55

N

Figure B

Outside NPWS Estate
Illawarra Escarpment State Conservation Area
Berkeley Nature Reserve
Five Islands Nature Reserve
Marshall Mount Road
Rock Creek
Southern Freeway
Yallah Road
Illawarra Highway
Princes Highway



Legend

- Study Area - 30km Buffer
- Floodplain Swamp Forest
- Riverbank Forest
- Creek Crossings

Ancillary Facilities

- Compound
- Stockpile

Survey areas

- Subject Site
- Study Area
- Conservation Reserves (NPWS Estate)
- NSW State Forests

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Figure D.2: Riparian and Floodplain Vegetation within 30 km of the Study Area

Date: 14 August 2012	Drawn by: RS/JMS
File: 15039	Checked by: JC
Location: P:\15000s\15039\Mapping\Variation 2\Offset Figures\15039_OS_FB_30kmVeg_20120814.mxd	

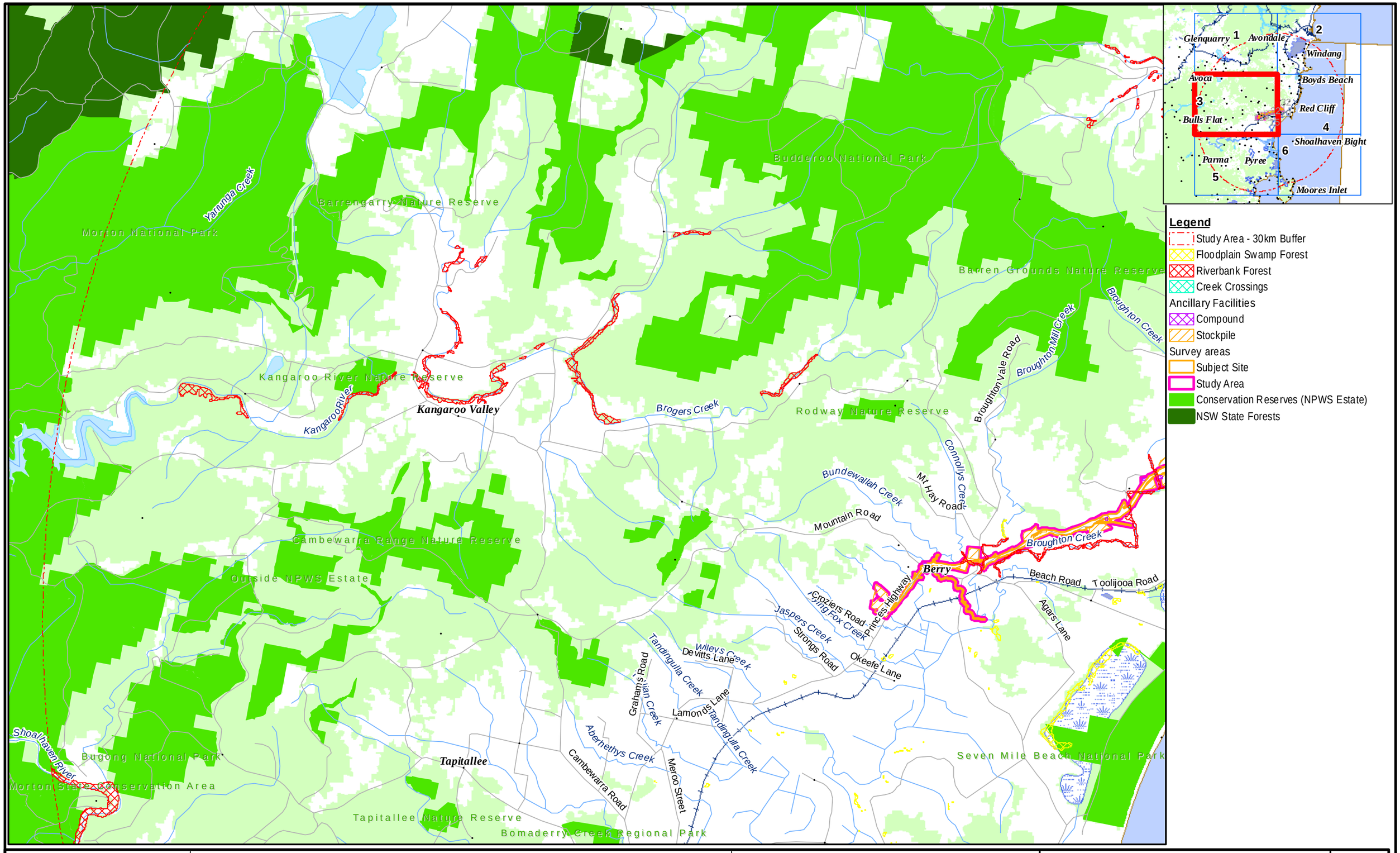
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0 5001,000 2,000 3,000 4,000 5,000 6,000
Metres

Scale: 1:100,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
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Figure B



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Figure D.3: Riparian and Floodplain Vegetation within 30 km of the Study Area

Date: 14 August 2012	Drawn by: RS/JMS
File: 15039	Checked by: JC
Location: P:\15000s\15039\Mapping\Variation 2\Offset Figures\15039_OS_FB_30kmVeg_20120814.mxd	

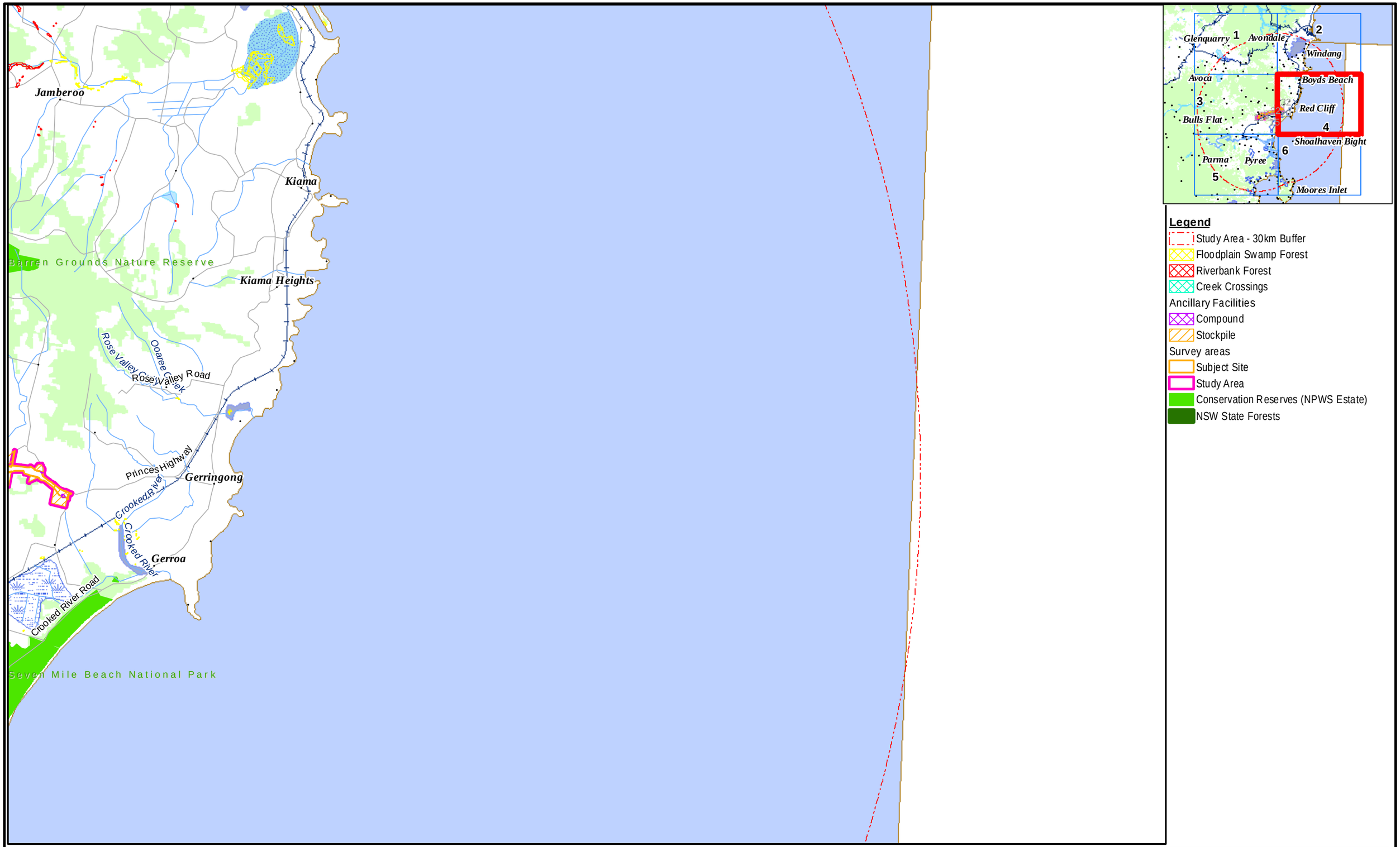
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Scale: 1:100,000 at A3
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Horizontal Datum: Geocentric Datum of Australia 1994
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Figure B



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Figure D.4: Riparian and Floodplain Vegetation within 30 km of the Study Area

Date: 14 August 2012	Drawn by: RS/JMS
File: 15039	Checked by: JC
Location: P:\15000s\15039\Mapping\Variation 2\Offset Figures\15039_OS_FB_30kmVeg_20120814.mxd	

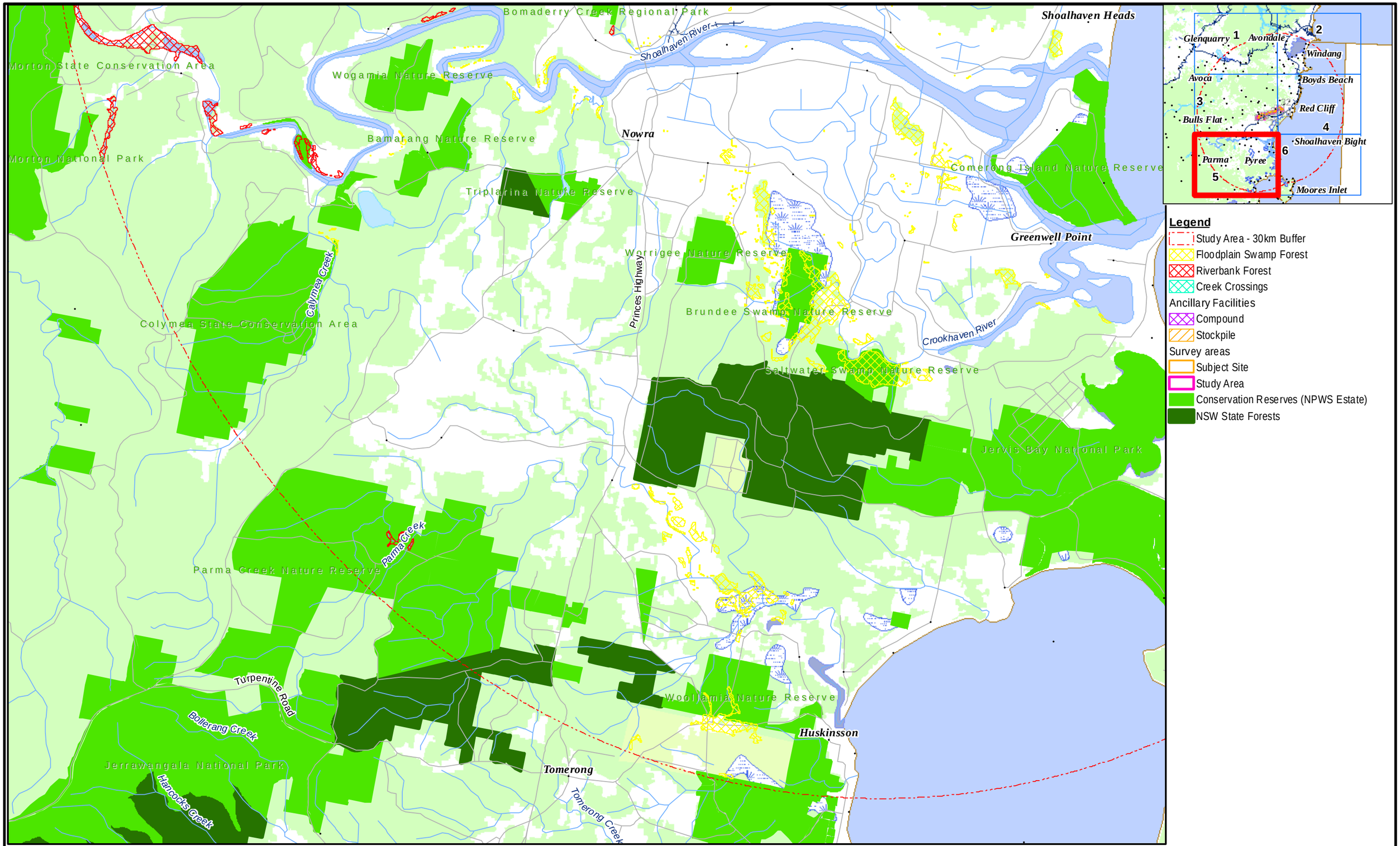
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Metres

Scale: 1:100,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 55

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Figure B



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Figure D.5: Riparian and Floodplain Vegetation within 30 km of the Study Area

Date: 14 August 2012	Drawn by: RS/JMS
File: 15039	Checked by: JC
Location: P:\15000s\15039\Mapping\Variation 2\Offset Figures\15039_OS_FB_30kmVeg_20120814.mxd	

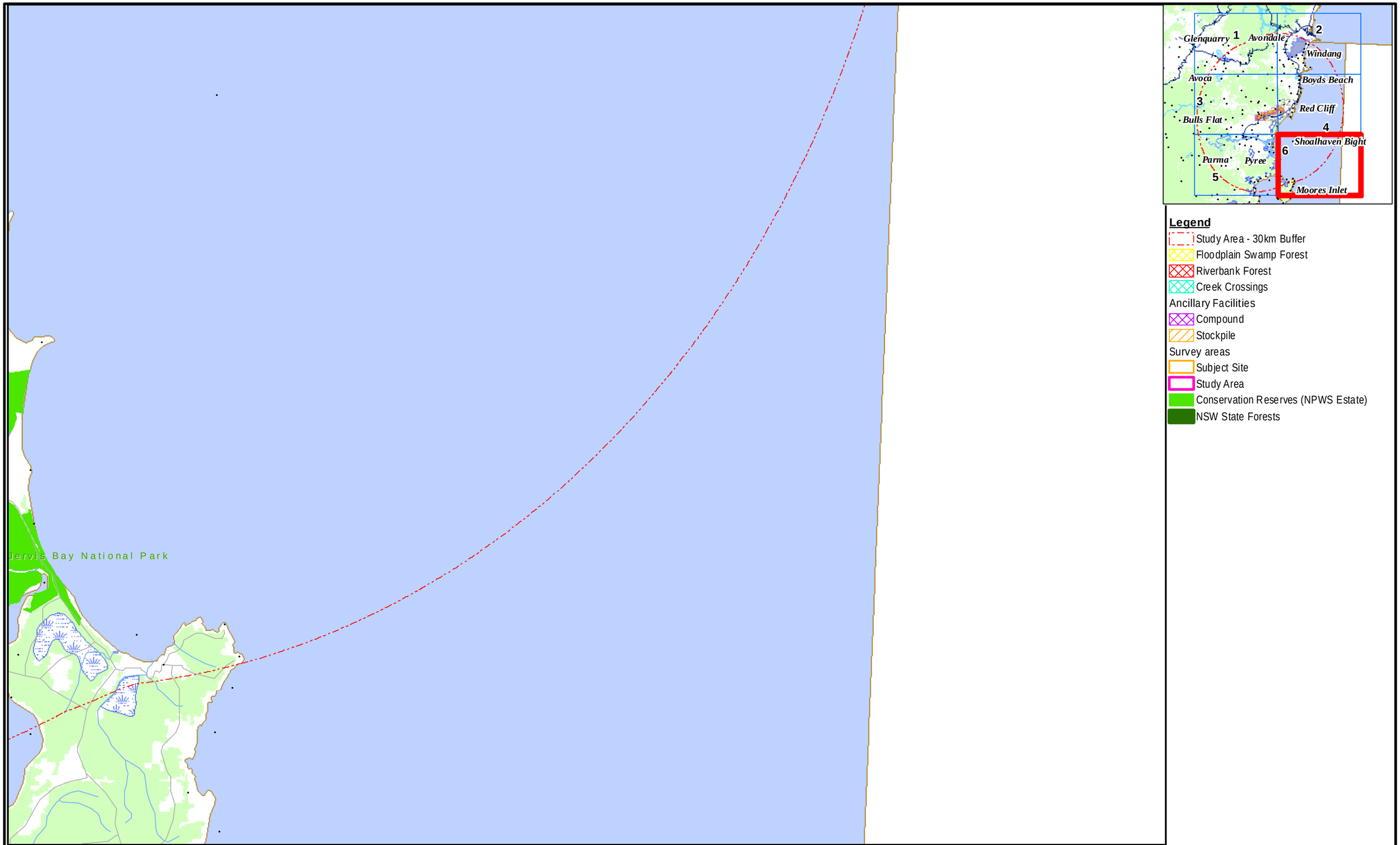
Acknowledgements:
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0 5001,000 2,000 3,000 4,000 5,000 6,000
Metres

Scale: 1:100,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 55

N

Figure B



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Figure D.6: Riparian and Floodplain Vegetation within 30 km of the Study Area

Date: 14 August 2012	Drawn by: RS/JMS
File: 15039	Checked by: JC
Location: P:\15000s\15039\Mapping\Variation 2\Offset Figures\15039_OS_FB_30kmVeg_20120814.mxd	

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Scale: 1:100,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 55

Figure B

Appendix F

OEH general biodiversity offset principles

OEH General biodiversity offset principles

The following principles suggested by OEH (2011) provide a framework for considering environmental impacts and developing offset proposals.

1 *Impacts must be avoided first by using prevention and mitigation measures.*

Offsets are then used to address remaining impacts. This may include modifying the proposal to avoid an area of biodiversity value or putting in place measures to prevent offsite impacts.

2 *All regulatory requirements must be met.*

Offsets cannot be used to satisfy approvals or assessments under other legislation, eg assessment requirements for Aboriginal heritage sites, pollution or other environmental impacts (unless specifically provided for by legislation or additional approvals).

3 *Offsets must never reward ongoing poor performance.*

Offset schemes should not encourage landholders to deliberately degrade or mismanage offset areas in order to increase the value from the offset.

4 *Offsets will complement other government programs.*

A range of tools is required to achieve the NSW Government's conservation objectives, including the establishment and management of new national parks, nature reserves, state conservation areas and regional parks and incentives for private landholders.

5 Offsets must be underpinned by sound ecological principles such as:

- The consideration of structure, function and compositional elements of biodiversity, including threatened species.
- Enhance biodiversity at a range of scales.
- Consider the conservation status of ecological communities.
- Ensure the long-term viability and functionality of biodiversity.

Biodiversity management actions, such as enhancement of existing habitat and securing and managing land of conservation value for biodiversity, can be suitable offsets. Reconstruction of ecological communities involves high risks and uncertainties for biodiversity outcomes and is generally less preferable than other management strategies, such as enhancing existing habitat.

6 *Offsets should aim to result in a net improvement in biodiversity over time.*

Enhancement of biodiversity in offset areas should be equal to or greater than the loss in biodiversity from the impact site. Setting aside areas for biodiversity conservation without additional management or increased security is generally not sufficient to offset against the loss of biodiversity. Factors to consider include protection of existing biodiversity (removal of threats), time-lag effects, and the uncertainties and risks associated with actions such as revegetation. Offsets may include enhancing habitat, reconstructing habitat in strategic areas to link areas of conservation value, or increasing buffer zones around areas of conservation value and removal of threats by conservation agreements or reservation.

7 *Offsets must be enduring - they must offset the impact of the development for the period that the impact occurs.*

As impacts on biodiversity are likely to be permanent, the offset should also be permanent and secured by a conservation agreement or reservation and management for biodiversity. Where land is donated to a public authority or a private conservation organisation and managed as a biodiversity offset, it should be accompanied by resources for its management. Offsetting should only proceed if an appropriate legal mechanism or instrument is used to secure the required actions.

8 *Offsets should be agreed prior to the impact occurring.*

Offsets should minimise ecological risks from time-lags. The feasibility and in-principle agreements to the necessary offset actions should be demonstrated prior to the approval of the impact. Legal commitments to the offset actions should be entered into prior to the commencement of works under approval.

9 *Offsets must be quantifiable - the impacts and benefits must be reliably estimated.*

Offsets should be based on quantitative assessment of the loss in biodiversity from the clearing or other development and the gain in biodiversity from the offset. The methodology must be based on the best available science, be reliable and used for calculating both the loss from the development and the gain from the offset. The methodology should include:

- The area of impact.
- The types of ecological communities and habitat/species affected.
- Connectivity with other areas of habitat/corridors.
- The condition of habitat.
- The conservation status and/or scarcity/rarity of ecological communities.
- Management actions.
- Level of security afforded to the offset site.

The best available information/data should be used when assessing impacts of biodiversity loss and gains from offsets. Offsets will be of greater value where:

- They protect land with high conservation significance.
- Management actions have greater benefits for biodiversity.
- The offset areas are not isolated or fragmented.
- The management for biodiversity is in perpetuity (e.g. secured through a conservation agreement).

Management actions must be deliverable and enforceable.

10 *Offsets must be targeted.*

They must offset impacts on the basis of like-for-like or better conservation outcome. Offsets should be targeted according to biodiversity priorities in the area, based on the conservation status of the ecological community, the presence of threatened species or their habitat, connectivity and the potential to enhance condition by management actions and the removal of threats. Only ecological communities that are equal or greater in conservation status to the type of ecological community lost can be used for offsets. One type of environmental benefit cannot be traded for another: for example, biodiversity offsets may also result in improvements in water quality or salinity but these benefits do not reduce the biodiversity offset requirements.

11 *Offsets must be located appropriately.*

Wherever possible, offsets should be located in areas that have the same or similar ecological characteristics as the area affected by the development.

12 *Offsets must be supplementary.*

They must be beyond existing requirements and not already funded under another scheme. Areas that have received incentive funds cannot be used for offsets. Existing protected areas on private land cannot be used for offsets unless additional security or management actions are implemented. Areas already managed by the government, such as national parks, flora reserves and public open space cannot be used as offsets.

13 *Offsets and their actions must be enforceable through development consent conditions, licence conditions, conservation agreements or a contract.*

Offsets must be audited to ensure that the actions have been carried out, and monitored to determine that the actions are leading to positive biodiversity outcomes.

Appendix G

EP&A Act Part 3A assessments of significance

EP&A Act Part 3A Assessments of Significance

Endangered ecological communities

River-flat eucalypt forest on coastal floodplain of the NSW North Coast, Sydney Basin and south east corner bioregions

River-flat eucalypt forest on coastal floodplains of the NSW North Coast, Sydney Basin and south east corner bioregions (RFEF) is listed as an Endangered Ecological Community in Part 3 of Schedule 1 of the TSC Act. It is equivalent to Riverbank forest which was identified along the riparian corridors of freshwater creeks including Broughton Creek (sites 17, 28 and 29).

Vegetation mapping by Shoalhaven City Council (Shoalhaven City Council, 2004), and discussions with one of the authors (M. Tozer, pers. comm. 2007) support Riverbank forest occurring within the locality. This differs from DEC 2005t mapping, which did not map Riverbank forest within the study area and has incorrectly mapped this community as Floodplain swamp forest.

The Riverbank forest in the study area was characterised by a tall native canopy of *Casuarina cunninghamiana* and an understorey completely dominated by a high density weed infestation. Natural structural layers were no longer intact and in most areas the mid storey and ground layers were completely dominated by weed species including *Ligustrum sinense, Lantana camara, Solanum mauritianum, Ageratina riparia* and *Tradescantia fluminescens*. These weed-infested areas were considered to have little capacity for the regeneration of natural vegetation without significant resources allocated to weed control and revegetation. Obvious disturbances to the Riverbank forest included heavy grazing and erosion.

About 65.7 hectares of Riverbank forest occurs in the locality. About 2.9 hectares would be directly impacted (2.6 ha by the roadway, 0.2 ha by temporary creek crossings and 0.1 ha by Town Creek diversion) and 7.1 hectares may be indirectly impacted (**Figure 3.1** and Appendix J).

Areas where RFEF will be impacted by either direct removal or edge effects for the construction and operation of the project including the permanent roadway, drainage diversion and temporary creek crossings are at:

- Bundewallah Creek north of Rawlings Lane (**Figure 3.1.4**, Appendix J).
- The junction of Bundewallah Creek and Connollys Creek and downstream to Broughton Mill Creek (**Figure 3.1.7**, Appendix J).
- Broughton Creek to the east of Berry on the southern side of the Princes Highway (**Figure 3.1.8**, Appendix J).
- Broughton Creek to the southeast and east of the intersection of Tomlins Road and Princes Highway, at Broughton (**Figure 3.1.12**, Appendix J).
- Broughton Creek to the east of the intersection of Thompson Road and Princes Highway, at Broughton (**Figure 3.1.13**, Appendix J).

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

N/A – RFEF is an endangered ecological community.

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

Based on the vegetation mapping (adapted from DEC 2005t), about 65.7 hectares of RFEF exists within the locality (five kilometre radius of the study area). The project would directly impact about 2.9 hectares of RFEF in the subject site, which equates to 4.41 per cent of this community in the locality. A further 7.1 hectares (10.81 per cent) of RFEF in the locality may be indirectly impacted by the project. Cumulatively up to 10 hectares, equating to 15.2 per cent of RFEF in the locality will be permanently affected by the project.

The main impact the of the project on RFEF habitat would be the reduction in width and the removal of the canopy of *Casuarina cunninghamiana* from the areas of RFEF within the subject site, and the subsequent alteration of plant community structure in the remaining areas beneath the proposed bridges.

Given the existing weed dominance in the understorey of the riparian vegetation, the project is unlikely to significantly alter the composition of the RFEF in the study area by introducing or increasing the spread of weeds. There may be some positive impacts from weed reduction and bush regeneration strategies in these areas as part of mitigation measures (Chapter 5).

The RFEF in the study area is currently grazed and highly altered by weed invasion, so further indirect impacts from edge effects are likely to be minimal.

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

N/A – RFEF is an endangered ecological community.

How is the project likely to affect current disturbance regimes?

Current disturbance regimes affecting RFEF in the study area are largely related to grazing and weed invasion. Natural disturbance regimes such as fire are no longer likely to influence the extent or functioning of this community within the study area.

The understorey of RFEF within the study area is dominated by invasive weed species, with very few native species remaining. The project would remove habitat in the study area and remove grazing pressures from any potential habitat that remains. The project may have some positive effects on the RFEF in the study area through mitigation measures to reduce the existing weed infestation (Chapter 5).

The natural flow regimes of the creeks that cross the study area have been historically altered by clearing and flood mitigation works and there are currently bridges over Broughton and Bundewallah creeks. It is considered unlikely that the bridging of the creeks as part of the project would further alter these flow regimes, provided that there are sufficient setbacks from the creeks.

How is the project likely to affect habitat connectivity?

The RFEF in the study area occurs along Broughton, Broughton Mill, Connollys and Bundewallah creeks. The current condition of the riparian vegetation is highly degraded, and already impacted by fragmentation and edge effects. The project would result in some further fragmentation of the vegetation community to occur at Bundewallah creek, and at three points on Broughton Creek. Edge effects are likely to occur to a small proportion of the EEC.

Given the existing weed dominance in the understorey of the RFEF, the project is unlikely to significantly affect the movement of characteristic native flora species through this community. If native ground layer species did persist in the understorey then dispersal may be facilitated in the areas of vegetation beneath the proposed bridges (Chapter 5). The main impact of the project on habitat connectivity would be the reduction in width and the removal of the canopy of *Casuarina cunninghamiana* from the areas of RFEF within the subject site and the subsequent alteration of plant community structure in these areas.

How is the project likely to affect critical habitat?

Under the TSC Act, the Director-General of Department of Environment and Climate Change maintains a Register of Critical Habitat. To date, no critical habitat has been declared for RFEF.

Conclusion

Up to 10 hectares, equating to 15.2 per cent, of this EEC within the locality will be either permanently removed or indirectly affected by the project. Mitigation measures including revegetation and rehabilitation (Chapter 5) will be undertaken to maintain or improve connectivity of RFEF. However, residual impacts (ie the permanent loss of EEC) will result from the project. An Offset Strategy (Appendix E) has been prepared to inform the development of an offset package to compensate for the loss of this EEC. The project is unlikely to result in a significant impact on RFEF in the locality provided the mitigation measures outlined in Chapter 5, and an adequate offset package, are implemented.

Illawarra lowlands grassy woodland in the Sydney Basin Bioregion

Illawarra lowlands grassy woodland in the Sydney basin bioregion (ILGW) is listed as an EEC in Part 3 of Schedule 1 of the TSC Act. This EEC is recorded in the Wollongong, Shellharbour and Kiama LGAs and occurs on relatively gently sloping to undulating lands less than about 200 metres elevation on Berry Siltstone, Budgong Sandstone and Quaternary alluvium. Eucalyptus species dominate the canopy stratum and the species composition of any stand is influenced by the size of the site and by recent disturbance history (NSW Scientific Committee 2008a).

As identified in **Table 3.1** South Coast grassy woodland (SCGW) and South Coast lowland swamp woodland (SCLSW) described by Tozer *et al* (2010) and mapped by (DEC 2005o) correspond to ILGW on the Illawarra Plain. SCGW occurs in the area from Wollongong to Milton and west to Yalwal. An extant area of 3100 hectares of SCGW, including about 180 hectares in conservation reserves, has been estimated by Tozer *et al* (2010). SCLSW is found in coastal valleys and floodplains, most extensively around Lake Illawarra and in the Moruya – Congo area, but with sporadic occurrences between including small areas near Worrigee, Kioloa and Nelligen. Tozer *et al* (2010) have estimated an extant area of 1100 hectares of SCLSW that includes 90 hectares in conservation reserves.

As a result of clearing for agriculture and other development, most ILGW remnants are small and fragmented with some remnants characterised by regrowth following clearing or other disturbances. Threats to ILGW include further clearing, grazing, weed invasion, selective logging, rubbish dumping, housing and hobby farm developments and physical damage from recreational activities (NSW Scientific Committee 2008a2).

A total of 47.6 hectares of ILGW is mapped in the locality by DEC (2005o). There is no ILGW mapped by DEC (2005o) in the study area or subject site. Field surveys have not identified ILGW on the subject site or in the study area. The nearest stands of the community mapped by DEC (2005o) are to the south of the project area in the vicinity of Harley Hill (**Figure 3.1** and Appendix J).

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

N/A – ILGW is an endangered ecological community.

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

ILGW does not occur in the subject site or study area. The project is unlikely to impact on the nearest mapped stands of ILGW in the locality. Habitat for ILGW has been identified as relatively gently sloping to undulating lands less than about 200 metres elevation on Berry Siltstone, Budgong Sandstone and Quaternary alluvium (NSW Scientific Committee 2008a). Additionally Tozer *et al* (2010) have described SCGW as being found on lower slopes in coastal rainshadow valleys below 350 metres ASL, with SCLSW occurring in coastal valleys and floodplains restricted to flats below 100 metres ASL with partially impeded drainage. Both forms of ILGW have been depleted throughout their range by land clearing and are subject to continuing impacts such as grazing and weed invasion. Habitat for the community in the locality and region has been significantly altered and the project will not affect any area of significant habitat for ILGW.

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

N/A

How is the project likely to affect current disturbance regimes?

ILGW has been subject to clearing for agriculture and other development such as recreational facilities, resulting in fragmentation, grazing, weed invasion and soil compaction (NSW Scientific Committee 2008a). The project will result in clearing of native vegetation but will not affect current disturbance regimes that may threaten remnant or regrowth ILGW or its potential habitat occurring in the locality.

How is the project likely to affect habitat connectivity?

The are several stands of vegetation mapped by DEC (2005o) to the south of the project area in the vicinity of Harley Hill (Figure 3.1 and Appendix J). The majority of the stands of ILGW occur on the edges of larger patches of native vegetation that have a moderate level of connectivity. None of these larger stands of native vegetation will be impacted by the project and habitat connectivity for the mapped stands of ILGW in the locality will be maintained.

How is the project likely to affect critical habitat?

Under the TSC Act, the Director-General of Department of Environment and Climate Change (now OEH) maintains a Register of Critical Habitat. To date, no critical habitat has been declared for ILGW.

Conclusion

There will not be an impact on ILGW in the locality as a result of the project as:

- ILGW is not recorded on or adjoining the study area in previous vegetation mapping or the site inspections.
- Habitat for mapped stands of ILGW in the locality will not be impacted.
- Areas of potential habitat for ILGW within or adjoining the study area have been subject to significant impacts such as vegetation clearing with these areas currently impacted by agriculture and severe weed infestation.

Illawarra subtropical rainforest in the Sydney Basin Bioregion

Illawarra subtropical rainforest in the Sydney basin bioregion (ISR) is listed as an EEC in Part 3 of Schedule 1 of the TSC Act. This EEC is recorded in the Wollongong, Shellharbour, Shoalhaven and Kiama LGA's and may occur elsewhere within the Sydney Basin Bioregion. The main occurrences of ISR are between Albion Park and Gerringong and north of Lake Illawarra on the Berkeley Hills. Outlying occurrences of ISR are known further south on the Shoalhaven River and westwards into Kangaroo Valley, where areas of Permian volcanic soils occur. The community generally occurs on the coastal plain and escarpment foothills, rarely extending onto the upper escarpment slopes (NSW Scientific Committee 2002).

Large areas of this EEC have been cleared for agriculture and the NSW Scientific Committee (2002) has determined that about 3400 hectares of the community remains, mainly on private land, with about 13 per cent of this (440 hectares) in reserved areas.

The vegetation survey and mapping by Tozer *et al* (2010) state that parts of Subtropical Dry Rainforest (SDR) and the closely related Subtropical Complex Rainforest (SCR) are considered to form ISR. As identified in **Table 3.1** of the main report, there is a total of 914.5 hectares of ISR mapped in the locality. Field surveys have not identified ISR on the subject site or in the study area. As discussed in Section 3.2.2 of the main report, ISR was recorded in the field surveys of the current investigation in the eastern area of the locality and is consistent with the DEC (2005o) vegetation mapping of **Figure 3.1** (and in Appendix J).

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

N/A – ISR is an endangered ecological community.

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

ISR does not occur in the subject site or study area. The project is unlikely to impact on the nearest mapped stands of ISR in the locality. Broad habitat for ISR has been identified by the NSW Scientific Committee (2002) as including the coastal plain and escarpment foothills, rarely extending onto the upper escarpment slopes on, but not limited to, coastal Permian volcanic soils.

The condition of the broader area of potential habitat for ISR in the locality is a reflection of the land use history of the region which is characterised by extensive clearing of the coastal plain and foothills for agriculture. The NSW Scientific Committee (2002) identified continuing impacts such as grazing and weed invasion as key threats to this EEC. Habitat for the community in the locality and region has been significantly altered and the project will not affect any area of significant habitat for ISR.

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

N/A

How is the project likely to affect current disturbance regimes?

ISR has been subject to clearing for agriculture resulting in fragmentation, grazing and weed invasion. In addition to these long term impacts continuing threats to the viability of this EEC include further clearing, quarrying, inappropriate fire regimes, rubbish dumping and hobby farm developments (NSW Scientific Committee 2002).

The project will result in clearing of native vegetation. However this will not affect current disturbance regimes that may threaten remnant or regrowth ISR or its potential habitat occurring in the locality.

How is the project likely to affect habitat connectivity?

ISR generally occurs as lineal stands in larger patches of native vegetation mapped by DEC (2005o) on the low hills to the southeast and foothills extending to the Illawarra escarpment the north of the project area (**Figure 3.1** of the main report). These larger stands of native vegetation have a moderate level of connectivity within the locality. The project will affect a fragmented corridor of native vegetation including mapped areas of ISR at the eastern end of the upgrade. However at a locality scale the amount of native vegetation and habitat for ISR that will be affected will not be significant and habitat connectivity for the mapped stands of ISR in the locality will be maintained at its current moderate level.

How is the project likely to affect critical habitat?

Under the TSC Act, the Director-General of Department of Environment, Climate Change and Water (now OEH) maintains a Register of Critical Habitat. To date, no critical habitat has been declared for ISR.

Conclusion

There will not be an impact on ISR of the locality as a result of the project as:

- ISR is not recorded in the study area in previous vegetation mapping or the site inspections.
- Habitat for mapped stands of ISR in the locality will not be impacted and current levels of habitat connectivity will be maintained.
- Areas of potential habitat for ISR within or adjoining the study area have been subject to significant impacts such as vegetation clearing with these areas currently impacted by agriculture and severe weed infestation.

Endangered and Vulnerable Flora

Cynanchum elegans White-flowered Wax Plant

Cynanchum elegans is listed as Endangered under the TSC Act.

Cynanchum elegans is a climber or twiner with a highly variable form and white tubular flowers (DEC 2005Š). Mature stems have a fissured corky bark and can grow to 10 metres long and 3.5 centimetres thick (DEC 2005Š). The leaves are paired (or rarely in threes), ovate to broadly ovate in shape (DEC 2005Š). The species is known to occur on the edge of dry rainforest vegetation (DEC 2005Š).

Cynanchum elegans was not recorded in the study area; the closest record of this species is about 3.5 kilometres to the north-east (DECCW 2011). However, potential habitat does exist within the study area in warm temperate layered forest. Potential habitat for *Cynanchum elegans* is considered to include coastal warm temperate rainforest, intermediate temperate rainforest, subtropical complex rainforest and subtropical dry rainforest. These vegetation communities occur as scattered patches throughout the locality.

About 6.9 hectares of potential habitat for *Cynanchum elegans* would be directly impacted as part of the project with further potential indirect impacts to an additional 5.3 hectares.

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

The following is known about the lifecycle of *Cynanchum elegans* (DEC 2005Š):

- Flowering occurs between August and May, with a peak in November. Flower abundance on individual plants varies from sparse to prolific.
- The fruit can take up to six months to mature.
- Seed production is variable and unreliable. Seeds are wind dispersed and released in a non-dormant state, hence are unlikely to persist in the soil seedbank.
- Plants are capable of suckering from rootstock in response to occasional slashing or grazing. The fire response of the species is unknown.

The following disturbances are thought to impact on the lifecycle of *Cynanchum elegans* (NPWS 2002):

- Loss of individuals – the project is not likely to result in the loss of any individuals of Cynanchum elegans.
- Fragmentation of habitat – the habitat for the species in the study area is already fragmented by cleared and disturbed land. The project impacts upon existing edges of potential habitat and would not increase fragmentation of potential habitat for the species.
- Modification of habitat – the potential habitat for Cynanchum elegans in the study area is already modified due to the ongoing impacts from edge effects (eg weeds) and disturbances such as grazing. The project may result in an increase in the intensity of some existing impacts.
- Damage to the soil seed bank – seeds of this species are wind dispersed and released in a non-dormant state, hence are unlikely to persist in the soil seedbank.
- Altered fire regime – the project is not likely to alter the fire regime of the local area.

Cynanchum elegans was not recorded in the study area, however the species has previously been recorded about 3.5 kilometres to the north-east of the study area. Potential habitat for the species occurs in the warm temperate layered forest in the study area. As no individuals have been recorded in the study area, it is unlikely that the project would have an adverse effect on the lifecycle of the species such that a viable population of the species would be placed at risk of extinction.

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

The species has not been recorded in the study area, however, potential habitat for the species occurs within warm temperate layered forest in the study area with further potential habitat in the locality occurring within coastal warm temperate rainforest, intermediate temperate rainforest, subtropical complex rainforest and subtropical dry rainforest. Vegetation mapping DEC (2005o) indicates about 2324.7 hectares of these potential habitats occur within the locality (five kilometre radius of the study area).

The potential habitat for this species within the study area is in moderate to poor condition, due to the dominance of exotic species in the understorey, altered community structure and existing fragmentation.

About 6.9 hectares of potential habitat for *Cynanchum elegans* would be directly impacted by the project. The area of potential habitat for *Cynanchum elegans* that would be removed as part of the project equates to 0.30 per cent of the extent of these plant communities in the locality.

Potential habitat for *Cynanchum elegans* that would be disturbed as part of the project occurs in the warm temperate layered forest in the north-east of the subject site. The areas to be cleared are at the edges of currently fragmented patches that were sampled as part of site 20. This vegetation was considered to be in poor condition along edges where large infestations of the noxious weed *Lantana camara* are present and have displaced most native species. These edges are likely to have little or no capacity for the regeneration of natural vegetation without significant resources allocated to weed control and revegetation.

The project would widen the existing cleared land, thus increase fragmentation. However it is unlikely to result in the isolation of areas of potential habitat for this species.

Given that the species has not been recorded in the study area and the relatively small area of potential habitat directly impacted compared with that in the locality, potential habitat in the study area is not considered to be vital for the long-term survival of the species in the locality.

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

The study area is about 3.5 kilometres south-west of the southern most record of *Cynanchum elegans* (DECCW 2009a). Given the large areas of potential habitat to the west of this record and the existing clearing, disturbance and fragmentation of potential habitat in and adjoining the study area, it is considered unlikely that the project would further limit any range extension of this species.

How is the project likely to affect current disturbance regimes?

The current disturbance regime in the warm temperate layered forest in the study area consists of fragmentation of patches by clearing, grazing disturbance and large infestations of the noxious weed *Lantana camara* along edges.

Given the small size, fragmentation and poor condition of vegetation that would be impacted, the project is not likely to increase the impact of weed invasion in the study area. However, mitigation measures are recommended to reduce the existing weed infestation and the likelihood of increased weed invasion in the impacted patches (Chapter 5).

How is the project likely to affect habitat connectivity?

There is currently limited connectivity in the potential habitat for *Cynanchum elegans* in the study area; although the patches of warm temperate layered forest are relatively close, the vegetation was considered to be in poor condition along edges where large infestations of the noxious weed *Lantana camara* are present and have displaced most native species. The areas to be cleared for the project are at the edges of these currently fragmented patches.

The project would increase the distance between the patches of potential habitat for *Cynanchum elegans* in the study area. However, it is likely that the edges of these patches do not currently form habitat for *Cynanchum elegans* due to large infestations of *Lantana camara.*

How is the project likely to affect critical habitat?

Under the TSC Act, the Director-General maintains a Register of Critical Habitat. To date, no critical habitat has been declared for *Cynanchum elegans.*

Conclusion

The nearest known record of *Cynanchum elegans* occurs about 3.5 kilometres north-east of the study area; this record is at the southern limit of the known distribution of this species. *Cynanchum elegans* was not recorded during the field surveys for this assessment. Potential habitat for this species that would be removed by the project represents a relatively small area that is already subject to existing edge effects and disturbances. For these reasons it is considered unlikely that the project would have a significant impact on this species.

Daphnandra sp. C 'Illawarra' Illawarra Socketwood

Daphnandra sp. 'Illawarra' is listed as Endangered on the TSC Act.

Daphnandra sp. 'Illawarra' is a rainforest tree growing to 20 metres tall, with coarsely toothed opposite leaves and small, pale, greenish white flowers (DEC 2005j). This species is known to occupy the rocky hillsides and gullies of the Illawarra lowlands, occasionally extending onto the upper escarpment slopes and is associated with rainforest and moist eucalypt forest (DEC 2005j).

Daphnandra sp. 'Illawarra' was not recorded in the study area; however this species was recorded in the locality during broader surveys, about 600 metres to the south of the study area around Toolijooa Ridge. There are also a number of OEH Atlas records of this species in the locality, with the closest about 130 metres to the south of the study area and 400 metres to the north of the study area.

Potential habitat does exist within the study area in Illawarra gully wet forest and warm temperate layered forest communities. Potential habitat exists in the locality in the following vegetation communities: Buderoo temperate rainforest, coastal warm temperate rainforest, escarpment foothills wet forest, Illawarra gully wet forest, intermediate temperate rainforest, subtropical complex rainforest, warm temperate layered forest, subtropical dry rainforest, and Yarrawarra temperate rainforest. These plant communities occur as scattered patches throughout the locality covering about 3011.8 hectares.

The project would have direct impacts on about 22.3 hectares of potential habitat for *Daphnandra* sp. 'Illawarra' in the subject site with potential indirect impacts to a further 15.4 hectares in the study area.

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

The following is known about the lifecycle of *Daphnandra* sp. 'Illawarra' (DEC 2005j):

- Flowers briefly in September and early October with fruits taking 10 to 12 months to mature.
- Capable of vegetative reproduction from stems (coppicing) and rhizomes (suckering).
- Low levels of seed production are suspected, with stems at most sites appearing to only produce 'pseudo-fruit' which lack seeds. Seed production has been reported from just two sites, only one of which has been confirmed to produce viable seed, and the extent to which this seed is capable of surviving in the wild is unknown.
- The species is possibly killed by fire.
- The pollination mechanisms of *Daphnandra* sp. C 'Illawarra' are unknown, as is the potential role that pollen vectors may play in the transfer of genetic material within and between sites.
- The predominant means of reproduction appears to be asexual (DEC2005i).

Daphnandra sp. C 'Illawarra' was not recorded in the study area; however this species was recorded in the locality during broader surveys, about 600 metres to the south of the study area around Toolijooa Ridge. There are also a number of OEH Atlas records of this species in the locality, with the closest about 130 metres to the south of the study area and 400 metres to the north of the study area. Potential habitat for the species does, however, exist within warm temperate layered forest and Illawarra gully wet forest within the study area, and the rainforest and wet forest plant communities in the locality.

Given the clonal nature of *Daphnandra* sp. C 'Illawarra', it is unlikely that the project would interrupt the lifecycle of this species.

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

Potential habitat *Daphnandra* sp. 'Illawarra' in the study area may occur within the Illawarra gully wet forest, and warm temperate layered forest communities, with further potential habitat in the rainforest and wet forest plant communities in the locality. Vegetation mapping by DEC (2005o) indicates about 3011.8 hectares of these potential habitats occur within the locality.

The project would directly impact about 22.3 hectares of potential habitat for *Daphnandra* sp. 'Illawarra' with potential indirect impacts to a further 15.4 hectares. These impacts would include clearing of native vegetation. The area of potential habitat that would be removed as part of the project equates to about 0.74 per cent of the extent of potential habitat for the species in the locality. This is not considered to be a significant proportion of habitat.

Given the potential habitat for this species within the study area is highly disturbed with exotic pasture and weeds, the project is considered unlikely to introduce further weed propagules to any remaining areas of habitat.

The project is not likely to have a significant effect on the habitat of the species in the locality.

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

The study area is at the southern limit of the known distribution of *Daphnandra* sp. C Illawarra.

The project is to the north of the southernmost records of *Daphnandra* sp. C Illawarra on Toolijooa Ridge. Therefore the project is not likely to prevent any further southwards expansion of this species.

How is the project likely to affect current disturbance regimes?

The current disturbance regime in the warm temperate layered forest in the study area consists of fragmentation of patches by clearing, grazing disturbance and large infestations of the noxious weed *Lantana camara* along edges.

Given the small size, fragmentation and poor condition of vegetation that would be impacted, the project is not likely to increase the impact of weed invasion in the study area. However, mitigation measures are recommended to reduce the existing weed infestation and the likelihood of increased weed invasion in the impacted patches (Chapter 5).

The project is likely to remove a portion of marginal potential habitat in the study area and remove grazing pressures from any potential habitat that remains.

How is the project likely to affect habitat connectivity?

The project would further fragment the already fragmented vegetation between two known populations of *Daphnandra* sp. C 'Illawarra'. These two populations are currently separated by about 850 metres with scattered patches of vegetation in poor condition between them.

The areas to be cleared to the north of the known population of *Daphnandra* sp. C 'Illawarra' include the edges of currently fragmented patches of warm temperate layered forest in poor condition along edges where large infestations of the noxious weed *Lantana camara* are present and have displaced most native species.

The project would widen the existing area of cleared land, thus increasing fragmentation. However, given the current fragmentation and infestation of *Lantana camara,* it is unlikely that the areas to be cleared to the north of the known population represent suitable habitat for *Daphnandra* sp. C 'Illawarra'.

How is the project likely to affect critical habitat?

Under the TSC Act, the Director-General maintains a Register of Critical Habitat. To date, no critical habitat has been declared for *Daphnandra* sp. C 'Illawarra'.

Conclusion

Daphnandra sp. C 'Illawarra' was not recorded in the study area; however, this species was recorded in the locality during broader surveys, about 600 metres to the south of the study area around Toolijooa Ridge. There are also a number of OEH Atlas records of this species in the locality, with the closest about 130 metres to the south of the study area and 400 metres to the north of the study area.

The alignment of the project avoids direct and indirect impacts on known records of this endangered species.

Potential habitat does exist within the study area in Illawarra gully wet forest and warm temperate layered forest communities. The project would have direct impacts on about 22.3 hectares of potential habitat for *Daphnandra* sp. 'Illawarra' in the subject site with potential indirect impacts to a further 15.4 hectares in the study area.

In determining the nature and magnitude of impacts on the potential habitat of *Daphnandra* sp. C 'Illawarra', the project is considered unlikely to have a significant impact as:

- The species was not recorded within the study area.
- The areas of potential habitat to be removed are currently fragmented and disturbed, particularly in the area to the north of the known population of this species on Toolijooa Ridge.

Irenepharsus trypherus Delicate Cress

Irenepharsus trypherus is listed as Endangered on the TSC Act.

Irenepharsus trypherus is a hairless annual or short-lived perennial herb that grows to 250 centimetres. It has a spreading to erect habit and is often multi-stemmed. The species typically inhabits steep rocky slopes near cliff lines and ridge tops, and less typically is found growing out of rock crevices or on narrow benches along cliff lines. The vast majority of sites are recorded from the upper slopes of the ridge systems that extend south and east of the Illawarra escarpment, although the species has also been recorded from the deep sandstone gorges of the Shoalhaven River (DEC 2005u).

Irenepharsus trypherus was not recorded in the study area, nor were there records for this species within a 10 kilometre radius of the study area (DECCW 2009a). However potential habitat does exist within the study area in Illawarra gully wet forest. Potential habitat for *Irenepharsus trypherus* is considered to include subtropical complex rainforest and wet sclerophyll forests. These include the following vegetation communities: coastal warm temperate rainforest, escarpment foothills wet forest, Illawarra gully wet forest, intermediate temperate rainforest, subtropical complex rainforest and subtropical dry rainforest. These vegetation communities occur as scattered patches throughout the locality and cover an area of about 1690.7 hectares.

About 15.4 hectares of potential habitat for *Irenepharsus trypherus* would be directly impacted as part of the project with further potential indirect impacts to an additional 10 hectares (**Table 4.2**).

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

The following is known about the lifecycle of *Irenepharsus trypherus* (DEC 2005u):

- Mature plants are capable of reshooting from dry or desiccated stems following light grazing, trampling or drought.
- The species is thought to be a prolific seeder, with disturbance and light levels influencing germination.
- The fire response of this species is unknown.

Activities likely to affect the lifecycle of the species are those that contribute to the following (DEC 2005i):

- Loss of individuals – *Irenepharsus trypherus* is not known to occur in the study area, therefore the project is not likely to result in the loss of individuals of this species.
- Fragmentation of habitat – the potential habitat for *Irenepharsus trypherus* is currently fragmented by the Princes Highway. The project intersects the southern edge of a large patch of Illawarra gully wet forest at site 15, with only the currently fragmented edge being further fragmented as a result of the project.
- Modification of habitat – the potential habitat for *Irenepharsus trypherus* in the study area is already modified due to the ongoing impacts from edge effects (eg weeds) and disturbances such as grazing. The project may result in an increase in the intensity of some existing impacts.
- Damage to the soil seed bank – the project may involve the removal of some soil. This may lead to damage of the soil seed bank of the study area.
- Altered fire regimes – the project is not likely to alter the fire frequency in the locality.

On the basis of the above, the project is considered unlikely to have an adverse effect on the lifecycle of the species such that a viable local population (if one exists) of the species would be placed at risk of extinction.

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

The species has not been recorded in the study area nor within 10 kilometres, however, potential habitat for the species occurs within Illawarra gully wet forest in the study area with further potential habitat in the locality occurring within coastal warm temperate rainforest, escarpment foothills wet forest, intermediate temperate rainforest, subtropical complex rainforest, subtropical dry rainforest and temperate littoral rainforest. Vegetation mapping by DEC (2005o) indicates about 1690.7 hectares of these potential habitats occur within the locality (five kilometre radius of the study area).

The potential habitat for this species within the study area ranges from poor to moderate in the south-west (sites 14 and 35), with remnant trees and a patchy or weed dominated understorey, to moderate to good condition in the central section (site 15), with a largely intact native tree, shrub and groundlayer along with infestations of woody weeds such as *Lantana camara*.

About 15.4 hectares of potential habitat for *Irenepharsus trypherus* would be directly impacted by the project. The area of potential habitat for *Irenepharsus trypherus* that would be removed as part of the project equates to 0.91 per cent of the extent of similar potential habitats mapped in the locality.

Given that the species has not been recorded in the study area and the relatively small area of potential habitat to be impacted in relation to that in the locality, potential habitat in the study area is not considered to be vital for the long-term survival of the species in the locality.

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

No. The study area is to the south-east of the known distribution of *Irenepharsus trypherus.* The closest record to the study area is at Minnamurra Falls, about 15 kilometres to the north-west.

How is the project likely to affect current disturbance regimes?

The potential habitat for *Irenepharsus trypherus* is currently fragmented by the Princes Highway. The project intersects the southern edge of a large patch of Illawarra gully wet forest at site 15, with only the currently fragmented edge being further fragmented as a result of the project. This area is already modified due to the ongoing impacts from edge effects (eg weeds) and disturbances such as grazing.

How is the project likely to affect habitat connectivity?

Potential habitat for *Irenepharsus trypherus* that would be impacted by the project is part of an already fragmented and cleared landscape. The largest patch of potential habitat that would be fragmented is the Illawarra gully wet forest at site 15, where the project intersects the southern, currently fragmented edge.

How is the project likely to affect critical habitat?

Under the TSC Act, the Director-General maintains a register of critical habitat. To date, no critical habitat has been declared for *Irenepharsus trypherus*.

Conclusion

Irenepharsus trypherus has not been recorded within 10 kilometres of the study area. In determining the nature and magnitude of impacts on the potential habitat of *Irenepharsus trypherus*, the project is considered unlikely to have a significant impact as:

- The species was not recorded during the field surveys of the study area.
- A relatively small area of potential habitat would be directly impacted.
- The project would result in minor fragmentation or isolation of the potential habitat.

However, the project has the potential to increase the operation of key threatening processes in the potential habitat of this species. On this basis, mitigation measures included in Chapter 5 of this report should be implemented in order to minimise potential indirect impacts resulting from the project

Zieria granulata Hill Zieria

Zieria granulata is listed as Endangered on the TSC Act.

This species is a tall bushy shrub that grows to six metres. The typical habitat is dry ridge tops and rocky outcrops on shallow volcanic soils, usually on Bombo Latite. Less frequently found on the moist slopes of the Illawarra escarpment and in low-lying areas on Quaternary sediments (DEC 2005'). The species is restricted to the Illawarra region. The species primarily occupies the coastal lowlands between Oak Flats and Toolijooa, in the local government areas of Shellharbour and Kiama.

Zieria granulata was not recorded in the study area, but was recorded in the locality during broader surveys, about 400 metres to the south of the study area on Toolijooa Ridge. There are also a number of OEH Atlas records of this species in the locality, with the closest record about 190 metres to the south-west of the study area.

Potential habitat for *Zieria granulata* does exist within the study area in Illawarra gully wet forest and warm temperate layered forest. The species also grows in highly disturbed areas such as road embankments and paddocks. Potential vegetation communities in the locality include: buderoo temperate rainforest, coastal warm temperate rainforest, escarpment foothills wet forest, Illawarra gully wet forest, intermediate temperate rainforest, subtropical complex rainforest, subtropical dry rainforest, and Yarrawarra temperate rainforest. These vegetation communities occur as scattered patches throughout the locality covering about 3011.8 hectares.

About 22.3 hectares of potential habitat for *Zieria granulata* would be directly impacted by the project with further potential indirect impacts to an additional 15.4 hectares of potential habitat.

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

Zieria granulata was not recorded in the study area. Numerous records of this species occur within 10 kilometres of the study area, with a large population on Toolijooa Ridge to the south. The closest record is about 190 metres to the south-west of the study area, near Broughton.

The following is known about the lifecycle of *Zieria granulata* (DEC 2005'):

- Flowering occurs between early spring and summer.
- Known to possess functional pollen although deformed pollen has been recorded for the species.
- Nectar seeking flies appear to be effective pollen vectors for this species; these flies are considered to be generalist pollinators and strong fliers that are capable of traversing open spaces.
- Seed dispersal is initially through forcible ejection from the mature fruit, and it is suspected that secondary dispersal by ants also occurs.
- Response to fire not known.

The project is unlikely to affect the lifecycle of the *Zieria granulata* individuals in the population that adjoins the study area.

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

Zieria granulata was not recorded in the study area. The project would result in direct impacts to about 22.3 hectares of potential habitat for the species. Based on the vegetation mapping, about 3011.8 hectares of potential habitat for *Zieria granulata* exists within the locality (five kilometre radius of the study area). The area of habitat in the study area to be directly impacted by the project equates to 0.74 per cent of similar habitat types in the locality.

The potential habitat for *Zieria granulata* in the study area is already modified due to ongoing impacts from edge effects (eg weeds) and disturbances such as grazing. The project may result in an increase in the intensity of some existing impacts.

The project is not likely to have a significant effect on the habitat of *Zieria granulata* in the locality.

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

The study area is at the southern limit of the known distribution of *Zieria granulata.* The project may further isolate the southernmost records of this species from the rest of the population to the north.

Potential habitat in the locality includes the following vegetation communities: Buderoo temperate rainforest, coastal warm temperate rainforest, warm temperate layered forest, escarpment foothills wet forest, Illawarra gully wet forest, intermediate temperate rainforest, subtropical complex rainforest, subtropical dry rainforest, south coast grassy woodland and Yarrawarra temperate rainforest. These vegetation communities occur as scattered patches throughout the locality and cover an area of about 3011.8 hectares. Some of these vegetation communities occur to the south of the known southern limit of *Zieria granulata* and there are is a highly fragmented corridor across Toolijooa Ridge and Harley Hill that may facilitate any range expansion of this species.

How is the project likely to affect current disturbance regimes?

The current disturbance regime in the warm temperate layered forest in the study area consists of fragmentation of patches by clearing, grazing disturbance and large infestations of the noxious weed *Lantana camara* along edges.

Given the small size, fragmentation and poor condition of vegetation that would be impacted, the project is not likely to increase the impact of weed invasion in the study area. However, mitigation measures are recommended to reduce the existing weed infestation and the likelihood of increased weed invasion in the impacted patches (Chapter 5).

The project is likely to remove a portion of marginal potential habitat in the study area and remove grazing pressures from any potential habitat that remains.

How is the project likely to affect habitat connectivity?

The alignment of the project avoids direct and indirect impacts on a known population of *Zieria granulata*. A relatively large population of this species on Toolijooa Ridge is about 400 metres to the south of the study area and would not be fragmented by the project.

The closest known record of *Zieria granulata* to the Toolijooa Ridge population is about 1.6 kilometres to the north-west. There are currently roads, cleared grazing lands and fragmented patches of vegetation between the two populations. The project would not further isolate the Toolijooa Ridge population of *Z. granulata* from another known population.

How is the project likely to affect critical habitat?

Under the TSC Act, the Director-General maintains a Register of Critical Habitat. To date, no critical habitat has been declared for *Zieria granulata*.

Conclusion

In determining the nature and magnitude of impacts on *Zieria granulata,* the project is considered unlikely to have a significant impact as:

- The species was not recorded within the study area, so there would be no impacts on known populations.
- A relatively small and disturbed area of potential habitat would be directly impacted.
- The project would not result in significant fragmentation or isolation of the potential habitat.

Pterostylis gibbosa Illawarra Greenhood

Pterostylis gibbosa is listed as Endangered on the TSC Act.

Pterostylis gibbosa is a deciduous orchid that is only visible above the ground between late summer and spring. Its rosette of leaves emerges from an underground tuberoid during late summer and autumn. A flower scape develops on mature plants over winter and flowering occurs between September and October, after which the leaf rosette withers and seed capsules develop (NPWS 2002).

Pterostylis gibbosa is currently known from five locations: Milbrodale in the Hunter Valley, Yallah (two sites) and Albion Park in the Illawarra and Nowra in the Shoalhaven. The total known population size of *Pterstylis gibbosa* in 2002 was about 4500 plants although this is likely to be higher given the extent of the Milbrodale and Worrigee Nature Reserve populations which had not been fully assessed as at the time of the publication of the Recovery Plan for the species (NPWS 2002).

The species occurs in open forest or woodland on flat or gently sloping land with poorly drained soils. Associated vegetation is usually woodland dominated by *Eucalyptus tereticornis* and *Melaleuca decora* with an open grassy understorey. Near Nowra, *Pterostylis gibbosa* is also associated with open forest dominated by *Corymbia maculata* and *Eucalyptus paniculata* with an open grassy understorey (NPWS 2002).

Pterostylis gibbosa was not recorded in the study area, nor were there records for this species within a 10 kilometre radius of the study area. NSW vegetation classes that the species is associated with are Coastal Valley Grassy Woodlands and Southern Lowland Wet Sclerophyll Forests (DEC 2005r). There are no plant communities in the locality that fall into the Southern Lowland Wet Sclerophyll Forests class. Two vegetation communities of the locality that fall into the Coastal Valley Grassy Woodland class are Illawarra Lowland Swamp Woodland and South Coast Grassy Woodland. Neither of these vegetation communities occur in the study area with the nearest stand of either about 2.5 kilometres south of the project. Potential habitat for the species in the locality consists of a total of 47.6 hectares of Coastal Valley Grassy Woodland.

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

The following is known about the lifecycle of *Pterostylis gibbosa* (NPWS 2002):

- Pterostylis species are generally pollinated by male gnats of the genus Mycomya (Fungus Gnats). Pollination occurs when the male Mycomya are deceived into attempting to copulate with the labellum. Nothing is known of the habitat requirements of Mycomya however it is suggested they are probably very common, but are not often seen due to their small size. Abundance of Mycomya is believed to peak in September, which is the main month of flowering of *Pterostylis gibbosa*. Studies on pollination rates have indicated that suitable adjoining pollinator habitat to a known site may be important for pollination success in addition to pollinator availability.
- The seed is dispersed by wind and reliant on a mycorrhizal fungus to support the first stages of growth after germination. *Pterostylis gibbosa* sheds seed in spring and is dormant until the following autumn.
- The species is capable of surviving fire, due to the regenerative capacity of its tuberoid. Occasional fire may be necessary to provide suitable conditions for the establishment of seeds and seedlings and to maintain habitat suitable for the survival of the species. Summer fires are assumed to have the least impact on Pterostylis gibbosa as the species remains dormant underground over summer, provided such fires are not of a sufficient intensity to destroy the underground tuber.

- Generally, the species is flexible in its response to climatic conditions with plants dying back in poor conditions and growing quickly in good times. Additionally, the plant may die back and reappear within a season. Grazing is thought to have either beneficial or deleterious effect on the species dependant on timing.

Activities likely to affect the lifecycle of the species are those that contribute to the following (DEC 2005i):

- Loss of individuals – *Pterostylis gibbosa* is not known to occur in the study area, therefore the project is not likely to result in the loss of individuals of this species.
- Fragmentation of habitat – there is no potential habitat for *Pterostylis gibbosa* in the study area. The potential habitat for the species in the locality is highly fragmented. The project will not contribute further fragmentation of the species potential habitat in the locality.
- Modification of habitat – the project will not affect the potential habitat of *Pterostylis gibbosa* in the locality by either direct or indirect impacts. The project is not likely to modify habitat for the species pollinators such that *Pterostylis gibbosa* would be adversely affected if were to occur in the locality.
- Damage to the soil seed bank – the project will not involve the removal or modification of the soil seed bank of potential habitat for the species in the locality.
- Altered fire regimes – the project is not likely to alter the fire frequency in the locality.

On the basis of the above, the project is considered unlikely to have an adverse effect on the lifecycle of the species such that a viable local population (if one exists) of the species would be placed at risk of extinction.

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

The species has not been recorded in the study area or within 10 kilometres of the project. Potential habitat for the species occurs in the Illawarra Lowland Swamp Woodland and South Coast Grassy Woodland vegetation communities of the locality. Mapping by DEC (2005o) has estimated an approximate 47.6 hectares of these potential habitats within the locality (five kilometre radius of the study area).

No area of known or potential habitat will be impacted by the project.

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

The project is near Nowra which is at the southern extent of the species distribution. However *Pterostylis gibbosa* is not currently recorded in the project locality and habitat for the species in the locality will not be affected.

How is the project likely to affect current disturbance regimes?

The potential habitat for *Pterostylis gibbosa* in the locality is highly fragmented as a result of vegetation clearing and agricultural land use. Although the project will impact on native vegetation, this will not affect the potential habitat of *Pterostylis gibbosa* to the south of the project area. Disturbance regimes such as grazing and weed invasion that are likely to occur in the potential habitat for this species will not be exacerbated as a result of the project.

How is the project likely to affect habitat connectivity?

Potential habitat for *Pterostylis gibbosa* will not be impacted by the project.

How is the project likely to affect critical habitat?

Under the TSC Act, the Director-General maintains a register of critical habitat. To date, no critical habitat has been declared for *Pterostylis gibbosa*.

Conclusion

Pterostylis gibbosa has not been recorded within 10 kilometres of the study area. In determining the nature and magnitude of impacts on the potential habitat of *Pterostylis gibbosa* the project is considered unlikely to have a significant impact as:

- The species was not recorded during the field surveys of the study area.
- The relatively small area of potential habitat for the species that occurs in the locality will not be directly or indirectly impacted.
- The project would result in minor additional fragmentation native vegetation that is not considered potential habitat for the species.

Cryptostylis hunteriana Leafless Tongue-orchid

Cryptostylis hunteriana is listed as Vulnerable on the TSC Act.

Cryptostylis hunteriana is a leafless saprophytic terrestrial orchid which produces an upright flower-stem to 45 centimetres tall, bearing five to 10 flowers. The flowering period is between November and February (DEC 2005e).

The species is known from a number of localities along the coast of NSW, Victoria and Queensland. In NSW, it appears to be most common in the Shoalhaven area (DEWHA 2008a), and observed in recent years at many sites between Batemans Bay and Nowra (DEC 2005e). *Cryptostylis hunteriana* does not appear to have well defined habitat preferences and is known from a range of communities (DEC 2005e). Associated soils include moist sands, moist to dry clay loam and occasionally in accumulated eucalypt leaves (DEWHA 2008a). The species occurs mostly in coastal heathlands, margins of coastal swamps and sedgelands, coastal forest, dry woodland, and lowland forest (DEWHA 2008a). The larger populations typically occur in woodland dominated by *Eucalyptus sclerophylla*, *E. sieberi, Corymbia gummifera* and *Allocasuarina littoralis*. The species appears to prefer open areas in the understorey of this community and is often found in association with *Cryptostylis subulata* and *Cryptostylis erecta* (DEC 2005e).

Cryptostylis hunteriana was not recorded in the study area, nor were there records for this species within a 10 kilometre radius of the study area. NSW vegetation classes that the species is associated with in the Sothern Rivers region are South East Dry Sclerophyll Forests, Sydney Hinterland Dry Sclerophyll Forests, Sydney Montane Dry Sclerophyll Forests, South Coast Heaths, Sydney Coastal Heaths and Sydney Montane Heaths (DEC 2005e)

Of the vegetation communities mapped in the locality Currambene-Batemans Lowlands Forest falls into the South East Dry Sclerophyll Forests class whilst Budderoo-Morton Plateau Forest falls within the Sydney Montane Dry Sclerophyll Forests class. Of these Currambene-Batemans Lowlands Forest occurs within the study area and subject site.

Potential habitat for the species in the locality consists of a total of 54.1 hectares of South East Dry Sclerophyll Forest and Sydney Montane Dry Sclerophyll Forest.

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

The following is known about the lifecycle of *Cryptostylis hunteriana.*

- Pollination of *Cryptostylis hunteriana* is via pseudocopulation by the male Ichneumon Wasp (*Lissopimpla excelsa*), and seeds are spread via wind transportation (DEWHA 2008a).
- The flowering period is broadly from August to February with flowering taking place earlier in Queensland than in NSW and Victoria. Estimates for time taken for a seed to germinate and flower could be from two and a half years to a more probable three or four and a half years based on existing knowledge of orchid reproduction (DEWHA 2008a).
- The species is spread either by wind transportation of seed or by seeds being dropped in the immediate vicinity once the flower head has fallen over and it is suggested that the likelihood of the species spreading by vegetative reproduction is low due to its poorly developed root system (DEWHA 2008a).
- Flowering intensity may be stimulated by previous fire events, however, fire during the flowering season has been identified as a potential threat to the species (DEWHA 2008a).
- The species may be dependent on a mychorrizal fungal association (DEWHA 2008a).

Activities likely to affect the lifecycle of the species are those that contribute to the following (DEC 2005i):

- Loss of individuals – *Cryptostylis hunteriana* is not known to occur in the study area, therefore the project is not likely to result in the loss of individuals of this species.
- Fragmentation of habitat – there is about 2.4 hectares of potential habitat for *Cryptostylis hunteriana* in the study area. The potential habitat for the species in the locality is about 54.1 hectares of highly fragmented vegetation communities. The project will not contribute further fragmentation of the species potential habitat in the locality.
- Modification of habitat – the project will affect 0.0002 hectares of potential habitat for *Cryptostylis hunteriana* in the locality by either direct or indirect impacts. The project is not likely to modify habitat for the species pollinators such that *Cryptostylis hunteriana* would be adversely affected if were to occur in the locality.
- Damage to the soil seed bank – the project will involve the removal and modification of the soil seed bank of potential habitat for the species in the locality.
- Altered fire regimes – the project is not likely to alter the fire frequency in the locality.

On the basis of the above, the project is considered unlikely to have an adverse effect on the lifecycle of the species such that a viable local population (if one exists) of the species would be placed at risk of extinction.

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

The species has not been recorded in the study area or within 10 kilometres of the project. Potential habitat for the species occurs in the Currambene-Batemans Lowlands Forest and Budderoo-Morton Plateau Forest communities of the locality. Mapping by DEC (2005o) has estimated an approximate 54.1 hectares of these potential habitats within the locality (five kilometre radius of the study area). Of this up to 0.0002 hectares of Currambene-Batemans Lowlands Forest may be affected by the project, equating to 0.0004 per cent of the potential habitat for the species in the locality.

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

The species is distributed from near Orbost in southern Victoria to near Grafton on the NSW north coast.

How is the project likely to affect current disturbance regimes?

The potential habitat for *Cryptostylis hunteriana* in the locality is highly fragmented as a result of vegetation clearing and agricultural land use. Apart from the loss of native vegetation that forms habitat for this species disturbance regimes such as grazing and weed invasion that are likely to occur in the potential habitat for this species will not be exacerbated as a result of the project.

How is the project likely to affect habitat connectivity?

Stands of Currambene-Batemans Lowlands Forest and Budderoo-Morton Plateau Forest in the locality are highly disjunct. Although the project will result in the future isolation of habitat for the species this is not considered significant as *Cryptostylis hunteriana* is not known from the locality.

How is the project likely to affect critical habitat?

Under the TSC Act, the Director-General maintains a register of critical habitat. To date, no critical habitat has been declared for *Cryptostylis hunteriana*.

Conclusion

Cryptostylis hunteriana has not been recorded within 10 kilometres of the study area. In determining the nature and magnitude of impacts on the potential habitat of *Cryptostylis hunteriana* the project is considered unlikely to have a significant impact as:

- The species was not recorded during the field surveys of the study area.
- The relatively small area of potential habitat for the species that occurs in the locality that will be impacted is not considered significant.
- The project would not result in significant additional fragmentation of native vegetation considered potential habitat for the species.

Genoplesium baueri

Genoplesium baueri is listed as Vulnerable under the TSC Act.

Genoplesium baueri is a terrestrial orchid about 6-15 centimetres high, with a sparse inflorescence of 1-6 flowers. Flowering time is from December to March. The species has been recorded from locations between Ulladulla and Port Stephens, with older records including Sydney suburbs of Cowan, Asquith, Wahroonga and Gladesville (DEC 2005i).

Genoplesium baueri occurs in sparse sclerophyll forest and moss gardens over sandstone (DEC 2005i). The majority of plants are found in relatively open areas but the largest population is located under a good overstorey and dense ground cover (ANOS 2008). The locations of some previous recordings are likely to now be within conservation reserves including Berowra Valley Regional Park, Royal National Park and Lane Cove National Park (DEC 2005i). Pollination of the genus Genoplesium is by small ferment flies such as the fruit fly Drosophila and flowering of the species may be enhanced by fire (Jones 2006).

Genoplesium baueri was not recorded in the study area, nor were there records for this species within a 10 kilometre radius of the study area. NSW vegetation classes that the species is associated with in the Sothern Rivers region are Sydney Coastal Dry Sclerophyll Forests and Sydney Montane Heaths (DEC 2005i). There are no vegetation communities mapped in the locality that fall into either of these vegetation classes.

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

The following is known about the lifecycle of *Genoplesium baueri*.

- Pollination of the genus Genoplesium is by small ferment flies such as the fruit fly Drosophila.
- Flowering time is from December to March.

Activities likely to affect the lifecycle of the species are those that contribute to the following (DEC 2005i):

- Loss of individuals – Genoplesium baueri is not known to occur in the study area, therefore the project is not likely to result in the loss of individuals of this species.
- Fragmentation of habitat – there is no habitat for Genoplesium baueri in the study area or locality.
- Modification of habitat – the project will not affect habitat for this species.
- Damage to the soil seed bank – the project will not involve the removal or modification of the soil seed bank of potential habitat for the species in the locality.
- Altered fire regimes – the project is not likely to alter the fire frequency in the locality.

On the basis of the above, the project is considered unlikely to have an adverse effect on the lifecycle of the species such that a viable local population (if one exists) of the species would be placed at risk of extinction.

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

The species has not been recorded in the study area or within 10 kilometres of the project. Potential habitat for the species includes vegetation that falls into the Sydney Coastal Dry Sclerophyll Forests and Sydney Montane Heaths NSW vegetation classes. No vegetation communities mapped in the locality fall into either of these classes.

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

The species occurs between Ulladulla and Port Stephens. The project area is not at the limits of the species known distribution.

How is the project likely to affect current disturbance regimes?

Although the project will impact on native vegetation, this will not affect potential habitat for the species.

How is the project likely to affect habitat connectivity?

No habitat for the species occurs in the locality.

How is the project likely to affect critical habitat?

Under the TSC Act, the Director-General maintains a register of critical habitat. To date, no critical habitat has been declared for *Genoplesium baueri*.

Conclusion

Genoplesium baueri has not been recorded within 10 kilometres of the study area and the locality does not support vegetation communities that provide habitat for the species. The project will not impact *Genoplesium baueri* or its potential habitat.

Endangered and Vulnerable Fauna

Ixobrychus flavicollis Black Bittern

The Black Bittern is listed as Vulnerable under Schedule 2 of the TSC Act.

The Black Bittern has been previously recorded on the edge of the study area adjacent to Town Creek (south of Berry), in 1988. There has been one other record of the Black Bittern in the locality; from 1990, to the south-east at Black Head (DECCW 2011).

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

The Black Bittern inhabits coastal wetlands and littoral habitats. Freshwater wetlands, fringed with dense vegetation such as melaleuca and casuarina are preferred (Marchant and Higgins 1990a). The species utilises billabongs, pools, and estuaries and tidal reaches of coastal creeks and rivers with fringing vegetation, which may only form a narrow band of cover (Marchant and Higgins 1990a).

The Black Bittern nests in trees over wetlands and watercourses in densely vegetated areas. It forages in low, marshy vegetation, or in shadows over shallow water and roost on the ground or in leafy trees (Marchant and Higgins 1990a).

Potential habitat for this species occurs within the riparian forest and woodland, and constructed wetland habitat within the study area. The project is likely to remove and/or disturb about 14.5 hectares of potential foraging and breeding habitat for this species. However, given the extent of potential habitat (eg riparian forest and woodland, constructed wetlands and estuarine habitats) within the locality (at least 270.4 hectares), it is unlikely the loss or disturbance of 5.4 per cent of potential habitat from the locality would disrupt the life cycle of the Black Bittern.

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

The project would directly impact 5.9 hectares of riparian forest and woodland, and constructed wetland (potential habitat) within the study area. Within the area of DEC vegetation mapping (as amended following the field surveys), this equates to only 2.2 per cent of the potential habitat available within the locality (at least 270.4 hectares). A further 8.6 hectares would be indirectly impacted. This equates to about 3.2 per cent of the potential habitat available within the locality. In total, 5.3 per cent of the available habitat in the locality would be impacted.

The riparian forest in the study area forms a local wildlife corridor that is also a component of the Seven Mile Beach National Park – Barren Grounds Nature Reserve wildlife corridor. The Black Bittern may use this riparian corridor to move throughout the landscape and it is therefore important for the long-term survival of the species within the locality. The proposed riparian corridor enhancement (through rehabilitation and revegetation) would help mitigate impacts on habitat connectivity for this species.

Given that the potential habitat to be removed is disturbed, the reasonable mobility of this species and provided that the mitigation measures to compensate for the loss of habitat connectivity described in Chapter 5 are implemented, it is considered unlikely that the project would have a significant impact on the habitat of the Black Bittern.

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

The Black Bittern has a wide distribution, from southern New South Wales (although rarely south of Sydney), north to Cape York and along the north coast to the Kimberley region (DEC 2005b). The study area is not at, or near, the limit of distribution for this species.

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

The Black Bittern habitat within the study area has been subjected to ongoing disturbances from grazing, recreational fishing and aquatic activities, edge effects due to the current highway, rural development and associated infrastructure. The project is likely to result in further disturbance from the road construction, although this would be temporary, and the diversion of Town Creek (permanent modification of habitat south of the diversion). Additionally, edge effects such as an increase in weeds and anthropogenic activities associated with the new highway are likely.

How is the project likely to affect habitat connectivity?

The majority of the study area is covered by cleared areas and grazed paddocks that contain little native vegetation; wildlife corridors in the study area, therefore, are limited. However, vegetation remnants at Toolijooa Ridge, Broughton Creek, site 15, Broughton Mill Creek and Bundewallah Creek form local corridors that are components of the regional Seven Mile Beach National Park – Barren Grounds Nature Reserve wildlife corridor. The project crosses these local wildlife corridors thereby creating (or increasing) a barrier to fauna movement between areas of habitat within the locality.

In order to mitigate impacts of corridor fragmentation, riparian corridor enhancement (through rehabilitation and revegetation) is proposed (Chapter 5). The proposed riparian corridor enhancement would help mitigate impacts on habitat connectivity for this species.

Given the mobility of the Black Bittern, and provided the mitigation measures described in Chapter 5 are implemented, it is considered unlikely that the project would significantly disrupt habitat connectivity.

How is the project likely to affect critical habitat?

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations or ecological communities. Under the TSC Act, the Director-General maintains a register of critical habitat. To date, no critical habitat has been declared for the Black Bittern (DECC 2008a).

Conclusion

Based on the above assessment the project is considered unlikely to have a significant impact on the Black Bittern.

Burhinus grallarius Bush Stone-curlew

The Bush Stone-curlew is listed as Endangered under Schedule 1 of the TSC Act.

The Bush Stone-curlew has not been recorded in the study area. The species has been previously recorded only once within 10 kilometres of the study area; about nine kilometres south of the study area, recorded in 1998 (DECCW 2011).

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

The Bush Stone-curlew is a nocturnal, ground-dwelling bird. It nests on the ground, near dead timber often within open woodlands that have a short grass or brushwood understorey. The species breeds in spring, laying two eggs in late August to mid December (DEC 2005f).

Potential habitat occurs within the forests and woodlands and surrounding farmland of the study area, particularly where there is a grassy understorey. The project is likely to directly impact about 27.8 hectares of potential habitat (eg eucalypt forest with grassy understorey and riparian forests) and indirectly impact a further 26.05 hectares. However, given the lack of records for this species in the study area and locality, and the extent of potential habitat within the locality (1282.6 hectares) it is unlikely the project would disrupt the life cycle of the Bush Stone-curlew.

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

The Bush Stone-curlew inhabits open forests and woodlands with a sparse grassy ground layer and fallen timber. The preferred habitat for this species consists of woodlands of casuarinas, eucalypts and acacias.

The project is likely to modify and/or remove about 53.9 hectares of potential foraging and breeding habitat for the Bush Stone-curlew. Within the area of DEC vegetation mapping (as amended following the field surveys), this equates to only 4.2 per cent of the potential habitat (eg eucalypt and casuarina grassy woodlands) available within the locality (1282.6 hectares).

The habitat to be impacted is predominantly disturbed roadside and disturbed riparian vegetation. Regardless, this disturbed habitat forms part of a discontinuous wildlife corridor between Seven Mile Beach National Park and Barren Grounds Nature Reserve and is therefore considered to be important for the long-term survival of the Bush Stone-curlew within the locality (if present). The proposed corridor fragmentation mitigation measures (Chapter 5) may help mitigate impacts on habitat connectivity for this species.

Given that the potential habitat to be removed is disturbed, the reasonable mobility of this species and provided that the mitigation measures to compensate for the loss of habitat connectivity described in Chapter 5 are implemented, it is considered unlikely that the project would have a significant impact on the habitat of the Bush Stone-curlew.

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

The Bush Stone-curlew is found throughout Australia except for the central southern coast and inland, the far south-east corner, and Tasmania (DEC 2005e). The study area is not at, or near, the limit of distribution for this species.

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

The study area has been subjected to ongoing disturbances from grazing and edge effects due to the current highway, rural development and associated infrastructure. The project is likely to result in further disturbance from the road construction, although this would be temporary, and additional edge effects such as an increase in weeds and anthropogenic activities associated with the new highway.

The project would also result in a wider barrier for fauna attempting to cross the new highway.

How is the project likely to affect habitat connectivity?

The majority of the study area is covered by cleared areas and grazed paddocks that contain little native vegetation; wildlife corridors in the study area, therefore, are limited. However, vegetation remnants at Toolijooa Ridge, Broughton Creek, site 15, Broughton Mill Creek and Bundewallah Creek form local corridors that are components of the regional Seven Mile Beach National Park – Barren Grounds Nature Reserve wildlife corridor. The project crosses these local wildlife corridors thereby creating (or increasing) a barrier to fauna movement between areas of habitat within the locality.

In order to mitigate impacts of corridor fragmentation, riparian corridor enhancement (through rehabilitation and revegetation) is proposed (Chapter 5). The proposed riparian corridor enhancement may help mitigate impacts on habitat connectivity for this species.

Given the mobility of the Bush Stone-curlew and provided the mitigation measures described in Chapter 5 are implemented, it is considered unlikely that the project would significantly disrupt habitat connectivity.

How is the project likely to affect critical habitat?

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations or ecological communities. Under the TSC Act, the Director-General maintains a register of critical habitat. To date, no critical habitat has been declared for the Bush Stone-curlew (DECC 2008a).

Conclusion

Based on the above assessment the project is considered unlikely to have a significant impact on the Bush Stone-curlew.

Callacephalon fimbriatum Gang-Gang Cockatoo

The Gang-gang Cockatoo is listed as Vulnerable under Schedule 2 of the TSC Act.

The Gang-gang Cockatoo was recorded during the field surveys south of the study area (site 8). This species has previously been recorded nine times (between 1994 and 2010) within the locality to the north, south and east of the study area. Additional records exit within 10 kilometres the north, south and west of the study area (Birds Australia 2011, DECCW 2011).

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

The Gang-gang Cockatoo occupies tall, montane forests and woodlands in summer, particularly in heavily timbered and mature wet sclerophyll forests (Higgins 1999). In winter, it occurs at lower altitudes in drier, more open eucalypt forests and woodlands, particularly in box-ironbark assemblages, or in dry forest in coastal areas (Shields and Crome 1992). The Gang-gang Cockatoo forages for seeds in the canopies of native and introduced trees, especially eucalypts (Higgins 1999). The principle foods of the species are wattle seeds, eucalypt seeds, exotic fruit and nuts and invertebrates (Cameron 2007).

Gang-gang Cockatoos nest in tree hollows (Gibbons and Lindermayer 1997), preferring live trees often near water with hollows between 70 centimetres – 200 centimetres deep and about 25 centimetres in diameter. These trees often occur in mature sclerophyll forest with a dense shrubby understorey. Although little is known about the movements of this species, it is considered to be mobile and known to migrate in response to food availability (DEC 2005p).

Potential breeding and foraging habitat for the Gang-gang Cockatoo occurs in the woodland and forest habitats of the study area. The project is likely to remove up to 27.8 hectares of this habitat with a further 26.05 hectares likely to be indirectly impacted. This may include the loss of hollows and foraging resources for the Gang-gang Cockatoo. However, given the mobility of this species and extent of habitat within the locality (3666.9 hectares), it is unlikely the loss/modification of 1.5 per cent of the available habitat for this species within the locality would disrupt the life cycle of the Gang-gang Cockatoo within the study area.

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

The study area contains potential foraging and breeding resources for the Gang-gang Cockatoo in the woodland and forest habitats. The project is likely to remove and/or modify about 53.9 hectares (27.8 hectares from direct impacts with a further 26.05 hectares indirectly impacted) of this potential habitat. Woodland and forest habitat are widely distributed within the locality; as such, it is unlikely the project would have a significant impact on the Gang-gang Cockatoo habitat within the locality.

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

The distribution of the Gang-gang Cockatoo extends from southern Victoria through south and central-eastern New South Wales (DEC2005p). The study area is not at, or near, the limit of distribution for this species.

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

The study area has been subjected to ongoing disturbances from grazing and edge effects due to the current highway, rural development and associated infrastructure. The proposal is likely to result in further disturbance from the road construction, although this would be temporary, and additional edge effects such as an increase in weeds and anthropogenic activities associated with the new highway.

How is the project likely to affect habitat connectivity?

The majority of the study area is covered by cleared areas and grazed paddocks that contain little native vegetation; wildlife corridors in the study area, therefore, are limited. However, vegetation remnants at Toolijooa Ridge, Broughton Creek, site 15, Broughton Mill Creek and Bundewallah Creek form local corridors that are components of the regional Seven Mile Beach National Park – Barren Grounds Nature Reserve wildlife corridor. The project crosses these local wildlife corridors thereby creating (or increasing) a barrier to fauna movement between areas of habitat within the locality. The highly mobile Gang-gang Cockatoo is unlikely to be impacted by the reduced connectivity within the locality.

How is the project likely to affect critical habitat?

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations or ecological communities. Under the TSC Act, the Director-General maintains a register of critical habitat. To date, no critical habitat has been declared for the Gang-gang Cockatoo (DECC 2008a).

Conclusion

Based on the above assessment the project is considered unlikely to have a significant impact on the Gang-gang Cockatoo.

Calyptorhynchus lathami Glossy Black-cockatoo

The Glossy Black-cockatoo is listed as Vulnerable under Schedule 2 of the TSC Act.

The Glossy Black-cockatoo has been previously recorded once within the locality (in 2005), about four kilometres to the east of the study area (DECCW 2011). Beyond the locality and within 10 kilometres of the study area, this species has been recorded at an additional four locations to the south and west of the study area (DECCW 2011). This species was not recorded during the field surveys.

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

The Glossy Black-cockatoo relies almost entirely on the seeds of a few species of *Allocasuarina* for food, these being *A. littoralis, A. torulosa* and *A. verticillata*. They also forage on *Angophora* fruit, sunflower seeds, pine cones and grubs in acacia and allocasuarina. This species is almost entirely arboreal coming to ground only to drink. They are dependent on large hollow-bearing trees in mature eucalypt trees for nesting (Higgins 1999).

The study area contains *Allocasuarina littoralis* and *Angophora floribunda* which are considered to be foraging trees for the Glossy Black-cockatoo. The study area may also provide breeding opportunities in the form of hollows.

The project would disturb and/or remove about 53.9 hectares (direct impacts of 27.8 hectares, indirect impacts 26.05 hectares) of the potential habitat resources for this species within the study area. However this only represents 4.2 per cent of the available habitat within the locality (1281.3 hectares). As such it is unlikely the project would disturb the life cycle of the Glossy Black-cockatoo.

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

The study area contains potential foraging and breeding resources for the Glossy Black-cockatoo in the woodland and forest habitats. The project is likely to remove and/or modify about 53.9 hectares (27.8 hectares from direct impacts with a further 26.05 hectares indirectly impacted) of this potential habitat. Woodland and forest habitat are widely distributed within the locality; as such, it is unlikely the project would have a significant impact on the Glossy Black-cockatoo habitat within the locality.

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

The distribution of the Glossy Black-cockatoo extends from the central Queensland coast to East Gippsland in Victoria, and inland to the southern tablelands and central western plains of New South Wales (DEC 2005q). The study area is not at, or near, the limit of distribution for this species.

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

The study area has been subjected to ongoing disturbances from grazing and edge effects due to the current highway, rural development and associated infrastructure. The project is likely to result in further disturbance from the road construction, although this would be temporary, and additional edge effects such as an increase in weeds and anthropogenic activities associated with the new highway.

How is the project likely to affect habitat connectivity?

The majority of the study area is covered by cleared areas and grazed paddocks that contain little native vegetation; wildlife corridors in the study area, therefore, are limited. However, vegetation remnants at Toolijooa Ridge, Broughton Creek, site 15, Broughton Mill Creek and Bundewallah Creek form local corridors that are components of the regional Seven Mile Beach National Park – Barren Grounds Nature Reserve wildlife corridor. The project crosses these local wildlife corridors thereby creating (or increasing) a barrier to fauna movement between areas of habitat within the locality. The highly mobile Glossy Black-cockatoo is unlikely to be impacted by the reduced connectivity within the locality.

How is the project likely to affect critical habitat?

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations or ecological communities. Under the TSC Act, the Director-General maintains a register of critical habitat. To date, no critical habitat has been declared for the Glossy Black-cockatoo (DECC 2008a).

Conclusion

Based on the above assessment the project is considered unlikely to have a significant impact on the Glossy Black-cockatoo.

Glossopsitta pusilla Little Lorikeet

The Little Lorikeet is listed as Vulnerable under Schedule 2 of the TSC Act.

The Little Lorikeet was not recorded within the study area, however it has been previously recorded five times (between 1993 and 2010) to the south of the locality in Coomonderry Swamp and Seven Mile Beach National Park (Birds Australia 2011, DECCW 2011). Two additional records occur within 10 kilometres to the north and south of the study area.

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

Little Lorikeets occur in dry, open eucalypt forests and woodlands. They are gregarious, usually foraging in small flocks, often with other species of lorikeet. They feed primarily on nectar and pollen in the tree canopy (flowering eucalypts), but also on a variety of other species including melaleucas and mistletoes. In coastal regions they have been known to forage on melaleucas, *Eucalyptus pilularis* (blackbutt) and *E .robusta* (swamp mahogany), the latter two being particularly important food sources for pollen and nectar respectively (NSW Scientific Committee 2008b). Little Lorikeets are generally considered to be nomadic, and move in response to food availability with irregular large or small influxes of individuals occurring at any time of year (Higgins 1999).

Little is known of the breeding requirement of the Little Lorikeet; however there are observations of nesting at heights between two metres and 15 metres, in small hollows in mostly smooth-barked eucalypts (NSW Scientific Committee 2008b).

Potential habitat trees for the Little Lorikeet in the form of melaleucas, *Eucalyptus pilularis and E. robusta* and limited breeding resources (smooth-barked *Corymbia maculata,* spotted gum) are present in the woodlands and forest habitats within the study area. The project is likely to directly disturb about 22.2 hectares of potential habitat and a further 17.5 hectares is likely to be indirectly impacted. However, breeding and foraging resources for this species are widely distributed within the locality (2425.7 hectares). Given that this species moves in response to food availability and the extent of further breeding habitat within the locality (including known habitat protected within Seven Mile Beach National Park) it is considered unlikely that the project would disrupt the life cycle of the Little Lorikeet.

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

The project would directly modify and/or remove about 22.2 hectares of potential habitat for the Little Lorikeet, with a further 17.5 hectares likely to be indirectly impacted. This would include disturbance to foraging resources and limited breeding resources. The Little Lorikeet habitat to be modified and/or removed by the project represents about 1.6 per cent of the available habitat for this species within the locality.

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

The Little Lorikeet distribution extends from north of Cairns, down the east coast of Australia, to Adelaide (NSW Scientific Committee 2008b). As a result the study area is not at, or near, the limit of distribution for this species.

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

The study area has been subjected to ongoing disturbances from grazing and edge effects due to the current highway, rural development and associated infrastructure. The project is likely to result in further disturbance from the road construction, although this would be temporary, and additional edge effects such as an increase in weeds and anthropogenic activities associated with the new highway.

How is the project likely to affect habitat connectivity?

The majority of the study area is covered by cleared areas and grazed paddocks that contain little native vegetation. Wildlife corridors intersected by the study area include the Seven Mile Beach National Park – Barren Grounds Nature Reserve wildlife corridor. Vegetation remnants at Toolijooa Ridge, Broughton Creek, site 15, Broughton Mill Creek and Bundewallah Creek are discontinuous parts of this corridor.

The project would involve removal of potential habitat trees from the study area. This is likely to cause some impact on local and regional wildlife corridors, particularly where the project crosses Toolijooa Ridge (once) and Broughton Creek (three times). However, given the Little Lorikeet is mobile it is unlikely the project would create new barriers or exacerbate existing barriers for this species.

How is the project likely to affect critical habitat?

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations or ecological communities. Under the TSC Act, the Director-General maintains a register of critical habitat. To date, no critical habitat has been declared for the Little Lorikeet (DECC 2008a).

Conclusion

Based on the above assessment the project is considered unlikely to have a significant impact on the Little Lorikeet.

Lathamus discolor Swift Parrot

The Swift Parrot is listed as Endangered under Schedule 1 of the TSC Act. The species is also listed as Endangered under the EPBC Act.

The Swift Parrot has not been recorded within the study area. The species has been previously recorded once within the locality (recorded in year 2000), about 2.5 kilometres south-east of the study area within Seven Mile Beach National Park (Birds Australia 2011). Another three records of the species occur within 10 kilometres of the study area to the north and south (DECCW 2011).

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

The Swift Parrot is a highly nomadic species that occurs in woodlands and forests in New South Wales (Higgins 1999). It migrates in response to food availability and seasonal changes. It is often recorded in New South Wales between May and August and breeds in Tasmania during the warmer seasons (Higgins 1999).

While on the mainland, Swift Parrots occur in areas where eucalypts are flowering profusely or where there are abundant lerp (from sap-sucking bugs) infestations. Favoured feed trees include winter-flowering species such as swamp mahogany *Eucalyptus robusta*, spotted gum *Corymbia maculata*, red bloodwood *C. gummifera*, mugga ironbark *E. sideroxylon*, and white box *E. albens*. Commonly used lerp-infested trees include grey box *E. microcarpa*, grey box *E. moluccana* and blackbutt *E. pilularis* (DEC 2005†).

The study area provides potential foraging habitat for the Swift Parrot within the eucalypt forests and woodlands. Three favoured feed tree species (*Corymbia maculata*, *C. gummifera* and *Eucalyptus pilularis*) occur within the study area. Only one species (*E. pilularis*) is dominant within any of the plant communities (Illawarra gully wet forest). The study area does not provide potential breeding habitat as the species breeds exclusively in Tasmania (Higgins 1999).

The project would impact potential foraging habitat for the Swift Parrot through the removal of eucalypt forest and woodland. About 22.2 hectares of eucalypt forest (potential foraging habitat) would be removed from the study area with a further 17.5 hectares affected by indirect impacts (eg edge effects). This equates to less than 1.6 per cent of eucalypt forest within the locality (2425.7 hectares). Given the availability of potential foraging habitat within the locality (including known habitat protected within Seven Mile Beach National Park), that no breeding habitat would be impacted and the high mobility of this species, it is considered unlikely that the project would disrupt the life cycle of the Swift Parrot.

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

The project would directly impact up to 22.2 hectares of potential foraging habitat (eucalypt forest) for the Swift Parrot (some of which contains preferred feed tree species). Within the area of DEC vegetation mapping (as amended following the field surveys), the habitat to be directly impacted represents 0.9 per cent of potential habitat within the locality (2425.7 hectares). A further 17.5 hectares of eucalypt forest would be indirectly affected (eg edge effects) by the project. This equates to about 0.7 per cent of potential habitat within the locality. In total, 1.6 per cent of the potential habitat occurring in the locality would be impacted by the project.

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

The Swift Parrot has a wide distribution as it breeds in Tasmania, but migrates to south eastern Australia from Victoria and the eastern parts of South Australia to south-east Queensland (DEC 2005 …). As a result the study area is not at, or near, the limit of distribution for this species.

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

The study area has been subjected to ongoing disturbances from grazing and edge effects due to the current highway, rural development and associated infrastructure. The project is likely to result in further disturbance from the road construction, although this would be temporary, and additional edge effects such as an increase in weeds and anthropogenic activities associated with the new highway.

How is the project likely to affect habitat connectivity?

The majority of the study area is covered by cleared areas and grazed paddocks that contain little native vegetation. Wildlife corridors intersected by the study area include the Seven Mile Beach National Park – Barren Grounds Nature Reserve wildlife corridor. Vegetation remnants at Toolijooa Ridge, Broughton Creek, site 15, Broughton Mill Creek and Bundewallah Creek are discontinuous parts of this corridor.

The project would involve removal of potential feed trees from the study area. The areas to be removed (predominantly roadside areas) are contiguous with intact forest that would remain. Given the availability of surrounding eucalypt forests, the small areas of proposed vegetation removal (the 22.2 hectares to be removed is made up of smaller areas spread along the 11.6 kilometres route, including proposed ancillary sites) and the high mobility of the Swift Parrot, it is considered unlikely that the project would significantly impact on the habitat connectivity for this species.

How is the project likely to affect critical habitat?

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations or ecological communities. Under the TSC Act, the Director-General maintains a register of critical habitat. To date, no critical habitat has been declared for the Swift Parrot (DECC 2008a).

Conclusion

Based on the above assessment the project is considered unlikely to have a significant impact on the Swift Parrot.

Neophema pulchella Turquoise Parrot

The Turquoise Parrot is listed as Vulnerable under Schedule 2 of the TSC Act.

The Turquoise Parrot was not recorded during the field surveys, however it has been previously recorded (six times between 1975 and 2009) to the north of the study area in Barren Grounds Nature Reserve (Birds Australia 2011, DECCW 2011).

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

Turquoise Parrots occur in open woodlands and eucalypt forests with a ground cover of grasses and understorey of low shrubs (Morris 1980). The species is found in the foothills of the Great Divide, including steep rocky ridges and gullies (Higgins 1999).

The Turquoise Parrot is usually seen in pairs or small, possibly family, groups and has also been reported in flocks of up to thirty individuals. The species prefers to feed in the shade of trees and spends most of the day on the ground searching for the seeds of grasses and herbaceous plants, or browsing on vegetable matter (DEC, 2005). It nests in hollow-bearing trees or hollows in tree stumps and prefers to breed in open grassy forests and woodlands, and gullies which are moist (Higgins 1999).

The study area provides potential foraging and breeding habitat for the Turquoise Parrot in the open forest and woodland habitats as well as riparian vegetation. The project is likely to remove about 27.8 hectares of this habitat with a further 26.05 hectares likely to be indirectly impacted. This is likely to include both tree hollows and hollows in tree stumps and logs. Given the mobility of the Turquoise Parrot and extent of similar habitat resources within the locality (1281.3 hectares), it is unlikely the project would disrupt the life cycle of the Turquoise Parrot.

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

The project is likely to clear potential foraging habitat in the form of flowering eucalypts and species of *Leucopogon* and *Austrodanthonia*. The Turquoise Parrot feeds on the seeds of these species and many other plant species. In addition to potential foraging habitat the project is likely to remove trees with hollows that provide breeding opportunities for the Turquoise Parrot. However given the extent of habitat resources in the locality, the loss or modification of about 4.2 per cent of available potential habitat within the locality is not considered to be significant.

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

The range of the Turquoise Parrot extends from southern Queensland through to northern Victoria, along the coastal plains and to the west of the Great Dividing Range (DEC 2005•). The study area is not at, or near, the limit of distribution for this species.

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

The study area has been subjected to ongoing disturbances from grazing and edge effects due to the current highway, rural development and associated infrastructure. The project is likely to result in further disturbance from the road construction, although this would be temporary, and additional edge effects such as an increase in weeds and anthropogenic activities associated with the new highway.

How is the project likely to affect habitat connectivity?

The majority of the study area is covered by cleared areas and grazed paddocks that contain little native vegetation. Wildlife corridors intersected by the study area include the Seven Mile Beach National Park – Barren Grounds Nature Reserve wildlife corridor. Vegetation remnants at Toolijooa Ridge, Broughton Creek, site 15, Broughton Mill Creek and Bundewallah Creek are discontinuous parts of this corridor.

The project is likely to remove potential habitat trees for the Turquoise Parrot within the wildlife corridors. However, the Turquoise Parrot is a mobile species. In most districts there is a post-breeding dispersal of parrots and local movements may also occur as a result of rainfall and water availability, which in turn affect food availability (Forshaw and Cooper 2002). Given the mobility of the Turquoise Parrot it is unlikely the project would create new barriers or exacerbate existing barriers for this species.

How is the project likely to affect critical habitat?

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations or ecological communities. Under the TSC Act, the Director-General maintains a register of critical habitat. To date, no critical habitat has been declared for the Turquoise Parrot (DECC 2008a).

Conclusion

Based on the above assessment the project is considered unlikely to have a significant impact on the Turquoise Parrot.

Forest Owls

The Barking Owl (*Ninox connivens*), Powerful Owl (*Ninox strenua*), Masked Owl (*Tyto novaehollandiae*) and Sooty Owl (*Tyto tenebricosa*) are each listed as Vulnerable under Schedule 2 of the TSC Act. These species have been grouped for the assessment of significance due to their similar habitat requirements.

The Barking Owl was not recorded during the field surveys. The species has been previously recorded twice within the locality, to the east and north-west of the study area in 1996 and 2007 (Bird's Australia 2011, DECCW 2011). One other record occurs 10 kilometres north of the study area, recorded in 1992 (DECCW 2011).

The Masked Owl was not recorded during the field surveys. There is one record of the Masked Owl within the locality (recorded in 1980) at Seven Mile Beach National Park, south of the study area (DECCW 2011). No other records of the species occur within 10 kilometres.

The Powerful Owl was recorded during the field surveys at site 15. The species has been previously recorded at seven other locations within the locality (dating between 1993 and 2009), occurring east and south-east of the study area (Birds Australia 2011, DECCW 2011). Beyond the locality and within 10 kilometres of the study area, an additional five records (dating between 1999 and 2001) occur to the north (Birds Australia 2011, DECCW 2011).

The Sooty Owl was not recorded during the field surveys. The species has been previously recorded at seven locations within the locality (dating between 1997 and 2008), all occurring north of the study area (Birds Australia 2011, DECCW 2011). An additional three records (dating between 1990 and 2001) exist about 10 kilometres north of the study area (Bird's Australia 2011, DECCW 2011).

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

The Barking Owl lives in forest and woodlands of tropical, temperate and semi-arid zones (Higgins 1999). The species has shown a preference in the area for dry ironbark woodlands (DEC 2005‡). The Masked Owl inhabits a diverse range of wooded habitat that provide tall or dense mature trees with hollows suitable for nesting and roosting, but is also recorded in woodlands adjacent to cleared areas (Higgins 1999). The Powerful Owl occupies wet and dry eucalypt forests and rainforests. It can occupy both unlogged and lightly logged forests, as well as undisturbed forests (Debus and Chafer 1994a). The species' foraging range can include urban areas. The Sooty Owl has been recorded in tall old-growth forests, including temperate and subtropical rainforests (Higgins 1999).

All the forest owls require large mature trees or stags with hollows at least 0.5 metres deep for nesting (Gibbons and Lindenmayer 1997). The Barking Owl favours nesting and roosting sites in woodland alongside watercourses (Higgins 1999). Masked Owls usually nest within dense forests or woodlands (Higgins 1999). Powerful Owls prefer hollows in large old trees rather than stags (Higgins 1999). Nest trees for this species are usually emergent with a diameter at breast height of at least 100 centimetres (Gibbons and Lindenmayer 1997). The Sooty Owl nests and roosts in hollows of tall (125 centimetres -161 centimetres in diameter) emergent trees, mainly eucalypts, in wet sclerophyll forest (Higgins 1999), often located in gullies (Gibbons and Lindenmayer 1997).

The Barking Owl is thought to have a home range of less than 200 hectares, although no detailed studies have been conducted. Masked Owl pairs have a large home-range of 500 hectares to 1000 hectares. Pairs of Powerful Owls are believed to have high fidelity to a small number of hollow-bearing nest trees and will defend a large home range of 400 hectares -1450 hectares. Sooty Owls have home ranges of between 200 hectares and 800 hectares (Higgins 1999).

Potential habitat for the forest owls occurs in the eucalypt and riparian forest and constructed wetland habitat within the study area. While it is considered likely that these species forage within the study area either regularly or occasionally, no preferred nesting habitat was observed within the area of direct impact (subject site). The project is therefore considered likely to directly impact foraging habitat only. Further foraging habitat, and potential nesting habitat may be indirectly impacted (eg edge effects) by the project. Specifically, up to 57.3 hectares of known and/or potential habitat would be modified and/or removed (30.4 hectares directly and 26.9 hectares indirectly). This equates to about 1.5 per cent of the known and/or potential habitat (eg eucalypt and riparian forest, rainforest, heathland and swamp forest) available in the locality (3805.3 hectares). Given the large home range of the forest owls; that removal of nesting habitat is unlikely; and, the extent of habitat resources available within the locality, it is unlikely that the project would disrupt the life cycle of the Barking Owl, Powerful Owl, Masked Owl or Sooty Owl.

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

The project would remove foraging habitat for these owls including the removal of trees with hollows that provide habitat for arboreal prey species. About 30.4 hectares of foraging habitat would be removed from the subject site. An additional 26.9 hectares containing foraging habitat and potential breeding habitat would be indirectly impacted by the project. Forest owls are highly mobile and are known to have a large home range. Given the extent of foraging and breeding resources within the locality it is unlikely the disturbance of 1.5 per cent of potential habitat would be significant for the owl species.

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

The Barking Owl's distribution extends across the entire mainland of Australia except for the central arid regions (DEC 2005a). The Powerful Owl is found in south eastern Australia, mainly on the coastal side of the Great Dividing Range from Mackay to south western Victoria (DEC 2005~). The Masked Owl populations are mostly found from the coast to the western plains of New South Wales (DEC 2005z), while the Sooty Owl is found along the coast, coastal escarpment and eastern tablelands of New South Wales (DEC 2005f). The study area is not at, or near, the limit of distribution for any of these species.

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

The study area has been subjected to ongoing disturbances from grazing and edge effects due to the current highway, rural development and associated infrastructure. The project is likely to result in further disturbance from the road construction, although this would be temporary, and additional edge effects such as an increase in weeds and anthropogenic activities associated with the new highway.

How is the project likely to affect habitat connectivity?

The majority of the study area is covered by cleared areas and grazed paddocks that contain little native vegetation. Wildlife corridors in the study area, therefore, are limited. However, vegetation remnants at Toolijooa Ridge, Broughton Creek, site 15, Broughton Mill Creek and Bundewallah Creek form local corridors that are components of the regional Seven Mile Beach National Park – Barren Grounds Nature Reserve wildlife corridor. The project crosses these local wildlife corridors thereby creating (or increasing) a barrier to fauna movement between areas of habitat within the locality. The highly mobile forest owls are unlikely to be impacted by the reduced connectivity within the locality.

How is the project likely to affect critical habitat?

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations or ecological communities. Under the TSC Act, the Director-General maintains a register of critical habitat. To date, no critical habitat has been declared for the Barking, Powerful, Masked or Sooty Owls (DECC 2008a).

Conclusion

Based on the above assessment the project is considered unlikely to have a significant impact on the Barking, Powerful, Masked or Sooty Owls.

Cercartetus nanus Eastern Pygmy-possum

The Eastern Pygmy-possum is listed as Vulnerable under Schedule 2 of the TSC Act.

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

The Eastern Pygmy-possum often nests in tree hollows, but can also construct its own nests (Ward and Turner 2008). Because of its small size it is able to utilise a range of hollow sizes including very small hollows (Gibbons and Lindenmayer 1997). It has been found to shelter in rotten stumps, holes in the ground, abandoned bird-nests, ringtail possum (*Pseudocheirus peregrinus*) dreys or thickets of vegetation, (eg grass-tree skirts) (DEC 2005n). Individuals would use a number of different hollows and an individual has been recorded using up to nine nest sites within a 0.5 hectare area over a five-month period (Ward 1990). The Eastern Pygmy-possum appears to be mainly solitary with males having non-exclusive home-ranges of up to 0.75 hectare (Ward and Turner 2008) and females about 0.35 hectare (DEC 2005n).

The Eastern Pygmy-possum has not been recorded in the study area or the locality. The species has been previously recorded at eight locations within 10 kilometres of the study area (recorded between 1999 and 2007), all to the north (DECCW 2011).

The study area provides potential foraging and breeding habitat for the Eastern Pygmy-possum within the eucalypt forests and woodlands. This species may also utilise wildlife corridors within the locality to move between areas of habitat.

About 22.2 hectares of eucalypt forest (potential foraging and breeding habitat) would be removed from the study area with a further 17.5 hectares affected by indirect impacts (eg edge effects). This equates to only 1.1 per cent of potential habitat (eg eucalypt forest, heathlands and rainforest) within the locality (3532.6 hectares). The impacts of the loss of potential habitat are amplified by the fragmentation of fauna movement corridors through the study area (see below). The project would not only result in the loss of potential habitat, it could also limit the ability of the Eastern Pygmy-possum to access other areas of habitat within the locality.

In order to mitigate impacts of corridor fragmentation, riparian corridor enhancement (through rehabilitation and revegetation) and fauna crossing structures are proposed (Chapter 5). The proposed riparian corridor enhancement and fauna under and over passes may help mitigate impacts on habitat connectivity for this species. Given the availability of potential habitat within the locality, the lack of records of the species within the locality, and provided the mitigation measures in Chapter 5 are implemented, it is considered unlikely that the project would have a significant impact on the life cycle of the Eastern Pygmy-possum.

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

The Eastern Pygmy-possum inhabits rainforest through to sclerophyll forest and tree heath, but in most areas woodlands and heath appear to be preferred. The species feeds largely on nectar and pollen collected from banksias, eucalypts and bottlebrushes; soft fruits are eaten when flowers are unavailable. It also feeds on insects throughout the year; this food source may be more important in habitats where flowers are less abundant such as wet forests (DEC 2005n, Ward and Turner 2008).

The project would directly impact up to 22.2 hectares of potential foraging habitat (eucalypt forest) for the Eastern Pygmy-possum. Within the area of DEC vegetation mapping (as amended following the field surveys), the habitat to be directly impacted represents 0.6 per cent of potential habitat within the locality (3532.6 hectares). A further 17.5 hectares of eucalypt forest would be indirectly affected (eg edge effects) by the project. This equates to about 0.5 per cent of potential habitat within the locality. In total, 1.1 per cent of the potential habitat occurring in the locality would be impacted by the project.

Potential habitat in the study area forms part of a discontinuous wildlife corridor between Seven Mile Beach National Park and Barren Grounds Nature Reserve and is therefore important for the long-term survival of the Eastern Pygmy-possum within the locality. The proposed riparian corridor enhancement (through rehabilitation and revegetation) may help mitigate impacts on habitat connectivity for this species.

It is considered unlikely that the project would have a significant impact on the habitat of the Eastern Pygmy-possum given that the potential habitat to be removed is disturbed, that similar resources occur immediately adjacent to the areas to be removed and provided that the mitigation measures to compensate for the loss of habitat connectivity described in Chapter 5 are implemented.

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

The Eastern Pygmy-possum can be found throughout south-eastern Australia, from southern Queensland to eastern South Australia and Tasmania (DEC 2005n). The study area is not at, or near, the limit of distribution for this species.

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

The study area has been subjected to ongoing disturbances from grazing and edge effects due to the current highway, rural development and associated infrastructure. The project is likely to result in further disturbance from the road construction, although this would be temporary, and additional edge effects such as an increase in weeds and anthropogenic activities associated with the new highway.

The project would also result in a wider barrier for fauna attempting to cross the new highway.

How is the project likely to affect habitat connectivity?

The project crosses the Toolijooa Ridge – Harley Hill and Broughton Creek corridors, as well as a number of smaller riparian and roadside corridors. By crossing these wildlife corridors, the project creates (or increases) a barrier to fauna movement between areas of potential habitat.

In order to mitigate impacts of corridor fragmentation, riparian corridor enhancement (through rehabilitation and revegetation) and fauna crossing structures are proposed (Chapter 5). The proposed riparian corridor enhancement and fauna under and over passes may help mitigate impacts on habitat connectivity for this species.

The Eastern Pygmy-possum has been recorded to the north of the project, but not to the south. As such, the project may not impact connectivity for this species, however, the mitigation measures described in Chapter 5 would help compensate for the loss of habitat connectivity in the event the species does on occasion use habitat to the south of the upgrade.

How is the project likely to affect critical habitat?

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations or ecological communities. Under the TSC Act, the Director-General maintains a register of critical habitat. To date, no critical habitat has been declared for the Eastern Pygmy-possum (DECC 2008a).

Conclusion

Based on the above assessment the project is considered unlikely to have a significant impact on the Eastern Pygmy-possum.

Dasyurus maculatus maculatus Spotted-tailed Quoll

The Spotted-tailed Quoll is listed as Vulnerable under Schedule 2 of the TSC Act. The species is also listed as Endangered under the EPBC Act.

The Spotted-tailed Quoll has been previously recorded 17 times within the locality (including as close as 200 metres to the study area), predominantly north and east of the study area (although records exist in all directions beyond the locality and within 10 kilometres). These records occurred between 1980 and 2010 (DECCW 2011).

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

The Spotted-tailed Quoll occurs in a range of habitats including sclerophyll forest and woodlands, coastal heathlands and rainforests (Dickman and Read 1992, Edgar and Belcher 1995). Occasional sightings have been made in open country, grazing lands, rocky outcrops and other treeless areas (NPWS 1999h).

This species' habitat requirements include suitable den sites (such as hollow logs, tree hollows, rocky outcrops or caves) and an abundance of food (NPWS 1999h). The diet of juveniles is dominated by invertebrates, small mammals and birds, while the diet of adults is dominated by medium-sized mammals (Belcher *et al*. 2008). Individuals require large areas of relatively intact vegetation through which to forage (NPWS 1999h). The home range of a female is between 180 hectares – 1000 hectares, while males have larger home ranges of between 2000 hectares – 5000 hectares (Belcher *et al*. 2008).

The study area provides potential foraging and denning habitat for the Spotted-tailed Quoll within the eucalypt and riparian forests and woodlands (including hollow-bearing trees and hollow logs). This species is also likely to utilise wildlife corridors within the locality to move between areas of habitat.

About 27.8 hectares of eucalypt and riparian forest (potential habitat) would be removed from the study area. The impacts of the loss of potential habitat are amplified by the fragmentation of fauna movement corridors through the study area. The project crosses the Toolijooa Ridge – Harley Hill and Broughton Creek corridors, as well as a number of smaller riparian and roadside corridors. By crossing these wildlife corridors, the project creates (or increases) a barrier to fauna movement between areas of habitat. Therefore, the project would not only result in the loss of potential habitat, it could also limit the ability of the Spotted-tailed Quoll to access other areas of habitat within the locality.

The project could result in either a complete halt to the movement of the Spotted-tailed Quoll across the study area or a reduced level of movement. Even a small reduction in movements can reduce genetic continuity within a population hence reducing the effective population size (Goosem 2002). In addition, the project may result in a higher rate of roadkill mortality as the species attempts to cross the wider highway.

In order to mitigate impacts of corridor fragmentation and roadkill, riparian corridor enhancement (through rehabilitation and revegetation) and fauna crossing structures are proposed (Chapter 5). Given the availability of known and potential habitat within the locality (including protected habitat within Seven Mile Beach National Park), the high mobility of this species and provided the mitigation measures in Chapter 5 are implemented, it is considered unlikely that the project would disrupt the life cycle of the Spotted-tailed Quoll.

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

The project would impact potential foraging and breeding habitat for the Spotted-tailed Quoll through the removal of eucalypt and riparian forest and woodland (including hollow-bearing trees and hollow logs). About 27.8 hectares of eucalypt and riparian forest (potential habitat) would be removed from the study area with a further 26.05 hectares affected by indirect impacts (eg edge effects). Within the area of DEC vegetation mapping (as amended following the field surveys), this equates to only 1.5 per cent of the potential habitat (eg eucalypt and riparian forest, rainforest and heathland) available within the locality (3667.1 hectares).

Although the Spotted-tailed Quoll is considered likely to occur in the study area, the habitat to be impacted is predominantly disturbed roadside and disturbed riparian vegetation. Regardless, this disturbed habitat forms part of a discontinuous wildlife corridor between Seven Mile Beach National Park and Barren Grounds Nature Reserve and is therefore considered to be of high importance for the long-term survival of the Spotted-tailed Quoll within the locality. The proposed riparian corridor enhancement (through rehabilitation and revegetation) and fauna underpasses will help mitigate impacts on habitat connectivity for this species.

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

Populations of the Spotted-tailed Quoll are found along both sides of the Great Dividing Range, from the Victorian to the Queensland borders (DEC 2005„). The study area is not at, or near, the limit of distribution for this species.

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

The study area has been subjected to ongoing disturbances from grazing and edge effects due to the current highway, rural development and associated infrastructure. The project is likely to result in further disturbance from the road construction, although this would be temporary, and additional edge effects such as an increase in weeds and anthropogenic activities associated with the new highway.

The project would also result in a wider barrier for the Spotted-tailed Quoll that may attempt to cross the new highway.

How is the project likely to affect habitat connectivity?

Given the distribution of records both north and south of the study area, and the close proximity of some records to the study area, it is considered likely that the Spotted-tailed Quoll occurs within and passes through the study area from time to time. The project crosses the Toolijooa Ridge – Harley Hill and Broughton Creek corridors, as well as a number of smaller riparian and roadside corridors. By crossing these wildlife corridors, the project creates (or increases) a barrier to fauna movement between areas of habitat. This may result in the fragmentation of a population of Spotted-tailed Quoll into two or more populations.

In order to mitigate impacts of corridor fragmentation, riparian corridor enhancement (through rehabilitation and revegetation) and fauna underpasses are proposed (Chapter 5). The proposed riparian corridor enhancement and underpasses will help mitigate impacts on habitat connectivity for this species.

How is the project likely to affect critical habitat?

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations or ecological communities. Under the TSC Act, the Director-General maintains a register of critical habitat. To date, no critical habitat has been declared for the Spotted-tailed Quoll (DECC 2008a).

Conclusion

Based on the above assessment the project is considered unlikely to have a significant impact on the Spotted-tailed Quoll.

Petaurus australis Yellow-bellied Glider

The Yellow-bellied Glider is listed as Vulnerable under Schedule 2 of the TSC Act.

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

Yellow-bellied Gliders live in family groups of between two and six individuals which commonly share a number of tree hollows. Family groups are territorial with exclusive home ranges of 30 hectares - 60 hectares depending on availability of denning hollows and food resources (NPWS 2003b). Very large expanses of forest (more than 15,000 hectares) are required to conserve viable populations (Goldingay 2008).

The Yellow-bellied Glider has not been recorded in the study area. The species has been previously recorded three times within the locality (between 1970 and 2002), twice to the north and once to the north-west (DECCW 2011). One additional record occurs about nine kilometres west of the study area and was recorded in 1970 (DECCW 2011).

The study area provides limited potential foraging habitat for the Yellow-bellied Glider within the eucalypt forests and woodlands. Based on the lack of critical habitat elements within the study area (eg sap-site trees, winter flowering eucalypts, mature trees suitable for den sites, a mosaic of different forest types and a very large expanse of forest), it is considered unlikely that the study area supports (or could support) a population of Yellow-bellied Glider. However, it is possible that the species moves through the study area on occasion between areas of potential habitat.

About 22.2 hectares of eucalypt forest (limited potential habitat) would be removed from the study area with a further 17.5 hectares affected by indirect impacts (eg edge effects). This equates to only 1.6 per cent of the potential habitat available within the locality (2425.7 hectares). The impacts of the loss of potential habitat are amplified by the fragmentation of fauna movement corridors through the study area (see below). The project would not only result in the loss of potential habitat, it could also limit the ability of the Yellow-bellied Glider to access other areas of habitat within the locality.

In order to mitigate impacts of corridor fragmentation, riparian corridor enhancement (through rehabilitation and revegetation) and fauna crossing structures are proposed (Chapter 5). Given the availability of known and potential habitat within the locality and the reasonable mobility of this species, the project may not impact connectivity for this species. However, the mitigation measures described in Chapter 5 would help compensate for the loss of habitat connectivity in the event the species does on occasion use habitat to the south and east of the upgrade.

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

Yellow-bellied Gliders are restricted to tall native forests in regions of high rainfall along the coast of NSW. Preferred habitats are productive, tall open sclerophyll forests where mature trees provide shelter and nesting hollows. The species feeds primarily on plant and insect exudates, including nectar, sap, honeydew and manna. Critical elements of habitat include sap-site trees, winter flowering eucalypts, mature trees suitable for den sites and a mosaic of different forest types (NPWS 1999j).

Known Yellow-bellied Glider feed trees (DEC 2004b) that were recorded during the field surveys include *Eucalyptus amplifolia, E. eugenioides, E. pilularis, E. saligna* and *Corymbia maculata*.

The project would directly impact up to 22.2 hectares of potential foraging habitat (eucalypt forest) for the Yellow-bellied Glider (some of which contains preferred feed tree species). Within the area of DEC vegetation mapping (as amended following the field surveys), the habitat to be directly impacted represents 0.9 per cent of potential habitat within the locality (2425.7 hectares). A further 17.5 hectares of eucalypt forest would be indirectly affected (eg edge effects) by the project. This equates to about 0.7 per cent of potential habitat within the locality. In total, 1.6 per cent of the potential habitat occurring in the locality would be impacted by the project.

Potential habitat in the study area forms part of a discontinuous wildlife corridor between Seven Mile Beach National Park and Barren Grounds Nature Reserve and is therefore important for the long-term survival of the Yellow-bellied Glider within the locality. The proposed riparian corridor enhancement (through rehabilitation and revegetation) and other measures such as rope bridges may help mitigate impacts on habitat connectivity for this species.

Given that the potential habitat to be removed is disturbed, that similar resources occur immediately adjacent to the areas to be removed and that the mitigation measures described in Chapter 5 would help compensate for the loss of habitat connectivity in the event the species does on occasion use habitat to the south and east of the upgrade, it is considered unlikely that the project would have a significant impact on the habitat of the Yellow-bellied Glider.

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

The Yellow-bellied Glider can be found along the entire eastern coast of Australia from southern Queensland to Victoria (NPWS 1999j). The study area is not at, or near, the limit of distribution for this species.

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

The study area has been subjected to ongoing disturbances from grazing and edge effects due to the current highway, rural development and associated infrastructure. The project is likely to result in further disturbance from the road construction, although this would be temporary, and additional edge effects such as an increase in weeds and anthropogenic activities associated with the new highway.

The project would also result in a wider barrier for any Yellow-bellied Glider attempting to cross the new highway.

How is the project likely to affect habitat connectivity?

The project crosses the Toolijooa Ridge – Harley Hill and Broughton Creek corridors, as well as a number of smaller riparian and roadside corridors. By crossing these wildlife corridors, the project creates (or increases) a barrier to fauna movement between areas of potential habitat.

In order to mitigate impacts of corridor fragmentation, riparian corridor enhancement (through rehabilitation and revegetation) and rope bridges are proposed (Chapter 5). The proposed riparian corridor enhancement and overpasses may help mitigate impacts on habitat connectivity for this species.

The Yellow-bellied Glider has been recorded within the locality to the north of the project, but not to the south. The disturbed and patchy nature of the vegetation to the south and east of the project is not high quality habitat for this species, and it may not occur in these areas. As such, the project may not impact connectivity for this species, however, the mitigation measures described in Chapter 5 would help compensate for the loss of habitat connectivity in the event the species does on occasion use habitat to the south and east of the upgrade.

How is the project likely to affect critical habitat?

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations or ecological communities. Under the TSC Act, the Director-General maintains a register of critical habitat. To date, no critical habitat has been declared for the Yellow-bellied Glider (DECC 2008a).

Conclusion

Based on the above assessment the project is considered unlikely to have a significant impact on the Yellow-bellied Glider.

Phascolarctos cinereus Koala

The Koala is listed as Vulnerable under Schedule 2 of the TSC Act.

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

Koalas live in breeding aggregations comprised of a dominant male, a small number of mature females, and juveniles (NPWS 2003a). The home range of Koalas varies depending on the quality of the habitat and the number of available food trees. Home ranges can vary from less than one hectare to 500 hectares (NPWS 2003a). Home ranges in the Pilliga State Forest overlapped for both sexes and were about 12 hectares for males and nine hectares for females. Koalas were found to continue to occupy all or part of their previous home-ranges after selective logging, and home-range sizes remained similar between logged and unlogged areas (Kavanagh *et al.* 2007).

The Koala was not recorded during the field surveys. There have been three records of the species within the locality (DECCW 2011); one record to the north and two records to the south of the study area (recorded between 2004 and 2005). Two additional records occur outside the locality but within 10 kilometres; one to the north-east (2004) and one to the south (1940).

The study area provides limited potential foraging habitat for the Koala within the eucalypt forests and woodlands. Although some preferred feed tree species were recorded during the field surveys (eg *Eucalyptus microcorys*, *E. racemosa*, *E. robusta* and *E. tereticornis*), none were dominant within the forest/woodland patches of the study area. Based on the low density of preferred feed trees and the absence of records of this well-recognised species within the study area, it is considered unlikely that the study area supports (or could support) a population of Koala. However, it is possible that the species moves through the study area on occasion between areas of potential habitat.

About 22.2 hectares of eucalypt forest (limited potential habitat) would be removed from the study area with a further 17.5 hectares affected by indirect impacts (eg edge effects). This equates to only 1.6 per cent of the potential habitat available within the locality (2425.7 hectares). The impacts of the loss of potential habitat are amplified by the fragmentation of fauna movement corridors through the study area (see below). The project would not only result in the loss of potential habitat, it could also limit the ability of the Koala to access other areas of habitat within the locality.

In order to mitigate impacts of corridor fragmentation, riparian corridor enhancement (through rehabilitation and revegetation) and fauna crossing structures are proposed (Chapter 5). Given the availability of known and potential habitat within the locality, the reasonable mobility of this species and provided the mitigation measures in Chapter 5 are implemented, it is considered unlikely that the project would have a significant impact on the life cycle of the Koala.

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

The Koala inhabits eucalypt forests and woodlands. The suitability of these forests for habitation depends on the size and species of trees present, soil nutrients, climate and rainfall (Reed and Lunney 1990, NPWS 2003a). Koalas feed on the foliage of more than 70 eucalypt species and 30 non-eucalypt species, but in any one area would select preferred browse species (DEC 2005v). Primary SEPP 44 feed trees include *Eucalyptus robusta*, *E. tereticornis*, *E. punctata, E. microcorys, E. haemostoma* and *E. signata* (Department of Planning 1995). Three of these species (*E. robusta*, *E. tereticornis* and *E. microcorys*) were recorded during the field surveys. The approved recovery plan for the Koala lists additional primary and secondary feed trees for the various Koala management areas (DECC 2008b). Feed trees from the south coast management area that were recorded during the field surveys include *E. amplifolia* and *E. tereticornis* (both primary feed trees).

The project would directly impact up to 22.2 hectares of potential foraging habitat (eucalypt forest) for the Koala (some of which contains preferred feed tree species). Within the area of DEC vegetation mapping (as amended following the field surveys), the habitat to be directly impacted represents 0.9 per cent of potential habitat within the locality (2425.7 hectares). A further 17.5 hectares of eucalypt forest would be indirectly affected (eg edge effects) by the project. This equates to about 0.7 per cent of potential habitat within the locality. In total, 1.6 per cent of the potential habitat occurring in the locality would be impacted by the project.

Potential habitat in the study area forms part of a discontinuous wildlife corridor between Seven Mile Beach National Park and Barren Grounds Nature Reserve and is therefore important for the long-term survival of the Koala within the locality. The proposed riparian corridor enhancement (through rehabilitation and revegetation) and fauna underpasses may help mitigate impacts on habitat connectivity for this species.

Provided the mitigation measures described in Chapter 5 are implemented, it is considered unlikely that the project would have a significant impact on the habitat of the Koala.

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

The Koala has a fragmented distribution throughout eastern Australia extending from north-east Queensland to the Eyre Peninsula in South Australia (DEC 2005v). The study area is not at, or near, the limit of distribution for this species.

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

The study area has been subjected to ongoing disturbances from grazing and edge effects due to the current highway, rural development and associated infrastructure. The project is likely to result in further disturbance from the road construction, although this would be temporary, and additional edge effects such as an increase in weeds and anthropogenic activities associated with the new highway.

The project would also result in a wider barrier for Koalas attempting to cross the new highway.

How is the project likely to affect habitat connectivity?

The Koala has been recorded within the locality to the north of the project near Foxground, and to the south near Foys Swamp and Back Forest. The Toolijooa Ridge – Harley Hill wildlife corridor may provide connectivity for this species. The project crosses the Toolijooa Ridge – Harley Hill and Broughton Creek corridors, as well as a number of smaller riparian and roadside corridors. By crossing these wildlife corridors, the project creates (or increases) a barrier to fauna movement between areas of potential habitat.

In order to mitigate impacts of corridor fragmentation, riparian corridor enhancement (through rehabilitation and revegetation) and fauna crossing structures are proposed (Chapter 5). The proposed riparian corridor enhancement and fauna underpasses may help mitigate impacts on habitat connectivity for this species.

Given the availability of known and potential habitat within the locality, the reasonable mobility of this species and provided the mitigation measures in Chapter 5 are implemented, it is considered unlikely that the project would have a major impact on habitat connectivity.

How is the project likely to affect critical habitat?

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations or ecological communities. Under the TSC Act, the Director-General maintains a register of critical habitat. To date, no critical habitat has been declared for the Koala (DECC 2008a).

Conclusion

Based on the above assessment the project is considered unlikely to have a significant impact on the Koala.

Pototous tridactylus Long-nosed Potoroo

The Long-nosed Potoroo is listed as Vulnerable under Schedule 2 of the TSC Act. The species is also listed as Vulnerable under the EPBC Act.

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

The Long-nosed Potoroo requires a dense understorey in heaths or forest for breeding (DEC 2005y). No heaths occur in the study area. Limited potential breeding habitat occurs within the eucalypt forest patches (the riparian forest is considered unlikely to provide potential breeding resources). The potential habitat is considered only marginal due to the disturbed nature of the habitat (ie roadside), and the lack of a nearby mosaic of micro-habitats (eg from dense, floristically simple sites for nesting, to open floristically diverse sites for obtaining food (Claridge *et al.* 2007)). Within the study area, site 15 provides the most opportunities given its reasonable size and connectivity to other areas of habitat. The project would result in the removal of only roadside vegetation from site 15, leaving the remainder of the patch intact.

The Long-nosed Potoroo has been previously recorded four times within the locality (twice in 1970 and twice in 1992), both to the north and south of the study area (DECCW 2011); although only one record occurs south of the study area. Beyond the locality and within 10 kilometres, additional records exist north of the study area with a large congregation in Barren Grounds Nature Reserve.

Given that the potential habitat to be removed is disturbed, that similar resources occur immediately adjacent to the areas to be removed and provided that the mitigation measures to compensate for the loss of habitat connectivity described in Chapter 5 are implemented, it is considered unlikely that the project would affect the lifecycle of the Long-nosed Potoroo.

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

The Long-nosed Potoroo inhabits coastal heaths and dry and wet sclerophyll forests. In NSW it is generally restricted to coastal heaths and forests east of the Great Dividing Range, with an annual rainfall exceeding 760 mm. Dense understorey with occasional open areas is an essential part of habitat, and may consist of grass-trees, sedges, ferns or heath, or of low shrubs of tea-trees or melaleucas. A sandy loam soil is also a common feature (Johnston 2008). One study of the species found that the Long-nosed Potoroo required a mosaic of micro-habitats, from dense, floristically simple sites for nesting, to open floristically diverse sites for obtaining food. This species appears to benefit from a lack of recent disturbance, including fire (Claridge *et al.* 2007). The Long-nosed Potoroo is sedentary and tends to be solitary, although would also aggregate in small groups. The Long-nosed Potoroo forages for fleshy fruit, seeds and plant tissue, arthropods, fungi, digging in the soil much like a bandicoot (Johnston 2008).

The project would directly impact up to 27.8 hectares of limited potential foraging and breeding habitat (eucalypt and riparian forest) for the Long-nosed Potoroo. Within the area of DEC vegetation mapping (as amended following the field surveys), the habitat to be directly impacted represents 0.8 per cent of potential habitat within the locality (3628.0 hectares). A further 26.05 hectares of eucalypt and riparian forest would be indirectly affected (eg edge effects) by the project. This equates to about 0.7 per cent of potential habitat within the locality. In total, 1.5 per cent of the potential habitat occurring in the locality would be impacted by the project.

Although the Long-nosed Potoroo has the potential to occur in the study area, the habitat to be impacted is predominantly disturbed roadside and disturbed riparian vegetation. Regardless, this disturbed habitat forms part of a discontinuous wildlife corridor between Seven Mile Beach National Park and Barren Grounds Nature Reserve and is therefore considered to be of high importance for the long-term survival of the Long-nosed Potoroo within the locality. The proposed riparian corridor enhancement (through rehabilitation and revegetation) and fauna underpasses may help mitigate impacts on habitat connectivity for this species.

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

The area of occupancy of the Long-nosed Potoroo extends from Queensland to eastern Victoria and Tasmania. Within New South Wales, there is a gap in records between Gosford and Kiama of almost 150 kilometres (NSW Government 2009). While the study area does not lie at or near the limit of the overall area of occupancy of the Long-nosed Potoroo, it does occur close to the southern edge of the record gap in New South Wales.

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

The study area has been subjected to ongoing disturbances from grazing and edge effects due to the current highway, rural development and associated infrastructure. The project is likely to result in further disturbance from the road construction, although this would be temporary, and additional edge effects such as an increase in weeds and anthropogenic activities associated with the new highway.

The project would also result in a wider barrier for the Long-nosed Potoroo that may attempt to cross the new highway.

How is the project likely to affect habitat connectivity?

Given the distribution of records both north and south of the study area it is considered possible that the Long-nosed Potoroo occurs within and passes through the study area from time to time. The fact that only one record occurs south of the study area (from 1992) may indicate the species is unlikely to cross the study area frequently or may be the result of insufficient survey in the area. The project crosses the Toolijooa Ridge – Harley Hill and Broughton Creek corridors, as well as a number of smaller riparian and roadside corridors. By crossing these wildlife corridors, the project creates (or increases) a barrier to fauna movement between areas of habitat.

In order to mitigate impacts of corridor fragmentation, riparian corridor enhancement (through rehabilitation and revegetation) and fauna underpasses are proposed (Chapter 5). The proposed riparian corridor enhancement and underpasses may help mitigate impacts on habitat connectivity for this species.

How is the project likely to affect critical habitat?

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations or ecological communities. Under the TSC Act, the Director-General maintains a register of critical habitat. To date, no critical habitat has been declared for the Long-nosed Potoroo (DECC 2008a).

Conclusion

Based on the above assessment the project is considered unlikely to have a significant impact on the Long-nosed Potoroo.

Pteropus poliocephalus Grey-headed Flying-fox

The Grey-headed Flying-fox is listed as Vulnerable under Schedule 2 of the TSC Act. The species is also listed as Vulnerable under the EPBC Act.

The Grey-headed Flying-fox was recorded foraging at site 15 during the field surveys. The species has also been previously recorded six times within the locality, predominantly to the south but also to the north-east and west. These records occurred between 1994 and 2008 (DECCW 2011).

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

The Grey-headed Flying-fox is found in a variety of habitats, including rainforest, mangroves, paperbark swamps, wet and dry sclerophyll forests and cultivated areas (Churchill 1998). The species is a canopy-feeding frugivore and nectarivore. Their major food source is Myrtaceae blossom (mostly eucalypt) and fruits such as native figs (*Ficus* spp.) and cultivated fruit orchards (Churchill 1998). Bats commute daily to foraging areas, usually within 15 kilometres of the day roost (Strahan 1995), although some individuals may travel up to 70 kilometres.

The study area provides known and potential foraging habitat for the Grey-headed Flying-fox within the eucalypt and riparian forests and woodlands. The project would result in the removal of about 27.8 hectares of foraging habitat for this species. An additional 26.05 hectares would be indirectly impacted (eg edge effects).

No evidence of a camp site (breeding habitat) was found within the study area. No Grey-headed Flying-fox colonies have been mapped within the locality; although the Bomaderry Creek camp is located approximately 10.5 kilometres southwest of Berry, and at Comerong Island approximately 12.2 kilometres south of the study area (DECCW 2008). Given the high mobility of the Grey-headed Flying-fox (able to travel up to 70 kilometres from a camp site) and the availability of known and potential habitat in the locality (including protected habitat within Seven Mile Beach National Park), the loss of 27.8 hectares eucalypt and riparian forest (predominantly disturbed roadside and disturbed riparian habitat) is unlikely to significantly disrupt the feeding behaviour and life history of the Grey-headed Flying-fox within the study area or locality.

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

The project would impact potential foraging habitat for the Grey-headed Flying-fox through the removal of eucalypt and riparian forest and woodland. About 27.8 hectares of eucalypt and riparian forest (known and/or potential foraging habitat) would be removed from the study area with a further 26.05 hectares affected by indirect impacts (eg edge effects). This equates to only 1.4 per cent of the potential habitat (eg eucalypt and riparian forest, rainforest, mangroves and paperbark swamps) available within the locality (3792.6 hectares). Given the availability of known and potential habitat within the locality (including protected habitat within Seven Mile Beach National Park), that no breeding habitat would be impacted and the high mobility of this species, it is considered unlikely that the project would have significant negative impacts on the Grey-headed Flying-fox habitat within the locality.

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

Populations of the Grey-headed Flying-fox are found within 200 kilometres of the eastern coast of Australia, from Bundaberg in Queensland to Melbourne in Victoria (DEC 2005t). The study area is not at, or near, the limit of distribution for this species.

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

Current disturbance regimes within the study area include grazing, edge effects from the current highway, rural development and associated infrastructure. The project is likely to result in further disturbance from the road construction, although this would be temporary, and edge effects such as an increase in weeds and anthropogenic activities associated with the new highway.

How is the project likely to affect habitat connectivity?

The project is likely to remove and/or modify about 53.9 hectares (27.8 hectares from direct impacts with a further 26.05 hectares indirectly impacted) of known and potential foraging habitat from the study area. The areas to be removed (predominantly roadside and riparian areas) are contiguous with intact forest that would remain. Given the availability of surrounding eucalypt and riparian forests, the small areas of proposed vegetation removal (the 27.8 hectares to be removed is made up of smaller areas spread along the 11.6 kilometres route including proposed ancillary sites) and the high mobility of the Grey-headed Flying-fox, it is considered unlikely that the project would create or exacerbate barriers for this species.

How is the project likely to affect critical habitat?

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations or ecological communities. Under the TSC Act, the Director-General maintains a register of critical habitat. To date, no critical habitat has been declared for the Grey-headed Flying-fox (DECC 2008a).

Conclusion

Based on the above assessment the project is considered unlikely to have a significant impact on the Grey-headed Flying-fox.

Cave-dependent Micro-bats

The Eastern Bentwing-bat (*Miniopterus schreibersii oceanensis*) and the Southern Myotis (*Myotis macropus*) are both listed as Vulnerable under Schedule 2 of the TSC Act. These two species have been considered together for this assessment based on their similar habitat requirements (ie cave-dependant).

The Eastern Bentwing-bat was detected during the field surveys at sites 3, 17, 28, 32 and close to 8. An additional four records occur within 10 kilometres of the study area (recorded between 1987 and 2007) to the north, south-east and south-west of the study area (DECCW 2011). Three of these records occur within the locality.

The Southern Myotis was recorded during the field surveys at sites 3, 15, 17, 28, 32 and close to 8. An additional three records occur within the locality (recorded between 2007 and 2008), south and south-west of the study area (DECCW 2011). No other records occur within 10 kilometres.

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

The Eastern Bentwing-bat and the Southern Myotis both utilise caves as roost sites. The Eastern Bentwing-bat uses a broad range of habitats including rainforests, wet and dry sclerophyll forests, open woodlands and open grasslands (Churchill 2008). The species roosts in caves, but can also use man-made structures such as mines and road culverts (Churchill 2008, Dwyer 1995). Specific caves are used as nursery caves, containing a large number of individuals, which can be used year after year (Churchill 2008, Dwyer 1995).

The Southern Myotis requires permanent water bodies, including streams, lakes and reservoirs for foraging (Churchill 2008). The Southern Myotis most commonly forages by raking the surface of waterbodies with their large, clawed feet to catch aquatic insects and small fish (Churchill 2008, Richards *et al.* 2008). This species also forages aerially taking prey such as moths, beetles, crickets and flies (Churchill 2008, Richards *et al.* 2008). The Southern Myotis roosts in caves, mines or tunnels, under bridges, in buildings, tree hollows, and even in dense foliage (Richards *et al.* 2008).

The study area provides known and/or potential foraging habitat in the form of eucalypt and riparian forests and constructed wetlands. No breeding or preferred roosting habitat (ie caves) occurs in the study area. Both species may roost under bridges or in culverts within the study area (although no evidence of roosting bats was observed under bridges or in culverts during the field surveys). The Southern Myotis may also roost in tree hollows within the study area, particularly near water bodies.

The project is likely to directly remove and/or modify about 27.8 hectares of potential foraging and roosting habitat for these species with a further 26.05 hectares likely to be indirectly impacted. It is unlikely that the project would remove or disturb caves within the study area; as such breeding habitat is unlikely to be impacted Although no evidence of roosting bats was observed under bridges or in culverts during the field surveys, pre-decommission surveys immediately prior to works have been detailed in the mitigation measures described in Chapter 5. Given the mobility of these species, the extent of available foraging and roosting habitat within the locality (3792.6 hectares) and the establishment of bat roost boxes, it is unlikely the lifecycle of the Eastern Bentwing-bat or Southern Myotis would be affected by the project.

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

Potential foraging grounds and potential roost sites for the two bat species may be impacted by vegetation clearing and run-off into waterways due to the project. Sedimentation barriers are expected to be installed as part of the construction phase which would reduce run-off into waterways.

About 27.8 hectares of potential habitat would be directly impacted with a further 26.05 hectares likely to be indirectly impacted. Potential habitats are widely distributed within the locality (3792.6 hectares); the project would result in the loss and/or disturbance of up to 1.4 per cent of these habitats. As such it is unlikely the habitat to be affected by the project (which is predominantly disturbed roadside and disturbed riparian vegetation) would be considered significant.

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

Eastern Bentwing-bat populations are found along the east and north-west coasts of Australia (DEC 2005k) while Southern Myotis populations are found along the coast from the north-west of Australia, across the top-end and south to western Victoria (DEC 2005w). The study area is not at, or near, the limit of distribution for either of these species.

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

The study area has been subjected to ongoing disturbances from grazing and edge effects due to the current highway, rural development and associated infrastructure. The project is likely to result in further disturbance from the road construction, although this would be temporary, and additional edge effects such as an increase in weeds and anthropogenic activities associated with the new highway.

How is the project likely to affect habitat connectivity?

The majority of the study area is covered by cleared areas and grazed paddocks that contain little native vegetation; wildlife corridors in the study area, therefore, are limited. However, vegetation remnants at Toolijooa Ridge, Broughton Creek, site 15, Broughton Mill Creek and Bundewallah Creek form local corridors that are components of the regional Seven Mile Beach National Park – Barren Grounds Nature Reserve wildlife corridor. The project crosses these local wildlife corridors thereby creating (or increasing) a barrier to fauna movement between areas of habitat within the locality. The Eastern Bentwing-bat and the Southern Myotis are highly mobile; therefore it is unlikely that these two bat species would be impacted by the reduced connectivity within the locality.

How is the project likely to affect critical habitat?

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations or ecological communities. Under the TSC Act, the Director-General maintains a register of critical habitat. To date, no critical habitat has been declared for the Eastern Bentwing-bat or the Southern Myotis (DECC 2008a).

Conclusion

Based on the above assessment the project is considered unlikely to have a significant impact on the Eastern Bentwing-bat or Southern Myotis.

Hollow-dependent Micro-bats

The Yellow-bellied Sheathtail-bat (*Saccolaimus flaviventris*), Eastern Freetail Bat (*Mormopterus norfolkensis*), Eastern False Pipistrelle (*Falsistrellus tasmaniensis*) and Greater Broad-nosed Bat (*Scoteanax rueppellii*) are listed as Vulnerable under Schedule 2 of the TSC Act. These four species have been considered together for this assessment based on their similar habitat requirements (ie tree hollow-dependant).

Note: a taxonomic revision of Australian molossids has led to a change of the Eastern Freetail Bat's scientific name from *Mormopterus norfolkensis* to *Micronomus norfolkensis* (Churchill 2008) however, as Census of Australian Vertebrates and OEH are yet to adopt the name change, *Mormopterus norfolkensis* is used in this report.

The Yellow-bellied Sheathtail-bat was detected during the field surveys at sites 3, 17, 28 and close to site 8. Four other records occur within 10 kilometres of the study area (recorded in 1995 and 2007) to the south and south-west of the study area (DECCW 2011). Two of these records occur within the locality.

The Eastern Freetail Bat was detected during the field surveys at sites 3, 17, 28, 32 and close to site 8. An additional three records occur within the locality (recorded between 2007 and 2008), south and south-west of the study area (DECCW 2011). No other records occur within 10 kilometres.

The Eastern False Pipistrelle was recorded during the field surveys at site 15. An additional three records occur within 10 kilometres of the study area (recorded between 1999 and 2008) to the north-east, south-east and south of the study area (DECCW 2011). Two of these records occur within the locality and the third occurs just outside the locality.

The Greater Broad-nosed Bat was detected during the field surveys at sites 3, 15, 18, 32 and close to site 8. An additional four records occur within the locality (recorded between 1995 and 2007), north, south and south-west of the study area (DECCW 2011). No other records occur within 10 kilometres.

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

All four bat species are known to be tree-hollow dependent (Churchill 2008). The Greater Broad-nosed Bat and Eastern Freetail Bat tend to forage along gaps and edges of forests and bushland patches (Churchill 2008), whereas the Eastern False Pipistrelle and Yellow-bellied Sheathtail-bat are faster fliers with greater manoeuvrability. The Eastern False Pipistrelle forages below or within the forest canopy while the Yellow-bellied Sheathtail-bat forages above the canopy (Churchill 2008).

The study area provides known and/or potential foraging and breeding habitat for the four bat species within the eucalypt and riparian forests and constructed wetlands. The project is likely to remove and/or disturb trees that provide potential breeding habitat for these species, and known/potential foraging grounds. Potential habitat to be disturbed by the project represents about 1.4 per cent of the available habitat (eg eucalypt and riparian forest, rainforest, heathland, swamp forest and wetlands) within the locality (3792.6 hectares). Given the four bat species are mobile, the extent of further breeding and foraging resources within the locality and the establishment of bat roost boxes, it is unlikely the project would disrupt the life cycle of the Yellow-bellied Sheathtail-bat, Eastern Freetail Bat, Eastern False Pipistrelle or Greater Broad-nosed Bat.

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

The project is likely to remove and/or disturb potential breeding and foraging resources for the four species within the study area. About 27.8 hectares of potential habitat would be directly impacted with a further 26.05 hectares likely to be indirectly impacted. Potential breeding and foraging habitats are widely distributed within the locality (3792.6 hectares); as such it is unlikely the habitat to be affected by the project (which is predominantly disturbed roadside and disturbed riparian vegetation) would be considered significant.

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

The Yellow-bellied Sheathtail-bat has a large distribution extending across northern and eastern Australia (DEC 2005•). The Eastern Freetail Bat is found along the entire east coast from south Queensland to southern New South Wales (DEC 2005m). The Eastern False Pipistrelle has populations occurring from southern Queensland to Victoria and Tasmania (DEC 2005l), while the Greater Broad-nosed Bat is also found along coastal eastern Australia from north-eastern Victoria to the Atherton Tableland, Queensland (DEC 2005r). As a result the study area is not at, or near, the limit of distribution for any of these species.

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

Current disturbance regimes include grazing and edge effects associated with the existing highway (rural residential development and infrastructure). The project is likely to result in further disturbance from the road construction, although this would be temporary, and additional edge effects such as an increase in weeds and anthropogenic activities associated with the new highway.

How is the project likely to affect habitat connectivity?

The majority of the study area is covered by cleared areas and grazed paddocks that contain little native vegetation. Wildlife corridors intersected by the study area include the Seven Mile Beach National Park – Barren Grounds Nature Reserve wildlife corridor. Vegetation remnants at Toolijooa Ridge, Broughton Creek, site 15, Broughton Mill Creek and Bundewallah Creek are discontinuous parts of this corridor.

The project would involve removal of potential habitat from the study area. This is likely to cause some impact on local wildlife corridors, particularly where the project crosses Toolijooa Ridge (once) and Broughton Creek (three times). However, given the mobility of the four bat species, it is unlikely the project would create new barriers or exacerbate existing barriers for these species.

How is the project likely to affect critical habitat?

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations or ecological communities. Under the TSC Act, the Director-General maintains a register of critical habitat. To date, no critical habitat has been declared for the Yellow-bellied Sheathtail-bat, Eastern Freetail Bat, Eastern False Pipistrelle or the Greater Broad-nosed Bat (DECC 2008a).

Conclusion

Based on the above assessment the project is considered unlikely to have a significant impact on the Yellow-bellied Sheathtail-bat, Eastern Freetail Bat, Eastern False Pipistrelle or Greater Broad-nosed Bat.

Litoria aurea **Green and Golden Bell Frog**

The Green and Golden Bell Frog is listed as endangered under Schedule 1 of the TSC Act and vulnerable under the EPBC Act.

Literature detailing Green and Golden Bell Frog habitat in NSW suggests that suitable breeding habitat for the species consists of ponds or slowly moving water bodies that are shallow (i.e. less than one metre deep), sunny (i.e. exposed to direct sunlight for at least six hours a day during the spring/summer season), fish-free, contain open water and emergent vegetation, and experience certain kinds of disturbance regimes such as fluctuating water level or inflow of salty water (Pyke and White 1996; Pike and White 2010; White and Pyke 2008; Pyke *et al.* 2002). The species also requires foraging and sheltering habitat in the form of low vegetation or solid object such as rock, timber and other human artefacts as well as submerged and floating vegetation over the water body. The species is known to disperse over large distances between suitable waterbodies. It is likely that the species disperses from core populations during seasons of high reproductive success.

The Green and Golden Bell Frog is known to breed during late winter to early autumn with a peak around January-February after heavy rain or storms (DSEWPaC 2011; Daly 1995; White 2001). Males call mostly at night, but occasionally by day (NSW DEC 2005g). The Green and Golden Bell Frog has a high fecundity with average clutch sizes containing approximately 3700 eggs (Pyke and White 2001; DSEWPaC 2011). Spawn is laid among aquatic vegetation and has been observed in December, January and February (Daly 1995). Metamorphosis appears to take six weeks on average following the hatching of eggs (Anstis 2002; DEWPaC 2011).

Gambusia are capable of preying on hatchlings and tadpoles of the Green and Golden Bell Frog and, in 1999 the NSW Science Committee determined that predation by Gambusia poses a serious threat to the survival of threatened species. It is now listed as a key threatening process under Schedule 3 of the TSC Act 1995 (NSW NPWS 2003).

Green and Golden Bell Frog populations in NSW have undergone a significant decline in numbers over the past few decades. Of the 31 populations known to exist in 1995, seven are considered to be extinct and four to be probably extinct leaving only 20 known populations comprised of 24 sub-populations (White and Pyke 2008).

The subject site and study area provide limited potential breeding, foraging and sheltering habitat. Constructed wetlands with emergent reeds provide sub-optimal breeding habitat, while areas surrounding these wetlands provide suitable foraging habitat. Farm dams and sections of Town Creek, Broughton Creek and Broughton Mill Creek with no fringing or emergent vegetation are considered unlikely to provide suitable breeding habitat for this species but may provide dispersal habitat on occasion. The predatory fish, *Gambusia holbrooki* (The Plague Minnow), was recorded in all constructed wetlands across the study area and in Town Creek. Following targeted surveys for the species at sites considered to provide potential habitat, the Green and Golden Bell Frog was not detected during surveys,

Given the presence of potential breeding, foraging and sheltering habitat throughout the study area (**Table 6.1**) and the potential for the species to disperse through the subject site on occasion, a precautionary approach has been adopted and the following Part 3A assessment of significance has been undertaken on the basis of the potential for temporary modification of non-limiting dispersal habitat.

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

The subject site does not provide breeding habitat, and no impacts to breeding habitat are likely to occur.

A Key Population of Green and Golden Bell Frog is located approximately three to five kilometres south of the study area at Coomonderry Swamp (and associated farm dams and swamps). This area is considered to be the most extensive wetland in which the frog has been recorded in New South Wales (DECC 2007). It is possible that individuals disperse from this core population to aquatic habitats of the study area in seasons of high reproductive success.

A total of 0.4 hectares (0.2 hectares as a result of the roadway and 0.2 hectares as a result of the Town Creek diversion) of constructed wetland habitat will be permanently removed as a result of the project, while an additional 0.3 hectares is considered to be indirectly impacted as a result of edge effects. The flow along the current Town Creek alignment will be maintained to an ecologically sustainable level and the management and mitigation measures in Section 5 of this report specific to other waterways will be implemented.

Given that the species was not detected during surveys, the lack of previous records in the Study area, the presence of Gambusia, and the temporary nature of impacts the project is not considered likely to impact the lifecycle for this species.

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

As detailed above, limited breeding and foraging habitat is present within the study area and sheltering and dispersal habitat is present in the subject site and study area. There is potential for the GGBF to disperse through the subject site and study area on occasion, particularly in seasons of high reproductive success at the nearby (3-5 km) Coomonderry Swamp population.

The potential impacts of the project are described in Section 4 of this report. No impacts to potential breeding habitat are likely to occur. The Town Creek diversion will intersect potential dispersal habitat, and although this may result in local changes to hydrology and disturbance of 0.2 hectares of constructed wetland forming part of the existing creek, the species is unlikely to regularly utilise this habitat for breeding, foraging, sheltering or over-wintering purposes due to the current disturbance regimes. Furthermore, impacts will be temporary in nature and are unlikely to permanently affect the current state of habitat. An additional 0.2 hectares of constructed habitat will be permanently removed as a result of the roadway. A number of mitigation measures have been recommended including bridges (underpasses) at each crossing of Broughton Creek and the retention and protection of existing riparian vegetation to allow for continued dispersal routes and refuge.

Given that impacts to dispersal habitat in the subject site will be temporary in nature, the flow along the current Town Creek alignment will be maintained to an ecologically sustainable level and provided that the management and mitigation measures in Section 5 of this report are adhered to, the project is not considered likely to significantly affect the habitat of this species.

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

The Green and Golden Bell Frog predominately occurs in coastal lowland between Yuragir National Park in northern New South Wales and Lake Wellington in Victoria. Some inland populations occur in NSW (DECC 2008).

The study area is not at or near the limit of distribution for this species.

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

Disturbance regimes thought to account for the recent disappearance and overall decline Green and Golden Bell Frog numbers in NSW outlined in the *Best Practice Guidelines for Green and Golden Bell Frog habitat* (DECC 2008) are thought to include:

- Loss of habitat;
- Disease (frog chytrid fungus);
- Introduced fish (e.g. plague minnow *Gambusia holbrooki* and carp *Cyprinus carpio*, which eat the eggs, tadpoles and hatchlings;
- Competition of habitat resources.

The subject site and study area have been subjected to ongoing disturbances from the township of Berry, existing Princes Highway, grazing, farming, drainage canals across the Shoalhaven flood plain and the deliberate introduction of Gambusia and Carp (Cyprinus carpio) into privately owned aquatic habitats (Daly 1996).

The project is likely to result in the removal of 0.2 hectares of potential dispersal habitat as part of the new road alignment and modify an additional 0.2 hectares of potential dispersal habitat through the diversion of Town Creek (also thought to contain Gambusia).

Given the presence of Chytrid fungus in nearby Green and Golden Bell Frog populations (F.Lemckert pers. comm,) and the presence of Gambusia in the subject site and study area, the project is unlikely to significantly exacerbate these disturbance regimes further.

How is the project likely to affect habitat connectivity?

Eleven Key Populations are known to occur in the Shoalhaven LGA (DEC 2005). A Key Population is located approximately three to five kilometres east of the study area at Coomonderry Swamp and is considered to be the most extensive wetland in which the frog has been recorded in New South Wales (DECC 2007). It is possible that individuals may disperse from this core population to aquatic habitats of the study area in seasons of high reproductive success.

The Town Creek diversion will intersect the low-lying closed grassland habitat throughout the study area. It is considered that this flood prone land, as well as the current established aquatic environments of the Study Area such as Town Creek, Broughton Mill Creek, Bundewallah Creek may provide dispersal habitat for the Green and Golden Bell Frog on occasion. A number of mitigation measures have been recommended including bridges (underpasses) at each crossing of Broughton Creek and the retention and protection of existing riparian vegetation to allow for continued dispersal routes and refuge.

Given that impacts to dispersal habitat in the study area will be temporary in nature, the flow along the current Town Creek alignment would be maintained to an ecologically sustainable level and provided that the dispersal opportunities are retained throughout other waterbodies (e.g. Broughton Creek underpasses), the project is not considered likely to affect habitat connectivity for the Green and Golden Bell Frog.

How is the project likely to affect critical habitat?

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations or ecological communities. Under the TSC Act, the Director-General maintains a register of critical habitat. To date, no critical habitat has been declared for the Green and Golden Bell Frog and the proposed action would not impact any other critical habitat.

Conclusion

Based on the above assessment and the 'key thresholds' listed in the steps of the assessment processes, the project is considered unlikely to have a significant impact on the Green and Golden Bell Frog as:

- The project is not likely to reduce the long-term viability of a local population of the Green and Golden Bell Frog in the Shoalhaven LGA, specifically at the Coomonderry Swamp Key Population;
- The project is not likely to accelerate the extinction of the Green and Golden Bell Frog or place it at risk of extinction; and
- The project will not adversely affect critical habitat for the Green and Golden Bell Frog.

Appendix H

Threatened fauna Part 3A assessment requirements

Potential impacts on threatened fauna and Part 3A assessment requirements

Common name	EPBC Act	TSC Act	Potential impacts on threatened species			EP&A Act Part 3A assessment of significance required?	Reasoning
			Individual death or injury?	Loss or disturbance of limiting foraging resources?	Loss or disturbance of limiting breeding resources?		
Green and Golden Bell Frog	V	E1	Unlikely	No	No	**Yes – undertaken as a precautionary measure**	Found in marshes, dams and stream sides, particularly those containing bulrushes or spikerushes. Can also occur in highly disturbed areas including industrial sites (NPWS 1999e, White and Pyke 1996). The Green and Golden Bell Frog has been recorded south of the study area within Foys and Coomonderry Swamps. Limited potential habitat occurs within the study area in the form of constructed wetlands with emergent reeds. Farm dams with no fringing or emergent vegetation and creeklines within the study area are considered unlikely to provide potential habitat for this species. Given the isolated nature of potentially suitable wetlands within the study area, and the absence of records of this conspicuous species, it is considered unlikely that the study area supports breeding habitat. The loss of about 0.4 hectares of constructed wetland habitat (**Table 4.1**) from the subject site is not likely to impact this species. A Part 3A assessment of significance is not considered necessary.
Spotted Harrier	-	V	Unlikely	No	No	No	The species occurs in open and wooded country with grassland nearby for hunting. It is more common in drier inland areas. Nests in trees (Marchant and Higgins 1993). Previously recorded north and south of the study area. The Spotted Harrier is likely to forage over farmland and possibly nest in forest or woodland patches within the study area. However, no limiting breeding or foraging resources would be impacted. The loss of about 27.8 hectares of non-limiting forest habitat (see **Table 4.1** directly impacted forest and woodland) over 11.6 kilometres of the project and non-limiting farmland is not likely to impact this species which is highly mobile. A Part 3A assessment of significance is not considered necessary.

Common name	EPBC Act	TSC Act	Potential impacts on threatened species			EP&A Act Part 3A assessment of significance required?	Reasoning
			Individual death or injury?	Loss or disturbance of limiting foraging resources?	Loss or disturbance of limiting breeding resources?		
Little Eagle	-	V	Unlikely	No	No	No	Most abundant in lightly timbered areas with open areas nearby, including farmland. May nest in farmland, woodland and forest in tall trees (Marchant and Higgins 1993). Previously recorded north, east and south-west of the study area. The Little Eagle is likely to forage over farmland and possibly nest in forest or woodland patches within the study area. However, no limiting breeding or foraging resources would be impacted. The loss of about 27.8 hectares of non-limiting forest habitat (see **Table 4.1** directly impacted forest and woodland) over 11.6 kilometres of the project and non-limiting farmland is not likely to impact this species which occupies a large territory. A Part 3A assessment of significance is not considered necessary.
Square-tailed Kite	-	V	Unlikely	No	No	No	Typically inhabits coastal forested and wooded lands of tropical and temperate Australia. They require large living trees for breeding, particularly near water with surrounding woodland or forest close by for foraging habitat (Marchant and Higgins 1993). Previously recorded south of the study area at Coomonderry Swamp and 10 kilometres to the south-west. The Square-tailed Kite may forage within the forests and woodlands of the study area for passerines and insects in the outer foliage and may nest in large trees along Broughton Creek. However, no limiting breeding or foraging resources would be impacted. The loss of about 27.8 hectares of non-limiting forest habitat (see **Table 4.1** directly impacted forest and woodland) over 11.6 kilometres of the project is not likely to impact this species which is known to forage within a hunting range of more than 100 square kilometres. A Part 3A assessment of significance is not considered necessary.

Common name	EPBC Act	TSC Act	Potential impacts on threatened species			EP&A Act Part 3A assessment of significance required?	Reasoning
			Individual death or injury?	Loss or disturbance of limiting foraging resources?	Loss or disturbance of limiting breeding resources?		
Osprey	M	V	Unlikely	No	No	No	The Osprey occurs in coastal waters, inlets, estuaries and offshore islands as well as terrestrial wetlands and coastal lands, catching fish for prey. It generally uses marine cliffs as nesting and roosting sites however nests can also be made high up in trees, usually within one kilometre of the sea (Marchant and Higgins 1993). The Osprey has been previously recorded south of the study area at Seven Mile Beach National Park. The species may occasionally forage over Broughton Creek within the study area. The loss of about 2.9 hectares of non-limiting Riverbank forest habitat (see **Table 4.1**) and associated creekline is not likely to impact this species. A Part 3A assessment of significance is not considered necessary.
Blue-billed Duck Freckled Duck	-	V	Unlikely	No	No	No	The Blue-billed Duck and Freckled Duck breed in deep water in large, permanent wetlands that are heavily vegetated (Simpson and Day 1996). Neither species has been previously recorded within 10 kilometres of the study area. Limited potential habitat occurs within the study area in the form of constructed wetlands with dense fringing and emergent vegetation. Farm dams with no fringing or emergent vegetation and creeklines within the study area are considered unlikely to provide potential habitat for these species (except perhaps in times of drought). Given the poor quality of potential habitat in the study area, the absence of records of both species within 10 kilometres of the study area and the presence of more potential habitat in the locality, it is considered unlikely that the loss of about 0.4 hectares of constructed wetland habitat (**Table 4.1**) would impact these species. Part 3A assessments of significance are not considered necessary for these two ducks.

Common name	EPBC Act	TSC Act	Potential impacts on threatened species			EP&A Act Part 3A assessment of significance required?	Reasoning
			Individual death or injury?	Loss or disturbance of limiting foraging resources?	Loss or disturbance of limiting breeding resources?		
Australasian Bittern	-	V	Unlikely	No	No	No	Inhabits terrestrial and estuarine wetlands, preferring wetlands with dense vegetation including rushes and reeds (NPWS 1999a). Previously recorded north-east, south-east and south of the study area (including within Coomonderry Swamp). Limited potential habitat occurs within the study area in the form of constructed wetlands with dense fringing and emergent vegetation. Farm dams with no fringing or emergent vegetation and creeklines within the study area are considered unlikely to provide potential habitat for this species. Given the poor quality of potential habitat in the study area and the presence of higher quality known habitat in the locality, it is considered unlikely that the loss of about 0.4 hectares of constructed wetland habitat (**Table 4.1**) would impact this species. A Part 3A assessment of significance is not considered necessary.
Black Bittern	-	V	Unlikely	No	No	**Yes**	Found along timbered watercourses, in wetlands with fringing trees and shrub vegetation. The sites where they occur are characterised by dense waterside vegetation (NPWS 1999b). Previously recorded on the edge of the study area adjacent to Town Creek (south of Berry) and south-east of the study area at Black Head. Limited potential habitat occurs within the study area in the form of creeklines and constructed wetlands where dense fringing and emergent vegetation occurs. Not all sections of creekline within the study area contain dense waterside vegetation and therefore, not all sections of creekline within the study area are considered potential habitat. Although no limiting breeding or foraging resources would be impacted, the project has the potential to affect connectivity between areas of potential habitat for the Black Bittern. Therefore a Part 3A assessment of significance has been completed for this species and is provided in Appendix G to this report.

Common name	EPBC Act	TSC Act	Potential impacts on threatened species			EP&A Act Part 3A assessment of significance required?	Reasoning
			Individual death or injury?	Loss or disturbance of limiting foraging resources?	Loss or disturbance of limiting breeding resources?		
Bush Stone-curlew	-	E1	Unlikely	No	No	**Yes**	Prefers lightly timbered open forest and woodland, or partly cleared farmland with remnants of woodland (Marchant and Higgins 1993). Previously recorded once, about nine kilometres south of the study area. Potential habitat occurs within the forests and woodlands and surrounding farmland of the study area. Although no limiting breeding or foraging resources would be impacted, the project has the potential to affect connectivity between areas of potential habitat for the Bush Stone-curlew. Therefore a Part 3A assessment of significance has been completed for this species and is provided in Appendix G to this report.
Gang-gang cockatoo	-	V	Possible	No	Yes	**Yes**	In low altitudes occurs in drier, more open eucalypt forests and woodlands. Breeds in tree hollows in montane forests (Higgins 1999). The Gang-gang Cockatoo was recorded during the field surveys south of the study area at site 8. The species has also been previously recorded north, south, east and west of the study area. The Gang-gang Cockatoo may forage within the forests and woodlands and nest in tree hollows of the study area. Given the number of records of the species in the locality and the loss of potential limiting breeding resources (ie tree hollows), a Part 3A assessment of significance has been completed for this species and is provided in Appendix G to this report.
Glossy Black-cockatoo	-	V	Possible	Yes	Yes	**Yes**	Inhabits forest with low nutrients, characteristically with key *Allocasuarina* spp. Breeds in tree hollows (NPWS 1999c). The Glossy Black-cockatoo was recorded during field surveys undertaken within the study area. The species has also been previously recorded north, south, east and west of the study area (although never within the locality; five kilometres). The Glossy Black-cockatoo may forage within the forests and woodlands and nest in tree hollows of the study area. Given the distribution of records of the species in relation to the study area and the loss of potential limiting breeding (ie tree hollows) and foraging (ie *Allocasuarina littoralis*) resources, a Part 3A assessment of significance has been completed for this species and is provided in Appendix G to this report.

Common name	EPBC Act	TSC Act	Potential impacts on threatened species			EP&A Act Part 3A assessment of significance required?	Reasoning
			Individual death or injury?	Loss or disturbance of limiting foraging resources?	Loss or disturbance of limiting breeding resources?		
Greater Sand Plover	M	V	Unlikely	No	No	No	Forages on intertidal sand and mudflats in estuaries, roosting during high tide on sandy beaches or rocky shores. Occasional sightings have also occurred on near-coast saltlakes, brackish swamps, shallow freshwater wetlands and grassed paddocks (NPWS 1999d). Previously recorded once, south-east of the study area at Seven Mile Beach National Park. No limiting breeding or foraging resources would be impacted and therefore a Part 3A assessment of significance is not considered necessary.
Black-necked Stork	-	E1	Unlikely	No	No	No	Found in swamps, mangroves and mudflats. Can also occur in dry floodplains and irrigated lands and occasionally forages in open grassy woodland. Nests in live or dead trees usually near water (Pizzey and Knight 1997). Previously recorded south-east of the study area at Crooked River and south of the study area at Coomonderry Swamp (records over 30 years old). Within the study area, the species may forage within farmland (including farm dams) and nest in trees along Broughton Creek. However, no limiting breeding or foraging resources would be impacted. The loss of non-limiting farmland habitat and about 2.9 hectares of non-limiting Riverbank forest habitat (**Table 4.1**) is not likely to impact this species. A Part 3A assessment of significance is not considered necessary.
Wompoo Fruit-dove Rose-crowned Fruit-dove Superb Fruit-dove	-	V	Unlikely	Yes	No	No	These species occur in rainforests and forage on fruit-bearing trees (Higgins and Davies 1996) such as those present within subtropical complex rainforest in the locality. Neither the Wompoo nor Rose-crowned Fruit-doves have been previously recorded within 10 kilometres of the study area. One record of the Superb Fruit-dove occurs outside the locality. Limited potential habitat occurs in the study area where fruit-bearing trees occur within forest close to rainforest. However, as no rainforest habitat (and therefore no limiting resources) would be impacted by the project, a Part 3A assessment of significance is not considered necessary for these species.

Common name	EPBC Act	TSC Act	Potential impacts on threatened species			EP&A Act Part 3A assessment of significance required?	Reasoning
			Individual death or injury?	Loss or disturbance of limiting foraging resources?	Loss or disturbance of limiting breeding resources?		
Pied Oystercatcher	-	V	Unlikely	No	No	No	An intertidal forager found on undisturbed sandy beaches and spits, tidal mudflats and estuaries. Occasionally found in paddocks near the coast (Pizzey and Knight 1997). Previously recorded south of the study area at Seven Mile Beach National Park and Coomonderry Swamp. No limiting breeding or foraging resources would be impacted by the project and therefore a Part 3A assessment of significance is not considered necessary.
Comb-crested Jacana	-	V	Unlikely	No	No	No	Occurs in freshwater wetlands, lagoons, Billabongs, swamps, lakes, rivers and reservoirs, generally with abundant floating aquatic vegetation (Marchant and Higgins 1993). The Comb-crested Jacana has not been previously recorded within 10 kilometres of the study area. Given the poor quality of potential habitat in the study area and the presence of higher quality known habitat in the locality, it is considered unlikely that the loss of about 0.4 hectares of constructed wetland habitat (Table 4.1) would impact this species. A Part 3A assessment of significance is not considered necessary.
Regent Honeyeater	E	E1	Unlikely	No	No	No	A semi-nomadic species occurring in temperate eucalypt woodlands and open forests. Most records are from box-ironbark eucalypt forest associations and wet lowland coastal forests (NPWS 1999g, Pizzey and Knight 1997). Previously recorded south of the study area at Seven Mile Beach National Park. The study area does not contain any of the preferred forest types for the Regent Honeyeater. The species may occasionally forage within the eucalypt forests of the study area however, no limiting foraging resources would be impacted. Further, the study area does not provide any breeding habitat for the species. The loss of about 22.2 hectares of non-limiting eucalypt forest/woodland habitat (see **Table 4.1** directly impacted eucalypt forest) is considered unlikely to impact this mobile species. Therefore a Part 3A assessment of significance is not considered necessary.

Common name	EPBC Act	TSC Act	Potential impacts on threatened species			EP&A Act Part 3A assessment of significance required?	Reasoning
			Individual death or injury?	Loss or disturbance of limiting foraging resources?	Loss or disturbance of limiting breeding resources?		
White-fronted Chat	-	V	Unlikely	No	No	No	The White-fronted Chat breeds and forages in saltmarsh and mangroves. The species may forage in open grasslands and sometimes in low shrubs bordering wetland areas. The White-fronted Chat has been previously recorded south of the study area in Coomonderry Swamp. The study area does not support preferred habitat however marginal potential habitat may occur in open grasslands surrounding constructed wetland habitat. Given the poor quality of potential habitat in the study area and the presence of higher quality known habitat in the locality, it is considered unlikely that the loss of about 0.4 hectares of constructed wetland habitat (**Table 4.1**) would impact this species. A Part 3A assessment of significance is not considered necessary.
Varied Sittella	-	V	Unlikely	No	No	No	Inhabit a wide variety of dry eucalypt forests and woodlands (Higgins and Peter 2002). Build nests in upright tree forks. Previously recorded north and south of the study area. Potential habitat occurs for this species within the study area in eucalypt forests and woodlands. The direct and permanent loss of about 22.2 hectares of non-limiting eucalypt forest/woodland habitat (see **Table 4.1**) is considered unlikely to impact this mobile species. Therefore a Part 3A assessment of significance is not considered necessary.
Olive Whistler	-	V	Unlikely	No	No	No	Found in a range of habitats including alpine thickets, wetter rainforest/woodlands, riparian vegetation and heaths (Pizzey and Knight 1997). Previously recorded north and south of the study area. Within the study area the species may forage within the forest/woodland patches (including riparian forest) and nest in forks of low shrubs. However, no limiting foraging or breeding resources would be impacted. The direct and permanent loss of about 27.8 hectares of non-limiting forest and woodland habitat (see **Table 4.1**) over 11.6 kilometres of the project is not likely to impact this mobile species. A Part 3A assessment of significance is not considered necessary.

Common name	EPBC Act	TSC Act	Potential impacts on threatened species			EP&A Act Part 3A assessment of significance required?	Reasoning
			Individual death or injury?	Loss or disturbance of limiting foraging resources?	Loss or disturbance of limiting breeding resources?		
Eastern Bristlebird	E	E1	Unlikely	No	No	No	Found in coastal woodlands, dense scrub and heathlands, particularly where it borders taller woodlands (Pizzey and Knight 1997). One recent record (2010) occurs north of the study area in Broughton. Also previously recorded north of the study area at Barren Grounds Nature Reserve. The study area does not contain preferred breeding or foraging habitat for this species (dense heath/sedgeland). The loss of non-limiting farmland predominantly bordering existing roadside is not likely to impact this species. A Part 3A assessment of significance is not considered necessary.
Diamond Firetail	-	V	Unlikely	No	No	No	Found in a range of habitat types including open eucalypt forest, mallee and acacia scrubs (Pizzey and Knight 1997). Often occur in vegetation along watercourses (Higgins *et al.* 2006). The study area may provide potential habitat in the form of eucalypt woodlands with a grassy understorey however no preferred habitat occurs in the study area. Further, the Diamond Firetail has not been previously recorded within 10 kilometres of the study area. The direct and permanent loss of about 27.8 hectares non-limiting forest and woodland habitat (see **Table 4.1**) over 11.6 kilometres of the project and non-limiting farmland is not likely to impact this mobile species. A Part 3A assessment of significance is not considered necessary.
Scarlet Robin	-	V	Unlikely	No	No	No	Occurs in forests, woodlands; and heavier vegetation when breeding. During autumn and winter occurs in more open and cleared areas (Morcombe 2003). Previously recorded north and south of the study area, but not within the locality. The Scarlet Robin may forage within the forests, woodlands and farmland of the study area for invertebrates and may build a nest within a fork of a tree (NSW Scientific Committee 2009b). However, no limiting breeding or foraging resources would be impacted. The direct and permanent loss of about 27.8 hectares non-limiting forest and woodland habitat (see **Table 4.1**) over 11.6 kilometres of the project and non-limiting farmland is not likely to impact this species. A Part 3A assessment of significance is not considered necessary.

Common name	EPBC Act	TSC Act	Potential impacts on threatened species			EP&A Act Part 3A assessment of significance required?	Reasoning
			Individual death or injury?	Loss or disturbance of limiting foraging resources?	Loss or disturbance of limiting breeding resources?		
Flame Robin	-	V	Unlikely	No	No	No	The preferred habitat in summer includes eucalyptus forests and woodland, whilst in winter prefers open woodlands and farmlands (Morecombe 2003). Previously recorded north of the study area, but not within the locality. The Flame Robin may forage within the forests, woodlands and farmland of the study area for invertebrates and may build a nest near the ground in a sheltered niche, ledge or shallow cavity in a tree, stump or bank (NSW Scientific Committee 2009a). However, no limiting breeding or foraging resources would be impacted. The direct and permanent loss of about 27.8 hectares non-limiting forest and woodland habitat (see **Table 4.1**) over 11.6 kilometres of the project and non-limiting farmland is not likely to impact this species. A Part 3A assessment of significance is not considered necessary.
Little Lorikeet	-	V	Possible	No	Yes	**Yes**	Mostly occurs in dry, open eucalypt forests and woodlands. Nests in hollows, particularly in *Eucalyptus viminalis*, *E. blakelyi* and *E. dealbata* (NSW Scientific Committee 2008b). Previously recorded south of the study area at Seven Mile Beach National Park and Coomonderry Swamp as well as 10 kilometres to the north of the study area. Within the study area the species may forage on nectar and pollen within the forest/woodland patches and nest in tree hollows (although none of the preferred tree species occur in the study area). Given the loss of potential limiting breeding resources (ie tree hollows), a Part 3A assessment of significance has been completed for this species and is provided in Appendix G to this report.

Common name	EPBC Act	TSC Act	Potential impacts on threatened species			EP&A Act Part 3A assessment of significance required?	Reasoning
			Individual death or injury?	Loss or disturbance of limiting foraging resources?	Loss or disturbance of limiting breeding resources?		
Swift Parrot	E	E1	Unlikely	Yes	No	**Yes**	The Swift Parrot occurs in woodlands and forests of NSW from May to August, where it feeds on eucalypt nectar, pollen and associated insects (Forshaw and Cooper 1981). Breeds in Tasmania (Pizzey and Knight 1997). Previously recorded north and south of the study area. Within the study area the Swift Parrot may forage within the eucalypt forest/woodland patches on/among tree species such as *Corymbia maculata, C. gummifera* and *Eucalyptus pilularis*. Although no breeding habitat occurs, given the loss of preferred feed tree species, a Part 3A assessment of significance has been completed for this species and is provided in Appendix G to this report.
Orange-bellied Parrot	ZM	C1	Unlikely	No	No	No	A coastal species inhabiting saltmarshes, sedgeplains, coastal dunes, pastures, shrublands and moorlands, generally within 10 kilometres of the coast. Breeds in Tasmania (OBPRT 1998). Previously recorded once, 9.5 kilometres south of study area. Within the study area the Orange-bellied Parrot may forage within farmland, however the species is more likely to utilise pastures adjacent to saltmarshes, which are absent from the study area. No limiting breeding or foraging resources would be impacted and therefore a Part 3A assessment of significance is not considered necessary.
Turquoise Parrot	-	V	Unlikely	No	Yes	**Yes**	Occurs in open woodlands and eucalypt forests with a ground cover of grasses and understorey of low shrubs (Morris 1980). Nest in hollow-bearing trees, either dead or alive; also in hollows in tree stumps (Higgins 1999). Previously recorded north of the study area at Barren Grounds Nature Reserve. Within the study area the Turquoise Parrot may forage within the forests and woodlands and surrounding farmland, and nest in tree hollows. Given the loss of potential limiting breeding resources (ie tree hollows), a Part 3A assessment of significance has been completed for this species and is provided in Appendix G to this report.

Common name	EPBC Act	TSC Act	Potential impacts on threatened species			EP&A Act Part 3A assessment of significance required?	Reasoning
			Individual death or injury?	Loss or disturbance of limiting foraging resources?	Loss or disturbance of limiting breeding resources?		
Eastern Ground Parrot	-	V	Unlikely	No	No	No	Mainly found in heathland, sedgeland or buttongrass plains providing medium to dense cover (Higgins 1999). One recent record (2010) occurs north of the study area in Broughton. Also previously recorded north of the study area at Barren Grounds Nature Reserve and once to the south at Seven Mile Beach National Park. The study area does not contain preferred breeding or foraging habitat for this species (dense heath/sedgeland). The loss of non-limiting farmland predominantly bordering existing roadside is not likely to impact this species. Therefore, a Part 3A assessment of significance is not considered necessary.
Australian Painted Snipe	V	E1	Unlikely	No	No	No	Prefers freshwater wetlands, ephemeral or permanent, although they have been recorded in brackish waters (Marchant and Higgins 1993). Not previously recorded within 10 kilometres of the study area. Potential habitat occurs within the study area in the form of constructed wetlands with emergent vegetation. Some farm dams surrounded by a grassy seepage area may also provide potential habitat for this species. Given the poor quality of potential habitat in the study area, the absence of records of the species within 10 kilometres and the presence of higher quality potential habitat in the locality (eg Foys and Coomonderry Swamps), it is considered unlikely that the loss of about 0.4 hectare of constructed wetland habitat (**Table 4.1**) and non-limiting farmland would impact this species. A Part 3A assessment of significance is not considered necessary.
Barking Owl Powerful Owl Masked Owl Sooty Owl	-	V	Possible	No	Yes	**Yes**	Inhabit a range of wooded habitats, including rainforest (Higgins 1999). All species have been previously recorded in the locality and the Powerful Owl was recorded during the field surveys (from site 15). These species forage over large home ranges for ground-dwelling and/or arboreal mammals. However, the foraging habitat within the study area is not considered to be limiting for these mobile species. These owls breed in tree hollows. Given the loss of potential limiting breeding resources (ie tree hollows), a Part 3A assessment of significance has been completed for these species and is provided in Appendix G to this report.

Common name	EPBC Act	TSC Act	Potential impacts on threatened species			EP&A Act Part 3A assessment of significance required?	Reasoning
			Individual death or injury?	Loss or disturbance of limiting foraging resources?	Loss or disturbance of limiting breeding resources?		
Eastern Pygmy-possum	-	V	Unlikely	No	No	**Yes**	Inhabits rainforest through to sclerophyll forest and tree heath. Banksias and myrtaceous shrubs and trees are a favoured food source (Turner and Ward 1995). Previously recorded between six kilometres and 10 kilometres north of the study area, but not within the locality. The Eastern Pygmy-possum breeds in hollows, cracks or fissures more than two centimetres diameter in trees, stumps or logs, or disused bird's nests or accumulations of shredded bark or leaf clumps in tree forks or under loose bark of eucalypts (DEC 2005n). Further, individuals will use a number of different hollows/nest sites (Ward 1990). Given this, the study area is considered unlikely to provide limiting breeding resources. The Eastern Pygmy-possum feeds largely on nectar and pollen collected from banksias, eucalypts and bottlebrushes (DEC 2005n). The study area is also considered unlikely to provide limiting foraging resources. Although no limiting breeding or foraging resources would be impacted, the project has the potential to affect connectivity between areas of potential habitat for the Eastern Pygmy-possum. Therefore, a Part 3A assessment of significance has been completed for this species and is provided in Appendix G to this report.
Spotted-tailed Quoll	E	V	Unlikely	No	Yes	**Yes**	Uses a range of habitats including sclerophyll forests and woodlands, coastal heathlands and rainforests (Dickman and Read 1992). Habitat requirements include suitable den sites, including hollow logs, hollow-bearing trees, rock crevices and caves, an abundance of food and an area of intact vegetation in which to forage (Edgar and Belcher 1995). Previously recorded just north of the study area at Broughton (east of site 15) and 0.5 kilometres south-east of the Toolijooa Road and Princes Highway intersection. Records further north and south exist also. In addition to the loss of a limiting breeding resource (ie tree hollows), the project has the potential to affect connectivity between areas of potential habitat for the Spotted-tailed Quoll. Therefore, a Part 3A assessment of significance has been completed for this species and is provided in Appendix G to this report.

Common name	EPBC Act	TSC Act	Potential impacts on threatened species			EP&A Act Part 3A assessment of significance required?	Reasoning
			Individual death or injury?	Loss or disturbance of limiting foraging resources?	Loss or disturbance of limiting breeding resources?		
White-footed Dunnart	-	V	Unlikely	No	No	No	Found in coastal dune vegetation, coastal forest, tussock grassland and sedgeland, heathland, woodland and forest. Shelter in a variety of microhabitats including hollows at the base of trees or fallen timber, burrows, grass clumps and rock crevices. The White-footed Dunnart is an opportunistic carnivore that feeds on a variety of ground-dwelling invertebrates and, occasionally, small lizards (DEC 2005Ž). Individuals occupy very small, discrete home ranges (80 metres–100 metres in length). Not previously recorded within 10 kilometres of the study area. The closest records occur about 23 kilometres north-west and south-west of the study area and are almost 15 years old. Within the study area, potential habitat is considered limited at best but may occur within the forest and woodland patches. No limiting breeding or foraging resources would be impacted. Given the above, it is considered unlikely that the White-footed Dunnart would be impacted by the project and therefore, a Part 3A assessment of significance is not considered necessary.
Yellow-bellied Glider	-	V	Unlikely	No	No	**Yes**	Preferred habitats are productive, tall open sclerophyll forests where mature trees provide shelter and nesting hollows. Critical elements of habitat include sap-site trees, winter flowering eucalypts, mature trees suitable for den sites and a mosaic of different forest types (NPWS 1999j). Very large expanses of forest (more than 15,000 hectares) are required to conserve viable populations (Goldingay 2008). Previously recorded north and north-west of the study area, within the locality. Based on the lack of key habitat elements within the study area, it is considered unlikely that the study area supports (or could support) a population of Yellow-bellied Glider. However, it is possible that the species moves through the study area on occasion between areas of potential habitat. Therefore, as the project has the potential to affect connectivity between areas of potential habitat for the Yellow-bellied Glider, a Part 3A assessment of significance has been completed for this species and is provided in Appendix G to this report.

Common name	EPBC Act	TSC Act	Potential impacts on threatened species			EP&A Act Part 3A assessment of significance required?	Reasoning
			Individual death or injury?	Loss or disturbance of limiting foraging resources?	Loss or disturbance of limiting breeding resources?		
Koala	V	V	Unlikely	No	No	**Yes**	Koalas feed almost exclusively on eucalypt foliage, and their preferences vary regionally (Martin *et al*. 2008). Primary feed trees include *Eucalyptus robusta, E. tereticornis, E. punctata, E. haemostoma* and *E. signata* (Department of Planning 1995). The Koala has been previously recorded north and south of the study area. Although some preferred feed tree species were recorded during the field surveys (eg *Eucalyptus microcorys, E. racemosa, E. robusta and E. tereticornis*), none were dominant within the forest/woodland patches of the study area. Based on the low density of preferred feed trees and the absence of records of this conspicuous species within the study area, it is considered unlikely that the study area supports (or could support) a population of Koala. However, it is possible that the species moves through the study area on occasion between areas of potential habitat. Therefore, as the project has the potential to affect connectivity between areas of potential habitat for the Koala, a Part 3A assessment of significance has been completed for this species and is provided in Appendix G to this report.
Long-nosed Potoroo	V	V	Unlikely	No	No	**Yes**	Inhabits coastal heath and wet and dry sclerophyll forests. Requires relatively thick ground cover where the soil is light and sandy. Previously recorded north and south of the study area, including within the locality. Potential habitat within the study area is considered to be limited but may occur within the forest and woodland patches. Although no limiting breeding or foraging resources would be impacted, the project has the potential to affect connectivity between areas of potential habitat for the Long-nosed Potoroo. Therefore, a Part 3A assessment of significance has been completed for this species and is provided in Appendix G to this report.

Common name	EPBC Act	TSC Act	Potential impacts on threatened species			EP&A Act Part 3A assessment of significance required?	Reasoning
			Individual death or injury?	Loss or disturbance of limiting foraging resources?	Loss or disturbance of limiting breeding resources?		
Grey-headed Flying-fox	V	V	Unlikely	No	No	**Yes**	This species is a canopy-feeding frugivore and nectarivore of rainforests, open forests, woodlands, melaleuca swamps and banksia woodlands. Roosts in large colonies (camps), commonly in dense riparian vegetation (Tidemann 1995). Recorded during field surveys at site 15. Also previously recorded north, south and south-west of the study area. Known camp site within Coomonderry Swamp. Although no limiting breeding or foraging resources would be impacted and the highly mobile species is unlikely to be impacted by habitat fragmentation, a Part 3A assessment of significance has been completed due to the known presence of the species within the study area and is provided at Appendix G to this report.
Large-eared Pied Bat	V	V	Unlikely	No	No	No	This species roosts in caves, Fairy Martin nests and mines, and beneath rock overhangs. Primarily found in dry sclerophyll forests and woodlands, but also found in rainforest fringes and subalpine woodlands (Churchill 2008, Hoye and Schulz 2008). Recorded once during 2007 surveys west of the current study area. One other record occurs 10 kilometres north of the study area. Potential habitat for the Large-eared Pied Bat within the study area is restricted to non-limiting foraging habitat (eg forest and woodland). The direct and permanent loss of about 27.8 hectares non-limiting forest and woodland habitat (see **Table 4.1**) over 11.6 kilometres of the project is not likely to impact this species. A Part 3A assessment of significance is not considered necessary.

Common name	EPBC Act	TSC Act	Potential impacts on threatened species			EP&A Act Part 3A assessment of significance required?	Reasoning
			Individual death or injury?	Loss or disturbance of limiting foraging resources?	Loss or disturbance of limiting breeding resources?		
Eastern Bentwing-bat Southern Myotis	-	V	Unlikely	No	No	**Yes**	Form maternity roosts in caves and mines. Also roost in culverts, buildings and under bridges. The Southern Myotis will also roost in tree hollows. They occur in a broad range of habitats including rainforest, wet and dry sclerophyll forest, paperbark forest and open grasslands (Churchill 2008). Forage aerially for insects. Both species were recorded during the field surveys within the study area. Although no limiting breeding or foraging resources would be impacted, given the known occurrence of the species within the study area and that the Southern Myotis may roost in tree hollows and man-made structures such as culverts, a Part 3A assessment of significance has been completed for these species and is provided in Appendix G to this report.
Yellow-bellied Sheathtail Bat Eastern Freetail Bat Eastern False Pipistrelle Greater Broad-nosed Bat	-	V	Possible	No	Yes	**Yes**	These species primarily roost and breed within tree hollows. All four microbats forage aerially for insects and may fly through the study areas hunting for moths, beetles, weevils, etc. However, the foraging habitat within the study area is not considered to be limiting for these mobile species. All four species were recorded during the field surveys within the study area. Given the loss of potential limiting breeding resources (ie tree hollows), a Part 3A assessment of significance has been completed for these species and is provided at Appendix G to this report.

Appendix I

EPBC Act Significant Impact Criteria Assessments

EPBC Act Significant Impact Criteria Assessments

Endangered and vulnerable flora species

Cynanchum elegans White-flowered Wax Plant

Cynanchum elegans is listed as a nationally Endangered species under the EPBC Act.

Potential habitat for this species is considered to exist within the warm temperate layered forest within the study area.

Is the action likely to lead to a long-term decrease in the size of a population of a species?

No individuals of *Cynanchum elegans* were recorded in the study area. The closest record to the study area, about 3.5 kilometres to the north-east, is the southernmost record of this species. The project is unlikely to lead to any decrease in this population.

Potential habitat within the study area is considered to exist within warm temperate layered forest. The project would directly impact 6.9 hectares of potential habitat for *Cynanchum elegans*. Potential habitat for the species in the locality (five kilometre radius of the study area) is 2,342.7 hectares. The project is therefore unlikely to lead to a long-term decrease in the size of an important population in the study area.

Is the action likely to reduce the area of occupancy of a species?

The closest record of *Cynanchum elegans* to the study area, about 3.5 kilometres to the north-east, is the southernmost record of this species. The study area does not currently represent an area of occupancy for this species. The warm temperate layered forest in the study area is considered potential habitat for this species.

Given the large areas of potential habitat to the west of the southernmost record of *Cynanchum elegans*, and the existing clearing, disturbance and fragmentation of potential habitat in and adjoining the study area, it is considered unlikely that the project would further limit any range extension of this species.

Is the action likely to fragment an existing population into two or more populations?

No known populations of *Cynanchum elegans* occur in the study area. Potential habitat for *Cynanchum elegans* occurs in warm temperate layered forest in the study area. The project would result in limited fragmentation, as the area of potential habitat has already been fragmented and impacted by cleared/grazing land. Therefore the project is unlikely to fragment an existing population into two or more populations.

Is the action likely to adversely affect habitat critical to the survival of a species?

The Commonwealth Environment Minister may identify and list habitat critical to the survival of a listed threatened species or ecological community. Details of this identified habitat are recorded in the Register of Critical Habitat. To date no areas of critical habitat have been listed for *Cynanchum elegans.*

Is the action likely to disrupt the breeding cycle of a population?

Cynanchum elegans was not recorded in the study area. The closest known record of the species is about 3.5 kilometres to the northeast of the study area

The following is known about the lifecycle of *Cynanchum elegans* (DEC 2005Š):

- Flowering occurs between August and May, with a peak in November. Flower abundance on individual plants varies from sparse to prolific.
- The fruit can take up to six months to mature.
- Seed production is variable and unreliable. Seeds are wind dispersed and released in a non-dormant state, hence are unlikely to persist in the soil seedbank.
- Plants are capable of suckering from rootstock in response to occasional slashing or grazing. The fire response of the species is unknown.

As no individuals have been recorded in the study area and there are unlikely to be individuals in the soil seed bank, the project is unlikely to disrupt the breeding cycle of an important population of this species.

Is the action likely to modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?

The project would result in direct impacts to about 6.9 hectares of potential habitat for *Cynanchum elegans*. Potential habitat for the species in the locality (five kilometre radius of the study area) is 2,342.7 hectares. The area of potential habitat that would be removed as part of the proposed development equates to 0.3 per cent of the extent of these plant communities in the locality.

The potential habitat for this species within the study area is in moderate to poor condition, due to the dominance of exotic species in the understorey, altered community structure and existing fragmentation. The project may result in an increase in the intensity of some existing impacts. However the project is not likely to result in the isolation or decrease in the availability of habitat for the species such that the species is likely to decline.

Is the action likely to result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat?

The project may increase the threat of weed invasion particularly given the presence of exotic perennial grasses along existing disturbed edges in the study area.

Is the action likely to introduce disease that may cause the species to decline?

The removal of about 6.9 hectares of potential habitat is not likely to introduce disease that may cause the species to decline. As a precaution, construction/earth moving vehicles should be washed down prior to use on site; this would help prevent the infection of native plants by the fungus, *Phytophthora cinnamomi*.

Is the action likely to interfere with the recovery of the species?

No recovery plan as published by DSEWPaC is available for *Cynanchum elegans.* The threatened species profile for *Cynanchum elegans* refers to nine priority actions to assist in recovery of the species (DEC 2005‰). Those relevant to the project include:

- Consider off-site impacts in the assessment of nearby developments.
- Install fencing to exclude livestock and machinery, and control access where required.
- Protect areas of known and potential habitat from clearing and further fragmentation.
- Restore degraded habitat using bush regeneration techniques.
- Mark sites and potential habitat onto maps used for planning maintenance work.
- Map known sites and conduct searches of potential habitat for new sites.

With the exception of the removal of a small area of potential habitat, the project is not inconsistent with the priority actions that relate to the recovery of *Cynanchum elegans*.

Conclusion
Based on the above assessment, *Cynanchum elegans* is unlikely to be significantly impacted by the project and, as such, a referral under the provisions of the EPBC Act is not recommended for this species.

Daphnandra sp. C 'Illawarra' Illawarra Socketwood

Daphnandra sp.C 'Illawarra' is listed as a nationally Endangered species under the EPBC Act.

Is the action likely to lead to a long-term decrease in the size of a population?

Daphnandra sp. C 'Illawarra' was not recorded in the study area; however this species was recorded in the locality during broader surveys, about 600 metres to the south of the study area around Toolijooa Ridge. There are also a number of OEH Atlas records of this species in the locality, with the closest about 130 metres to the south of the study area and 400 metres to the north of the study area.

Potential habitat exists within the study area in Illawarra gully wet forest and warm temperate layered forest communities. Potential habitat exists in the locality in the following vegetation communities: Buderoo temperate rainforest, coastal warm temperate rainforest, escarpment foothills wet forest, littoral thicket, Illawarra gully wet forest, intermediate temperate rainforest, subtropical complex rainforest, warm temperate layered forest, subtropical dry rainforest and Yarrawarra temperate rainforest. These vegetation communities occur as scattered patches throughout the locality covering about 3011.8 hectares.

About 22.3 hectares of potential habitat for *Daphnandra* sp. C 'Illawarra' would be directly impacted as part of the project with further potential indirect impacts to an additional 15.4 hectares of potential habitat.

Direct impacts to 22.3 hectares of potential habitat for *Daphnandra* sp. C 'Illawarra' is not likely to lead to a long-term decrease in the size of a population.

Is the action likely to reduce the area of occupancy of the species?

Daphnandra sp. C 'Illawarra' is known to occupy the rocky hillsides and gullies of the Illawarra lowlands, occasionally extending onto the upper escarpment slopes and is associated with rainforest and moist eucalypt forest (DEC 2005j). The study area is at the southern limit of the known distribution of this species. The project may further isolate the southernmost records of this species from the rest of the population to the north.

Potential habitat in the locality includes the following vegetation communities: Buderoo temperate rainforest, coastal warm temperate rainforest, escarpment foothills wet forest, Illawarra gully wet forest, intermediate temperate rainforest, subtropical complex rainforest, warm temperate layered forest, subtropical dry rainforest and Yarrawarra temperate rainforest. These vegetation communities occur as scattered patches throughout the locality and cover an area of about 3011.8 hectares. These vegetation communities occur to the south of the known southern limit of *Daphnandra* sp. C 'Illawarra' and there are is a highly fragmented corridor across Toolijooa Ridge and Harley Hill that may facilitate any range expansion of this species.

The project is not considered likely to reduce the area of occupancy of *Daphnandra* sp. C 'Illawarra'.

Is the action likely to fragment an existing population into two or more populations?

The alignment of the project avoids direct and indirect impacts on a known population of *Daphnandra* sp. C 'Illawarra'.

The project would further fragment the already fragmented vegetation between two known populations of *Daphnandra* sp. C 'Illawarra'. These two populations are currently separated by about 850 metres with scattered patches of vegetation in poor condition between them.

Is the action likely to adversely affect habitat critical to the survival of a species?

The Commonwealth Environment Minister may identify and list habitat critical to the survival of a listed threatened species or ecological community. Details of this identified habitat are recorded in the Register of Critical Habitat. To date no areas of critical habitat has been listed for *Daphnandra* sp. C 'Illawarra'.

Is the action likely to disrupt the breeding cycle of a population?

Daphnandra sp. C 'Illawarra' was not recorded in the study area; however, this species was recorded in the locality during broader surveys, about 600 metres to the south of the study area around Toolijooa Ridge. There are also a number of OEH Atlas records of this species in the locality, with the closest about 130 metres to the south of the study area and 400 metres to the north of the study area.

The following is known about the breeding cycle of *Daphnandra* sp. 'Illawarra' (DEC 2005j):

- Flowers briefly in September and early October with fruits taking 10 to 12 months to mature.
- Capable of vegetative reproduction from stems (coppicing) and rhizomes (suckering).
- Low levels of seed production are suspected, with stems at most sites appearing to only produce 'pseudo-fruit' which lack seeds. Seed production has been reported from just two sites, only one of which has been confirmed to produce viable seed, and the extent to which this seed is capable of surviving in the wild is unknown.
- The pollination mechanisms of *Daphnandra* sp. C 'Illawarra' are unknown, as is the potential role that pollen vectors may play in the transfer of genetic material within and between sites.
- The predominant means of reproduction appears to be asexual (DEC 2005i).

The project is unlikely to disrupt the breeding cycle of the population of *Daphnandra* sp. C 'Illawarra' to the south of the study area.

Is the action likely to modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?

The project would result in direct impacts to about 22.3 hectares of potential habitat for *Daphnandra* sp. C 'Illawarra'.

The areas to be cleared to the north of the known population of *Daphnandra* sp. C 'Illawarra' include the edges of currently fragmented patches of warm temperate layered forest in poor condition along edges where large infestations of the noxious weed *Lantana camara* are present and have displaced most native species. These edges are likely to have little or no capacity for the regeneration of natural vegetation without significant resources allocated to weed control and revegetation.

The project would widen the existing area of cleared land, thus increasing fragmentation. However given the current fragmentation and infestation of *Lantana camara,* it is unlikely that the areas to be cleared to the north of the known population represent suitable habitat for *Daphnandra* sp. C 'Illawarra'.

On this basis, the project is not likely to result in the isolation or decrease in the availability of habitat for *Daphnandra* sp. C 'Illawarra' such that the species is likely to decline.

Is the action likely to result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species´ habitat?

The warm temperate layered forest to be cleared to the north of the known population of *Daphnandra* sp. C 'Illawarra' is in poor condition with large infestations of the noxious weed *Lantana camara* present. These edges are likely to have little or no capacity for the regeneration of natural vegetation without significant resources allocated to weed control and revegetation.

The project is likely to remove the portion of marginal potential habitat in the study area and remove grazing pressures from any potential habitat that remains.

Is the action likely to introduce disease that may cause the species to decline?

The direct removal of about 22.3 hectares of potential habitat is not likely to introduce disease that may cause the species to decline. As a precaution, construction/earth moving vehicles should be washed down prior to use on site; this would help prevent the infection of native plants by the fungus, *Phytophthora cinnamomi*.

Is the action likely to interfere with the recovery of the species?

A recovery plan for *Daphnandra* sp. C 'Illawarra' has been published by DSEWPaC. The threatened species profile for *Daphnandra* sp. C 'Illawarra' refers to nine priority actions to assist in recovery of the species (DEC 2005v). Those relevant to the project include (DEC 2005Š):

- Consider off-site impacts in the assessment of nearby developments.
- Install fencing to exclude livestock and machinery, and control access where required.
- Protect areas of known and potential habitat from clearing and further fragmentation.
- Restore degraded habitat using bush regeneration techniques.
- Mark sites and potential habitat onto maps used for planning maintenance work.
- Map known sites and conduct searches of potential habitat for new sites.

With the exception of the removal of 22.3 hectares of potential habitat, the project is not inconsistent with the priority actions that relate to the recovery of *Daphnandra* sp. C 'Illawarra'.

Conclusion

Based on the above assessment, *Daphnandra* sp. C 'Illawarra' is unlikely to be significantly impacted by the project and, as such, a referral under the provisions of the EPBC Act is not recommended for this species.

Irenepharsus trypherus Delicate Cress

Irenepharsus trypherus is listed as a nationally Endangered species under the EPBC Act.

Is the action likely to lead to a long-term decrease in the size of a population?

Irenepharsus trypherus was not recorded in the study area, nor were there records for this species within a 10 kilometre radius of the study area (DECCW 2009a). However, potential habitat does exist within the study area in Illawarra gully wet forest. Potential habitat for *Irenepharsus trypherus* is considered to include subtropical complex rainforest and wet sclerophyll forests. These include the following vegetation communities: coastal warm temperate rainforest, escarpment foothills wet forest, Illawarra gully wet forest, intermediate temperate rainforest, subtropical complex rainforest, subtropical dry rainforest, and temperate littoral rainforest. These vegetation communities occur as scattered patches throughout the locality and cover an area of about 1690.7 hectares.

About 15.4 hectares of potential habitat for *Irenepharsus trypherus* would be directly impacted as part of the project with further potential indirect impacts to an additional 10 hectares.

Direct impacts to 15.4 hectares of potential habitat for *Irenepharsus trypherus* is not likely to lead to a long-term decrease in the size of a population.

Is the action likely to reduce the area of occupancy of the species?

Irenepharsus trypherus is mostly recorded from the upper slopes of the ridge systems that extend south and east of the Illawarra escarpment, although the species has also been recorded from the deep sandstone gorges of the Shoalhaven River (DEC 2005u). There have been no recordings of the species within 10 kilometres of the study area.

The removal of 15.4 hectares of potential habitat for the species in the study area is not likely to reduce the area of occupancy of the species. Potential habitat in the locality includes the following vegetation communities: coastal warm temperate rainforest, escarpment foothills wet forest, Illawarra gully wet forest, intermediate temperate rainforest, subtropical complex rainforest, subtropical dry rainforest and temperate littoral rainforest. These vegetation communities occur as scattered patches throughout the locality and cover an area of about 1690.7 hectares.

Is the action likely to fragment an existing population into two or more populations?

No known populations of *Irenepharsus trypherus* occur in the study area. Potential habitat for *Irenepharsus trypherus* occurs in Illawarra gully wet forest in the study area. The project intersects the southern edge of a large patch of Illawarra gully wet forest at site 15, with only the currently fragmented edge being further fragmented as a result of the project. Therefore the project is unlikely to fragment an existing population into two or more populations.

Is the action likely to adversely affect habitat critical to the survival of a species?

The Commonwealth Environment Minister may identify and list habitat critical to the survival of a listed threatened species or ecological community. Details of this identified habitat are recorded in the Register of Critical Habitat. To date no areas of critical habitat has been listed for *Irenepharsus trypherus*.

Is the action likely to disrupt the breeding cycle of a population?

The following is known about the lifecycle of *Irenepharsus trypherus* (DEC 2005u):

- Mature plants are capable of reshooting from dry or desiccated stems following light grazing, trampling, or drought.
- The species is thought to be a prolific seeder, with disturbance and light levels influencing germination.
- The fire response of this species is unknown.

Irenepharsus trypherus was not recorded in the study area, nor within a 10 kilometre radius of the study area. Since no individuals have been recorded in the study area, nor the locality, the project is unlikely to disrupt the breeding cycle of a population.

Is the action likely to modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?

The species has not been recorded in the study area nor within 10 kilometres, however potential habitat for the species occurs within Illawarra gully wet forest in the study area with further potential habitat in the locality occurring within coastal warm temperate rainforest, escarpment foothills wet forest, intermediate temperate rainforest, subtropical complex rainforest, subtropical dry rainforest, and temperate littoral rainforest. Vegetation mapping by DEC (2005o) indicates about 1690.7 hectares of these potential habitats occur within the locality (five kilometre radius of the study area).

The potential habitat for this species within the study area ranges from poor to moderate in the southwest (sites 14 and 35), with remnant trees and a patchy or weed dominated understorey, to moderate to good condition in the central section (site 15), with a largely intact native tree, shrub and groundlayer along with infestations of woody weeds such as *Lantana camara*.

About 15.4 hectares of potential habitat for *Irenepharsus trypherus* would be directly impacted by the proposed development. The area of potential habitat for *Irenepharsus trypherus* that would be removed as part of the project equates to 0.9 per cent of the extent of similar potential habitats mapped in the locality.

Given that the species has not been recorded in the study area and the relatively small area of potential habitat to be impacted in relation to that in the locality, the project is not likely to modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.

Is the action likely to result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species´ habitat?

The proposed development may increase the threat of weed invasion particularly given the presence of exotic perennial grasses along existing disturbed edges in the study area.

Is the action likely to introduce disease that may cause the species to decline?

The direct removal of about 15.4 hectares of potential habitat is not likely to introduce disease that may cause the species to decline. As a precaution, construction/earth moving vehicles should be washed down prior to use on site; this would help prevent the infection of native plants by the fungus, *Phytophthora cinnamomi*.

Is the action likely to interfere with the recovery of the species?

A recovery plan published by DSEWPaC is available for *Irenepharsus trypherus*. The threatened species profile for *Irenepharsus trypherus* refers to nine priority actions to assist in recovery of the species (DEC 2005v). Those relevant to the project include (DEC 2005Š):

- Consider off-site impacts in the assessment of nearby developments.
- Install fencing to exclude livestock and machinery, and control access where required.
- Protect areas of known and potential habitat from clearing and further fragmentation.
- Restore degraded habitat using bush regeneration techniques.
- Mark sites and potential habitat onto maps used for planning maintenance work.
- Map known sites and conduct searches of potential habitat for new sites.

The project and associated mitigation measures are not inconsistent with the above listed recovery actions.

With the exception of the removal of 15.4 hectares of potential habitat, the project is not inconsistent with the priority actions that relate to the recovery of *Irenepharsus trypherus*.

Conclusion

Based on the above assessment, *Irenepharsus trypherus* is unlikely to be significantly impacted by the project and, as such, a referral under the provisions of the EPBC Act is not recommended for this species.

Pterostylis gibbosa

Pterostylis gibbosa is listed as a nationally Endangered species under the EPBC Act.

Is the action likely to lead to a long-term decrease in the size of a population of the species?

Pterostylis gibbosa was not recorded in the study area, nor were there records for this species within a 10 kilometre radius of the study area (**Figure 3.2**).

The nearest populations of the species in the Shoalhaven LGA are at Worrigee Nature Reserve to the south of the study area. To the north the populations of the species are known at Albion Park in Shellharbour LGA and at Yallah in Wollongong LGA. There are no known populations of the species in the Kiama LGA.

The project will not directly or indirectly result in the decrease in the size a known population of the species in the study area, the locality, or the Sydney Basin Bioregion.

Is the action likely to reduce the area of occupancy of a population?

The study area and locality do not support a known population of the species. The project will not reduce the area of occupancy of the nearest known populations in the Shoalhaven, Shellharbour or Wollongong LGA's.

Is the action likely to fragment an existing population into two or more populations?

The study area and locality do not support a population of the species. The nearest known populations of Pterostylis gibbosa in the Shoalhaven, Shellharbour and Wollongong LGA's and elsewhere in the Sydney Basin Bioregion will not be fragmented into two or more populations.

Is the action likely to adversely affect habitat critical to the survival of a species?

There is an approved recovery plan for *Pterostylis gibbosa* (NPWS 2002) but no habitat critical for the survival of the species has been listed on the Register of Critical Habitat maintained by the Minister for the Environment under the EPBC Act. There is no potential habitat identified for this species on the in the study area. Potential habitat for the species in the locality is not considered to be habitat critical for survival of the species. Habitat that is important for the survival of the species in the Shoalhaven, Shellharbour and Wollongong LGA's will not be adversely affected by the project. Additionally the project is unlikely to significantly affect the habitat of flora and fauna species associated with Pterostylis gibbosa to compromise its survival at a local, regional or bioregional scale.

Is the action likely to disrupt the breeding cycle of a population?

The study area and locality are not known to support an important population of *Pterostylis gibbosa*. Pterostylis species are generally pollinated by male gnats of the genus Mycomya (Fungus Gnats). Nothing is known of the habitat requirements of Mycomya however it is suggested they are probably very common, but are not often seen due to their small size. Abundance of Mycomya is believed to peak in September, which is the main month of flowering of *Pterostylis gibbosa* (NPWS 2002). Studies on pollination rates have indicated that suitable adjoining pollinator habitat to a known site may be important for pollination success in addition to pollinator availability (NPWS 2002). The seed is dispersed by wind and reliant on a mycorrhizal fungus to support the first stages of growth after germination. The species is capable of surviving fire, due to the regenerative capacity of its tuberoid.

No potential habitat for the species will be affected by the project. Additionally the majority of vegetated corridors in the locality will be retained that maintain pathways for the dispersal and exchange of genetic reproductive material and organisms that may be important components of the species lifecycle throughout the locality. This would include but not be limited to habitat for invertebrate or vertebrates providing pollination and seed dispersal for plant species that characterise vegetation *Pterostylis gibbosa* is strongly associated with.

The project is unlikely to affect fire frequency and intensity or the presence of mycorrhizal fungi the species is associated with such that the breeding cycle of an important population in the region is disrupted.

Is the action likely to modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?

Pterostylis gibbosa was not recorded in the study area and has not been previously recorded in the locality (**Figure 3.2**). There is no potential habitat for the species in the study area. Additionally the project will not result in direct or indirect impacts to any potential habitat for the species in the locality. The quality of potential habitat for *Pterostylis gibbosa* in the locality area is likely to be significantly modified due to the ongoing impacts from edge effects (eg weeds) and disturbances such as grazing.

In the locality and to the east of the project the conservation reserve Seven Mile Beach National Park is likely to support one or multiple vegetation communities that provide good quality habitat for the species.

In consideration of the above, the project is not likely to result in the isolation or decrease in the availability of habitat for the species such that the species is likely to decline.

Is the action likely to result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species´ habitat?

Native plant communities in the locality including those that may provide potential habitat for the species are affected by invasive exotic flora and fauna species as a result of current and previous land management. The project is unlikely to result in the further establishment of invasive flora and fauna species in the potential habitats of *Pterostylis gibbosa* in the locality.

Is the action likely to introduce disease that may cause the species to decline?

No diseases have been identified as threats to *Pterostylis gibbosa* by OEH or DSEWPaC. It is considered unlikely that the proposal would introduce any diseases that may cause the species to decline.

Is the action likely to interfere substantially with the recovery of the species?

The proposal is unlikely to interfere substantially with the recovery of *Pterostylis gibbosa* at a local, regional or bioregional level.

Conclusion

Based on the above assessment, *Pterostylis gibbosa* is unlikely to be significantly impacted by the proposal, and as such, a Referral under the provisions of the EPBC Act is not recommended for these species.

Cryptostylis hunteriana

Cryptostylis hunteriana is listed as a nationally Vulnerable species under the EPBC Act.

Is the action likely to lead to a long-term decrease in the size of an important population?

Cryptostylis hunteriana was not recorded in the study area, nor were there records for this species within a 10 kilometre radius of the study area (**Figure 3.2**).

There are no known populations of the species in the Kiama LGA. Important populations of the species to the south in Shoalhaven LGA are at Jervis Bay National Park, Triplarina Nature Reserve and Cambewarra Nature Reserve. In addition to these other important populations of the species in the Sydney Basin Bioregion are the largest known Australian population at Bulahdelah, and those at Ku-ring-gai Chase and Morton National Parks (DEWHA 2008a).

The project will not directly or indirectly result in the decrease in the size important or viable populations of the species in the study area, the locality, or the Sydney Basin Bioregion.

Is the action likely to reduce the area of occupancy of an important population?

The study area and locality do not support an important population of the species. The project will not reduce the area of occupancy of important populations in the Shoalhaven LGA, or Sydney Basin Bioregion.

Is the action likely to fragment an existing important population into two or more populations?

The study area and locality do not support an important population of the species. Important populations of *Cryptostylis hunteriana* in the Shoalhaven LGA and elsewhere in the Sydney Basin Bioregion will not be fragmented into two or more populations.

Is the action likely to adversely affect habitat critical to the survival of a species?

No habitat critical for the survival of the species has been listed on the Register of Critical Habitat maintained by the minister under the EPBC Act. The potential habitat identified for this species on the subject site and in the study area is not considered to be habitat critical for survival of the species. Additionally the proposed action is unlikely to significantly affect the habitat of flora and fauna species associated with *Cryptostylis hunteriana* to compromise its survival at a regional or bioregional scale.

Is the action likely to disrupt the breeding cycle of an important population?

The study area and locality do not support an important population of *Cryptostylis hunteriana*. Key features of the breading cycle of the species include pollination by the male Ichneumon Wasp (*Lissopimpla excelsa*) and seeds are spread via wind transportation (DEWHA 2010a). Flowering intensity may be stimulated by previous fire events, however, fire during the flowering season has been identified as a potential threat to the species (DEWHA 2008a). The species may be dependent on a mycorrhizal fungal association (DEWHA 2008a).

Although potential habitat for the species will be affected by the proposal the majority of vegetated corridors in the locality will be retained that maintain pathways for the dispersal and exchange of genetic reproductive material and organisms that are important components of the species lifecycle throughout the locality. This would include but not be limited to habitat for the Ichneumon Wasp and other invertebrate or vertebrates providing pollination and seed dispersal for plant species that characterise vegetation *Cryptostylis hunteriana* is strongly associated with.

The project is unlikely to affect fire frequency and intensity or the presence of mycorrhizal fungi the species is associated with such that the breeding cycle of an important population in the region is disrupted.

Is the action likely to modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?

Cryptostylis hunteriana was not recorded in the study area and has not been previously recorded in the locality (**Figure 3.2**). The project would result in direct impacts to about 0.0002 hectares and indirect impacts to about 2.4 hectares of potential habitat for the species. The potential habitat for *Cryptostylis hunteriana* in the study area is significantly modified due to the ongoing impacts from edge effects (eg weeds) and disturbances such as grazing. The project may result in an increase in the intensity of some existing impacts.

In the locality and to the east of the project the conservation reserve Seven Mile Beach National Park is likely to support one or multiple vegetation communities that provide good quality habitat for the species.

In consideration of the above, the project is not likely to result in the isolation or decrease in the availability of habitat for the species such that the species is likely to decline.

Is the action likely to result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species habitat?

Native plant communities throughout the study area and locality including those that may provide potential habitat for the species are affected by invasive exotic flora and fauna species as a result of current and previous land management. The project is unlikely to result in the further establishment of invasive flora and fauna species in the potential habitats of *Cryptostylis hunteriana*.

Is the action likely to introduce disease that may cause the species to decline?

No diseases have been identified as threats to *Cryptostylis hunteriana* by OEH or DSEWPaC. It is considered unlikely that the proposal would introduce any diseases that may cause the species to decline.

Is the action likely to interfere substantially with the recovery of the species?

The proposal is unlikely to interfere substantially with the recovery of *Cryptostylis hunteriana* at a regional or bioregional level.

Conclusion

Based on the above assessment, *Cryptostylis hunteriana* is unlikely to be significantly impacted by the project, and as such, a Referral under the provisions of the EPBC Act is not recommended for these species.

Zieria granulata Hill Zieria

Zieria granulata is listed as a nationally Vulnerable species under the EPBC Act.

Is the action likely to lead to a long-term decrease in the size of an important population?

The alignment of the project avoids direct and indirect impacts on a known population of *Zieria granulata*. This species was not recorded in the study area, but was recorded in the locality during broader surveys, about 400 metres to the south of the study area on Toolijooa Ridge. There are also a number of OEH Atlas records of this species in the locality, with the closest record about 190 metres to the south-west of the study area.

Potential habitat for *Zieria granulata* exists within rainforest, grassy woodland and wet forest communities. These include the vegetation communities: Buderoo temperate rainforest, coastal warm temperate rainforest, escarpment foothills wet forest, Littoral thickets, warm temperate layered forest, Illawarra gully wet forest, intermediate temperate rainforest, subtropical complex rainforest, subtropical dry rainforest, south coast grassy woodland and Yarrawarra temperate rainforest. These vegetation communities occur as scattered patches throughout the locality covering about 3011.8 hectares. Furthermore, *Zieria granulata* can also occur in highly disturbed areas with no or limiting vegetation (DEC 2005').

About 22.3 hectares of potential habitat for *Zieria granulata* would be directly impacted by the project with further potential indirect impacts to an additional 15.4 hectares of potential habitat.

Direct impacts to about 0.7 per cent of potential habitat occurring in the locality for *Zieria granulata* is not likely to lead to a long-term decrease in the size of a population.

Is the action likely to reduce the area of occupancy of the species?

The study area is at the southern limit of the known distribution of *Zieria granulata*. The project may further isolate the southernmost records of this species from the rest of the population to the north.

Potential habitat in the locality includes the following vegetation communities: Buderoo temperate rainforest, coastal warm temperate rainforest, warm temperate layered forest, escarpment foothills wet forest, Illawarra gully wet forest, intermediate temperate rainforest, subtropical complex rainforest, subtropical dry rainforest, south coast grassy woodland and Yarrawarra temperate rainforest. These vegetation communities occur as scattered patches throughout the locality and cover an area of about 3011.8 hectares. Some of these vegetation communities occur to the south of the known southern limit of *Zieria granulata* and there are is a highly fragmented corridor across Toolijooa Ridge and Harley Hill that may facilitate any range expansion of this species.

The project is not considered likely to reduce the area of occupancy of *Zieria granulata*.

Is the action likely to fragment an existing population into two or more populations?

The alignment of the project avoids direct and indirect impacts on a known population of *Zieria granulata*. A relatively large population of this species on Toolijooa Ridge is about 400 metres to the south of the study area and would not be fragmented by the project.

The closest known record of *Zieria granulata* to the Toolijooa Ridge population is about 1.6 kilometres to the north-west. There are currently roads, cleared grazing lands and fragmented patches of vegetation between the two populations. The project would not further isolate the Toolijooa Ridge population of *Z. granulata* from another known population.

Is the action likely to adversely affect habitat critical to the survival of a species?

The Commonwealth Environment Minister may identify and list habitat critical to the survival of a listed threatened species or ecological community. Details of this identified habitat are recorded in the Register of Critical Habitat. To date no areas of critical habitat have been listed for *Zieria granulata*.

Is the action likely to disrupt the breeding cycle of a population?

Zieria granulata was not recorded in the study area. Numerous records of this species occur within 10 kilometres of the study area, with a large population on Toolijooa Ridge to the south. The closest record is about 190 metres to the south-west of the study area, near Broughton.

The following is known about the breeding cycle of *Zieria granulata* (DEC 2005):

- Flowering occurs between early spring and summer.
- Known to possess functional pollen although deformed pollen has been recorded for the species.
- Nectar seeking flies appear to be effective pollen vectors for this species; these flies are considered to be generalist pollinators and strong fliers that are capable of traversing open spaces.
- Seed dispersal is initially through forcible ejection from the mature fruit, and it is suspected that secondary dispersal by ants also occurs.

The project is unlikely to disrupt the breeding cycle of a population.

Is the action likely to modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?

Zieria granulata was not recorded in the study area. The project would result in direct impacts to about 22.3 hectares of potential habitat for the species. The potential habitat for *Zieria granulata* in the study area is already modified due to the ongoing impacts from edge effects (eg weeds) and disturbances such as grazing. The project may result in an increase in the intensity of some existing impacts. On this basis, the project is not likely to result in the isolation or decrease in the availability of habitat for the species such that the species is likely to decline.

Is the action likely to result in invasive species that are harmful to vulnerable species becoming established in the vulnerable species´ habitat?

Many of the patches of vegetation within the study area contain exotic weeds as a dominant understorey, or have a significant amount of weeds in stratums. This is due to historic clearing and grazing in the area.

The project is likely to remove the portion of marginal potential habitat in the study area and remove grazing pressures from any potential habitat that remains.

Is the action likely to introduce disease that may cause the species to decline?

The direct removal of about 22.3 hectares of potential habitat is not likely to introduce disease that may cause the species to decline. As a precaution, construction/earth moving vehicles should be washed down prior to use on site; this would help prevent the infection of native plants by the fungus, *Phytophthora cinnamomi*.

Is the action likely to interfere with the recovery of the species?

A recovery plan published by DECC is available for *Zieria granulata*. The threatened species profile for *Zieria granulata* refers to thirteen priority actions to assist in recovery of the species (DEC 2005‘). Those relevant to the project include (DEC 2005‘):

- Consider off-site impacts in the assessment of nearby developments.
- Install fencing to exclude livestock and machinery, and control access where required.
- Protect areas of known and potential habitat from clearing and further fragmentation.
- Restore degraded habitat using bush regeneration techniques.
- Mark sites and potential habitat onto maps used for planning maintenance work.
- Map known sites and conduct searches of potential habitat for new sites.

With the exception of the removal of 22.3 hectares of potential habitat, the project is not inconsistent with the priority actions that relate to the recovery of *Zieria granulata*.

Conclusion

Based on the above assessment, *Zieria granulata* is unlikely to be significantly impacted by the project and, as such, a referral under the provisions of the EPBC Act is not recommended for this species.

Endangered and vulnerable fauna species

Lathamus discolor Swift Parrot

The Swift Parrot is listed as Endangered under the EPBC Act. The species is also listed as Endangered under the TSC Act.

Is there a real chance or a possibility that the action will lead to a long-term decrease in the size of a population of the species?

The Swift Parrot is a highly nomadic species that occurs in woodlands and forests in NSW (Higgins 1999). It migrates in response to food availability and seasonal changes. It is often recorded in NSW between May and August and breeds in Tasmania during the warmer seasons (Higgins 1999).

While on the mainland, Swift Parrots occur in areas where eucalypts are flowering profusely or where there are abundant lerp (from sap-sucking bugs) infestations. Favoured feed trees include winter-flowering species such as swamp mahogany *Eucalyptus robusta*, spotted gum *Corymbia maculata*, red bloodwood *C. gummifera*, mugga ironbark *E. sideroxylon*, and white box *E. albens*. Commonly used lerp-infested trees include grey box *E. microcarpa*, grey box *E. moluccana* and blackbutt *E. pilularis* (DEC 2005†).

The Swift Parrot has not been recorded within the study area. The species has been previously recorded once within the locality (recorded in year 2000), about 2.5 kilometres south-east of the study area within Seven Mile Beach National Park (Bird's Australia 2011). Another three records of the species occur within 10 kilometres of the study area to the north and south (DECCW 2011).

The study area provides potential foraging habitat for the Swift Parrot within the eucalypt forests and woodlands. Three favoured feed tree species (*Corymbia maculata*, *C. gummifera* and *Eucalyptus pilularis*) occur within the study area. Only one species (*E. pilularis*) is dominant within any of the plant communities (Illawarra gully wet forest). The study area does not provide potential breeding habitat as the species breeds exclusively in Tasmania (Higgins 1999).

The project would impact potential foraging habitat for the Swift Parrot through the removal of eucalypt forest and woodland. About 22.2 hectares of eucalypt forest (potential foraging habitat) would be removed from the study area with a further 17.5 hectares affected by indirect impacts (eg edge effects). This equates to less than 1.6 per cent of eucalypt forest within the locality (2425.7 hectares). Given the availability of potential foraging habitat within the locality (including known habitat protected within Seven Mile Beach National Park), that no breeding habitat would be impacted and the high mobility of this species, it is considered unlikely that the project would lead to a long-term decrease in the size of a population of the Swift Parrot.

Is there a real chance or a possibility that the action will reduce the area of occupancy of the species?

The study area does not lie at or near the limit of the area of occupancy of the Swift Parrot, which extends from south-east Queensland through New South Wales, Victoria to South Australia and Tasmania.

Given the distribution of records of the Swift Parrot within 10 kilometres of the study area and the presence of preferred feed tree species, it is possible the parrot may utilise resources within the study area from time to time. However, given the high mobility of the Swift Parrot (able to migrate between Tasmania and south eastern mainland) and the availability of known and potential habitat in the locality (including protected habitat within Seven Mile Beach National Park), the loss of 22.2 hectares eucalypt forest (predominantly disturbed roadside habitat) is unlikely to reduce the area of occupancy of the species.

Is there a real chance or a possibility that the action will fragment an existing population into two or more populations?

Swift Parrots are winter migrants to NSW, and travel to foraging sites on a cyclic basis depending on food availability (DEC 2005†). The project would involve removal of potential feed trees from the study area. The areas to be removed (predominantly roadside areas) are contiguous with intact forest that would remain. Given the availability of surrounding eucalypt forests, the small areas of proposed vegetation removal (the 22.2 hectares to be removed is made up of smaller areas spread along the 11.6 kilometre route including proposed ancillary sites) and the high mobility of the Swift Parrot, it is considered unlikely that the project would fragment an existing population into two or more populations.

Is there a real chance or a possibility that the action will adversely affect habitat critical to the survival of the species?

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations or ecological communities. A Register of Critical Habitat is maintained by the Minister under the EPBC Act. To date, no critical habitat has been declared for the Swift Parrot (DEWHA 2009d).

Critical habitat can also refer to areas that are necessary for activities such as foraging, breeding or dispersal; for the long-term maintenance of the species; to maintain genetic diversity and long-term evolutionary development; or for the reintroduction of populations or recovery of the species (DEWHA 2009d).

The project would impact potential foraging habitat for the Swift Parrot through the removal of eucalypt forest and woodland, but no breeding habitat would be impacted as this species breeds in Tasmania. The project is considered unlikely to affect habitat critical to the survival of the species, given the mobility of the species, the availability of surrounding eucalypt forests, and the small areas of proposed vegetation removal.

Is there a real chance or a possibility that the action will disrupt the breeding cycle of a population of the species?

The Swift Parrot breeds exclusively in Tasmania during the warmer seasons (Higgins 1999). It is a highly nomadic species that occurs in woodlands and forests in NSW during winter, and migrates in response to food availability and seasonal changes (Higgins 1999).

Given the impacts to potential foraging habitat are unlikely to lead to a long-term decrease in the size of a population of the Swift Parrot (described above) and that no breeding habitat would be impacted (as the species breeds exclusively in Tasmania), it is considered unlikely that the project would disrupt the breeding cycle of a population of the Swift Parrot.

Is there a real chance or a possibility that the action will modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?

The project would directly impact up to 22.2 hectares of potential foraging habitat (eucalypt forest) for the Swift Parrot (some of which contains preferred feed tree species). Within the area of OEH vegetation mapping (as amended following the field surveys), the habitat to be directly impacted represents 0.9 per cent of potential habitat within the locality (2425.7 hectares). A further 17.5 hectares of eucalypt forest would be indirectly affected (eg edge effects) by the project. This equates to about 0.7 per cent of potential habitat within the locality. In total, 1.6 per cent of the potential habitat occurring in the locality would be impacted by the project.

Although some preferred feed tree species of the Swift Parrot occur in the study area (*Corymbia maculata*, *C. gummifera* and *Eucalyptus pilularis*), the habitat to be impacted is predominantly disturbed, roadside vegetation and is considered to be of low importance for the long-term survival of the Swift Parrot. Given this, the absence of records of the species within the study area and the species' high mobility, the loss and/or disturbance of 1.6 per cent of potential habitat within the locality is considered unlikely to modify, destroy, remove,

isolate or decrease the availability or quality of habitat to the extent that the Swift Parrot is likely to decline.

Is there a real chance or a possibility that the action will result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species habitat?

Predation or competition by invasive species is not listed as a threat to the Swift Parrot by the OEH or DSEWPaC (Swift Parrot Recovery Team 2001). The project is unlikely to result in the introduction or exacerbation of any invasive species that is harmful to the Swift Parrot in the study area.

Is there a real chance or a possibility that the action will introduce disease that may cause the species to decline?

Infection by *Psittacine circoviral* (beak and feather) disease (PCD) affecting endangered psittacine species is listed as a key threatening process (NSW Scientific Committee 2008a, DEH 2005b). Swift parrots are considered to have a high potential for being adversely impacted by PCD due to their low population numbers and the fact that PCD has been recorded in wild birds in NSW (NSW Scientific Committee 2008a). The project is unlikely to result in the introduction of PCD into the study area, or increase the incidence of PCD in birds in NSW.

Is there a real chance or a possibility that the action will interfere with the recovery of the species?

DSEWPaC has developed a national recovery plan for the Swift Parrot (Swift Parrot Recovery Team 2001). One recovery objective outlined in this plan relevant to the project is:

- Implement management strategies at the landscape scale to protect and improve priority habitats and sites resulting in a sustained improvement in carrying capacity.

No breeding habitat would be impacted. Although a number of preferred feed tree species occur within the study area, only one species (*E*. *pilularis*) is dominant within any of the plant communities (Illawarra gully wet forest). Further, most of the potential habitat to be removed is disturbed roadside vegetation. Given the above, the low importance of the potential habitat within the study area and that only 1.6 per cent of potential habitat within the locality would be impacted, it is unlikely that the project would interfere with this recovery objective.

Conclusion

Based on the above assessment the Swift Parrot is unlikely to be significantly impacted by the project, and as such, a Referral under the provisions of the EPBC Act is not recommended for this species.

Dasyurus maculatus maculatus Spotted-tailed Quoll

The Spotted-tailed Quoll is listed as Endangered under the EPBC Act. The species is also listed as Vulnerable under the TSC Act.

Is there a real chance or a possibility that the action will lead to a long-term decrease in the size of a population of the species?

The Spotted-tailed Quoll occurs in a range of habitats including sclerophyll forest and woodlands, coastal heathlands and rainforests (Dickman and Read 1992, Edgar and Belcher 1995). Occasional sightings have been made in open country, grazing lands, rocky outcrops and other treeless areas (NPWS 1999h).

This species' habitat requirements include suitable den sites (such as hollow logs, tree hollows, rocky outcrops or caves) and an abundance of food (NPWS 1999h). The diet of juveniles is dominated by invertebrates, small mammals and birds, while the diet of adults is dominated by medium-sized mammals (Belcher *et al.* 2008). Individuals require large areas of relatively intact vegetation through which to forage (NPWS 1999h). The home range of a female is between 180 hectares – 1000 hectares, while males have larger home ranges of between 2000 hectares – 5000 hectares (Belcher *et al.* 2008).

The Spotted-tailed Quoll has been previously recorded 17 times within the locality (including as close as 200 metres to the study area), predominantly north and east of the study area (although records exist in all directions beyond the locality and within 10 kilometres). These records occurred between 1980 and 2010 (DECCW 2011).

The study area provides potential foraging and denning habitat for the Spotted-tailed Quoll within the eucalypt and riparian forests and woodlands. This species is also likely to utilise wildlife corridors within the locality to move between areas of habitat.

About 27.8 hectares of eucalypt and riparian forest (potential habitat) would be removed from the study area with a further 26.05 hectares affected by indirect impacts (eg edge effects). This equates to only 1.5 per cent of the potential habitat (eg eucalypt and riparian forest, rainforest and heathland) available within the locality (3667.1 hectares). The impacts of the loss of potential habitat are amplified by the fragmentation of fauna movement corridors through the study area. The project crosses the Toolijooa Ridge – Harley Hill and Broughton Creek corridors, as well as a number of smaller riparian and roadside corridors. By crossing these wildlife corridors, the project creates (or increases) a barrier to fauna movement between areas of habitat. Therefore, the project would not only result in the loss of potential habitat, it could also limit the ability of the Spotted-tailed Quoll to access other areas of habitat within the locality.

The project could result in either a complete halt to the movement of the Spotted-tailed Quoll across the study area or a reduced level of movement. Even a small reduction in movements can reduce genetic continuity within a population hence reducing the effective population size (Goosem 2002). In addition, the project may result in a higher rate of roadkill mortality as the species attempts to cross the wider highway. However, provided the dedicated fauna underpasses, riparian corridor enhancement and bridges over creek crossings are implemented (see Chapter 5), the project is unlikely to result in a long-term decrease in the size of a population of the Spotted-tailed Quoll.

Is there a real chance or a possibility that the action will reduce the area of occupancy of the species?

The study area does not lie at or near the limit of the area of occupancy of the Spotted-tailed Quoll, which extends between the Victorian and Queensland borders in New South Wales.

The study area lies south of a broader distribution of records of the species (eg between Barren Grounds Nature Reserve and Cambewarra Range Nature Reserve) that extend north and south of the study area. Impacts to the Spotted-tailed Quoll occurring within the study area and surrounds are unlikely to reduce the species' extent through this broader distribution of records. Given this, and that the study area does not occur at or near the limit of the area of occupancy of the Spotted-tailed Quoll, the project is unlikely to reduce the area of occupancy for this species.

Is there a real chance or a possibility that the action will fragment an existing population into two or more populations?

Given the distribution of records both north and south of the study area, and the close proximity of some records to the study area, it is considered likely that the Spotted-tailed Quoll occurs within and passes through the study area from time to time. The project crosses the Toolijooa Ridge – Harley Hill and Broughton Creek corridors, as well as a number of smaller riparian and roadside corridors. By crossing these wildlife corridors, the project creates (or increases) a barrier to fauna movement between areas of habitat. This may result in the fragmentation of a population of Spotted-tailed Quoll into two or more populations.

However, the proposed dedicated fauna underpasses (and associated fauna fencing), riparian corridor enhancement (through rehabilitation and revegetation), and bridges over creek crossings will help mitigate impacts on habitat connectivity for this species.

Is there a real chance or a possibility that the action will adversely affect habitat critical to the survival of the species?

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations or ecological communities. A Register of Critical Habitat is maintained by the Minister under the EPBC Act. To date, no critical habitat has been declared for the Spotted-tailed Quoll (DEWHA 2009d).

Critical habitat can also refer to areas that are necessary for activities such as foraging, breeding or dispersal; for the long-term maintenance of the species; to maintain genetic diversity and long-term evolutionary development; or for the reintroduction of populations or recovery of the species (DEWHA 2009d).

It is considered likely that the Spotted-tailed Quoll occurs within and passes through the study area from time to time. By crossing the Toolijooa Ridge – Harley Hill and Broughton Creek wildlife corridors, as well as a number of smaller riparian and roadside corridors, the project creates (or increases) a barrier to fauna movement between areas of habitat. This may result in the fragmentation of a population of Spotted-tailed Quoll into two or more populations, which could limit the genetic diversity of the populations. However, the proposed dedicated fauna underpasses (and associated fauna fencing), riparian corridor enhancement (through rehabilitation and revegetation), and bridges over creek crossings will help mitigate impacts on habitat connectivity for this species.

Is there a real chance or a possibility that the action will disrupt the breeding cycle of a population of the species?

The Spotted-tailed Quoll requires suitable den sites (such as hollow logs, tree hollows, rock outcrops or caves) for breeding (DEC 2005). Within the study area, hollow-bearing trees and hollow logs provide potential breeding habitat for this species. Most of the areas to be removed that contain such breeding resources are disturbed due to the existing road and ongoing agricultural practices. The patches of vegetation to be removed are contiguous, however, with intact forest that also contains the same potential breeding resources.

The project is unlikely to impact high quality potential breeding resources for the Spotted-tailed Quoll within the study area, however, the impacts to the local wildlife corridors could affect dispersal of the species. This could result in reduced breeding success of a local population. However, the proposed dedicated fauna underpasses (and associated fauna fencing), riparian corridor enhancement (through rehabilitation and revegetation), and bridges over creek crossings will help mitigate any potential impacts on habitat connectivity for this species.

Is there a real chance or a possibility that the action will modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?

The project would directly impact up to 27.8 hectares of potential foraging and breeding habitat (eucalypt and riparian forest) for the Spotted-tailed Quoll. Within the area of OEH vegetation mapping (as amended following the field surveys), the habitat to be directly impacted represents 0.8 per cent of potential habitat within the locality (3667.1 hectares). A further 26.05 hectares of eucalypt and riparian forest would be indirectly affected (eg edge effects) by the project. This equates to about 0.7 per cent of potential habitat within the locality. In total, about 1.5 per cent of the potential habitat occurring in the locality would be impacted by the project.

Although the Spotted-tailed Quoll is considered likely to occur in the study area, the habitat to be modified, destroyed and/or removed is predominantly disturbed roadside and disturbed riparian vegetation. The project is considered unlikely to decrease the availability or quality of habitat to the extent that the species may decline. Regardless, this disturbed habitat forms part of a discontinuous wildlife corridor between Seven Mile Beach National Park and Barren Grounds Nature Reserve and is therefore considered to be of high importance for the long-term survival of the Spotted-tailed Quoll occurring within the study area and surrounds. It is considered possible that the project would isolate areas of habitat (through the creation of a movement barrier; ie the highway) to the extent that the Spotted-tailed Quoll may decline.

However, the proposed dedicated fauna underpasses (and associated fauna fencing), riparian corridor enhancement (through rehabilitation and revegetation), and bridges over creek crossings will help mitigate impacts on habitat connectivity for this species.

Is there a real chance or a possibility that the action will result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species habitat?

DSEWPaC identifies predation and competition by/with the red fox (*Vulpes vulpes*), dingo (*Canis lupus dingo*), domestic dog (*Canis lupus familiaris*) and cats (*Felis catus*) as a threat to the Spotted-tailed Quoll (DEWHA 2009e). These species are likely to be already present within the study area and may already be having an effect on the Spotted-tailed Quoll. Further, the project has the ability to increase their extent or abundance within the study area via the use of underpasses.

Although only anecdotal evidence exists, DSEWPaC identifies poisoning by the cane toad (*Bufo marinus*) as a potential threat to the Spotted-tailed Quoll (DEWHA 2009e). However, the study area occurs well south of the southern limit of the cane toad's current distribution and the project is unlikely to result in this species becoming established in the study area or locality. It is recommended that the vegetation management plan states no use of sugar cane mulch in revegetation and/or landscaping works (to reduce the risk of cane toad transportation).

Is there a real chance or a possibility that the action will introduce disease that may cause the species to decline?

DSEWPaC does not list disease as a threat to the Spotted-tailed Quoll (DEWHA 2009e). The project is unlikely to lead to the introduction of a disease that would cause a decline in the Spotted-tailed Quoll.

Is there a real chance or a possibility that the action will interfere with the recovery of the species?

There is currently no published recovery plan for the Spotted-tailed Quoll. DSEWPaC identify the red fox, feral cat and cane toad as threats to the recovery of the Spotted-tailed Quoll within respective threat abatement plans (DEWHA 2008d, DEWHA 2008c, DSEWPaC 2011). Dedicated fauna underpasses, whilst serving to main connectivity either side of the highway for native fauna, may encourage exotic pest species such as cats and foxes to cross the highway also. Maintaining habitat connectivity for the Spotted-tailed Quoll provides the opportunity for dispersal and to maintain and/or strengthen genetic continuity and an effective population size, thus giving the species a fighting chance against existing pest species.

As mentioned above, the cane toad may also pose a threat to the recovery of the Spotted-tailed Quoll. However, the study area occurs well south of the southern limit of the cane toad's current distribution and the project is unlikely to result in this species becoming established in the study area or locality. It is recommended that the vegetation management plan states no use of sugar cane mulch in revegetation and/or landscaping works (to reduce the risk of cane toad transportation).

The project would result in the removal of some forested areas containing hollow-bearing trees and hollows logs, including riparian vegetation. However, as discussed above, the areas to be removed are already disturbed. Similar habitat resources occur and would remain adjacent to the cleared areas. A vegetation management plan (including weed control) is proposed to help minimise impacts on fauna and fauna habitats (Chapter 5).

The project could result in a higher rate of roadkill for the Spotted-tailed Quoll however the inclusion of dedicated fauna underpasses with fauna fencing (see Chapter 5) is likely to reduce this risk. Monitoring of road kill could be undertaken during the operational phase of the project and if identified as an issue, additional fauna fencing may be required.

Conclusion

Based on the above assessment, and provided the mitigation measures outlined above and detailed in Chapter 5 are implemented, the Spotted-tailed Quoll is unlikely to be significantly impacted by the project, and as such, a Referral under the provisions of the EPBC Act is not recommended for this species.

Potorous tridactylus Long-nosed Potoroo

The Long-nosed Potoroo is listed as Vulnerable under the EPBC Act. The species is also listed as Vulnerable under the TSC Act.

A population of this species occurring in the study area and/or locality may be considered an 'important population' as it may be necessary for maintaining genetic diversity.

Is the action likely to lead to a long-term decrease in the size of an important population of a species?

The Long-nosed Potoroo inhabits coastal heaths and dry and wet sclerophyll forests. In NSW it is generally restricted to coastal heaths and forests east of the Great Dividing Range, with an annual rainfall exceeding 760 mm. Dense understorey with occasional open areas is an essential part of habitat, and may consist of grass-trees, sedges, ferns or heath, or of low shrubs of tea-trees or melaleucas. A sandy loam soil is also a common feature (Johnston 2008). One study of the species found that the Long-nosed Potoroo required a mosaic of micro-habitats, from dense, floristically simple sites for nesting, to open floristically diverse sites for obtaining food. This species appears to benefit from a lack of recent disturbance, including fire (Claridge *et al.* 2007). The Long-nosed Potoroo is sedentary and tends to be solitary, although would also aggregate in small groups. The Long-nosed Potoroo forages for fleshy fruit, seeds and plant tissue, arthropods, fungi, digging in the soil much like a bandicoot (Johnston 2008).

The Long-nosed Potoroo has been previously recorded four times within the locality (twice in 1970 and twice in 1992), both to the north and south of the study area (DECCW 2011); although only one record occurs south of the study area. Beyond the locality and within 10 kilometres, additional records exist north of the study area with a large congregation in Barren Grounds Nature Reserve.

The study area provides limited potential foraging and nesting habitat for the Long-nosed Potoroo within the eucalypt and riparian forests. This species may also utilise wildlife corridors within the locality to move between areas of habitat.

About 27.8 hectares of eucalypt and riparian forest (limited potential habitat) would be removed from the study area with a further 26.05 hectares affected by indirect impacts (eg edge effects). This equates to only 1.5 per cent of the potential habitat (eg eucalypt and riparian forest, rainforest, melaleuca forest and heathland) available within the locality (3628.0 hectares). The impacts of the loss of potential habitat are amplified by the fragmentation of fauna movement corridors through the study area. The project crosses the Toolijooa Ridge – Harley Hill and Broughton Creek corridors, as well as a number of smaller riparian and roadside corridors. By crossing these wildlife corridors, the project creates (or increases) a barrier to fauna movement between areas of habitat. Therefore, the project would not only result in the loss of potential habitat, it could also limit the ability of the Long-nosed Potoroo to access other areas of habitat within the locality.

The project could result in either a complete halt to the movement of the Long-nosed Potoroo across the study area or a reduced level of movement. Even a small reduction in movements can reduce genetic continuity within a population hence reducing the effective population size (Goosem 2002). In addition, the project may result in a higher rate of roadkill mortality if the species attempts to cross the wider highway. However, provided the dedicated fauna underpasses, riparian corridor enhancement and bridges over creek crossings are implemented (see Chapter 5), the project is unlikely to result in a long-term decrease in the size of a population of the Long-nosed Potoroo.

Is the action likely to reduce the area of occupancy of an important population?

The area of occupancy of the Long-nosed Potoroo extends from Queensland to eastern Victoria and Tasmania. Within New South Wales, there is a gap in records between Gosford and Kiama of almost 150 kilometres (NSW Government 2009). While the study area does not lie at or near the limit of the overall area of occupancy of the Long-nosed Potoroo, it does occur close to the southern edge of the record gap in New South Wales (NSW Government 2009).

The study area lies south of a greater concentration of records of the species (eg Barren Grounds Nature Reserve and Cambewarra Range Nature Reserve). As only one record of the species occurs south of the study area (recorded in 1992), it is unlikely that impacts to the Long-nosed Potoroo occurring within the study area and surrounds would result in a reduction of the species' extent in these nature reserves. Given this, and that the study area does not occur at or near the limit of the overall area of occupancy of the Long-nosed Potoroo, the project is unlikely to reduce the area of occupancy of an important population.

Is the action likely to fragment an existing population into two or more populations?

Given the distribution of records both north and south of the study area it is considered possible that the Long-nosed Potoroo occurs within and passes through the study area from time to time. The fact that only one record occurs south of the study area (from 1992) may indicate the species is unlikely to cross the study area frequently or may be the result of insufficient survey in the area. The project crosses the Toolijooa Ridge – Harley Hill and Broughton Creek corridors, as well as a number of smaller riparian and roadside corridors. By crossing these wildlife corridors, the project creates (or increases) a barrier to fauna movement between areas of habitat. This may result in the fragmentation of a population of Long-nosed Potoroo into two or more populations.

However, the proposed dedicated fauna underpasses (and associated fauna fencing), riparian corridor enhancement (through rehabilitation and revegetation), and bridges over creek crossings will help mitigate impacts on habitat connectivity for this species.

Is the action likely to adversely affect habitat critical to the survival of a species?

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations or ecological communities. A Register of Critical Habitat is maintained by the Minister under the EPBC Act. To date, no critical habitat has been declared for the Long-nosed Potoroo (DEWHA 2009d).

Critical habitat can also refer to areas that are necessary for activities such as foraging, breeding or dispersal; for the long-term maintenance of the species; to maintain genetic diversity and long-term evolutionary development; or for the reintroduction of populations or recovery of the species (DEWHA 2009d). There is no consistent pattern to the habitat of the Long-nosed Potoroo (SE Mainland); it can be found in wet eucalypt forests (Seebeck 1995), coastal heaths and scrubs (Mason 1997). The main factors would appear to be access to some form of dense vegetation for shelter (Bennett 1987) and the presence of an abundant supply of fungi for food (Claridge et al. 1992). The potential habitat within the study area is considered only marginal due to the disturbed nature of the habitat (ie roadside), and the lack of a nearby mosaic of micro-habitats (eg from dense, floristically simple sites for nesting, to open floristically diverse sites for obtaining food (Claridge *et al.* 2007)). Given the above, the project is considered unlikely to affect critical foraging or breeding habitat of the Long-nosed Potoroo. However, habitat critical to the dispersal of an important population may be affected by the creation of a movement barrier (ie the highway).

The proposed dedicated fauna underpasses (and associated fauna fencing), riparian corridor enhancement (through rehabilitation and revegetation), and bridges over creek crossings will help mitigate impacts on habitat connectivity for this species.

Is the action likely to disrupt the breeding cycle of an important population?

The Long-nosed Potoroo requires a dense understorey in heaths or forest for breeding (DEC 2005y). No heaths occur in the study area. Limited potential breeding habitat occurs within the eucalypt forest patches (the riparian forest is considered unlikely to provide potential breeding resources). The potential habitat is considered only marginal due to the disturbed nature of the habitat (ie roadside), and the lack of a nearby mosaic of micro-habitats (eg from dense, floristically simple sites for nesting, to open floristically diverse sites for obtaining food (Claridge *et al.* 2007)). Within the study area, site 15 provides the most opportunities given its reasonable size and connectivity to other areas of habitat. The project would result in the removal of only roadside vegetation from site 15, leaving the remainder of the patch intact.

The project is unlikely to impact high quality potential breeding resources for the Long-nosed Potoroo within the study area, however, the impacts to the local wildlife corridors could affect dispersal of the species. This could result in reduced breeding success of a local population. However, the proposed dedicated fauna underpasses (and associated fauna fencing), riparian corridor enhancement (through rehabilitation and revegetation), and bridges over creek crossings will help mitigate impacts on habitat connectivity for the Long-nosed Potoroo.

Is the action likely to modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?

The project would directly impact up to 27.8 hectares of limited potential foraging and breeding habitat (eucalypt and riparian forest) for the Long-nosed Potoroo. Within the area of OEH vegetation mapping (as amended following the field surveys), the habitat to be directly impacted represents 0.8 per cent of potential habitat within the locality (3628.0 hectares). A further 26.05 hectares of eucalypt and riparian forest would be indirectly affected (eg edge effects) by the project. This equates to about 0.7 per cent of potential habitat within the locality. In total, 1.5 per cent of the potential habitat occurring in the locality would be impacted by the project.

Although the Long-nosed Potoroo has the potential to occur in the study area, the habitat to be modified, destroyed and/or removed is predominantly disturbed roadside and disturbed riparian vegetation. The project is considered unlikely to decrease the availability or quality of habitat to the extent that the species may decline. Regardless, this disturbed habitat forms part of a discontinuous wildlife corridor between Seven Mile Beach National Park and Barren Grounds Nature Reserve and is therefore considered to be of high importance for the long-term survival of the Long-nosed Potoroo occurring within the study area and surrounds. It is considered possible that the project would isolate areas of habitat (through the creation of a movement barrier; ie the highway) to the extent that the Long-nosed Potoroo may decline

However, the proposed dedicated fauna underpasses (and associated fauna fencing), riparian corridor enhancement (through rehabilitation and revegetation), and bridges over creek crossings will help mitigate impacts on habitat connectivity for this species.

Is the action likely to result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat;

DSEWPaC does not identify any threats to the Long-nosed Potoroo (DEWHA 2009c).

Is the action likely to introduce disease that may cause the species to decline?

DSEWPaC does not list disease as a threat to the Long-nosed Potoroo (DEWHA 2009c).

Is the action likely to interfere substantially with the recovery of the species?

There is currently no recovery plan for the Long-nosed Potoroo.

DSEWPaC identify the red fox as a threat to the recovery of the Long-nosed Potoroo within the threat abatement plan for predation by the European red fox (DEWHA 2008d). Dedicated fauna underpasses, whilst serving to maintain connectivity either side of the highway for native fauna, may encourage exotic pest species such as foxes to cross the highway also. Maintaining habitat connectivity for the Long-nosed Potoroo provides the opportunity for dispersal and to maintain and/or strengthen genetic continuity and an effective population size, thus giving the species a fighting chance against existing pest species.

Targeted surveys were conducted for the Long-nosed Potoroo. The project would result in the removal of limited potential habitat. However, as discussed above, the areas to be removed are already disturbed. Similar habitat resources occur and would remain adjacent to the cleared areas. A vegetation management plan (including weed control) is proposed to help minimise impacts on fauna and fauna habitats (Chapter 5).

The project has the potential to impact on the ability of the Long-nosed Potoroo to cross the highway. However, the mitigation measures described in Chapter 5 including fauna underpasses, riparian corridor enhancement (through rehabilitation and revegetation), and bridges over creek crossings would help compensate for the loss of habitat connectivity in the event the species does on occasion use habitat to the south and east of the upgrade.

Conclusion

Based on the above assessment, the Long-nosed Potoroo is unlikely to be significantly impacted by the project, and as such, a Referral under the provisions of the EPBC Act is not recommended for this species.

Pteropus poliocephalus Grey-headed Flying-fox

The Grey-headed Flying-fox is listed as Vulnerable under the EPBC Act. The species is also listed as Vulnerable on the TSC Act.

Is the action likely to lead to a long-term decrease in the size of an important population of a species?

The Grey-headed Flying-fox is found in a variety of habitats, including rainforest, mangroves, paperbark swamps, wet and dry sclerophyll forests and cultivated areas (Churchill 1998). The species is a canopy-feeding frugivore and nectarivore. Their major food source is Myrtaceae blossom (mostly eucalypt) and fruits such as native figs (*Ficus* spp.) and cultivated fruit orchards (Churchill 1998). Bats commute daily to foraging areas, usually within 15 kilometres of the day roost (Strahan 1995), although some individuals may travel up to 70 kilometres. Grey-headed flying-foxes seasonally congregate in large camps of up to 200,000 individuals (Churchill 1998). The availability of blossom in the surrounding area influences the number of bats in a camp (Churchill 1998).

The Grey-headed Flying-fox was recorded foraging at site 15 during the field surveys. The species has also been previously recorded six times within the locality, predominantly to the south but also to the north-east and west. These records occurred between 1994 and 2008 (DECCW 2011).

The study area provides known and potential foraging habitat for the Grey-headed Flying-fox within the eucalypt and riparian forests and woodlands. No evidence of a camp site (breeding habitat) was found within the study area. Known camp sites occur within Coomonderry Swamp approximately 5.5 kilometres southeast of Berry, and at Bomaderry Creek approximately 13 kilometres southwest of the study area.

The project would impact potential foraging habitat for the Grey-headed Flying-fox through the removal of eucalypt and riparian forest and woodland. About 27.8 hectares of eucalypt and riparian forest (known and/or potential foraging habitat) would be removed from the study area with a further 26.05 hectares affected by indirect impacts (eg edge effects). This equates to only 1.4 per cent of the potential habitat (eg eucalypt and riparian forest, rainforest, mangroves and paperbark swamps) available within the locality (3792.6 hectares; which also fits the description of 'critical foraging habitat' (DECCW 2009b). Given the availability of known and potential habitat within the locality (including protected habitat within Seven Mile Beach National Park), that no breeding habitat would be impacted and the high mobility of this species, it is considered unlikely that the project would lead to a long-term decrease in the size of an important population of the Grey-headed Flying-fox.

Is the action likely to reduce the area of occupancy of an important population?

The study area does not lie at or near the limit of the area of occupancy of the Grey-headed Flying-fox, which extends from Bundaberg in Queensland to Melbourne in Victoria (DEC 2005t).
The Grey-headed Flying-fox is known to forage in the study area. Given the distribution of records of the species within 10 kilometres, individuals from the Bomaderry Creek and Comerong Island camps are likely to utilise resources within the study area. However, given the high mobility of the Grey-headed Flying-fox (able to travel up to 70 kilometres from a camp site) and the availability of known and potential habitat in the locality (including protected habitat within Seven Mile Beach National Park), the loss of 27.8 hectares eucalypt and riparian forest considered to be 'critical foraging habitat' (predominantly disturbed roadside and disturbed riparian habitat) is unlikely to reduce the area of occupancy of an important population of the species.

Is the action likely to fragment an existing population into two or more populations?

Grey-headed flying-foxes commute daily to foraging areas, usually within 15 kilometres of the day roost (Strathan 1995), although some individuals may travel up to 70 kilometres. The project would involve removal of known and potential foraging habitat from the study area. The areas to be removed (predominantly roadside and riparian areas) are contiguous with intact forest that would remain. Given the availability of surrounding eucalypt and riparian forests, the small areas of proposed vegetation removal (the 27.8 hectares to be removed is made up of smaller areas spread along the 11.6 kilometres route including proposed ancillary sites) and the high mobility of the Grey-headed Flying-fox, it is considered unlikely that the project would fragment an existing population into two or more populations.

Is the action likely to adversely affect habitat critical to the survival of a species?

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations or ecological communities. A Register of Critical Habitat is maintained by the Minister under the EPBC Act. To date, no critical habitat has been declared for the Grey-headed Flying-fox (DEWHA 2009d).

Critical habitat can also refer to areas that are necessary for activities such as foraging, breeding or dispersal; for the long-term maintenance of the species; to maintain genetic diversity and long-term evolutionary development; or for the reintroduction of populations or recovery of the species (DEWHA 2009d). The *Draft National Recovery Plan for the Grey-headed Flying-fox* Pteropus poliocephalus (DECCW 2009b) describes foraging habitat that is considered critical to the survival of the species. The vegetation to be removed by the project is consistent with criteria number three listed in the recovery plan: natural foraging habitat that is productive during the final weeks of gestation, and during the weeks of birth, lactation and conception (September to May). Therefore, the project would adversely affect habitat critical to the survival of the Grey-headed Flying-fox, according to the draft recovery plan (DECCW 2009b). However, the foraging habitat to be directly impacted is predominantly disturbed roadside and disturbed riparian vegetation (ie in poor condition); and constitutes only 1.4 per cent of that available in the locality.

Is the action likely to disrupt the breeding cycle of an important population?

Pregnant Grey-headed Flying-foxes congregate in maternity camps, giving birth to a single young a couple of weeks later (Churchill 1998). No Grey-headed Flying-fox colonies have been mapped within the locality; although the Bomaderry Creek camp is located approximately 10.5 kilometres southwest of Berry, and at Comerong Island approximately 12.2 kilometres south of the study area (DECCW 2008). Breeding is unlikely to occur within the study area.

Given the impacts to potential foraging habitat are unlikely to lead to a long-term decrease in the size of an important population of the Grey-headed Flying-fox (described above) and that no breeding habitat would be impacted, it is considered unlikely that the project would disrupt the breeding cycle of an important population of the Grey-headed Flying-fox.

Is the action likely to modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?

The project would directly impact up to 27.8 hectares of known and potential foraging habitat (eucalypt and riparian forest) for the Grey-headed Flying-fox. Within the area of OEH vegetation mapping (as amended following the field surveys), the habitat to be directly impacted represents 0.7 per cent of potential habitat within the locality (3792.6 hectares; which also fits the description of 'critical foraging habitat' (DECCW 2009b). A further 26.05 hectares of eucalypt and riparian forest would be indirectly affected (eg edge effects) by the project. This equates to about 0.7 per cent of potential habitat within the locality. In total, 1.4 per cent of the potential habitat occurring in the locality would be impacted by the project.

Although the Grey-headed Flying-fox is known to forage in the study area, and that the habitat fits the description of 'critical foraging habitat' (DECCW 2009b), the habitat to be directly impacted is predominantly disturbed roadside and disturbed riparian vegetation and is considered to be of low to moderate importance for the long-term survival of the Grey-headed Flying-fox. Given this, the large (and diverse) extent of potential habitat available in the locality (3792.6 hectares; which also fits the description of 'critical foraging habitat' (DECCW 2009b) and the species' high mobility, the loss and/or disturbance of 1.4 per cent of potential habitat within the locality is considered unlikely to modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the Grey-headed Flying-fox is likely to decline.

Is the action likely to result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat;

DSEWPaC identifies competition with the black flying-fox (*Pteropus alecto*) as a threat to the Grey-headed Flying-fox due to shared roosting and foraging resources (DEWHA 2009b). However, the study area occurs well south of the southern limit of the black flying-fox's distribution with sporadic records for the species in Sydney, Taree and Port Macquarie (DEC 2005c); and the project is unlikely to result in this species becoming established in the study area or locality.

Is the action likely to introduce disease that may cause the species to decline?

The Grey-headed Flying-fox may be susceptible to pathogens such as the Australian bat Lyssavirus and pollutants such as lead (DEWHA 2009b). The project is unlikely to introduce the Australian bat Lyssavirus to the study area. Although the project would result in the increased capacity for traffic movement, and therefore possibly increased exhaust gases in the environment, it is unlikely to increase the incidence of lead to the point that the Grey-headed Flying-fox would decline.

Is the action likely to interfere substantially with the recovery of the species?

OEH (on behalf of DSEWPaC) has developed a draft national recovery plan for the Grey-headed Flying-fox (DEWHA 2009b). The following recovery objectives outlined in this plan relevant to the project include:

1. Identify and protect foraging habitat critical to the survival of Grey-headed Flying-foxes throughout their range.
2. Identify, protect and enhance roosting habitat critical to the survival of Grey-headed Flying-foxes.

The Grey-headed Flying-fox is known to forage within the study area and the foraging habitat is considered to be critical to the species' survival (DECCW 2009b). However, the foraging habitat to be directly impacted (0.7 per cent of that occurring in the locality) is predominantly disturbed roadside and disturbed riparian vegetation (ie in poor condition). Whilst adjoining areas of foraging habitat would be subject to indirect impacts such as weed invasion and increased light penetration (also 0.7 per cent of that occurring in the locality), the habitat would not be removed. Further, the majority of potential habitat occurring in the locality also likely meets the criteria for identification as 'critical foraging habitat' (DECCW 2009b).

No evidence of a camp site (roosting/breeding habitat) was found within the study area. No Grey-headed Flying-fox colonies have been mapped within the locality; although the Bomaderry Creek camp is located approximately 10.5 kilometres southwest of Berry, and at Comerong Island approximately 12.2 kilometres south of the study area (DECCW 2008)., These camps would not be impacted by the project.

Given that evidence of a camp site was not found within the study area, and that a total of only 1.4 per cent of potential habitat within the locality would be impacted (directly and indirectly), it is unlikely that the project would interfere with these recovery objectives.

Conclusion

Based on the above assessment the Grey-headed Flying-fox is unlikely to be significantly impacted by the project, and as such, a Referral under the provisions of the EPBC Act is not recommended for this species.

Phascolarctos cinereus Koala

The Koala is listed as Vulnerable under the EPBC Act. The species is also listed as Vulnerable under the TSC Act.

Is the action likely to lead to a long-term decrease in the size of an important population of a species?

Koalas live in breeding aggregations comprised of a dominant male, a small number of mature females, and juveniles (DECC 2008). The home range of Koalas varies depending on the quality of the habitat and the number of available food trees. Home ranges can vary from less than one hectare to 500 hectares (DECC 2008). Home ranges in the Pilliga State Forest overlapped for both sexes and were about 12 hectares for males and nine hectares for females. Koalas were found to continue to occupy all or part of their previous home-ranges after selective logging, and home-range sizes remained similar between logged and unlogged areas (Kavanagh *et al.* 2007).

The Koala was not recorded during the field surveys. There have been three records of the species within the locality (DECCW 2011); one record to the north and two records to the south of the study area (recorded between 2004 and 2005). Two additional records occur outside the locality but within 10 kilometres; one to the north-east (2004) and one to the south (1940).

The study area provides limited potential foraging habitat for the Koala within the eucalypt forests and woodlands. Although some preferred feed tree species were recorded during the field surveys (eg *Eucalyptus microcorys*, *E. racemosa*, *E. robusta* and *E. tereticornis*), none were dominant within the forest/woodland patches of the study area. Based on the low density of preferred feed trees and the absence of records of this well-recognised species within the study area, it is considered unlikely that the study area supports (or could support) a population of Koala. However, it is possible that the species moves through the study area on occasion between areas of potential habitat.

About 22.2 hectares of eucalypt forest (limited potential habitat) would be removed from the study area with a further 17.5 hectares affected by indirect impacts (eg edge effects). This equates to only 1.6 per cent of the potential habitat available within the locality (2425.7 hectares). The impacts of the loss of potential habitat are amplified by the fragmentation of fauna movement corridors through the study area (see below). The project would not only result in the loss of potential habitat, it could also limit the ability of the Koala to access other areas of habitat within the locality.

In order to mitigate impacts of corridor fragmentation, riparian corridor enhancement (through rehabilitation and revegetation) and fauna crossing structures are proposed (Chapter 5). Given the availability of known and potential habitat within the locality, the reasonable mobility of this species and provided the mitigation measures in Chapter 5 are implemented, the project is unlikely to result in a long-term decrease in the size of an important population of the Koala.

Is the action likely to reduce the area of occupancy of an important population?

The Koala has a fragmented distribution throughout eastern Australia extending from north-east Queensland to the Eyre Peninsula in South Australia (DEC 2005v). The study area is not at, or near, the limit of distribution for this species.

The project would directly impact up to 22.2 hectares of potential foraging habitat (eucalypt forest) for the Koala (some of which contains preferred feed tree species). Within the area of DEC vegetation mapping (as amended following the field surveys), the habitat to be directly impacted represents 0.9 per cent of potential habitat within the locality (2425.7 hectares). A further 17.5 hectares of eucalypt forest would be indirectly affected (eg edge effects) by the project. This equates to about 0.7 per cent of potential habitat within the locality. In total, 1.6 per cent of the potential habitat occurring in the locality would be impacted by the project.

Given the lack of records of this conspicuous species in the locality; that a total of only 1.6 per cent potential habitat would be impacted by the project (either directly or indirectly); that the study area is not at, or near, the limit of distribution for this species; and, provided the mitigation measures in Chapter 5 are implemented (to reduce impacts to wildlife corridors), the project is unlikely to reduce the area of occupancy of an important population of Koala.

Is the action likely to fragment an existing population into two or more populations?

The Koala has been recorded within the locality to the north of the project near Foxground, and to the south near Foys Swamp and Back Forest. The Toolijooa Ridge – Harley Hill wildlife corridor may provide connectivity for this species. The project crosses the Toolijooa Ridge – Harley Hill and Broughton Creek corridors, as well as a number of smaller riparian and roadside corridors. By crossing these wildlife corridors, the project creates (or increases) a barrier to fauna movement between areas of potential habitat.

In order to mitigate impacts of corridor fragmentation, riparian corridor enhancement (through rehabilitation and revegetation) and fauna crossing structures are proposed (Chapter 5). The proposed riparian corridor enhancement and fauna underpasses may help mitigate impacts on habitat connectivity for this species.

Given the availability of known and potential habitat within the locality, the reasonable mobility of this species and provided the mitigation measures in Chapter 5 are implemented, it is considered unlikely that the project would result in the fragmentation of a population of Koala into two or more populations.

Is the action likely to adversely affect habitat critical to the survival of a species?

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations or ecological communities. A Register of Critical Habitat is maintained by the Minister under the EPBC Act. To date, no critical habitat has been declared for the Koala (DEWHA 2009d).

Critical habitat can also refer to areas that are necessary for activities such as foraging, breeding or dispersal; for the long-term maintenance of the species; to maintain genetic diversity and long-term evolutionary development; or for the reintroduction of populations or recovery of the species (DEWHA 2009d).

In addition to the general criteria by DEWHA (2009) to define critical habitat the *Interim koala referral advice for proponents* (DSEWPaC, 2012) provide a more detailed set of criteria to define habitat critical to the survival of the Koala focusing on primary and secondary food tree species cited in the NSW Recovery Plan for the species (DECC, 2008). The DSEWPaC (2012) critical habitat criteria are assessed below and with reference to the Koala food tree species inventory for the NSW south coast from DECC (2008).

Habitat critical to the survival of the koala is currently considered to be areas of forest or woodland where:

- *Primary koala food tree species comprise at least 30 per cent of the overstorey trees*.

  Primary koala food tree species recorded in the current surveys are *Eucalyptus amplifolia* ssp. *amplifolia* and *Eucalyptus tereticornis*. In combination these two tree species comprise less than 30% of the overstorey trees.

- *Primary koala food tree species comprise less than 30 per cent of the overstorey trees, but together with secondary food tree species comprise at least 50 per cent of the overstorey trees.*

  The primary koala food tree species *Eucalyptus amplifolia* ssp*. amplifolia* and *Eucalyptus tereticornis* in combination comprise less than 30 per cent of the overstorey trees. The secondary koala food tree species *Eucalyptus scias* ssp. *scias* is recorded in the current surveys. In combination the two primary and one secondary food tree species comprise less than 30 per cent of the overstorey trees.

- *Primary food tree species are absent but secondary food tree species alone comprise at least 50 per cent of the overstorey trees.*

  In combination the two primary and one secondary food tree species comprise less than 30 per cent of the overstorey trees.

- *The above qualities may be absent in a forest or woodland but other essential habitat features are present and adjacent to areas exhibiting the above qualities.*

  DECC (2008) suggest that habitat for koalas is influenced by a range of factors such as species and size of trees present, structural diversity of the vegetation, soil nutrients, climate and rainfall, size and disturbance history of the habitat patch. Finer scale habitat features for these factors include the diversity of other non feed tree species, the presence of suitable shelter trees, some groundcover vegetation and other features such as hollow logs, leaf chemistry and its relationship to soil nutrient status, soil moisture and proximity to waterways, edge effects on patches of habitat and presence of predators (DECC, 2008). In summary other essential habitat features mentioned are affected by the long history of rural land use and the associated impacts. The study area is unlikely to support a matrix of high quality additional essential habitat features critical to the survival of the species in the region.

- *A relatively high density of koalas is supported, regardless of the presence of food tree species. Koala population densities vary across their range and regional data should be used to judge relative density.*

  There have been three records of the species within the locality (DECCW 2011) including one record to the north and two records to the south of the study area (recorded between 2004 and 2005). Two additional records occur outside the locality but within 10 kilometres; one to the north-east (2004) and one to the south (1940). These records are not considered to represent a relatively high density of koalas.

- *Habitat critical to the survival of the koala is also considered to be any form of landscape corridor which is essential to the dispersal of koalas between forest or woodland habitats.*

  Corridors at local and regional scale are discussed in Section 3.8 of the report and mapped in mapped in Figure 3.4. In summary the project creates (or increases) a barrier to fauna movement between areas of potential habitat. In order to mitigate impacts of corridor fragmentation, riparian corridor enhancement (through rehabilitation and revegetation) and fauna crossing structures are proposed (Chapter 5). The proposed riparian corridor enhancement and fauna underpasses may help mitigate impacts on habitat connectivity for this species.

It is considered possible that the Koala occurs within and passes through the study area from time to time. By crossing the Toolijooa Ridge – Harley Hill and Broughton Creek wildlife corridors, as well as a number of smaller riparian and roadside corridors, the project creates (or increases) a barrier to fauna movement between areas of habitat. This may result in the fragmentation of a population of Koala into two or more populations, which could limit the genetic diversity of the populations. However, the proposed dedicated fauna underpasses (and associated fauna fencing), riparian corridor enhancement (through rehabilitation and revegetation), and bridges over creek crossings will help mitigate impacts on habitat connectivity for this species.

Is the action likely to disrupt the breeding cycle of an important population?

The Koala inhabits eucalypt forests and woodlands. The suitability of these forests for habitation depends on the size and species of trees present, soil nutrients, climate and rainfall (Reed and Lunney 1990, DECC 2008). Koalas live in breeding aggregations comprised of a dominant male, a small number of mature females, and juveniles, with adult Koalas generally exhibiting long-term fidelity to their individual home range areas (DECC 2008). Based on the low density of preferred feed trees and the absence of records of this conspicuous species within the study area, it is considered unlikely that the study area supports (or could support) a breeding population of Koala. However, it is possible that the species moves through the study area on occasion between areas of potential habitat.

Potential habitat in the study area forms part of a discontinuous wildlife corridor between Seven Mile Beach National Park and Barren Grounds Nature Reserve and is therefore important for the long-term survival of the Koala within the locality. Impacts to the wildlife corridors could affect dispersal of the species which could result in reduced breeding success of a local population.

Provided the mitigation measures described in Chapter 5 are implemented (to minimise potential impacts to wildlife movement corridors), it is considered unlikely that the project would disrupt the breeding cycle of an important population of Koala.

Is the action likely to modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?

The project would directly impact up to 22.2 hectares of potential foraging habitat (eucalypt forest) for the Koala (some of which contains preferred feed tree species). Within the area of DEC vegetation mapping (as amended following the field surveys), the habitat to be directly impacted represents 0.9 per cent of potential habitat within the locality (2425.7 hectares). A further 17.5 hectares of eucalypt forest would be indirectly affected (eg edge effects) by the project. This equates to about 0.7 per cent of potential habitat within the locality. In total, 1.6 per cent of the potential habitat occurring in the locality would be impacted by the project.

Although the Koala has the potential to occur in the study area, the habitat to be modified, destroyed and/or removed is predominantly disturbed roadside and disturbed riparian vegetation. The project is considered unlikely to decrease the availability or quality of habitat to the extent that the species may decline. Regardless, this disturbed habitat forms part of a discontinuous wildlife corridor between Seven Mile Beach National Park and Barren Grounds Nature Reserve and is therefore important for the long-term survival of the Koala occurring within the study area and surrounds. It is considered possible that the project may isolate areas of habitat (through the creation of a movement barrier; ie the highway).

However, the proposed dedicated fauna underpasses (and associated fauna fencing), riparian corridor enhancement (through rehabilitation and revegetation), and bridges over creek crossings will help mitigate impacts on habitat connectivity for this species. Therefore, the project is considered unlikely to result in the decline of the Koala.

Is the action likely to result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat?

DSEWPaC identifies predation by dogs as a threat to the Koala (DSEWPaC 2012). However, dogs are already present in the study area and the project is unlikely to increase their prevalence. Refuge poles (timber poles) erected within and/or at the entrances to fauna underpasses are recommended (Chapter 5) to allow arboreal mammals (such as the Koala) a place to seek refuge should they encounter a terrestrial predator (eg dog) whilst attempting to make a crossing.

Is the action likely to introduce disease that may cause the species to decline?

The two primary known diseases that threaten the Koala are Chlamydia and Koala Retrovirus. Chlamydia can be transmitted between Koalas sexually, to young in the birth canal, and possibly through fighting. The Koala Retrovirus is transmitted genetically (ie by inheritance) from parents to offspring and possibly by close contact, including from infected mothers to their joeys via the milk (DSEWPaC 2012). The project is considered unlikely to result in the introduction of these diseases into the study area.

It is possible that individual Koalas in the study area already carry these diseases. Chlamydiosis may contribute to local declines or extinctions in small, isolated populations, where recruitment rates between populations are low and mortalities from other threats are high. There is some evidence that Chlamydiosis may be exacerbated by the Koala Retrovirus (DSEWPaC 2012). Given this, maintaining habitat connectivity to avoid population isolation, encourage high recruitment rates and to reduce mortality, is of high importance to assisting Koalas battle such diseases. The dedicated fauna underpasses described in Chapter 5 are proposed to help maintain habitat connectivity.

Is the action likely to interfere substantially with the recovery of the species?

There is currently no published national recovery plan for the Koala.

DSEWPaC identify loss and fragmentation of habitat, vehicle strike, disease, and predation by the dog as a threat to the recovery of the Koala (DSEWPaC 2012). Dedicated fauna underpasses, whilst serving to maintain connectivity either side of the highway for native fauna, may encourage exotic pest species such as dogs to cross the highway also. Maintaining habitat connectivity for the Koala provides the opportunity for dispersal and to maintain and/or strengthen genetic continuity and an effective population size, thus giving the species improved odds against existing pest species and diseases. The recommended fauna exclusion fencing and refuge poles would also help to minimise the impacts of vehicle strike and terrestrial predator attack (during a crossing attempt), respectively.

The project is considered unlikely to interfere substantially with the recovery of the Koala.

Conclusion

Based on the above assessment, the Koala is unlikely to be significantly impacted by the project, and as such, a Referral under the provisions of the EPBC Act is not recommended for this species.

Litoria aurea **Green and Golden Bell Frog**

The Green and Golden Bell Frog is listed as Vulnerable under the EPBC Act. The species is also listed as Endangered under the TSC Act.

The Draft Recovery Plan for the Green and Golden Bell Frog (DEC 2005) refers to 11 Key Populations within the Shoalhaven LGA, one of which occurs in the locality of the study area. Coomonderry Swamp, located approximately four kilometres east of the study area is listed as a Key Population. No Green and Golden Bell Frog have been recorded in the study area however, given that the size of Green and Golden Bell Frog populations can rapidly expand during seasons of high breeding success, individuals are known to disperse across the landscape from core populations during these conditions and that the species has been known to disperse up to three kilometres in a night, farm dams and areas of low lying floodplain are considered to provide connective habitat for the Coomonderry Swamp population (including the associated farm dams and Foys Swamp to the north) to the study area.

Therefore it is considered that an 'important population' of the Green and Golden Bell Frog may occur within the study area for dispersal purposes on occasion, particularly following seasons of high reproductively. As there is potential for the works to result in a "break in continuity of vegetation (of) vegetated corridors linking habitat" an Assessment of significance has been undertaken based on non-limiting dispersal habitat according to the significant impact thresholds outlined in DEWHA (2009b).

Is the action likely to lead to a long-term decrease in the size of an important population of a species?

The Town Creek diversion will intersect the low-lying closed grassland habitat throughout the study area. It is considered that this flood prone land, as well as the current established aquatic environments of the Study Area such as Town Creek, Broughton Mill Creek, Bundewallah Creek may provide dispersal habitat for the Green and Golden Bell Frog on occasion. A number of mitigation measures have been recommended including bridges (underpasses) at each crossing of Broughton Creek and the retention and protection of existing riparian vegetation to allow for continued dispersal routes and refuge.

Given that Green and Golden Bell Frog are considered to be rare visitors to the study area and that impacts to dispersal habitat in the study area will be temporary in nature, the project is not considered likely action likely to lead to a long-term decrease in the size of an important population of the Green and Golden Bell Frog.

Is the action likely to reduce the area of occupancy of an important population?

The current known area of occupancy of the Green and Golden Bell Frog is centralised around the Coomonderry Swamp Key Population. It is possible that individuals disperse from this area to aquatic habitats of the study area in seasons of high reproductive success. The Town Creek diversion will intersect the low-lying closed grassland habitat throughout the study area. It is considered that this flood prone land, as well as the current established aquatic environments of the Study Area such as Town Creek, Broughton Mill Creek, Bundewallah Creek may provide dispersal habitat for the Green and Golden Bell Frog on occasion.

It is unlikely that the project will impact the existing area of occupancy of an important population located at Coomonderry Swamp or their dispersal requirements.

Is the action likely to fragment an existing population into two or more populations?

The Green and Golden Bell Frog have been recorded within the locality to the south at Coomonderry Swamp and to the east in farm dams and Foys Swamp. There are currently no records west of the study area and it is considered unlikely that the project would result in the fragmentation of a population of Green and Golden Bell Frog into two or more populations.

Is the action likely to adversely affect habitat critical to the survival of a species?

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations or ecological communities. A Register of Critical Habitat is maintained by the Minister under the EPBC Act. Critical habitat can also refer to areas that are necessary for activities such as foraging, breeding or dispersal; for the long-term maintenance of the species; to maintain genetic diversity and long-term evolutionary development; or for the reintroduction of populations or recovery of the species (DEWHA 2009d).

To date, no critical habitat has been declared for the Green and Golden Bell Frog and the proposed action would not impact any other critical habitat, such as that located at Coomonderry Swamp.

Is the action likely to disrupt the breeding cycle of an important population?

The subject site does not provide breeding habitat, and no impacts to breeding habitat are likely to occur. It is possible that individuals disperse from this core population to aquatic habitats of the study area in seasons of high reproductive success, although given the current disturbance regimes within the study area, breeding unlikely to be successful. Therefore, the project is not considered likely to impact the breeding cycle of an important population.

Is the action likely to modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?

As detailed above, limited breeding and foraging habitat is present within the study area and sheltering and dispersal habitat is present in the subject site and study area. There is potential for the GGBF to disperse through the subject site and study area on occasion, particularly in seasons of high reproductive success at the nearby (3-5 km) Coomonderry Swamp population.

The Town Creek diversion will intersect potential dispersal habitat, and although this may result in local changes to hydrology and disturbance of 0.2 hectares of constructed wetland forming part of the existing creek, the species is unlikely to regularly utilise this habitat for breeding, foraging, sheltering or over-wintering purposes due to the current disturbance regimes. Furthermore, impacts will be temporary in nature and are unlikely to permanently affect the current state of habitat. An additional 0.2 hectares of constructed habitat will be permanently removed as a result of the roadway.

Given that impacts to dispersal habitat in the subject site will be temporary in nature, the flow along the current Town Creek alignment will be maintained to an ecologically sustainable level and the species is only considered to occur within the study area on rare occasions for dispersal purposes, the project is not considered likely to modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.

Is the action likely to result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat?

Gambusia was recorded in all waterbodies across the study area. Gambusia are capable of preying on hatchlings and tadpoles of the Green and Golden Bell Frog and, in 1999 the NSW Science Committee determined that predation by Gambusia poses a serious threat to the survival of threatened species. It is now listed as a key threatening process under Schedule 3 of the TSC Act 1995 (NSW NPWS 2003).

Given that this invasive species is already present in all potential habitats of the study area, it is unlikely that the project will result in the further establishment of this invasive species.

Is the action likely to introduce disease that may cause the species to decline?

Green and Golden Bell Frogs are known to be highly susceptible to the effects of Chytrid fungus. Chytrid is consider to be present in nearby Green and Golden Bell Frog populations (F.Lemckert pers. comm,). It is also likely that individuals dispersing through the study area on occasion may already contain the disease.

The project is unlikely to significantly introduce or exacerbate the spread of disease that places the species at further risk of decline.

Is the action likely to interfere substantially with the recovery of the species?

The project is considered unlikely to interfere substantially with the recovery of the Green and Golden Bell Frog given the already limited nature of suitable habitat available within the study area, the distance to know suitable breeding habitat and that impacts associated with the project are likely to be temporary in nature.

Conclusion

According to DEWHA (2009a), there is a possibility of a significant impact on the Green and Golden Bell Frog, and a referral under the EPBC Act should be considered, if the action proposed results in:

- *The removal or degradation of aquatic or ephemeral habitat either where the Green and Golden Bell Frog has been recorded since 1995 or habitat that has been assessed as being suitable according to these guidelines. This can include impacts from chytrid, Gambusia originating offsite*

  Given that the species is not considered to be a permanent resident of the study area, removal or degradation of aquatic or ephemeral habitats in the study area will be temporary in nature and the flow along the current Town Creek alignment will be maintained to an ecologically sustainable level, it is considered unlikely that the project will result in the removal or degradation of habitat as listed above.

- *The removal or degradation of terrestrial habitat within 200 metres of habitat identified in threshold 1*

  See above.

- *Breaking the continuity of vegetation fringing ephemeral or permanent waterways or other vegetated corridors linking habitats meeting the criteria in threshold 1*

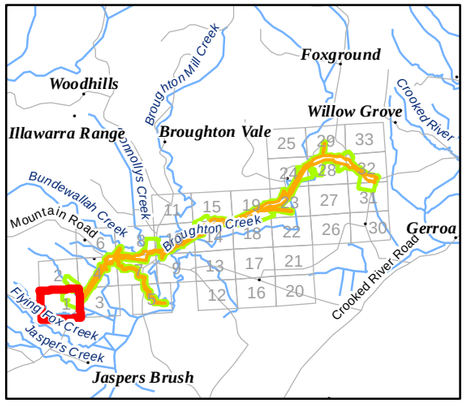
  The project will be undertaken in accordance with the guidelines set out in the recovery plan for this species as connectivity will be maintained through the measures listed above. This will ensure that the project would not interfere with the recovery of the species. Given that impacts to dispersal habitat in the study area will be temporary in nature, the flow along the current Town Creek alignment will be maintained to an ecologically sustainable level and provided that the management and mitigation measures in Section 5 of this report are adhered to, the project is not considered likely to affect habitat connectivity for the Green and Golden Bell Frog population at Coomonderry Swamp. Given the temporary and limited nature of the works, and the implementation of the mitigation measures listed above to maintain connectivity, it is considered unlikely that the project will result in a break in the continuity of vegetation fringing waterways or corridors linking habitat listed above.

Based on the above assessment and key thresholds, the Green and Golden Bell Frog is unlikely to be significantly impacted by the project, and as such, a Referral under the provisions of the EPBC Act is not recommended for this species.

Appendix J

Figure mapbooks





Legend

- Survey sites
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.1.1: Survey sites

Date: 13 July 2012	Drawn by: RS/JS/ANP
File: 13194	Checked by: JC
Location:P:\15000s\15039\Mapping\Variaition 1\Variation 1 Figures\13194_S2_F2-1_Sites_130712.mxd	

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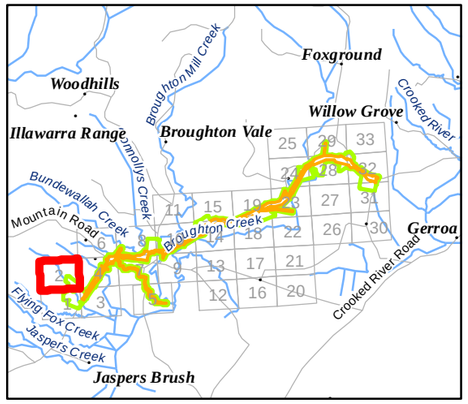
0 60 120 180 240
Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.1





Legend

- Survey sites
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.1.2: Survey sites

Date: 13 July 2012	Drawn by: RS/JS/ANP
File: 13194	Checked by: JC
Location:P:\15000s\15039\Mapping\Variaition 1\Variation 1 Figures\13194_S2_F2-1_Sites_130712.mxd	

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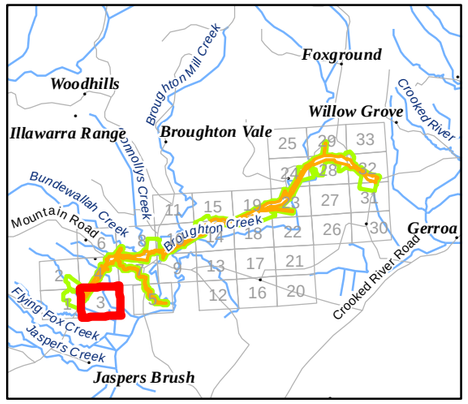
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Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.1





Legend

- Survey sites
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.1.3: Survey sites

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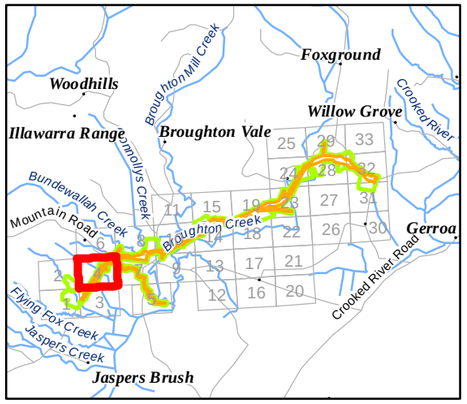
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Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.1





Legend

- Survey sites
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.1.4: Survey sites

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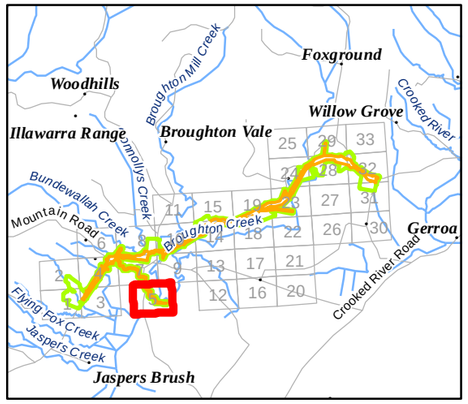
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Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.1





Legend

- Survey sites
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.1.5: Survey sites

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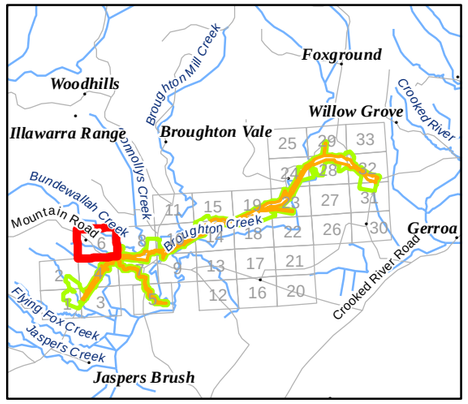
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Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.1





Legend

- Survey sites
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.1.6: Survey sites

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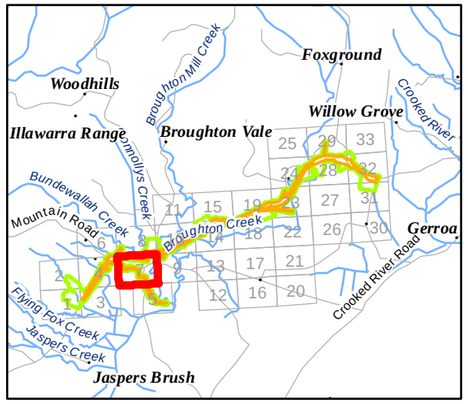
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Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.1





Legend

- Survey sites
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.1.7: Survey sites

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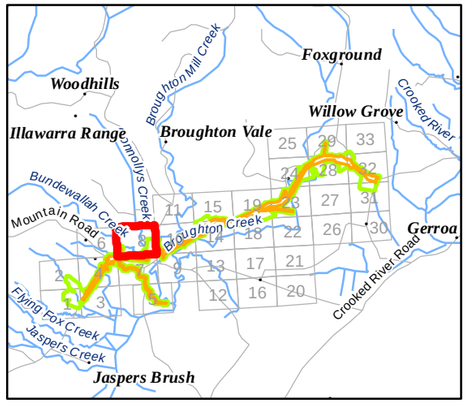
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Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.1





Legend

- Survey sites
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.1.8: Survey sites

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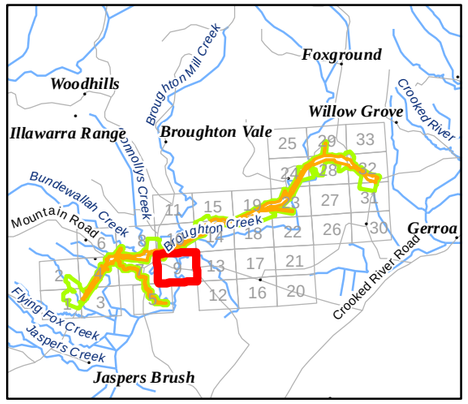
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Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.1





Legend

- Survey sites
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.1.9: Survey sites

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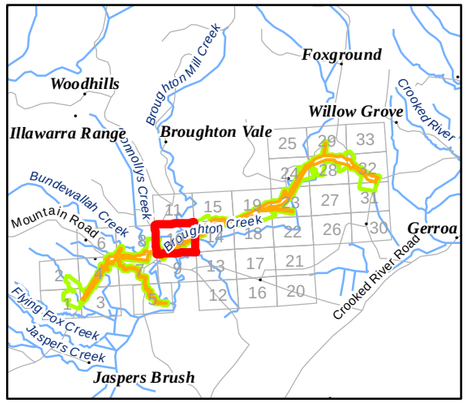
0 60 120 180 240
Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.1





Legend

- Survey sites
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.1.10: Survey sites

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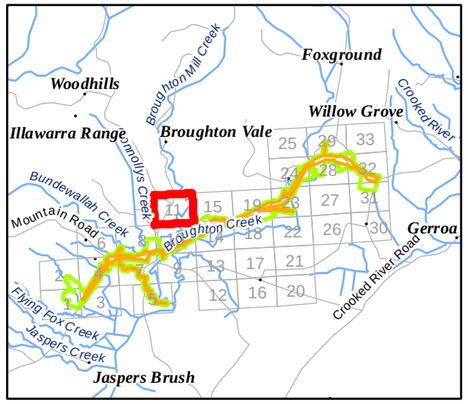
0 60 120 180 240
Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.1





Legend

- Survey sites
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.1.11: Survey sites

Date: 13 July 2012	Drawn by: RS/JS/ANP
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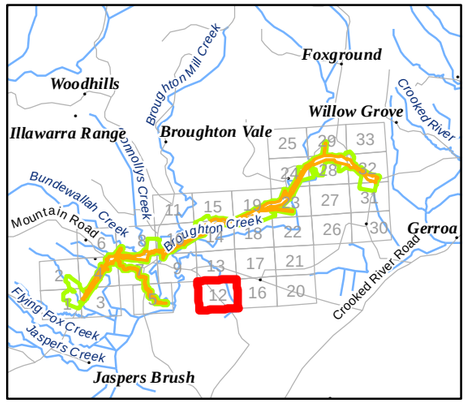
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Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.1





Legend

- Survey sites
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.1.12: Survey sites

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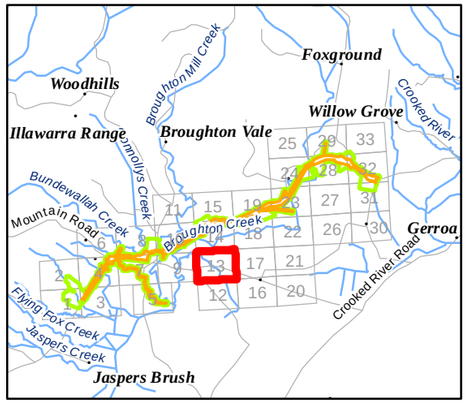
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Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.1





Legend

- Survey sites
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.1.13: Survey sites

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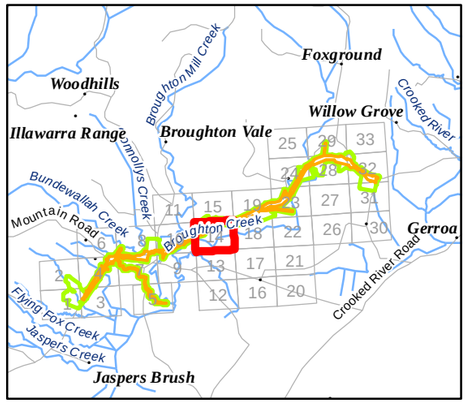
0 60 120 180 240
Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.1





Legend

- Survey sites
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.1.14: Survey sites

Date: 13 July 2012	Drawn by: RS/JS/ANP
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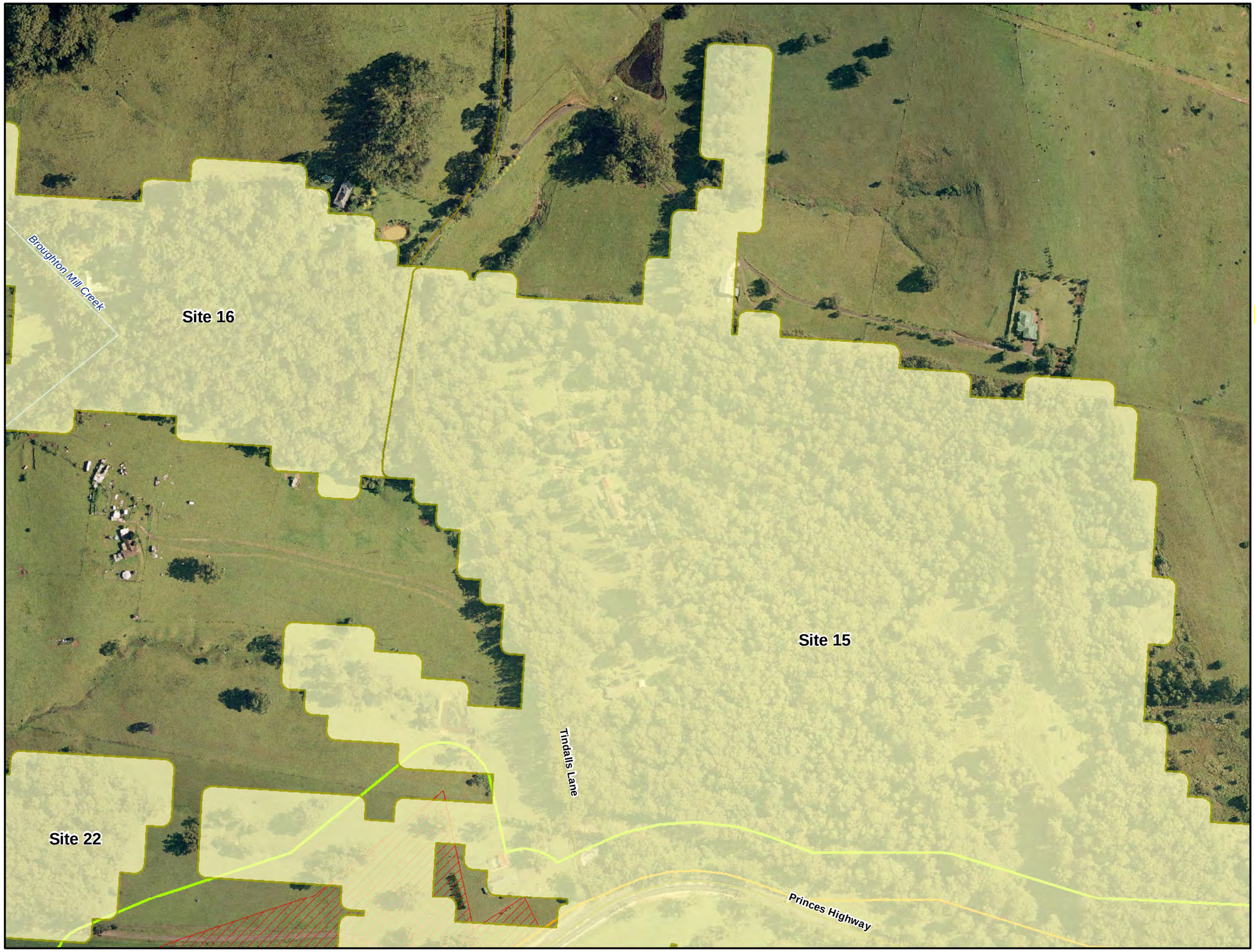
Acknowledgements:
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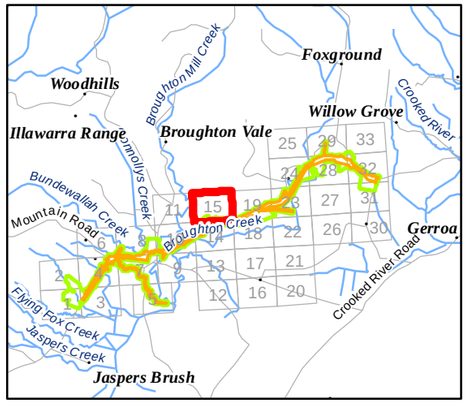
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Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.1





Legend

- Survey sites
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.1.15: Survey sites

Date: 13 July 2012	Drawn by: RS/JS/ANP
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0 60 120 180 240
Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.1

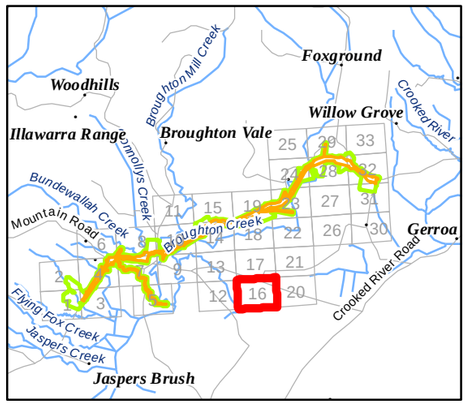
Site 7

Site 6

Site 25

Wire Lane

Beach Road



Legend

- Survey sites
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.1.16: Survey sites

Date: 13 July 2012	Drawn by: RS/JS/ANP
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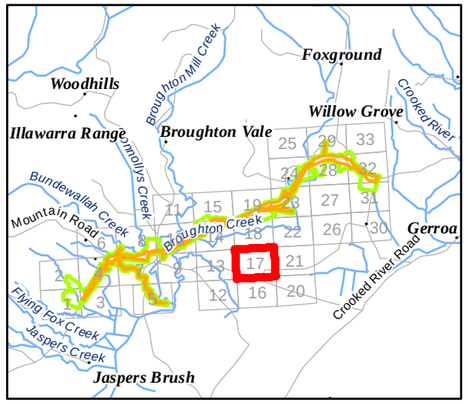
Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.1





Legend

- Survey sites
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.1.17: Survey sites

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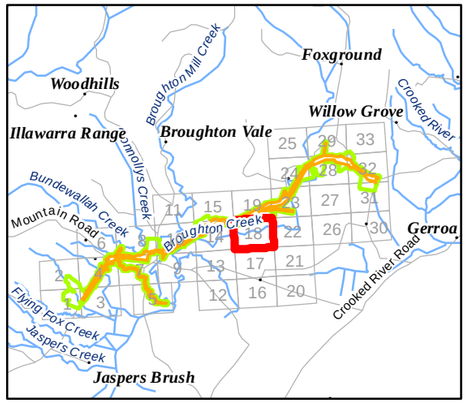
0 60 120 180 240
Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.1





Legend

- Survey sites
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.1.18: Survey sites

Date: 13 July 2012	Drawn by: RS/JS/ANP
File: 13194	Checked by: JC
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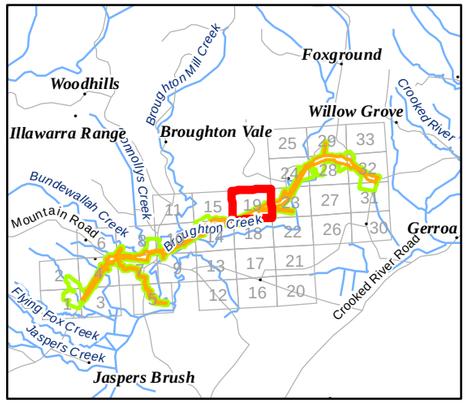
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Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.1





Legend

- Survey sites
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.1.19: Survey sites

Date: 13 July 2012	Drawn by: RS/JS/ANP
File: 13194	Checked by: JC
Location:P:\15000s\15039\Mapping\Variaition 1\Variation 1 Figures\13194_S2_F2-1_Sites_130712.mxd	

Acknowledgements:
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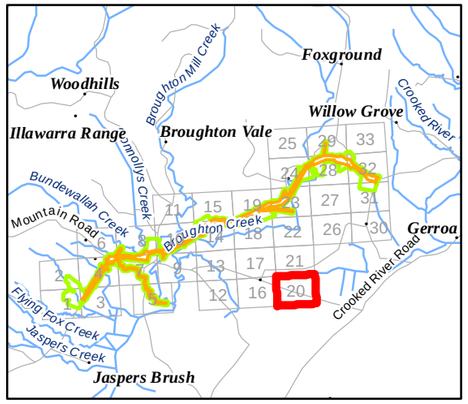
0 60 120 180 240
Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.1





Legend

- Survey sites
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.1.20: Survey sites

Date: 13 July 2012	Drawn by: RS/JS/ANP
File: 13194	Checked by: JC
Location:P:\15000s\15039\Mapping\Variaition 1\Variation 1 Figures\13194_S2_F2-1_Sites_130712.mxd	

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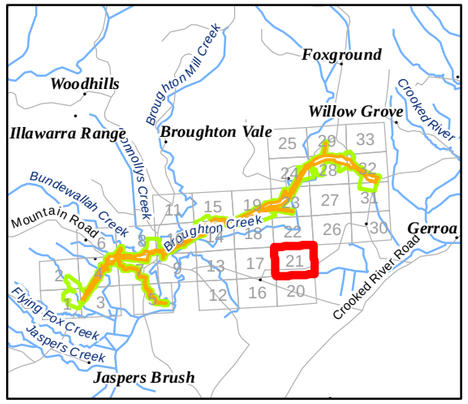
0 60 120 180 240
Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.1





Legend

- Survey sites
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.1.21: Survey sites

Date: 13 July 2012	Drawn by: RS/JS/ANP
File: 13194	Checked by: JC
Location:P:\15000s\15039\Mapping\Variaition 1\Variation 1 Figures\13194_S2_F2-1_Sites_130712.mxd	

Acknowledgements:
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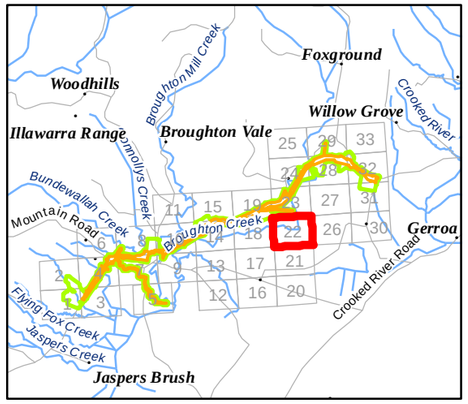
0 60 120 180 240
Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.1





Legend

- Survey sites
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.1.22: Survey sites

Date: 13 July 2012	Drawn by: RS/JS/ANP
File: 13194	Checked by: JC
Location:P:\15000s\15039\Mapping\Variaition 1\Variation 1 Figures\13194_S2_F2-1_Sites_130712.mxd	

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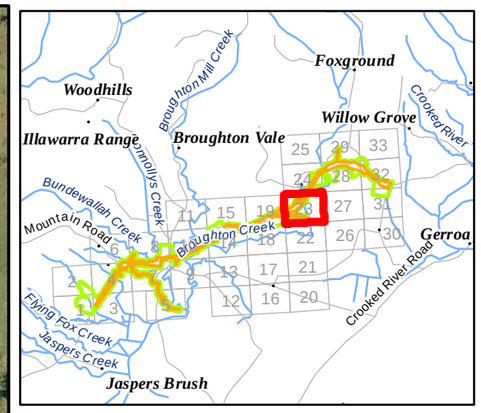
0 60 120 180 240
Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.1





Legend

- Survey sites
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.1.23: Survey sites

Date: 13 July 2012	Drawn by: RS/JS/ANP
File: 13194	Checked by: JC
Location:P:\15000s\15039\Mapping\Variaition 1\Variation 1 Figures\13194_S2_F2-1_Sites_130712.mxd	

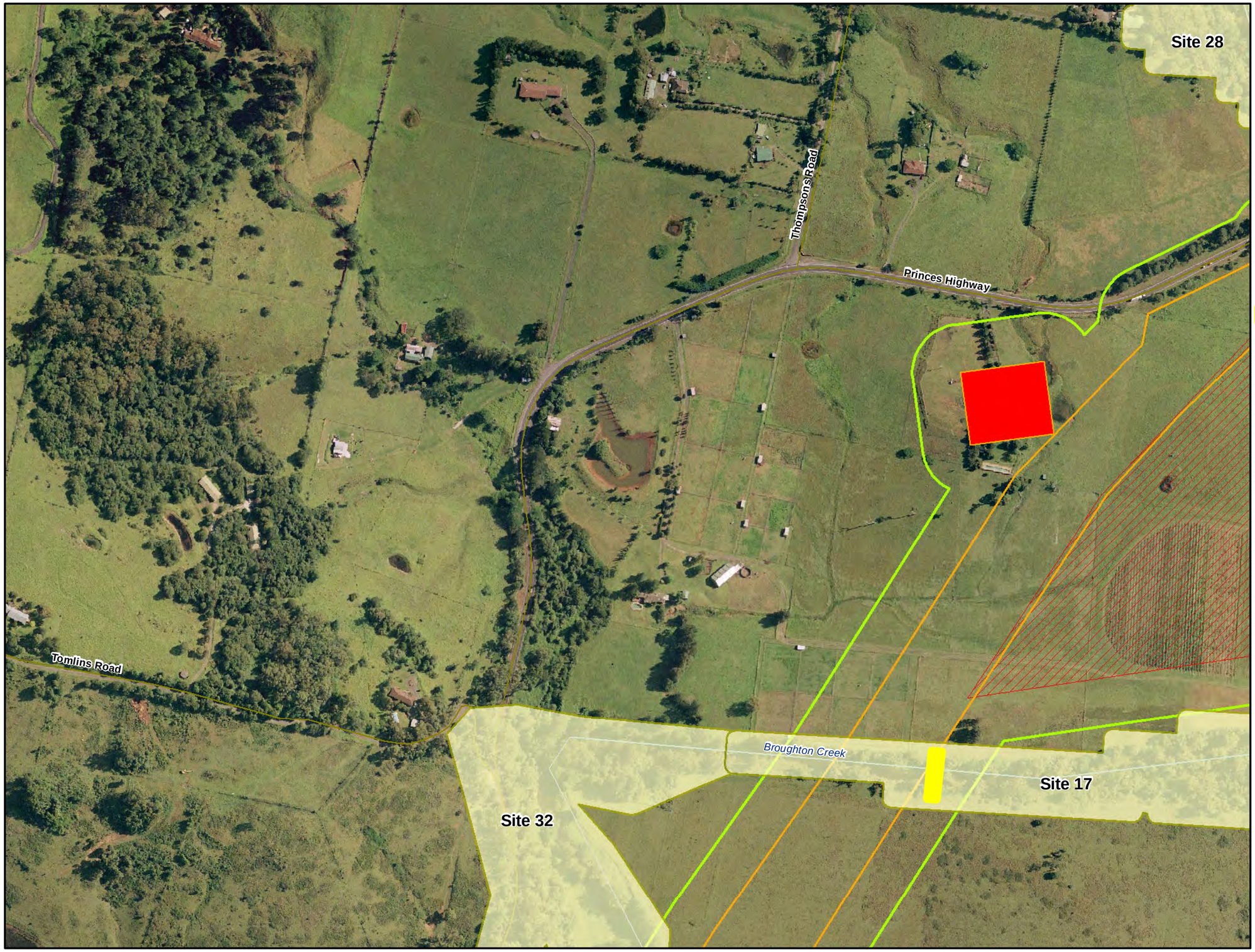
Acknowledgements:
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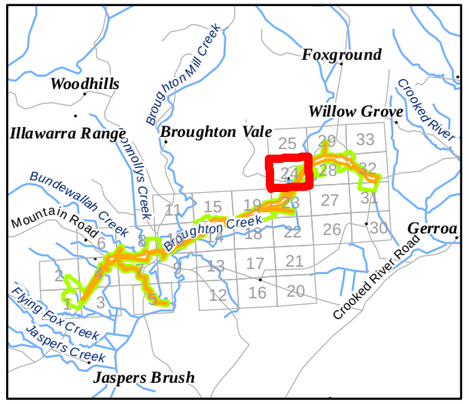
0 60 120 180 240
Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.1





Legend

- Survey sites
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.1.24: Survey sites

Date: 13 July 2012 | Drawn by: RS/JS/ANP

File: 13194 | Checked by: JC

Location:P:\15000s\15039\Mapping\Variaition 1\Variation 1 Figures\13194_S2_F2-1_Sites_130712.mxd

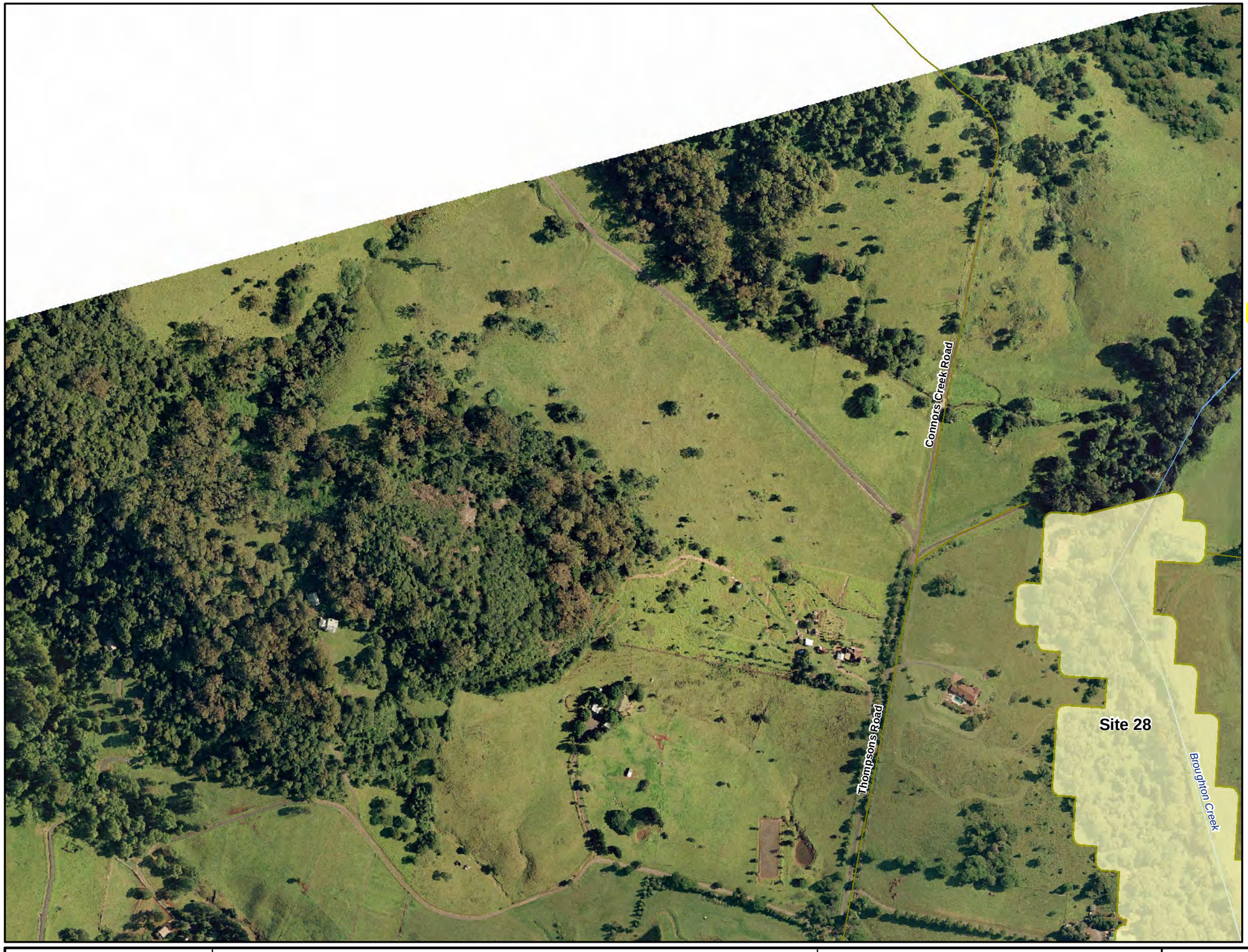
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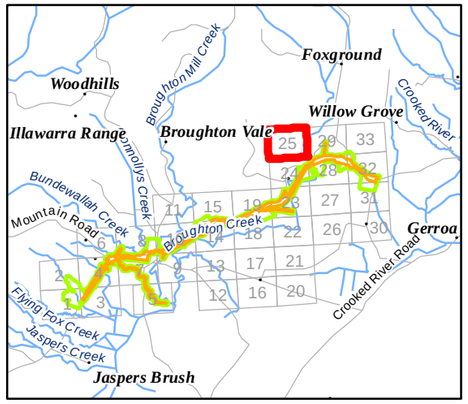
0 60 120 180 240
Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.1





Legend

- Survey sites
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.1.25: Survey sites

Date: 13 July 2012	Drawn by: RS/JS/ANP
File: 13194	Checked by: JC
Location:P:\15000s\15039\Mapping\Variaition 1\Variation 1 Figures\13194_S2_F2-1_Sites_130712.mxd	

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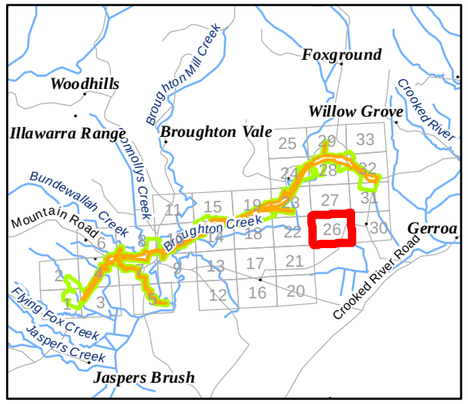
0 60 120 180 240
Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.1





Legend

- Survey sites
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.1.26: Survey sites

Date: 13 July 2012	Drawn by: RS/JS/ANP
File: 13194	Checked by: JC
Location:P:\15000s\15039\Mapping\Variaition 1\Variation 1 Figures\13194_S2_F2-1_Sites_130712.mxd	

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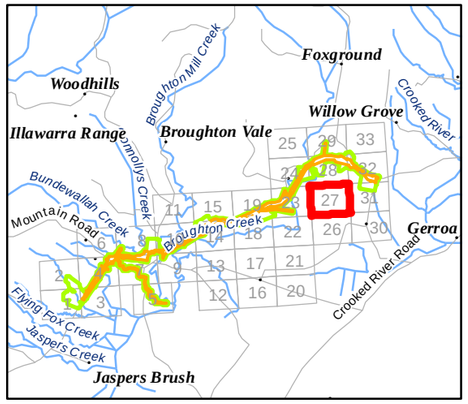
0 60 120 180 240
Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.1





Legend

- Survey sites
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.1.27: Survey sites

Date: 13 July 2012	Drawn by: RS/JS/ANP
File: 13194	Checked by: JC
Location:P:\15000s\15039\Mapping\Variaition 1\Variation 1 Figures\13194_S2_F2-1_Sites_130712.mxd	

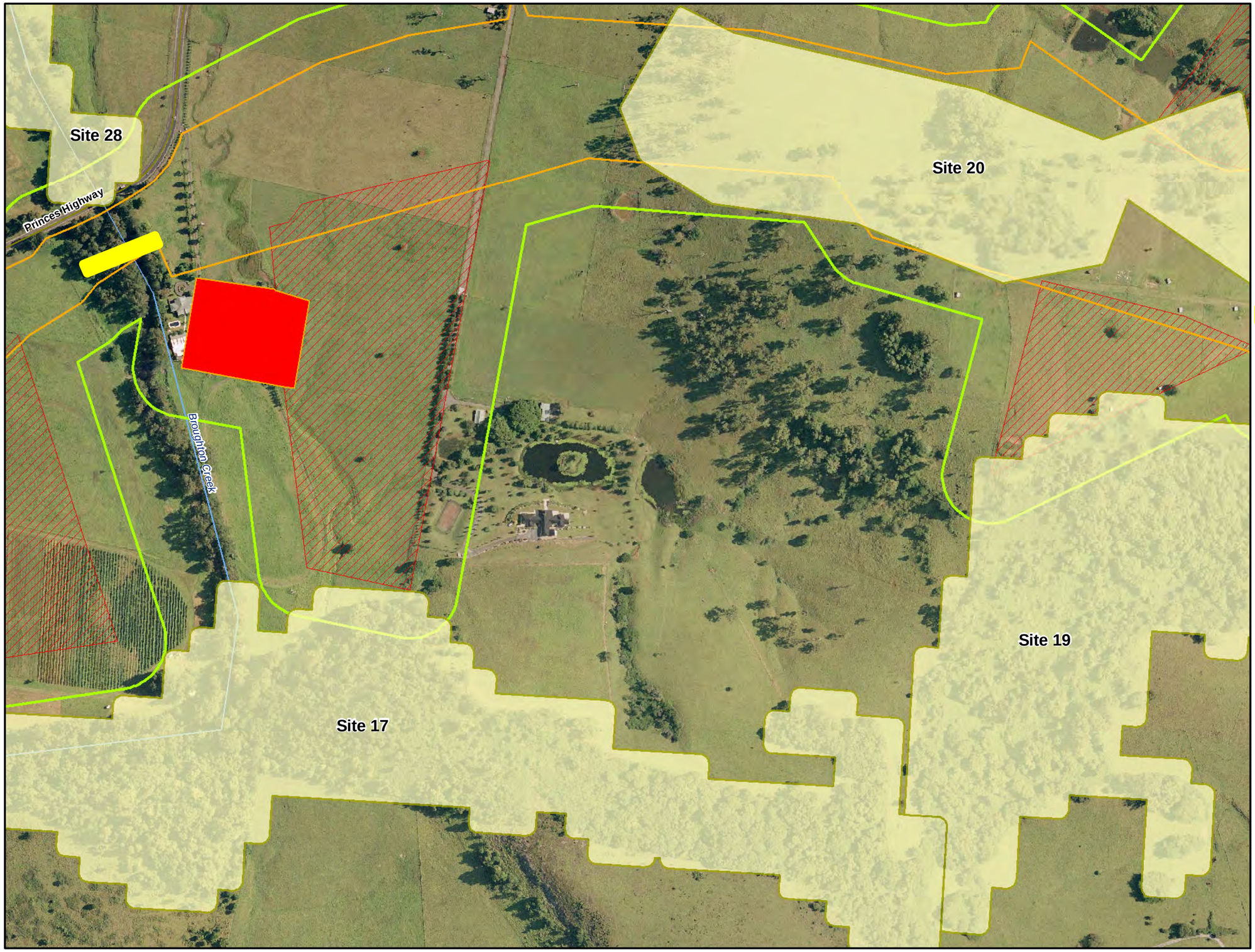
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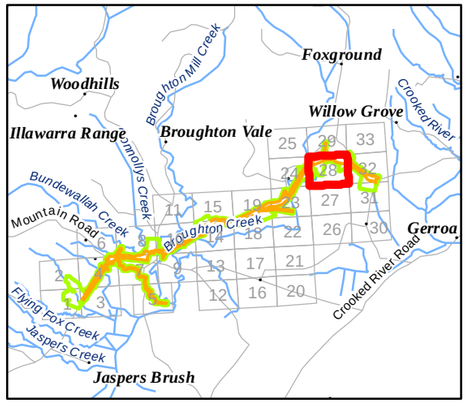
0 60 120 180 240
Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.1





Legend

- Survey sites
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.1.28: Survey sites

Date: 13 July 2012	Drawn by: RS/JS/ANP
File: 13194	Checked by: JC
Location:P:\15000s\15039\Mapping\Variaition 1\Variation 1 Figures\13194_S2_F2-1_Sites_130712.mxd	

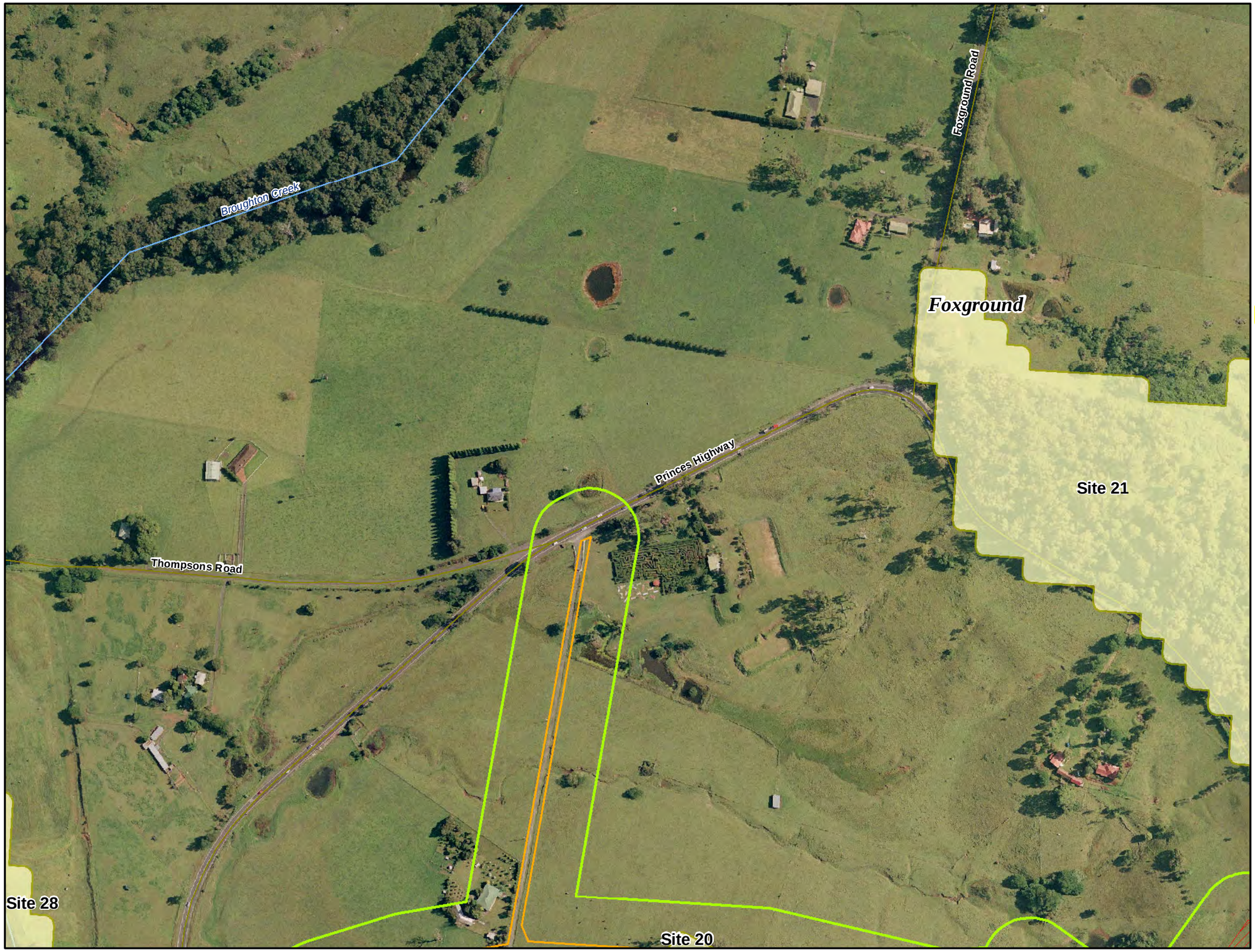
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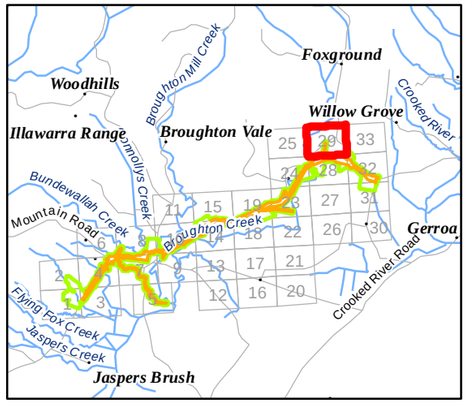
0 60 120 180 240
Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.1





Legend

- Survey sites
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.1.29: Survey sites

Date: 13 July 2012	Drawn by: RS/JS/ANP
File: 13194	Checked by: JC
Location:P:\15000s\15039\Mapping\Variaition 1\Variation 1 Figures\13194_S2_F2-1_Sites_130712.mxd	

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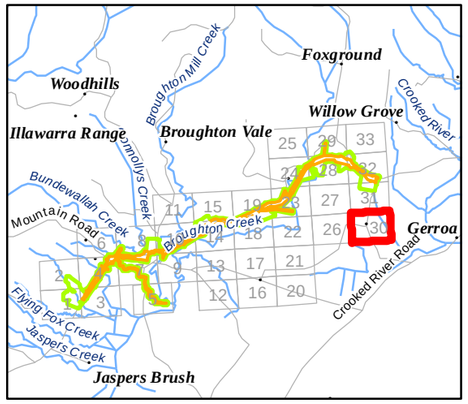
0 60 120 180 240
Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.1





Legend

- Survey sites
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.1.30: Survey sites

Date: 13 July 2012	Drawn by: RS/JS/ANP
File: 13194	Checked by: JC
Location:P:\15000s\15039\Mapping\Variaition 1\Variation 1 Figures\13194_S2_F2-1_Sites_130712.mxd	

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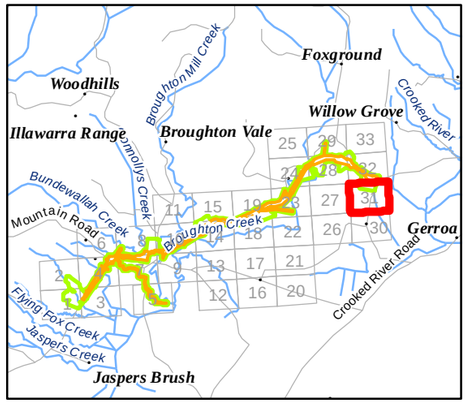
0 60 120 180 240
Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.1





Legend

- Survey sites
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.1.31: Survey sites

Date: 13 July 2012	Drawn by: RS/JS/ANP
File: 13194	Checked by: JC
Location:P:\15000s\15039\Mapping\Variaition 1\Variation 1 Figures\13194_S2_F2-1_Sites_130712.mxd	

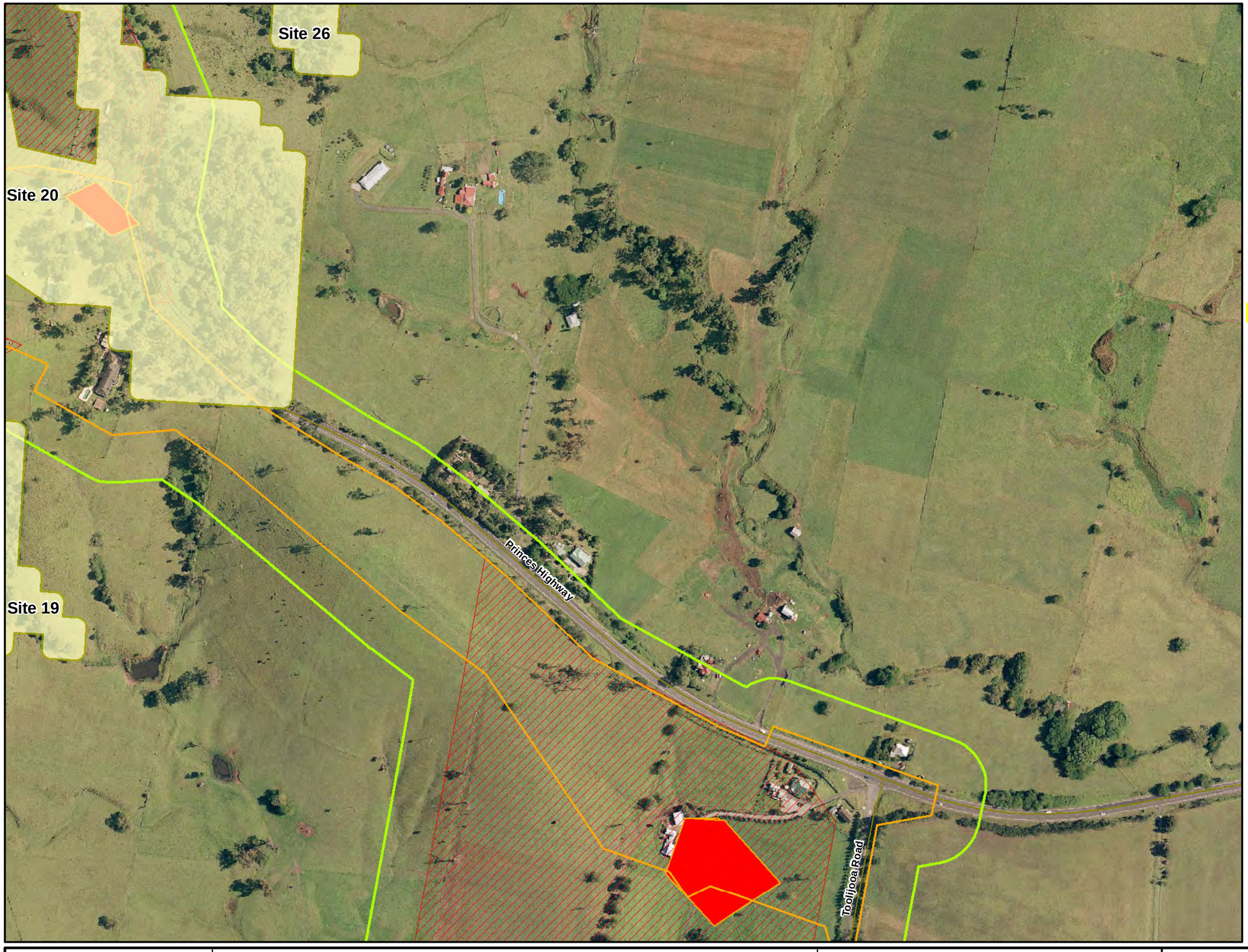
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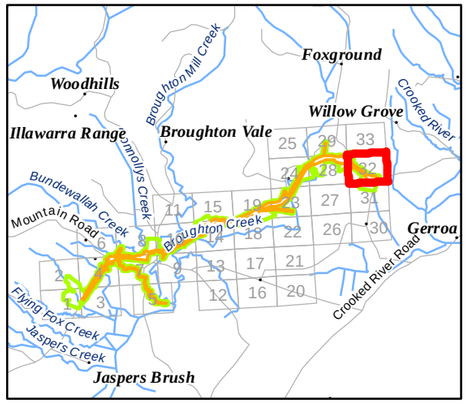
0 60 120 180 240
Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.1





Legend

- Survey sites
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.1.32: Survey sites

Date: 13 July 2012	Drawn by: RS/JS/ANP
File: 13194	Checked by: JC
Location:P:\15000s\15039\Mapping\Variaition 1\Variation 1 Figures\13194_S2_F2-1_Sites_130712.mxd	

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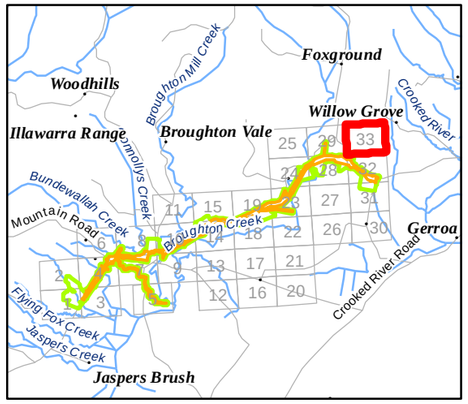
0 60 120 180 240
Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.1





Legend

- Survey sites
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.1.33: Survey sites

Date: 13 July 2012	Drawn by: RS/JS/ANP
File: 13194	Checked by: JC
Location:P:\15000s\15039\Mapping\Variaition 1\Variation 1 Figures\13194_S2_F2-1_Sites_130712.mxd	

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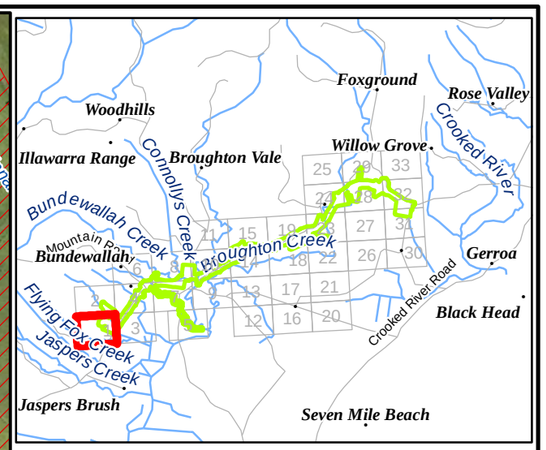
0 60 120 180 240
Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.1





Legend

(No. Refers to Quadrats listed in Appendix A)

- Summer 2007 - Habitat condition assessment
- Summer 2007 - Quadrat
- Spring 2008 - Quadrat
- Autumn 2009 - Habitat condition assessment
- Autumn 2009 - Quadrat
- Summer 2007 - Random meander transect
- Spring 2008 - Random meander transect
- Autumn 2009 - Random meander transect
- Spring 2011 - Town Creek Random meander transect
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.2.1: Location of flora survey effort

Date: 1 August 2012	Drawn by: RS/JMS/ANP
File: 13194	Checked by: JC
Location:P:\15000s\15039\Mapping\Variation 2\Variation 2 figures\15039_S2_F2-2_SurveyFlora_130712.mxd	

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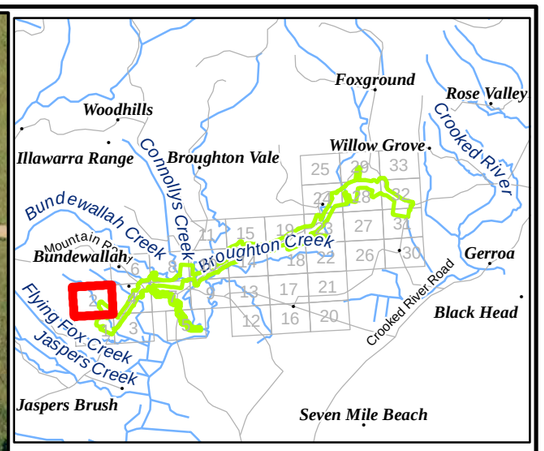
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Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.2





Legend

(No. Refers to Quadrats listed in Appendix A)

- Summer 2007 - Habitat condition assessment
- Summer 2007 - Quadrat
- Spring 2008 - Quadrat
- Autumn 2009 - Habitat condition assessment
- Autumn 2009 - Quadrat
- Summer 2007 - Random meander transect
- Spring 2008 - Random meander transect
- Autumn 2009 - Random meander transect
- Spring 2011 - Town Creek Random meander transect
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.2.2: Location of flora survey effort

Date: 1 August 2012	Drawn by: RS/JMS/ANP
File: 13194	Checked by: JC
Location:P:\15000s\15039\Mapping\Variation 2\Variation 2 figures\15039_S2_F2-2_SurveyFlora_130712.mxd	

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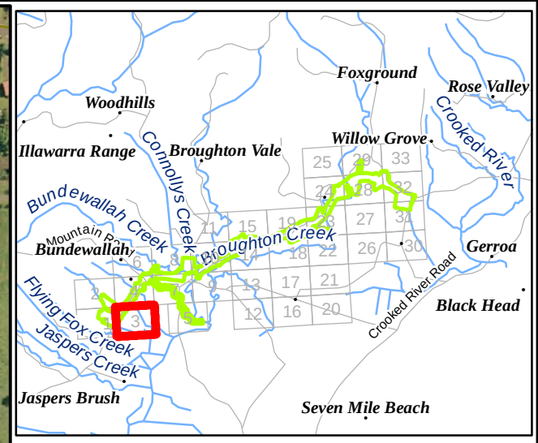
0 50 100 150 200
Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.2





Legend

(No. Refers to Quadrats listed in Appendix A)

- Summer 2007 - Habitat condition assessment
- Summer 2007 - Quadrat
- Spring 2008 - Quadrat
- Autumn 2009 - Habitat condition assessment
- Autumn 2009 - Quadrat
- Summer 2007 - Random meander transect
- Spring 2008 - Random meander transect
- Autumn 2009 - Random meander transect
- Spring 2011 - Town Creek Random meander transect
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.2.3: Location of flora survey effort

Date: 1 August 2012	Drawn by: RS/JMS/ANP
File: 13194	Checked by: JC
Location:P:\15000s\15039\Mapping\Variation 2\Variation 2 figures\15039_S2_F2-2_SurveyFlora_130712.mxd	

Acknowledgements:
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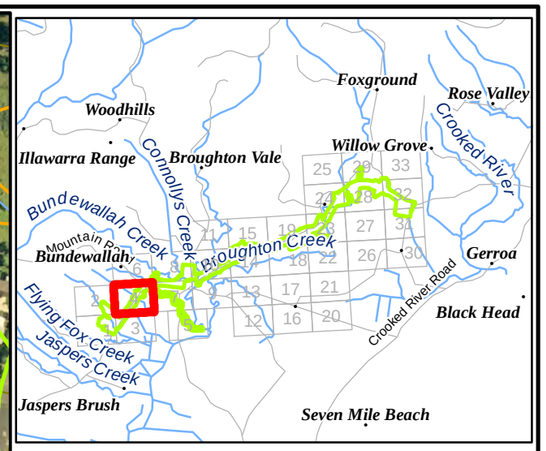
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Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.2





Legend

(No. Refers to Quadrats listed in Appendix A)

- Summer 2007 - Habitat condition assessment
- Summer 2007 - Quadrat
- Spring 2008 - Quadrat
- Autumn 2009 - Habitat condition assessment
- Autumn 2009 - Quadrat
- Summer 2007 - Random meander transect
- Spring 2008 - Random meander transect
- Autumn 2009 - Random meander transect
- Spring 2011 - Town Creek Random meander transect
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.2.4: Location of flora survey effort

Date: 1 August 2012	Drawn by: RS/JMS/ANP
File: 13194	Checked by: JC
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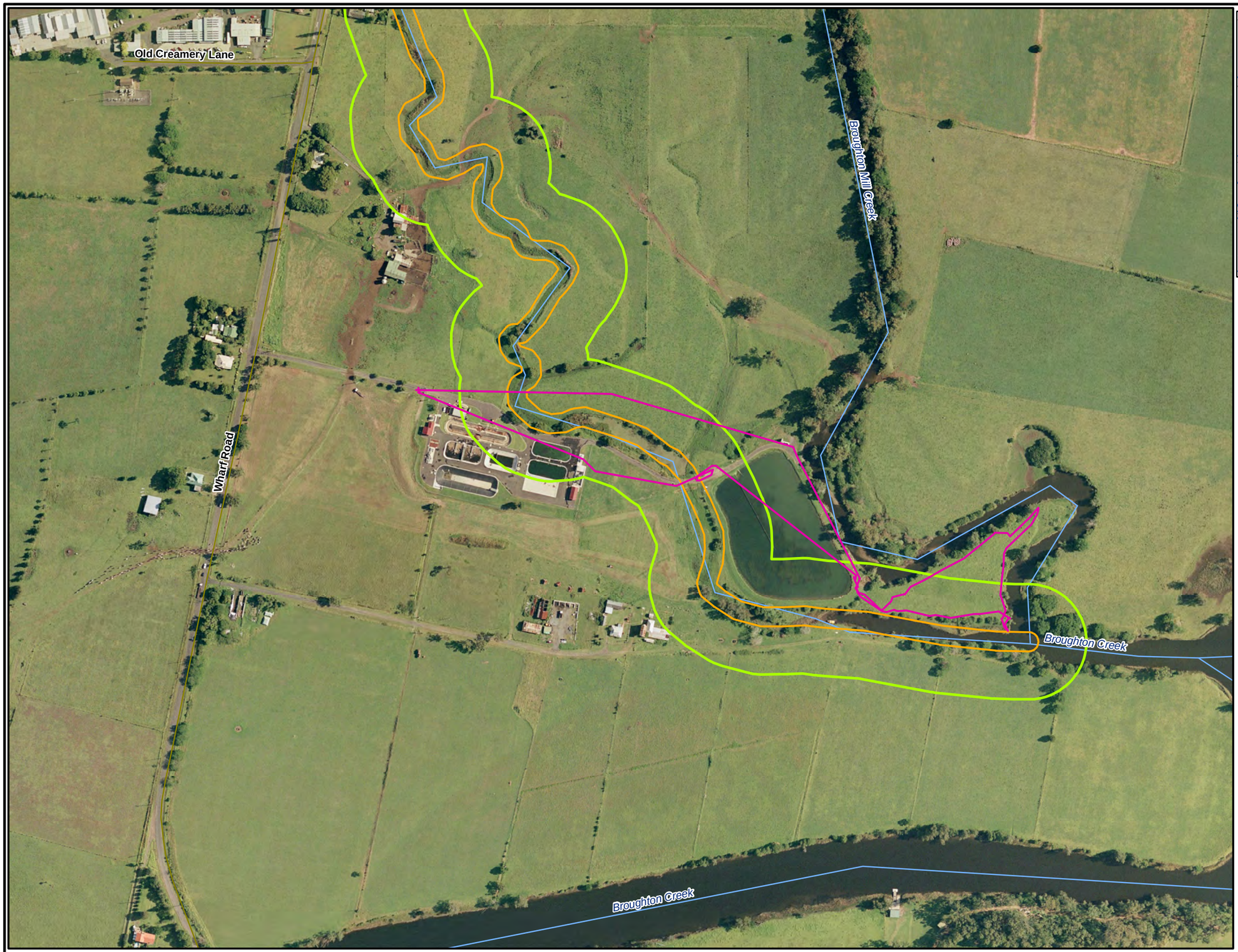
Acknowledgements:
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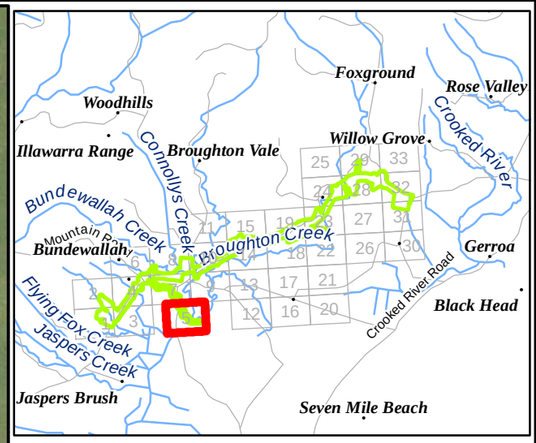
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Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.2





Legend

(No. Refers to Quadrats listed in Appendix A)

- Summer 2007 - Habitat condition assessment
- Summer 2007 - Quadrat
- Spring 2008 - Quadrat
- Autumn 2009 - Habitat condition assessment
- Autumn 2009 - Quadrat
- Summer 2007 - Random meander transect
- Spring 2008 - Random meander transect
- Autumn 2009 - Random meander transect
- Spring 2011 - Town Creek Random meander transect
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.2.5: Location of flora survey effort

Date: 1 August 2012	Drawn by: RS/JMS/ANP
File: 13194	Checked by: JC
Location:P:\15000s\15039\Mapping\Variation 2\Variation 2 figures\15039_S2_F2-2_SurveyFlora_130712.mxd	

Acknowledgements:
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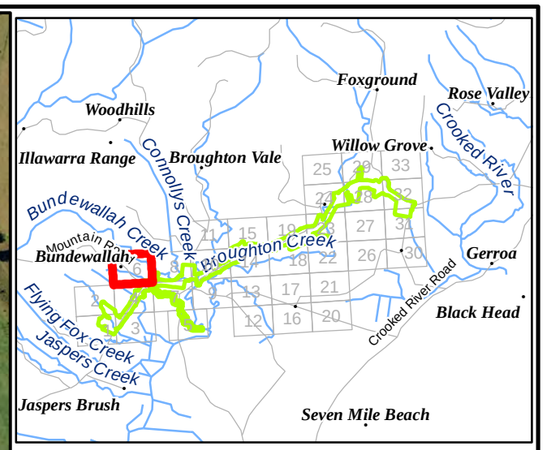
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Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.2





Legend

(No. Refers to Quadrats listed in Appendix A)

- Summer 2007 - Habitat condition assessment
- Summer 2007 - Quadrat
- Spring 2008 - Quadrat
- Autumn 2009 - Habitat condition assessment
- Autumn 2009 - Quadrat
- Summer 2007 - Random meander transect
- Spring 2008 - Random meander transect
- Autumn 2009 - Random meander transect
- Spring 2011 - Town Creek Random meander transect
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.2.6: Location of flora survey effort

Date: 1 August 2012	Drawn by: RS/JMS/ANP
File: 13194	Checked by: JC
Location:P:\15000s\15039\Mapping\Variation 2\Variation 2 figures\15039_S2_F2-2_SurveyFlora_130712.mxd	

Acknowledgements:
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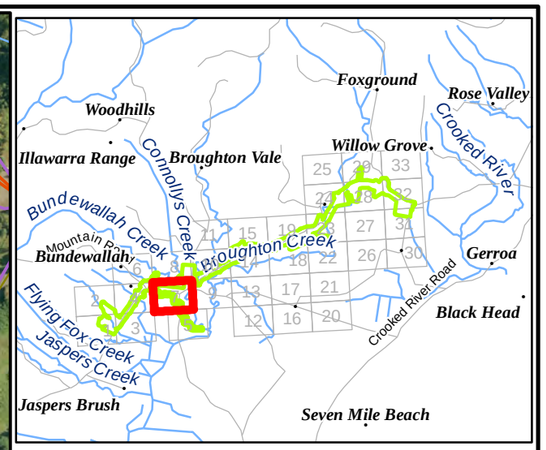
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Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.2





Legend

(No. Refers to Quadrats listed in Appendix A)

- Summer 2007 - Habitat condition assessment
- Summer 2007 - Quadrat
- Spring 2008 - Quadrat
- Autumn 2009 - Habitat condition assessment
- Autumn 2009 - Quadrat
- Summer 2007 - Random meander transect
- Spring 2008 - Random meander transect
- Autumn 2009 - Random meander transect
- Spring 2011 - Town Creek Random meander transect
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.2.7: Location of flora survey effort

Date: 1 August 2012	Drawn by: RS/JMS/ANP
File: 13194	Checked by: JC
Location:P:\15000s\15039\Mapping\Variation 2\Variation 2 figures\15039_S2_F2-2_SurveyFlora_130712.mxd	

Acknowledgements:
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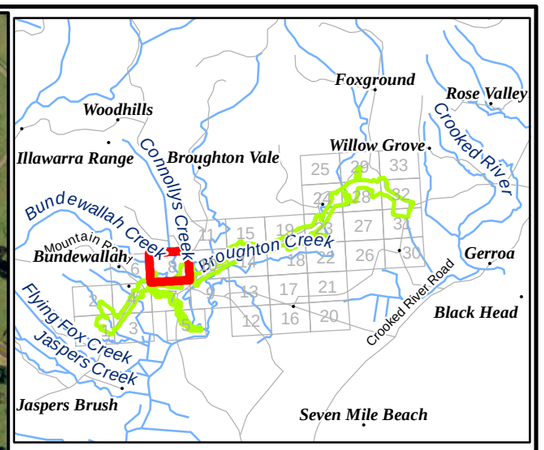
0 50 100 150 200
Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.2





Legend

(No. Refers to Quadrats listed in Appendix A)

- Summer 2007 - Habitat condition assessment
- Summer 2007 - Quadrat
- Spring 2008 - Quadrat
- Autumn 2009 - Habitat condition assessment
- Autumn 2009 - Quadrat
- Summer 2007 - Random meander transect
- Spring 2008 - Random meander transect
- Autumn 2009 - Random meander transect
- Spring 2011 - Town Creek Random meander transect
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.2.8: Location of flora survey effort

Date: 1 August 2012	Drawn by: RS/JMS/ANP
File: 13194	Checked by: JC
Location:P:\15000s\15039\Mapping\Variation 2\Variation 2 figures\15039_S2_F2-2_SurveyFlora_130712.mxd	

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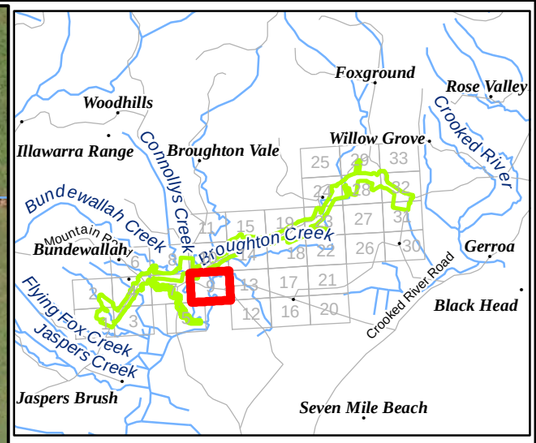
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Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.2





Legend

(No. Refers to Quadrats listed in Appendix A)

- Summer 2007 - Habitat condition assessment
- Summer 2007 - Quadrat
- Spring 2008 - Quadrat
- Autumn 2009 - Habitat condition assessment
- Autumn 2009 - Quadrat
- Summer 2007 - Random meander transect
- Spring 2008 - Random meander transect
- Autumn 2009 - Random meander transect
- Spring 2011 - Town Creek Random meander transect
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.2.9: Location of flora survey effort

Date: 1 August 2012	Drawn by: RS/JMS/ANP
File: 13194	Checked by: JC
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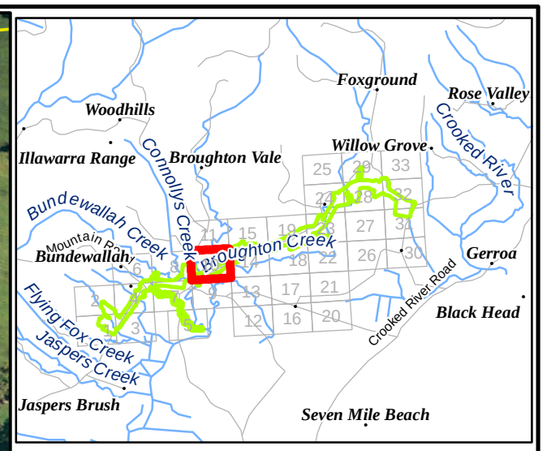
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Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.2





Legend

(No. Refers to Quadrats listed in Appendix A)

- Summer 2007 - Habitat condition assessment
- Summer 2007 - Quadrat
- Spring 2008 - Quadrat
- Autumn 2009 - Habitat condition assessment
- Autumn 2009 - Quadrat
- Summer 2007 - Random meander transect
- Spring 2008 - Random meander transect
- Autumn 2009 - Random meander transect
- Spring 2011 - Town Creek Random meander transect
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.2.10: Location of flora survey effort

Date: 1 August 2012	Drawn by: RS/JMS/ANP
File: 13194	Checked by: JC
Location:P:\15000s\15039\Mapping\Variation 2\Variation 2 figures\15039_S2_F2-2_SurveyFlora_130712.mxd	

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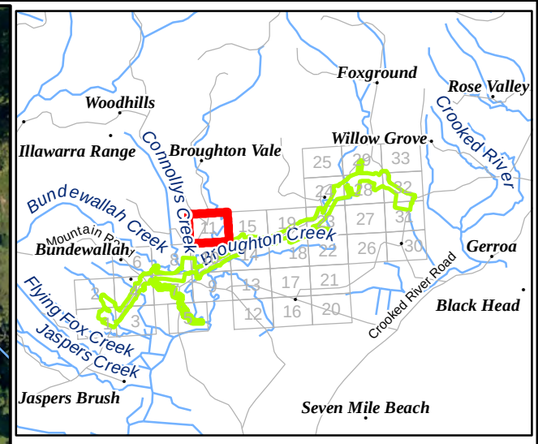
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Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.2





Legend

(No. Refers to Quadrats listed in Appendix A)

- Summer 2007 - Habitat condition assessment
- Summer 2007 - Quadrat
- Spring 2008 - Quadrat
- Autumn 2009 - Habitat condition assessment
- Autumn 2009 - Quadrat
- Summer 2007 - Random meander transect
- Spring 2008 - Random meander transect
- Autumn 2009 - Random meander transect
- Spring 2011 - Town Creek Random meander transect
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.2.11: Location of flora survey effort

Date: 1 August 2012	Drawn by: RS/JMS/ANP
File: 13194	Checked by: JC
Location:P:\15000s\15039\Mapping\Variation 2\Variation 2 figures\15039_S2_F2-2_SurveyFlora_130712.mxd	

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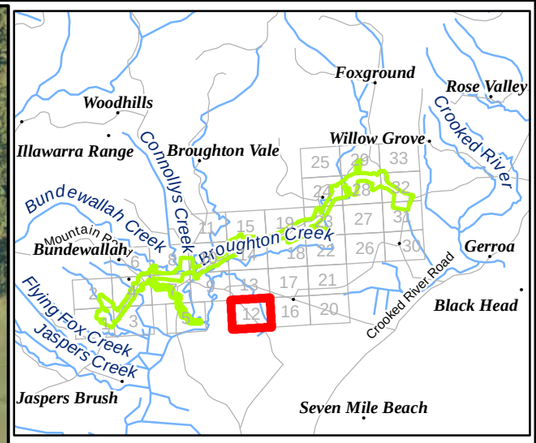
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Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.2





Legend

(No. Refers to Quadrats listed in Appendix A)

- Summer 2007 - Habitat condition assessment
- Summer 2007 - Quadrat
- Spring 2008 - Quadrat
- Autumn 2009 - Habitat condition assessment
- Autumn 2009 - Quadrat
- Summer 2007 - Random meander transect
- Spring 2008 - Random meander transect
- Autumn 2009 - Random meander transect
- Spring 2011 - Town Creek Random meander transect
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.2.12: Location of flora survey effort

Date: 1 August 2012	Drawn by: RS/JMS/ANP
File: 13194	Checked by: JC
Location:P:\15000s\15039\Mapping\Variation 2\Variation 2 figures\15039_S2_F2-2_SurveyFlora_130712.mxd	

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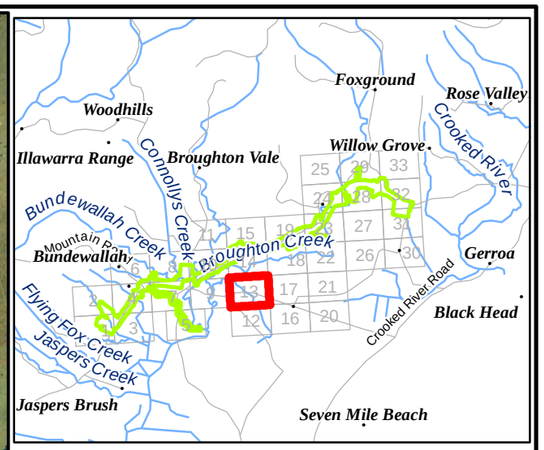
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Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.2





Legend

(No. Refers to Quadrats listed in Appendix A)

- Summer 2007 - Habitat condition assessment
- Summer 2007 - Quadrat
- Spring 2008 - Quadrat
- Autumn 2009 - Habitat condition assessment
- Autumn 2009 - Quadrat
- Summer 2007 - Random meander transect
- Spring 2008 - Random meander transect
- Autumn 2009 - Random meander transect
- Spring 2011 - Town Creek Random meander transect
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.2.13: Location of flora survey effort

Date: 1 August 2012	Drawn by: RS/JMS/ANP
File: 13194	Checked by: JC
Location:P:\15000s\15039\Mapping\Variation 2\Variation 2 figures\15039_S2_F2-2_SurveyFlora_130712.mxd	

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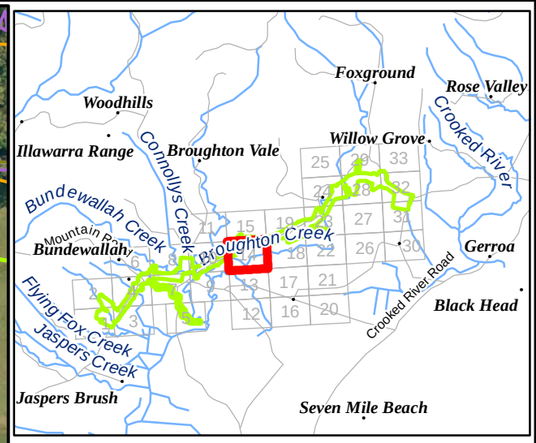
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Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.2





Legend

(No. Refers to Quadrats listed in Appendix A)

- Summer 2007 - Habitat condition assessment
- Summer 2007 - Quadrat
- Spring 2008 - Quadrat
- Autumn 2009 - Habitat condition assessment
- Autumn 2009 - Quadrat
- Summer 2007 - Random meander transect
- Spring 2008 - Random meander transect
- Autumn 2009 - Random meander transect
- Spring 2011 - Town Creek Random meander transect
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.2.14: Location of flora survey effort

Date: 1 August 2012	Drawn by: RS/JMS/ANP
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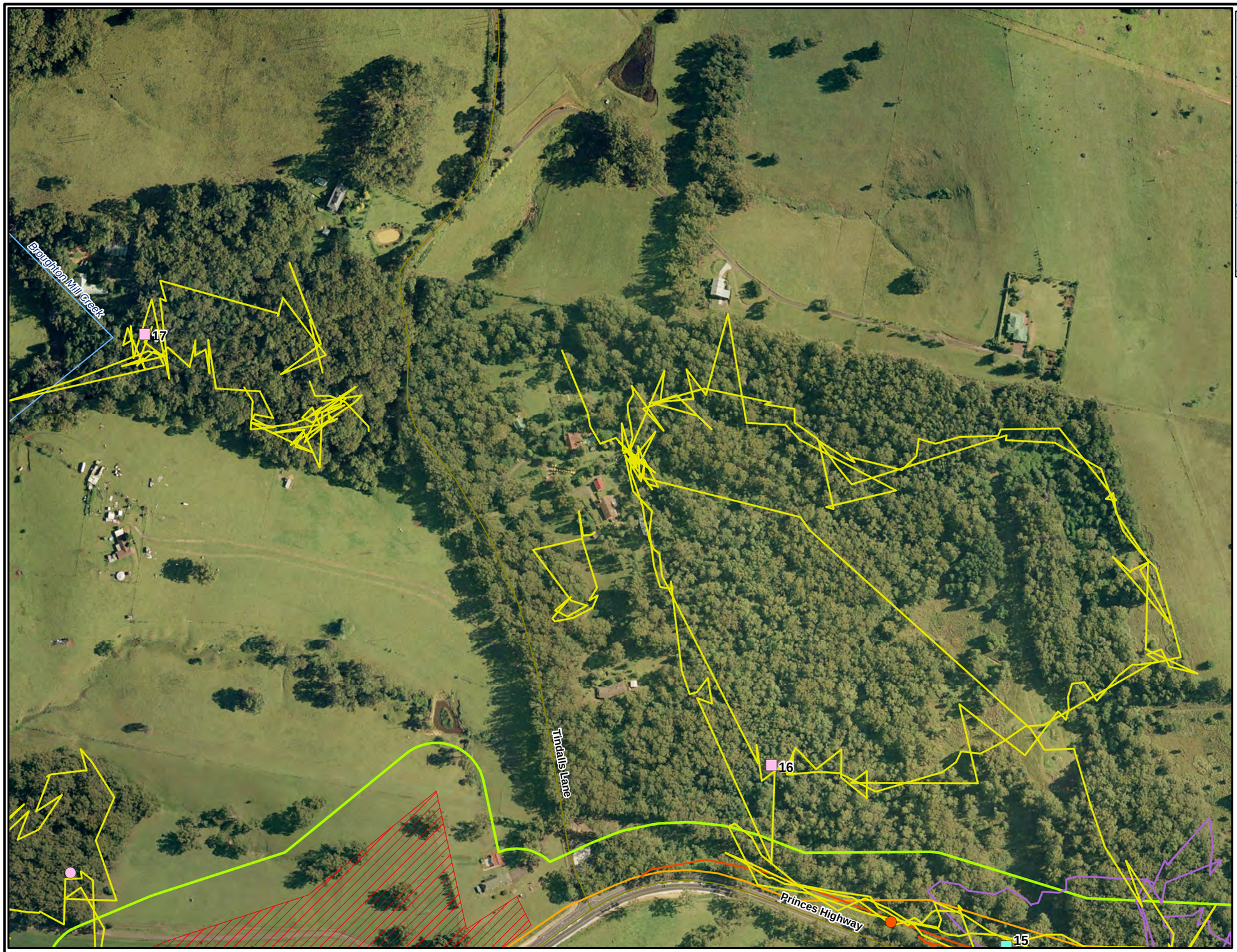
Acknowledgements:
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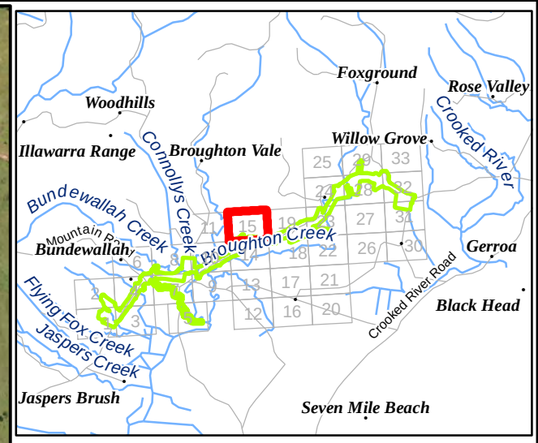
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Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.2





Legend

(No. Refers to Quadrats listed in Appendix A)

- Summer 2007 - Habitat condition assessment
- Summer 2007 - Quadrat
- Spring 2008 - Quadrat
- Autumn 2009 - Habitat condition assessment
- Autumn 2009 - Quadrat
- Summer 2007 - Random meander transect
- Spring 2008 - Random meander transect
- Autumn 2009 - Random meander transect
- Spring 2011 - Town Creek Random meander transect
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.2.15: Location of flora survey effort

Date: 1 August 2012	Drawn by: RS/JMS/ANP
File: 13194	Checked by: JC
Location:P:\15000s\15039\Mapping\Variation 2\Variation 2 figures\15039_S2_F2-2_SurveyFlora_130712.mxd	

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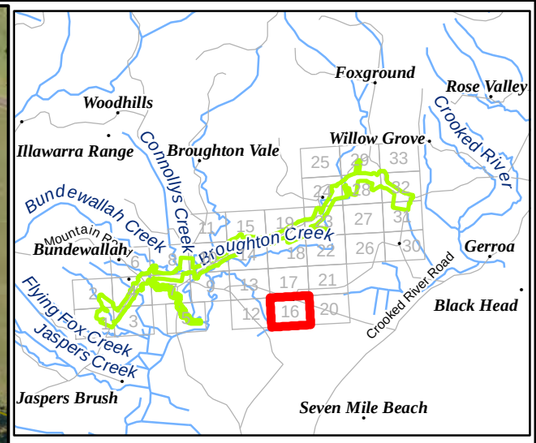
0 50 100 150 200
Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.2





Legend

(No. Refers to Quadrats listed in Appendix A)

- Summer 2007 - Habitat condition assessment
- Summer 2007 - Quadrat
- Spring 2008 - Quadrat
- Autumn 2009 - Habitat condition assessment
- Autumn 2009 - Quadrat
- Summer 2007 - Random meander transect
- Spring 2008 - Random meander transect
- Autumn 2009 - Random meander transect
- Spring 2011 - Town Creek Random meander transect
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.2.16: Location of flora survey effort

Date: 1 August 2012	Drawn by: RS/JMS/ANP
File: 13194	Checked by: JC
Location:P:\15000s\15039\Mapping\Variation 2\Variation 2 figures\15039_S2_F2-2_SurveyFlora_130712.mxd	

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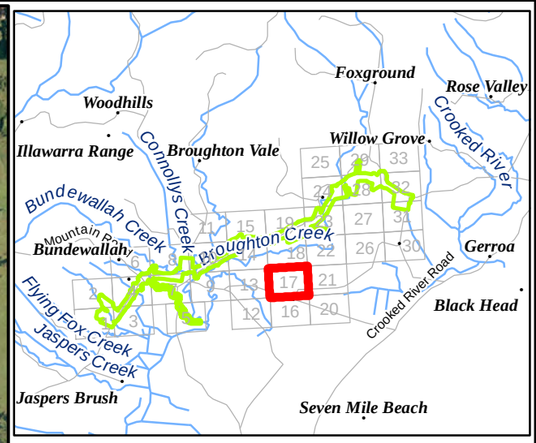
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Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.2





Legend

(No. Refers to Quadrats listed in Appendix A)

- Summer 2007 - Habitat condition assessment
- Summer 2007 - Quadrat
- Spring 2008 - Quadrat
- Autumn 2009 - Habitat condition assessment
- Autumn 2009 - Quadrat
- Summer 2007 - Random meander transect
- Spring 2008 - Random meander transect
- Autumn 2009 - Random meander transect
- Spring 2011 - Town Creek Random meander transect
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.2.17: Location of flora survey effort

Date: 1 August 2012	Drawn by: RS/JMS/ANP
File: 13194	Checked by: JC
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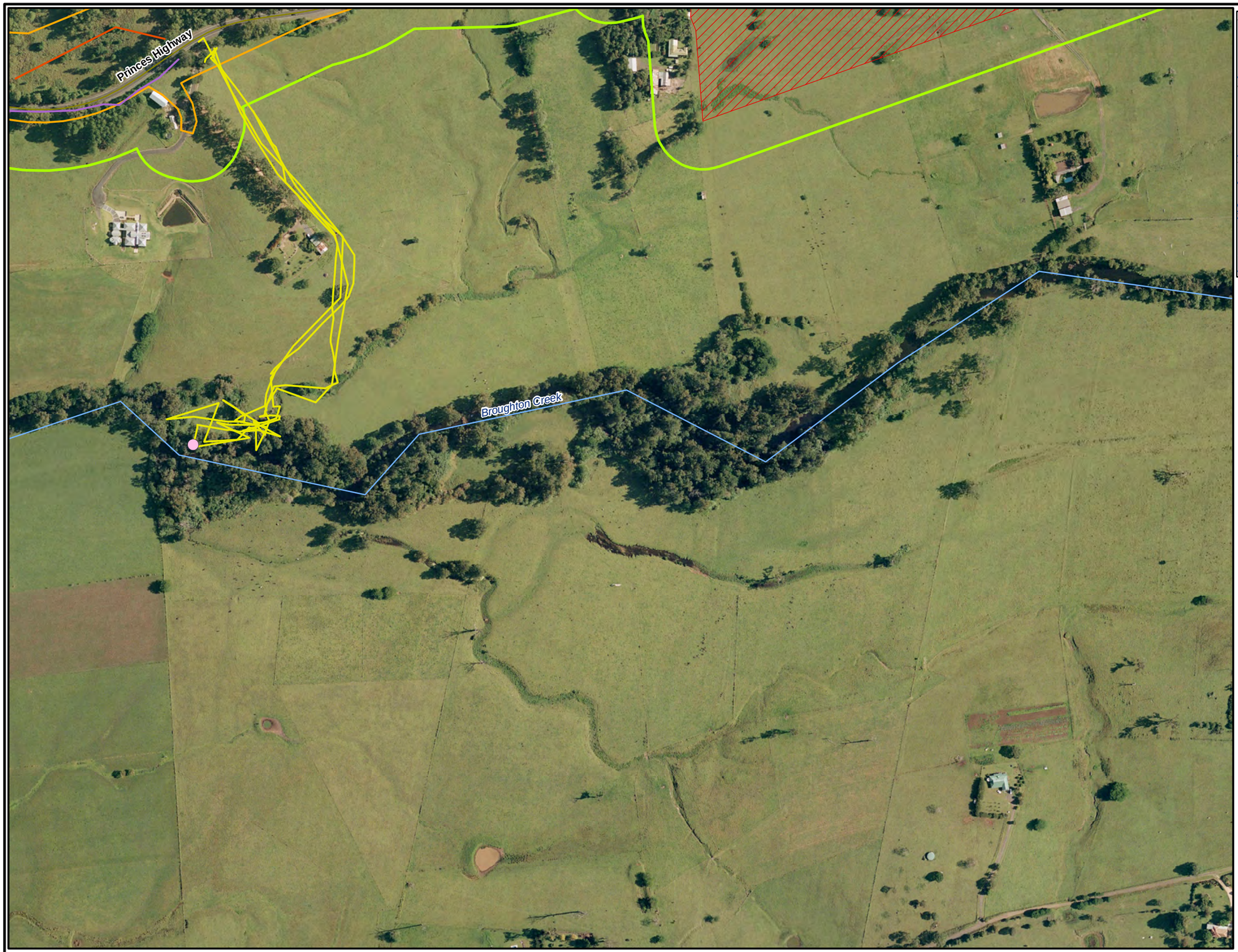
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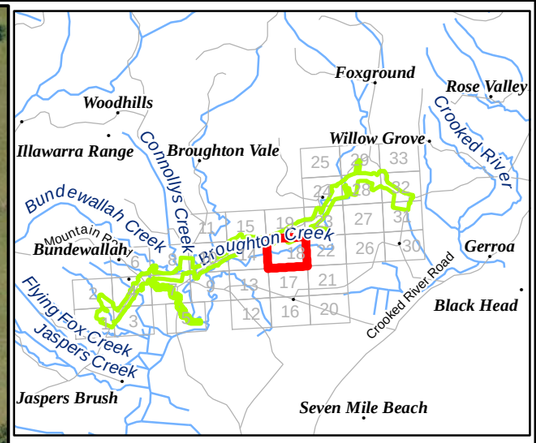
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Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.2





Legend

(No. Refers to Quadrats listed in Appendix A)

- Summer 2007 - Habitat condition assessment
- Summer 2007 - Quadrat
- Spring 2008 - Quadrat
- Autumn 2009 - Habitat condition assessment
- Autumn 2009 - Quadrat
- Summer 2007 - Random meander transect
- Spring 2008 - Random meander transect
- Autumn 2009 - Random meander transect
- Spring 2011 - Town Creek Random meander transect
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.2.18: Location of flora survey effort

Date: 1 August 2012	Drawn by: RS/JMS/ANP
File: 13194	Checked by: JC
Location:P:\15000s\15039\Mapping\Variation 2\Variation 2 figures\15039_S2_F2-2_SurveyFlora_130712.mxd	

Acknowledgements:
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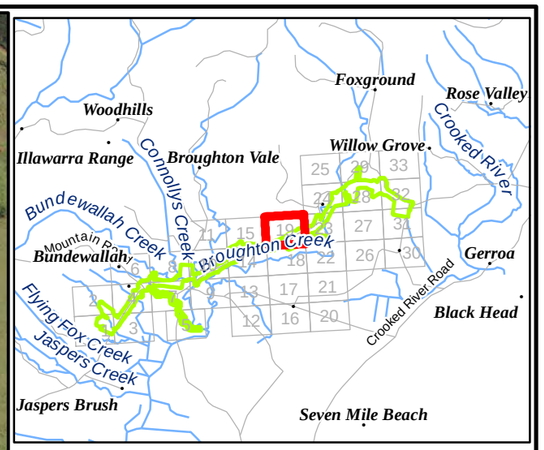
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Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.2





Legend

(No. Refers to Quadrats listed in Appendix A)

- Summer 2007 - Habitat condition assessment
- Summer 2007 - Quadrat
- Spring 2008 - Quadrat
- Autumn 2009 - Habitat condition assessment
- Autumn 2009 - Quadrat
- Summer 2007 - Random meander transect
- Spring 2008 - Random meander transect
- Autumn 2009 - Random meander transect
- Spring 2011 - Town Creek Random meander transect
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.2.19: Location of flora survey effort

Date: 1 August 2012	Drawn by: RS/JMS/ANP
File: 13194	Checked by: JC
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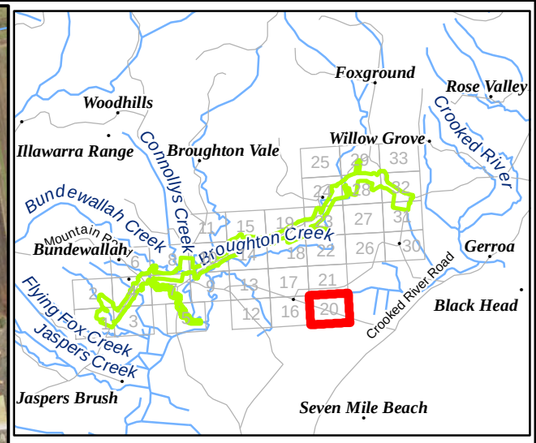
0 50 100 150 200
Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.2





Legend

(No. Refers to Quadrats listed in Appendix A)

- Summer 2007 - Habitat condition assessment
- Summer 2007 - Quadrat
- Spring 2008 - Quadrat
- Autumn 2009 - Habitat condition assessment
- Autumn 2009 - Quadrat
- Summer 2007 - Random meander transect
- Spring 2008 - Random meander transect
- Autumn 2009 - Random meander transect
- Spring 2011 - Town Creek Random meander transect
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.2.20: Location of flora survey effort

Date: 1 August 2012	Drawn by: RS/JMS/ANP
File: 13194	Checked by: JC
Location:P:\15000s\15039\Mapping\Variation 2\Variation 2 figures\15039_S2_F2-2_SurveyFlora_130712.mxd	

Acknowledgements:
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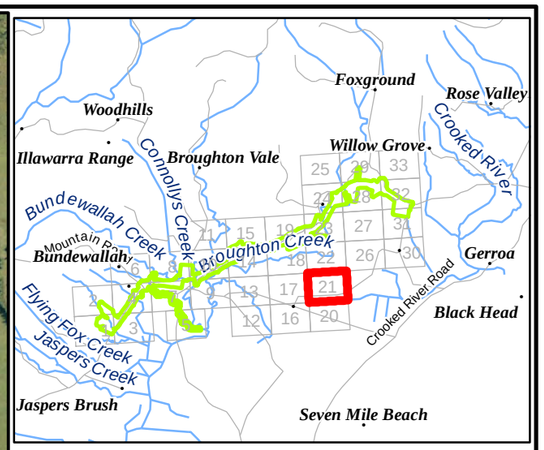
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Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.2





Legend

(No. Refers to Quadrats listed in Appendix A)

- Summer 2007 - Habitat condition assessment
- Summer 2007 - Quadrat
- Spring 2008 - Quadrat
- Autumn 2009 - Habitat condition assessment
- Autumn 2009 - Quadrat
- Summer 2007 - Random meander transect
- Spring 2008 - Random meander transect
- Autumn 2009 - Random meander transect
- Spring 2011 - Town Creek Random meander transect
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.2.21: Location of flora survey effort

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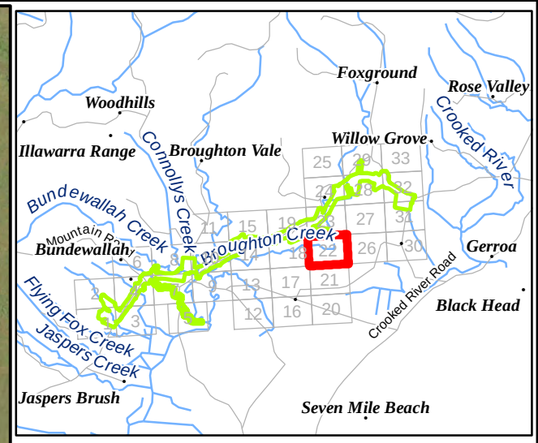
0 50 100 150 200
Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.2





Legend

(No. Refers to Quadrats listed in Appendix A)

- Summer 2007 - Habitat condition assessment
- Summer 2007 - Quadrat
- Spring 2008 - Quadrat
- Autumn 2009 - Habitat condition assessment
- Autumn 2009 - Quadrat
- Summer 2007 - Random meander transect
- Spring 2008 - Random meander transect
- Autumn 2009 - Random meander transect
- Spring 2011 - Town Creek Random meander transect
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.2.22: Location of flora survey effort

Date: 1 August 2012	Drawn by: RS/JMS/ANP
File: 13194	Checked by: JC
Location:P:\15000s\15039\Mapping\Variation 2\Variation 2 figures\15039_S2_F2-2_SurveyFlora_130712.mxd	

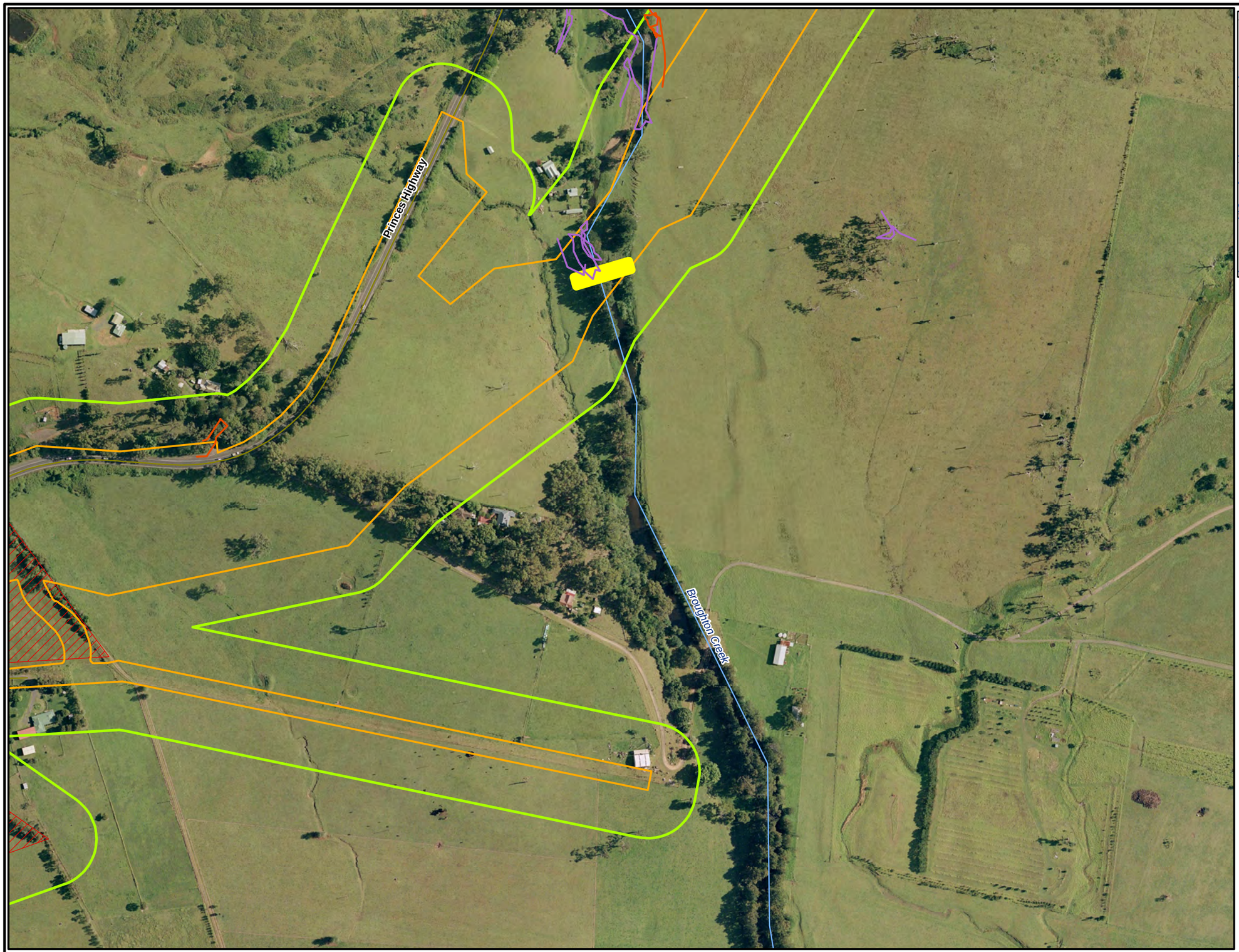
Acknowledgements:
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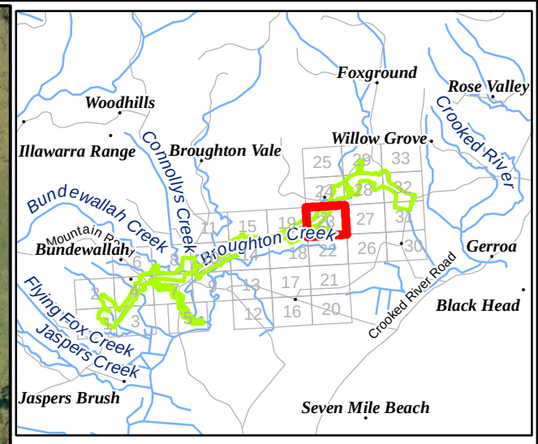
0 50 100 150 200
Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.2





Legend

(No. Refers to Quadrats listed in Appendix A)

- Summer 2007 - Habitat condition assessment
- Summer 2007 - Quadrat
- Spring 2008 - Quadrat
- Autumn 2009 - Habitat condition assessment
- Autumn 2009 - Quadrat
- Summer 2007 - Random meander transect
- Spring 2008 - Random meander transect
- Autumn 2009 - Random meander transect
- Spring 2011 - Town Creek Random meander transect
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.2.23: Location of flora survey effort

Date: 1 August 2012	Drawn by: RS/JMS/ANP
File: 13194	Checked by: JC
Location:P:\15000s\15039\Mapping\Variation 2\Variation 2 figures\15039_S2_F2-2_SurveyFlora_130712.mxd	

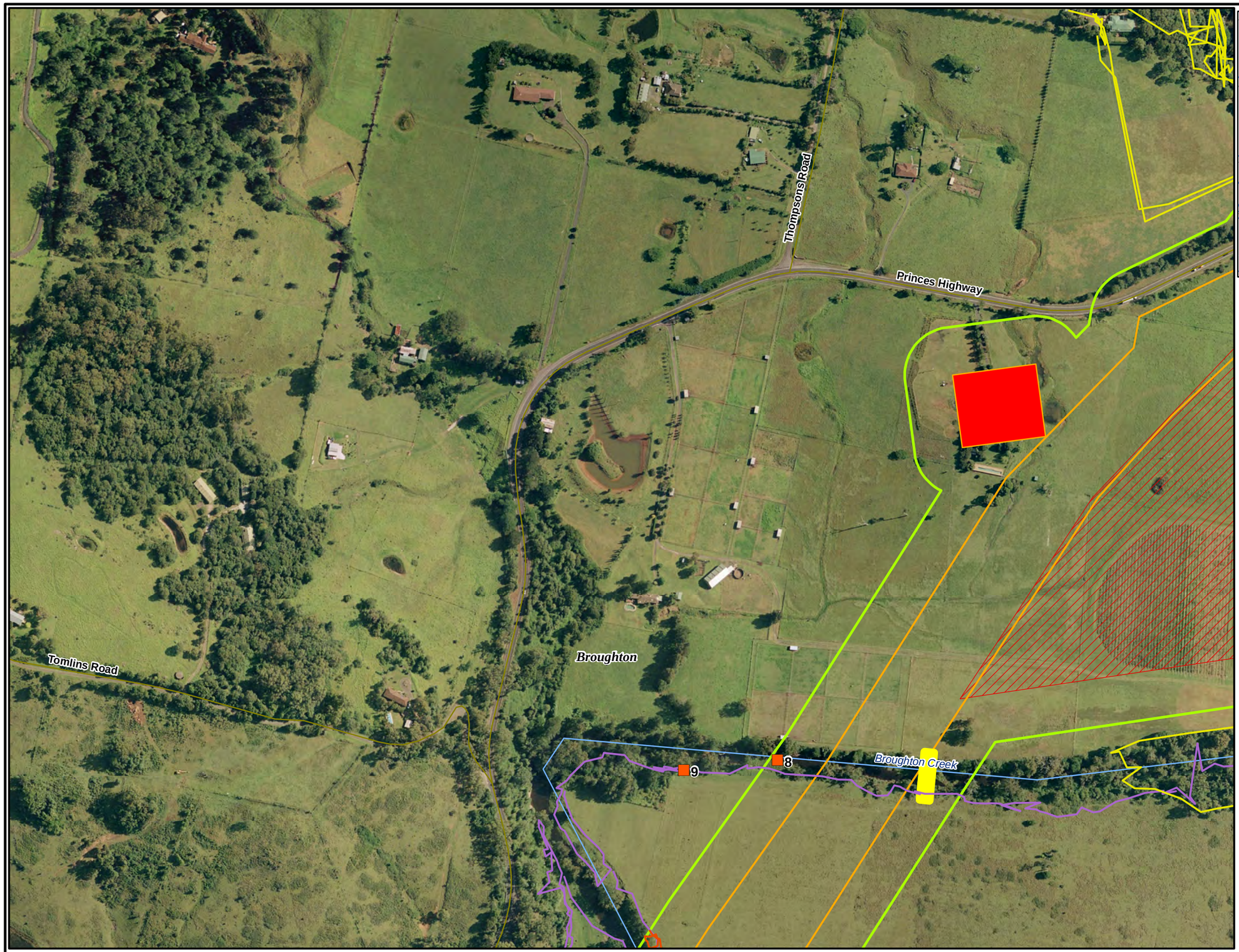
Acknowledgements:
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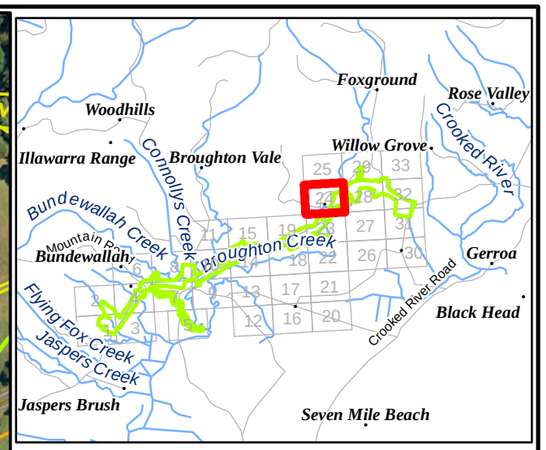
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Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.2





Legend

(No. Refers to Quadrats listed in Appendix A)

- Summer 2007 - Habitat condition assessment
- Summer 2007 - Quadrat
- Spring 2008 - Quadrat
- Autumn 2009 - Habitat condition assessment
- Autumn 2009 - Quadrat
- Summer 2007 - Random meander transect
- Spring 2008 - Random meander transect
- Autumn 2009 - Random meander transect
- Spring 2011 - Town Creek Random meander transect
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.2.24: Location of flora survey effort

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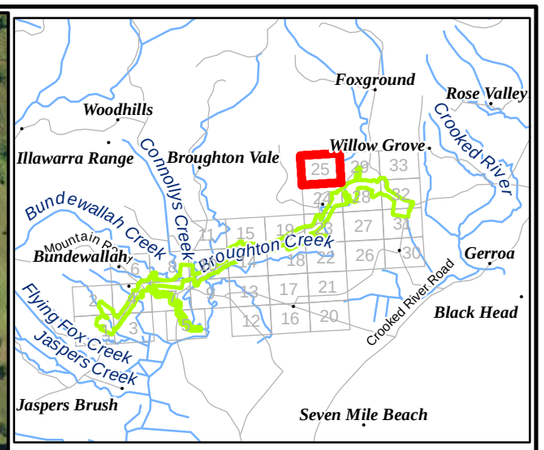
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Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.2





Legend

(No. Refers to Quadrats listed in Appendix A)

- Summer 2007 - Habitat condition assessment
- Summer 2007 - Quadrat
- Spring 2008 - Quadrat
- Autumn 2009 - Habitat condition assessment
- Autumn 2009 - Quadrat
- Summer 2007 - Random meander transect
- Spring 2008 - Random meander transect
- Autumn 2009 - Random meander transect
- Spring 2011 - Town Creek Random meander transect
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.2.25: Location of flora survey effort

Date: 1 August 2012	Drawn by: RS/JMS/ANP
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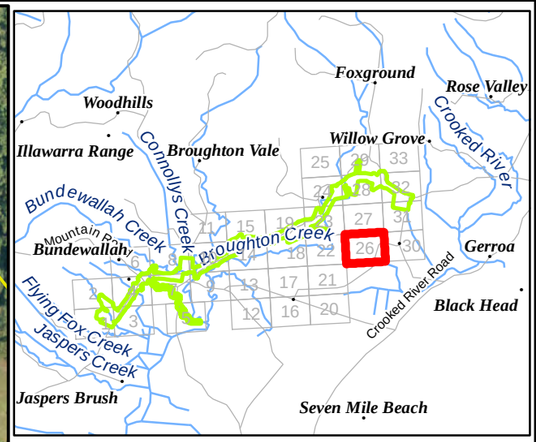
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Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.2





Legend

(No. Refers to Quadrats listed in Appendix A)

- Summer 2007 - Habitat condition assessment
- Summer 2007 - Quadrat
- Spring 2008 - Quadrat
- Autumn 2009 - Habitat condition assessment
- Autumn 2009 - Quadrat
- Summer 2007 - Random meander transect
- Spring 2008 - Random meander transect
- Autumn 2009 - Random meander transect
- Spring 2011 - Town Creek Random meander transect
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.2.26: Location of flora survey effort

Date: 1 August 2012	Drawn by: RS/JMS/ANP
File: 13194	Checked by: JC
Location:P:\15000s\15039\Mapping\Variation 2\Variation 2 figures\15039_S2_F2-2_SurveyFlora_130712.mxd	

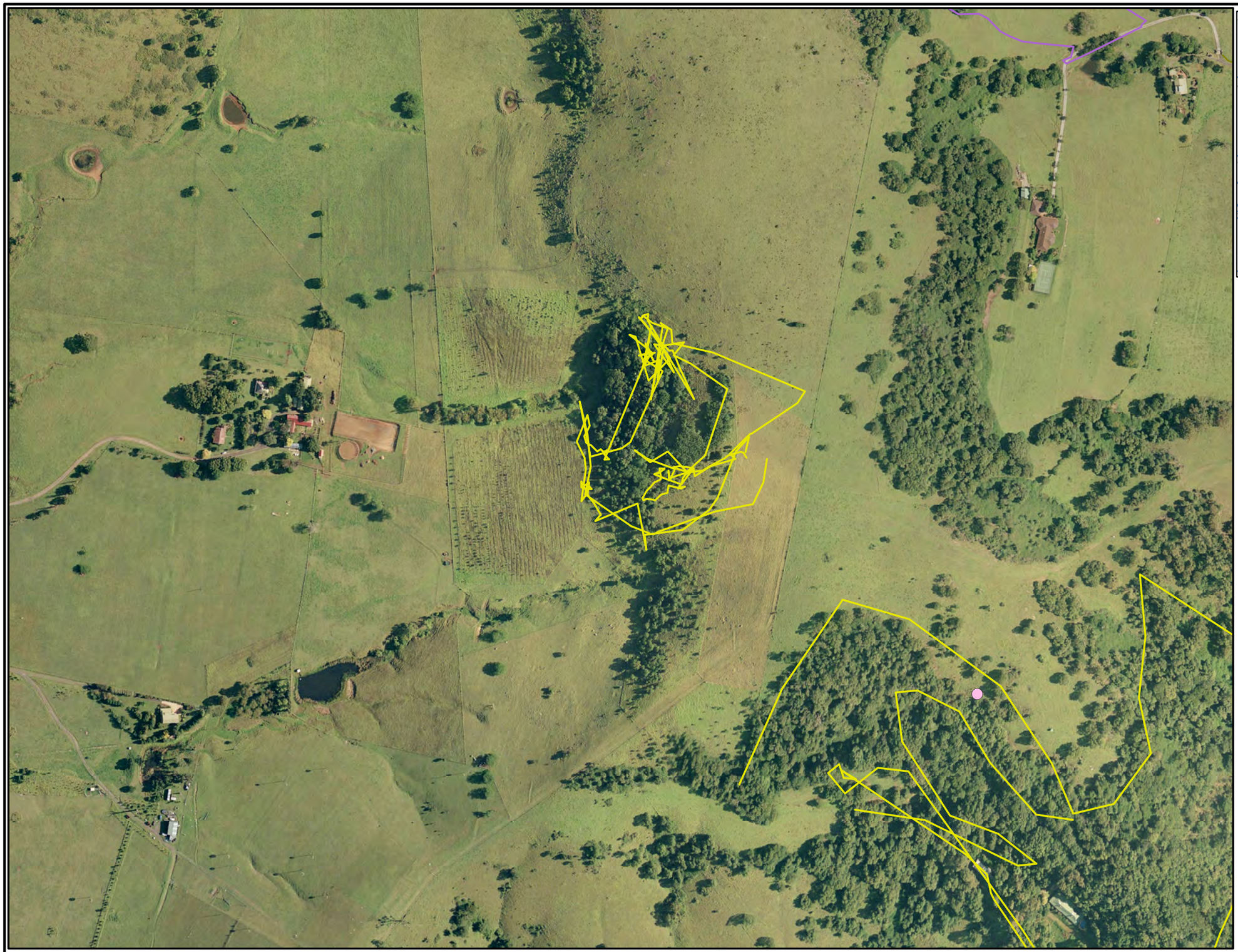
Acknowledgements:
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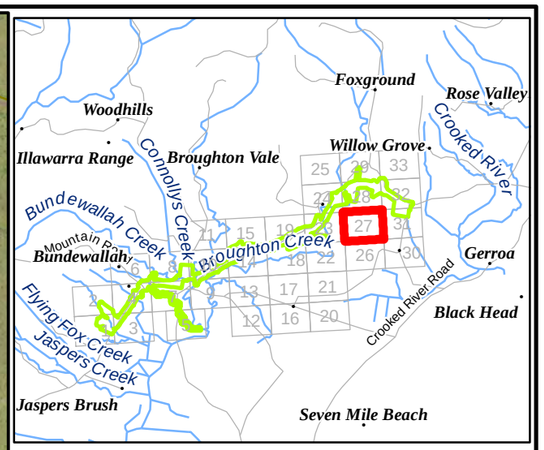
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Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.2





Legend

(No. Refers to Quadrats listed in Appendix A)

- Summer 2007 - Habitat condition assessment
- Summer 2007 - Quadrat
- Spring 2008 - Quadrat
- Autumn 2009 - Habitat condition assessment
- Autumn 2009 - Quadrat
- Summer 2007 - Random meander transect
- Spring 2008 - Random meander transect
- Autumn 2009 - Random meander transect
- Spring 2011 - Town Creek Random meander transect
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.2.27: Location of flora survey effort

Date: 1 August 2012	Drawn by: RS/JMS/ANP
File: 13194	Checked by: JC
Location:P:\15000s\15039\Mapping\Variation 2\Variation 2 figures\15039_S2_F2-2_SurveyFlora_130712.mxd	

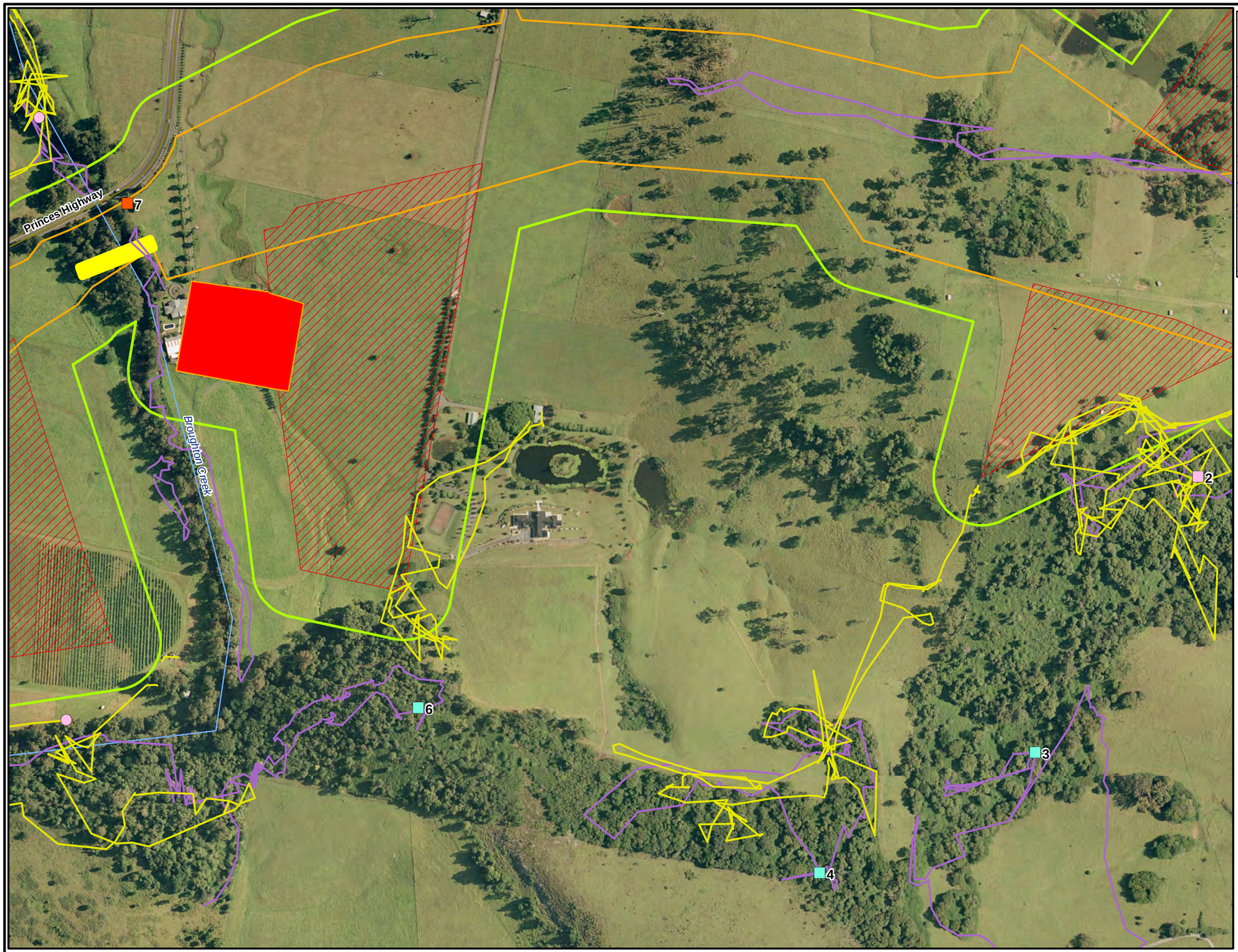
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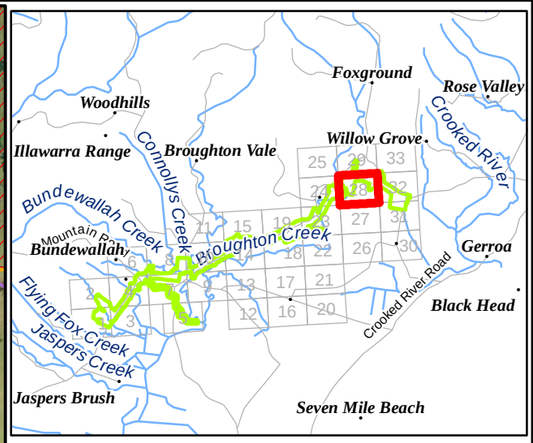
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Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.2





Legend

(No. Refers to Quadrats listed in Appendix A)

- Summer 2007 - Habitat condition assessment
- Summer 2007 - Quadrat
- Spring 2008 - Quadrat
- Autumn 2009 - Habitat condition assessment
- Autumn 2009 - Quadrat
- Summer 2007 - Random meander transect
- Spring 2008 - Random meander transect
- Autumn 2009 - Random meander transect
- Spring 2011 - Town Creek Random meander transect
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.2.28: Location of flora survey effort

Date: 1 August 2012	Drawn by: RS/JMS/ANP
File: 13194	Checked by: JC
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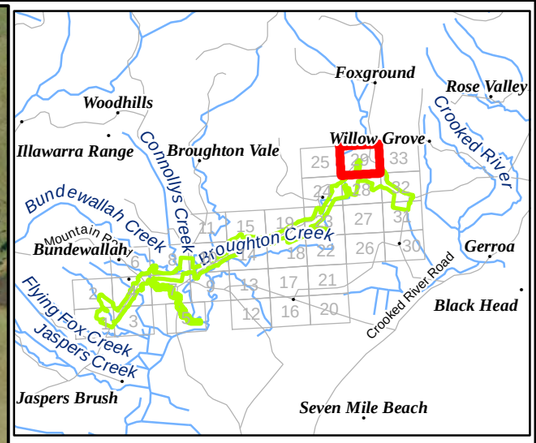
0 50 100 150 200
Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.2





Legend

(No. Refers to Quadrats listed in Appendix A)

- Summer 2007 - Habitat condition assessment
- Summer 2007 - Quadrat
- Spring 2008 - Quadrat
- Autumn 2009 - Habitat condition assessment
- Autumn 2009 - Quadrat
- Summer 2007 - Random meander transect
- Spring 2008 - Random meander transect
- Autumn 2009 - Random meander transect
- Spring 2011 - Town Creek Random meander transect
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.2.29: Location of flora survey effort

Date: 1 August 2012	Drawn by: RS/JMS/ANP
File: 13194	Checked by: JC
Location:P:\15000s\15039\Mapping\Variation 2\Variation 2 figures\15039_S2_F2-2_SurveyFlora_130712.mxd	

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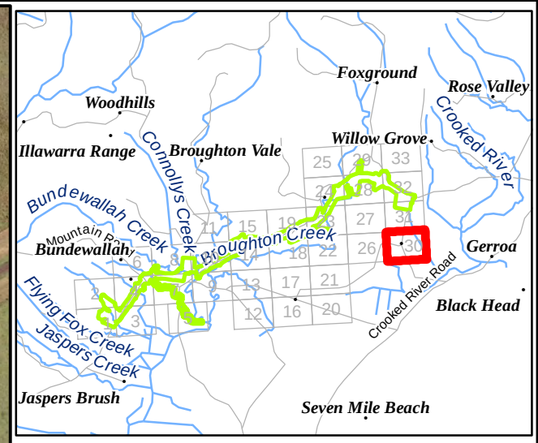
0 50 100 150 200
Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.2





Legend

(No. Refers to Quadrats listed in Appendix A)

- Summer 2007 - Habitat condition assessment
- Summer 2007 - Quadrat
- Spring 2008 - Quadrat
- Autumn 2009 - Habitat condition assessment
- Autumn 2009 - Quadrat
- Summer 2007 - Random meander transect
- Spring 2008 - Random meander transect
- Autumn 2009 - Random meander transect
- Spring 2011 - Town Creek Random meander transect
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.2.30: Location of flora survey effort

Date: 1 August 2012	Drawn by: RS/JMS/ANP
File: 13194	Checked by: JC
Location:P:\15000s\15039\Mapping\Variation 2\Variation 2 figures\15039_S2_F2-2_SurveyFlora_130712.mxd	

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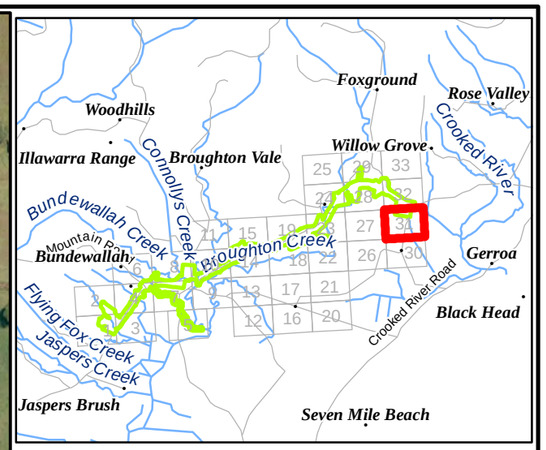
0 50 100 150 200
Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.2





Legend

(No. Refers to Quadrats listed in Appendix A)

- Summer 2007 - Habitat condition assessment
- Summer 2007 - Quadrat
- Spring 2008 - Quadrat
- Autumn 2009 - Habitat condition assessment
- Autumn 2009 - Quadrat
- Summer 2007 - Random meander transect
- Spring 2008 - Random meander transect
- Autumn 2009 - Random meander transect
- Spring 2011 - Town Creek Random meander transect
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.2.31: Location of flora survey effort

Date: 1 August 2012	Drawn by: RS/JMS/ANP
File: 13194	Checked by: JC
Location:P:\15000s\15039\Mapping\Variation 2\Variation 2 figures\15039_S2_F2-2_SurveyFlora_130712.mxd	

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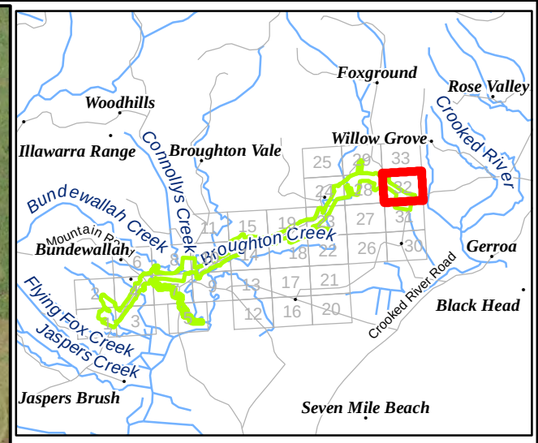
0 50 100 150 200
Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.2





Legend

(No. Refers to Quadrats listed in Appendix A)

- Summer 2007 - Habitat condition assessment
- Summer 2007 - Quadrat
- Spring 2008 - Quadrat
- Autumn 2009 - Habitat condition assessment
- Autumn 2009 - Quadrat
- Summer 2007 - Random meander transect
- Spring 2008 - Random meander transect
- Autumn 2009 - Random meander transect
- Spring 2011 - Town Creek Random meander transect
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.2.32: Location of flora survey effort

Date: 1 August 2012	Drawn by: RS/JMS/ANP
File: 13194	Checked by: JC
Location:P:\15000s\15039\Mapping\Variation 2\Variation 2 figures\15039_S2_F2-2_SurveyFlora_130712.mxd	

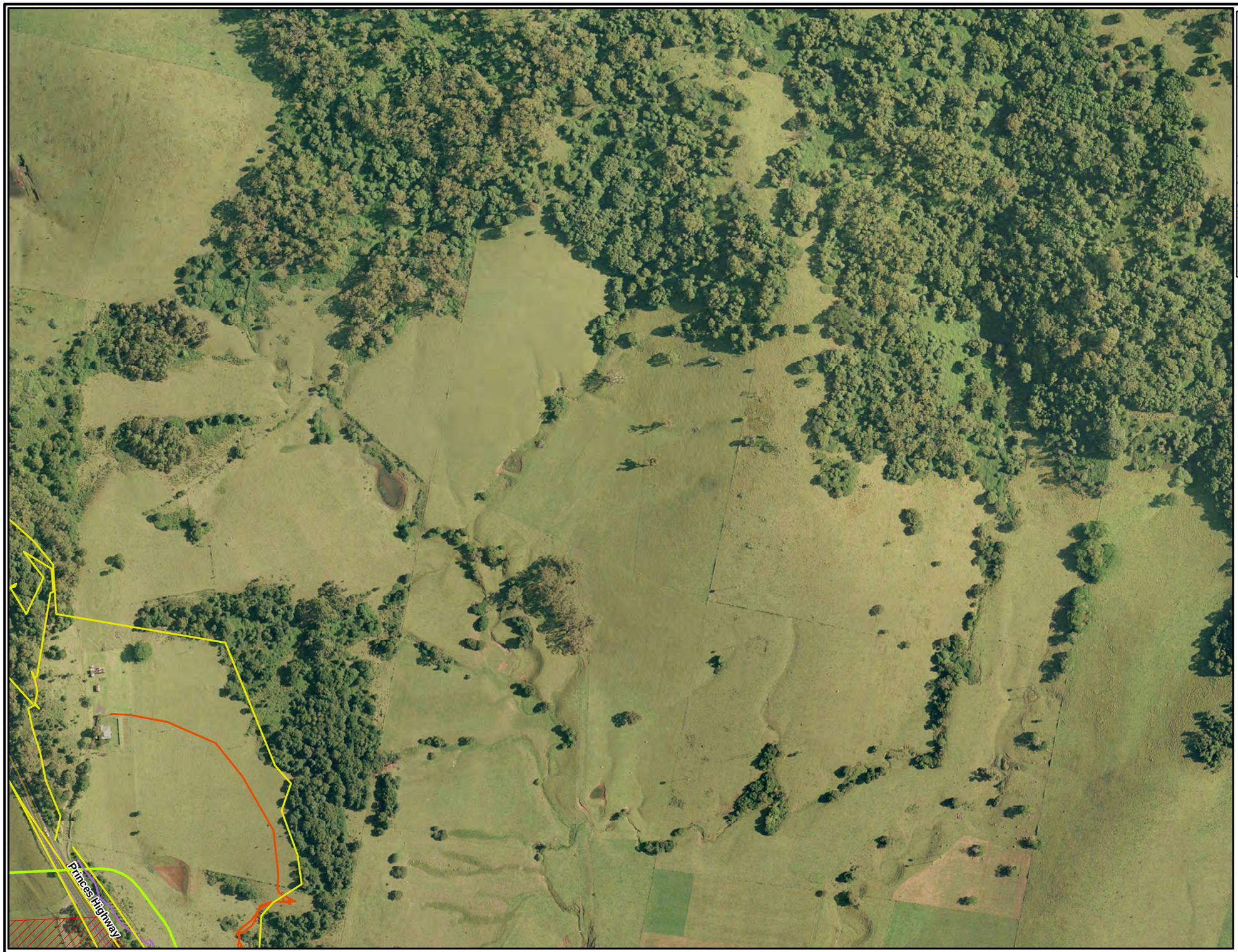
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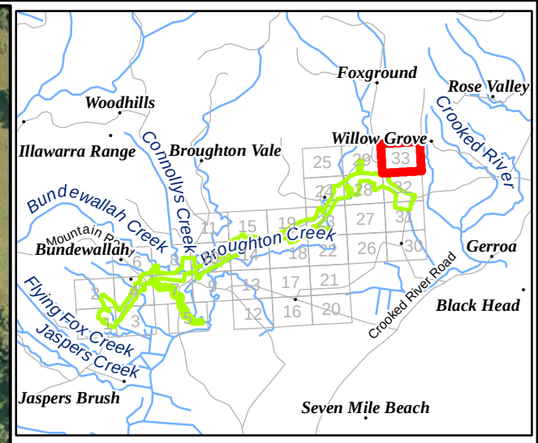
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Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.2





Legend

(No. Refers to Quadrats listed in Appendix A)

- Summer 2007 - Habitat condition assessment
- Summer 2007 - Quadrat
- Spring 2008 - Quadrat
- Autumn 2009 - Habitat condition assessment
- Autumn 2009 - Quadrat
- Summer 2007 - Random meander transect
- Spring 2008 - Random meander transect
- Autumn 2009 - Random meander transect
- Spring 2011 - Town Creek Random meander transect
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 2.2.33: Location of flora survey effort

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File: 13194	Checked by: JC
Location:P:\15000s\15039\Mapping\Variation 2\Variation 2 figures\15039_S2_F2-2_SurveyFlora_130712.mxd	

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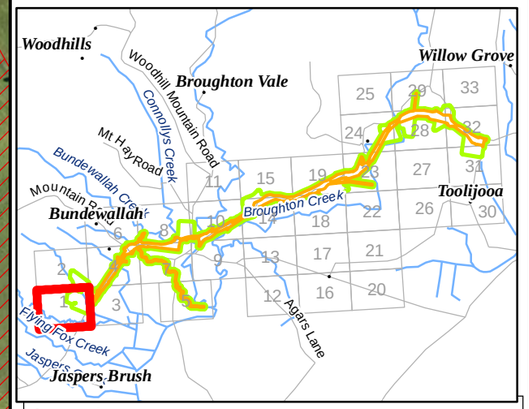
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Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.2





Legend

Survey points
- Summer 2007, Anabat
- Summer 2007, Anabat/Harp Trap
- Summer 2007, Anabat/Owl Call Playback
- Summer 2007, Bird Survey
- Summer 2007, Habitat Assessment
- Summer 2007, Harp Trap
- Summer 2007, Owl Call Playback
- Summer 2007, Spotlighting
- Spring 2008, Anabat
- Spring 2008, Bird Survey
- Spring 2008, Frog Spotlight
- Spring 2008, Habitat Assessment
- Spring 2008, Owl Call Playback
- Autumn 2009, Bird Survey
- Autumn 2009, Call Playback
- Autumn 2009, Frog Spotlight
- Autumn 2009, Habitat Assessment
- Autumn 2009, Spotlighting

Survey transects
- Summer 2007 - Bird Survey
- Summer 2007 - Elliot Trap
- Summer 2007 - Cage Trap
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey/Spotlighting
- Summer 2007 - Spotlighting
- Summer 2007 - Spotlighting/Nocturnal Bird Survey
- Spring 2008 - Bird survey
- Spring 2008 - Elliot Trap/Cage Trap
- Spring 2008 - Elliot Trap/Cage Trap/Hair Tube
- Spring 2008 - Spotlighting
- Spring 2008 - Spotlighting/Nocturnal Bird Survey
- Autumn 2009 - Bird survey
- Autumn 2009 - Cage Trap
- Autumn 2009 - Spotlighting
- Spring 2011 - Town Creek general survey and habitat assessments
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites
- Subject Site - Compound
- Subject Site - Stockpile
- Study Area
- RoadNameExtent

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Figure 2.3.1: Location of fauna survey effort

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Location: P:\15000s\15039\Mapping\Variation 2\Variation 2 figures\15039_S2_F2-3_survey_fauna_010812.mxd	

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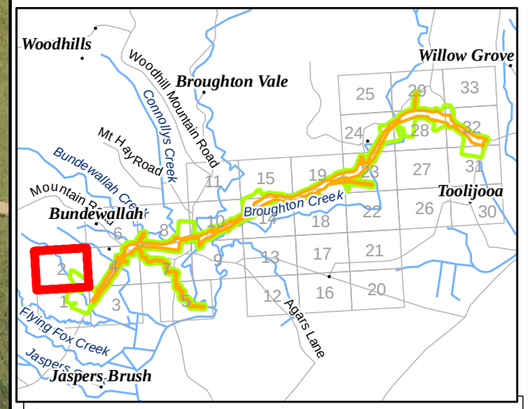
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Metres

Scale: 1: 4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.3





Legend

Survey points

- Summer 2007, Anabat
- Summer 2007, Anabat/Harp Trap
- Summer 2007, Anabat/Owl Call Playback
- Summer 2007, Bird Survey
- Summer 2007, Habitat Assessment
- Summer 2007, Harp Trap
- Summer 2007, Owl Call Playback
- Summer 2007, Spotlighting
- Spring 2008, Anabat
- Spring 2008, Bird Survey
- Spring 2008, Frog Spotlight
- Spring 2008, Habitat Assessment
- Spring 2008, Owl Call Playback
- Autumn 2009, Bird Survey
- Autumn 2009, Call Playback
- Autumn 2009, Frog Spotlight
- Autumn 2009, Habitat Assessment
- Autumn 2009, Spotlighting

Survey transects

- Summer 2007 - Bird Survey
- Summer 2007 - Elliot Trap
- Summer 2007 - Cage Trap
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey/Spotlighting
- Summer 2007 - Spotlighting
- Summer 2007 - Spotlighting/Nocturnal Bird Survey
- Spring 2008 - Bird survey
- Spring 2008 - Elliot Trap/Cage Trap
- Spring 2008 - Elliot Trap/Cage Trap/Hair Tube
- Spring 2008 - Spotlighting
- Spring 2008 - Spotlighting/Nocturnal Bird Survey
- Autumn 2009 - Bird survey
- Autumn 2009 - Cage Trap
- Autumn 2009 - Spotlighting
- Spring 2011 - Town Creek general survey and habitat assessments
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area
- RoadNameExtent

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Figure 2.3.2: Location of fauna survey effort

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File: 13194	Checked by: JC
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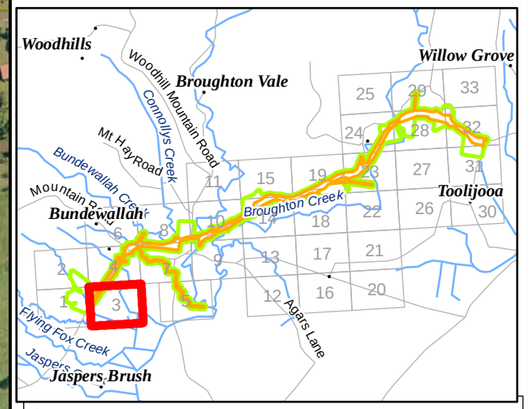
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Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.3





Legend

Survey points
- Summer 2007, Anabat
- Summer 2007, Anabat/Harp Trap
- Summer 2007, Anabat/Owl Call Playback
- Summer 2007, Bird Survey
- Summer 2007, Habitat Assessment
- Summer 2007, Harp Trap
- Summer 2007, Owl Call Playback
- Summer 2007, Spotlighting
- Spring 2008, Anabat
- Spring 2008, Bird Survey
- Spring 2008, Frog Spotlight
- Spring 2008, Habitat Assessment
- Spring 2008, Owl Call Playback
- Autumn 2009, Bird Survey
- Autumn 2009, Call Playback
- Autumn 2009, Frog Spotlight
- Autumn 2009, Habitat Assessment
- Autumn 2009, Spotlighting

Survey transects
- Summer 2007 - Bird Survey
- Summer 2007 - Elliot Trap
- Summer 2007 - Cage Trap
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey/Spotlighting
- Summer 2007 - Spotlighting
- Summer 2007 - Spotlighting/Nocturnal Bird Survey
- Spring 2008 - Bird survey
- Spring 2008 - Elliot Trap/Cage Trap
- Spring 2008 - Elliot Trap/Cage Trap/Hair Tube
- Spring 2008 - Spotlighting
- Spring 2008 - Spotlighting/Nocturnal Bird Survey
- Autumn 2009 - Bird survey
- Autumn 2009 - Cage Trap
- Autumn 2009 - Spotlighting
- Spring 2011 - Town Creek general survey and habitat assessments
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites
- Subject Site - Compound
- Subject Site - Stockpile
- Study Area
- RoadNameExtent

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Figure 2.3.3: Location of fauna survey effort

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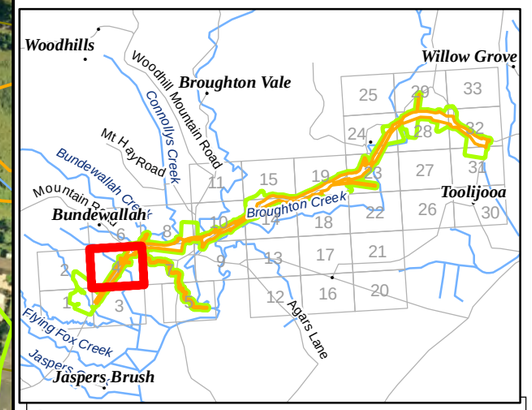
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Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.3





Legend

Survey points
- Summer 2007, Anabat
- Summer 2007, Anabat/Harp Trap
- Summer 2007, Anabat/Owl Call Playback
- Summer 2007, Bird Survey
- Summer 2007, Habitat Assessment
- Summer 2007, Harp Trap
- Summer 2007, Owl Call Playback
- Summer 2007, Spotlighting
- Spring 2008, Anabat
- Spring 2008, Bird Survey
- Spring 2008, Frog Spotlight
- Spring 2008, Habitat Assessment
- Spring 2008, Owl Call Playback
- Autumn 2009, Bird Survey
- Autumn 2009, Call Playback
- Autumn 2009, Frog Spotlight
- Autumn 2009, Habitat Assessment
- Autumn 2009, Spotlighting

Survey transects
- Summer 2007 - Bird Survey
- Summer 2007 - Elliot Trap
- Summer 2007 - Cage Trap
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey/Spotlighting
- Summer 2007 - Spotlighting
- Summer 2007 - Spotlighting/Nocturnal Bird Survey
- Spring 2008 - Bird survey
- Spring 2008 - Elliot Trap/Cage Trap
- Spring 2008 - Elliot Trap/Cage Trap/Hair Tube
- Spring 2008 - Spotlighting
- Spring 2008 - Spotlighting/Nocturnal Bird Survey
- Autumn 2009 - Bird survey
- Autumn 2009 - Cage Trap
- Autumn 2009 - Spotlighting
- Spring 2011 - Town Creek general survey and habitat assessments
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites
- Subject Site - Compound
- Subject Site - Stockpile
- Study Area
- RoadNameExtent

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Figure 2.3.4: Location of fauna survey effort

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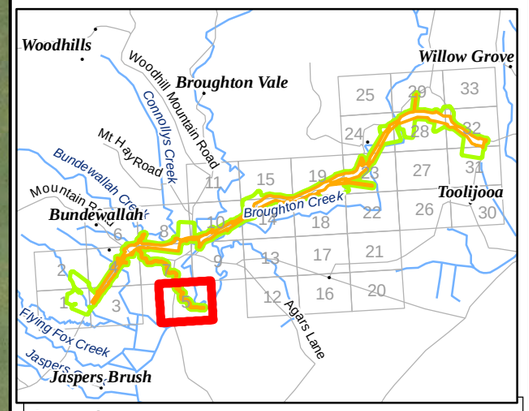
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Metres

Scale: 1: 4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.3





Legend

Survey points
- Summer 2007, Anabat
- Summer 2007, Anabat/Harp Trap
- Summer 2007, Anabat/Owl Call Playback
- Summer 2007, Bird Survey
- Summer 2007, Habitat Assessment
- Summer 2007, Harp Trap
- Summer 2007, Owl Call Playback
- Summer 2007, Spotlighting
- Spring 2008, Anabat
- Spring 2008, Bird Survey
- Spring 2008, Frog Spotlight
- Spring 2008, Habitat Assessment
- Spring 2008, Owl Call Playback
- Autumn 2009, Bird Survey
- Autumn 2009, Call Playback
- Autumn 2009, Frog Spotlight
- Autumn 2009, Habitat Assessment
- Autumn 2009, Spotlighting

Survey transects
- Summer 2007 - Bird Survey
- Summer 2007 - Elliot Trap
- Summer 2007 - Cage Trap
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey/Spotlighting
- Summer 2007 - Spotlighting
- Summer 2007 - Spotlighting/Nocturnal Bird Survey
- Spring 2008 - Bird survey
- Spring 2008 - Elliot Trap/Cage Trap
- Spring 2008 - Elliot Trap/Cage Trap/Hair Tube
- Spring 2008 - Spotlighting
- Spring 2008 - Spotlighting/Nocturnal Bird Survey
- Autumn 2009 - Bird survey
- Autumn 2009 - Cage Trap
- Autumn 2009 - Spotlighting
- Spring 2011 - Town Creek general survey and habitat assessments
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites
- Subject Site - Compound
- Subject Site - Stockpile
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- RoadNameExtent

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Figure 2.3.5: Location of fauna survey effort

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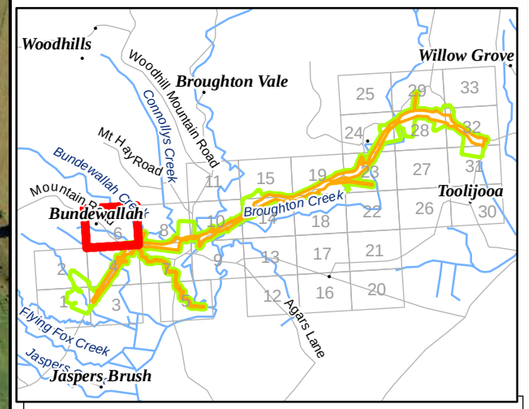
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Scale: 1: 4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.3





Legend

Survey points
- Summer 2007, Anabat
- Summer 2007, Anabat/Harp Trap
- Summer 2007, Anabat/Owl Call Playback
- Summer 2007, Bird Survey
- Summer 2007, Habitat Assessment
- Summer 2007, Harp Trap
- Summer 2007, Owl Call Playback
- Summer 2007, Spotlighting
- Spring 2008, Anabat
- Spring 2008, Bird Survey
- Spring 2008, Frog Spotlight
- Spring 2008, Habitat Assessment
- Spring 2008, Owl Call Playback
- Autumn 2009, Bird Survey
- Autumn 2009, Call Playback
- Autumn 2009, Frog Spotlight
- Autumn 2009, Habitat Assessment
- Autumn 2009, Spotlighting

Survey transects
- Summer 2007 - Bird Survey
- Summer 2007 - Elliot Trap
- Summer 2007 - Cage Trap
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey/Spotlighting
- Summer 2007 - Spotlighting
- Summer 2007 - Spotlighting/Nocturnal Bird Survey
- Spring 2008 - Bird survey
- Spring 2008 - Elliot Trap/Cage Trap
- Spring 2008 - Elliot Trap/Cage Trap/Hair Tube
- Spring 2008 - Spotlighting
- Spring 2008 - Spotlighting/Nocturnal Bird Survey
- Autumn 2009 - Bird survey
- Autumn 2009 - Cage Trap
- Autumn 2009 - Spotlighting
- Spring 2011 - Town Creek general survey and habitat assessments
- Subject Site - Temporary Creek Crossings
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Ancillary Sites
- Subject Site - Compound
- Subject Site - Stockpile
- Study Area
- RoadNameExtent

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Figure 2.3.6: Location of fauna survey effort

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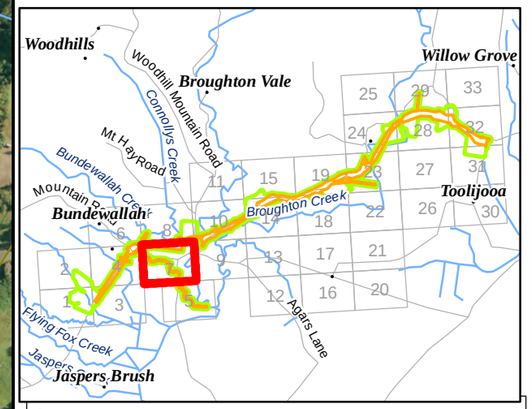
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Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.3





Legend

Survey points
- Summer 2007, Anabat
- Summer 2007, Anabat/Harp Trap
- Summer 2007, Anabat/Owl Call Playback
- Summer 2007, Bird Survey
- Summer 2007, Habitat Assessment
- Summer 2007, Harp Trap
- Summer 2007, Owl Call Playback
- Summer 2007, Spotlighting
- Spring 2008, Anabat
- Spring 2008, Bird Survey
- Spring 2008, Frog Spotlight
- Spring 2008, Habitat Assessment
- Spring 2008, Owl Call Playback
- Autumn 2009, Bird Survey
- Autumn 2009, Call Playback
- Autumn 2009, Frog Spotlight
- Autumn 2009, Habitat Assessment
- Autumn 2009, Spotlighting

Survey transects
- Summer 2007 - Bird Survey
- Summer 2007 - Elliot Trap
- Summer 2007 - Cage Trap
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey/Spotlighting
- Summer 2007 - Spotlighting
- Summer 2007 - Spotlighting/Nocturnal Bird Survey
- Spring 2008 - Bird survey
- Spring 2008 - Elliot Trap/Cage Trap
- Spring 2008 - Elliot Trap/Cage Trap/Hair Tube
- Spring 2008 - Spotlighting
- Spring 2008 - Spotlighting/Nocturnal Bird Survey
- Autumn 2009 - Bird survey
- Autumn 2009 - Cage Trap
- Autumn 2009 - Spotlighting
- Spring 2011 - Town Creek general survey and habitat assessments
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites
- Subject Site - Compound
- Subject Site - Stockpile
- Study Area
- RoadNameExtent

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Figure 2.3.7: Location of fauna survey effort

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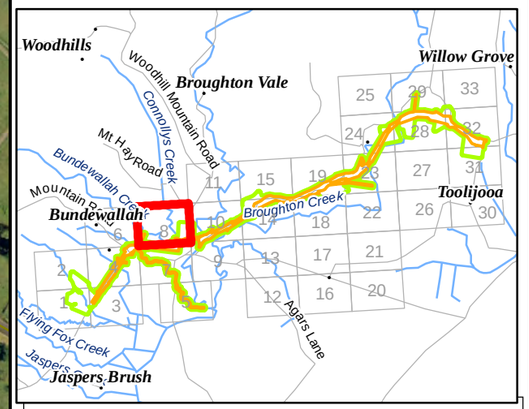
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Scale: 1: 4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.3





Legend

Survey points
- Summer 2007, Anabat
- Summer 2007, Anabat/Harp Trap
- Summer 2007, Anabat/Owl Call Playback
- Summer 2007, Bird Survey
- Summer 2007, Habitat Assessment
- Summer 2007, Harp Trap
- Summer 2007, Owl Call Playback
- Summer 2007, Spotlighting
- Spring 2008, Anabat
- Spring 2008, Bird Survey
- Spring 2008, Frog Spotlight
- Spring 2008, Habitat Assessment
- Spring 2008, Owl Call Playback
- Autumn 2009, Bird Survey
- Autumn 2009, Call Playback
- Autumn 2009, Frog Spotlight
- Autumn 2009, Habitat Assessment
- Autumn 2009, Spotlighting

Survey transects
- Summer 2007 - Bird Survey
- Summer 2007 - Elliot Trap
- Summer 2007 - Cage Trap
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey/Spotlighting
- Summer 2007 - Spotlighting
- Summer 2007 - Spotlighting/Nocturnal Bird Survey
- Spring 2008 - Bird survey
- Spring 2008 - Elliot Trap/Cage Trap
- Spring 2008 - Elliot Trap/Cage Trap/Hair Tube
- Spring 2008 - Spotlighting
- Spring 2008 - Spotlighting/Nocturnal Bird Survey
- Autumn 2009 - Bird survey
- Autumn 2009 - Cage Trap
- Autumn 2009 - Spotlighting
- Spring 2011 - Town Creek general survey and habitat assessments
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites
- Subject Site - Compound
- Subject Site - Stockpile
- Study Area
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Figure 2.3.8: Location of fauna survey effort

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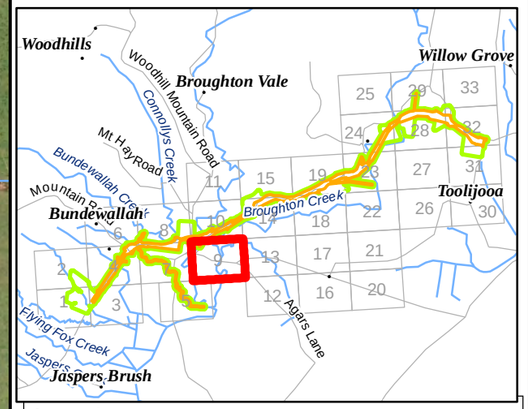
0 40 80 120 160 200
Metres

Scale: 1: 4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.3





Legend

Survey points
- Summer 2007, Anabat
- Summer 2007, Anabat/Harp Trap
- Summer 2007, Anabat/Owl Call Playback
- Summer 2007, Bird Survey
- Summer 2007, Habitat Assessment
- Summer 2007, Harp Trap
- Summer 2007, Owl Call Playback
- Summer 2007, Spotlighting
- Spring 2008, Anabat
- Spring 2008, Bird Survey
- Spring 2008, Frog Spotlight
- Spring 2008, Habitat Assessment
- Spring 2008, Owl Call Playback
- Autumn 2009, Bird Survey
- Autumn 2009, Call Playback
- Autumn 2009, Frog Spotlight
- Autumn 2009, Habitat Assessment
- Autumn 2009, Spotlighting

Survey transects
- Summer 2007 - Bird Survey
- Summer 2007 - Elliot Trap
- Summer 2007 - Cage Trap
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey/Spotlighting
- Summer 2007 - Spotlighting
- Summer 2007 - Spotlighting/Nocturnal Bird Survey
- Spring 2008 - Bird survey
- Spring 2008 - Elliot Trap/Cage Trap
- Spring 2008 - Elliot Trap/Cage Trap/Hair Tube
- Spring 2008 - Spotlighting
- Spring 2008 - Spotlighting/Nocturnal Bird Survey
- Autumn 2009 - Bird survey
- Autumn 2009 - Cage Trap
- Autumn 2009 - Spotlighting
- Spring 2011 - Town Creek general survey and habitat assessments
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites
- Subject Site - Compound
- Subject Site - Stockpile
- Study Area
- RoadNameExtent

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Figure 2.3.9: Location of fauna survey effort

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File: 13194	Checked by: JC
Location: P:\15000s\15039\Mapping\Variation 2\Variation 2 figures\15039_S2_F2-3_survey_fauna_010812.mxd	

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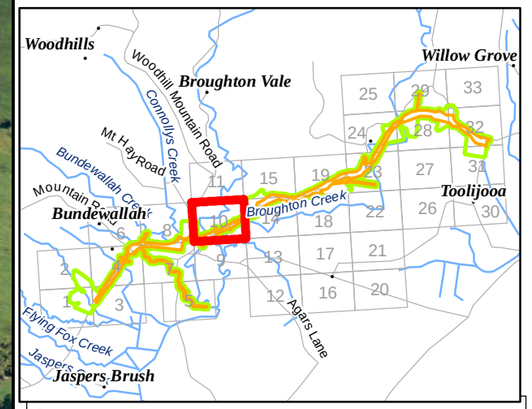
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Metres

Scale: 1: 4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.3





Legend

Survey points
- Summer 2007, Anabat
- Summer 2007, Anabat/Harp Trap
- Summer 2007, Anabat/Owl Call Playback
- Summer 2007, Bird Survey
- Summer 2007, Habitat Assessment
- Summer 2007, Harp Trap
- Summer 2007, Owl Call Playback
- Summer 2007, Spotlighting
- Spring 2008, Anabat
- Spring 2008, Bird Survey
- Spring 2008, Frog Spotlight
- Spring 2008, Habitat Assessment
- Spring 2008, Owl Call Playback
- Autumn 2009, Bird Survey
- Autumn 2009, Call Playback
- Autumn 2009, Frog Spotlight
- Autumn 2009, Habitat Assessment
- Autumn 2009, Spotlighting

Survey transects
- Summer 2007 - Bird Survey
- Summer 2007 - Elliot Trap
- Summer 2007 - Cage Trap
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey/Spotlighting
- Summer 2007 - Spotlighting
- Summer 2007 - Spotlighting/Nocturnal Bird Survey
- Spring 2008 - Bird survey
- Spring 2008 - Elliot Trap/Cage Trap
- Spring 2008 - Elliot Trap/Cage Trap/Hair Tube
- Spring 2008 - Spotlighting
- Spring 2008 - Spotlighting/Nocturnal Bird Survey
- Autumn 2009 - Bird survey
- Autumn 2009 - Cage Trap
- Autumn 2009 - Spotlighting
- Spring 2011 - Town Creek general survey and habitat assessments
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites
- Subject Site - Compound
- Subject Site - Stockpile
- Study Area
- RoadNameExtent

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Figure 2.3.10: Location of fauna survey effort

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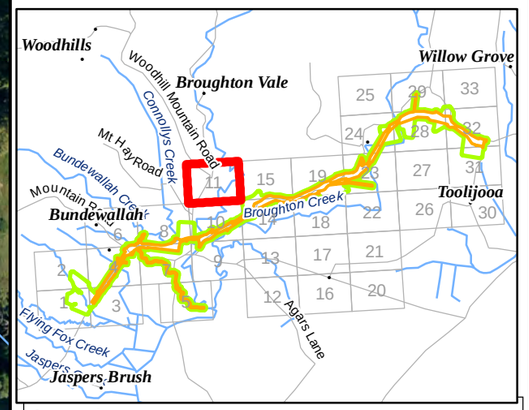
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Scale: 1: 4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.3





Legend

Survey points
- Summer 2007, Anabat
- Summer 2007, Anabat/Harp Trap
- Summer 2007, Anabat/Owl Call Playback
- Summer 2007, Bird Survey
- Summer 2007, Habitat Assessment
- Summer 2007, Harp Trap
- Summer 2007, Owl Call Playback
- Summer 2007, Spotlighting
- Spring 2008, Anabat
- Spring 2008, Bird Survey
- Spring 2008, Frog Spotlight
- Spring 2008, Habitat Assessment
- Spring 2008, Owl Call Playback
- Autumn 2009, Bird Survey
- Autumn 2009, Call Playback
- Autumn 2009, Frog Spotlight
- Autumn 2009, Habitat Assessment
- Autumn 2009, Spotlighting

Survey transects
- Summer 2007 - Bird Survey
- Summer 2007 - Elliot Trap
- Summer 2007 - Cage Trap
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey/Spotlighting
- Summer 2007 - Spotlighting
- Summer 2007 - Spotlighting/Nocturnal Bird Survey
- Spring 2008 - Bird survey
- Spring 2008 - Elliot Trap/Cage Trap
- Spring 2008 - Elliot Trap/Cage Trap/Hair Tube
- Spring 2008 - Spotlighting
- Spring 2008 - Spotlighting/Nocturnal Bird Survey
- Autumn 2009 - Bird survey
- Autumn 2009 - Cage Trap
- Autumn 2009 - Spotlighting
- Spring 2011 - Town Creek general survey and habitat assessments
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites
- Subject Site - Compound
- Subject Site - Stockpile
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- RoadNameExtent

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Figure 2.3.11: Location of fauna survey effort

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File: 13194	Checked by: JC
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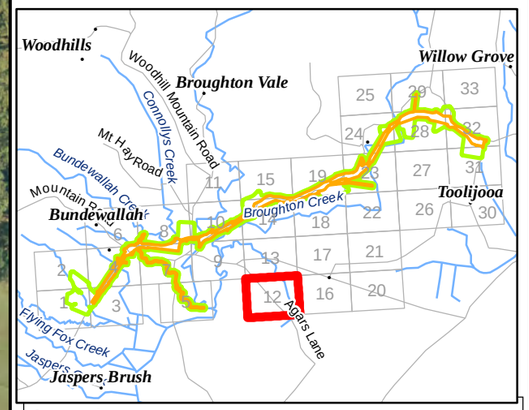
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Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.3





Legend

Survey points

- Summer 2007, Anabat
- Summer 2007, Anabat/Harp Trap
- Summer 2007, Anabat/Owl Call Playback
- Summer 2007, Bird Survey
- Summer 2007, Habitat Assessment
- Summer 2007, Harp Trap
- Summer 2007, Owl Call Playback
- Summer 2007, Spotlighting
- Spring 2008, Anabat
- Spring 2008, Bird Survey
- Spring 2008, Frog Spotlight
- Spring 2008, Habitat Assessment
- Spring 2008, Owl Call Playback
- Autumn 2009, Bird Survey
- Autumn 2009, Call Playback
- Autumn 2009, Frog Spotlight
- Autumn 2009, Habitat Assessment
- Autumn 2009, Spotlighting

Survey transects

- Summer 2007 - Bird Survey
- Summer 2007 - Elliot Trap
- Summer 2007 - Cage Trap
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey/Spotlighting
- Summer 2007 - Spotlighting
- Summer 2007 - Spotlighting/Nocturnal Bird Survey
- Spring 2008 - Bird survey
- Spring 2008 - Elliot Trap/Cage Trap
- Spring 2008 - Elliot Trap/Cage Trap/Hair Tube
- Spring 2008 - Spotlighting
- Spring 2008 - Spotlighting/Nocturnal Bird Survey
- Autumn 2009 - Bird survey
- Autumn 2009 - Cage Trap
- Autumn 2009 - Spotlighting
- Spring 2011 - Town Creek general survey and habitat assessments
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
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Figure 2.3.12: Location of fauna survey effort

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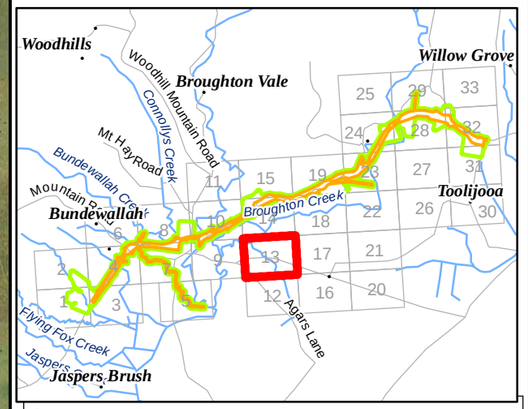
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Scale: 1: 4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.3





Legend

Survey points
- Summer 2007, Anabat
- Summer 2007, Anabat/Harp Trap
- Summer 2007, Anabat/Owl Call Playback
- Summer 2007, Bird Survey
- Summer 2007, Habitat Assessment
- Summer 2007, Harp Trap
- Summer 2007, Owl Call Playback
- Summer 2007, Spotlighting
- Spring 2008, Anabat
- Spring 2008, Bird Survey
- Spring 2008, Frog Spotlight
- Spring 2008, Habitat Assessment
- Spring 2008, Owl Call Playback
- Autumn 2009, Bird Survey
- Autumn 2009, Call Playback
- Autumn 2009, Frog Spotlight
- Autumn 2009, Habitat Assessment
- Autumn 2009, Spotlighting

Survey transects
- Summer 2007 - Bird Survey
- Summer 2007 - Elliot Trap
- Summer 2007 - Cage Trap
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey/Spotlighting
- Summer 2007 - Spotlighting
- Summer 2007 - Spotlighting/Nocturnal Bird Survey
- Spring 2008 - Bird survey
- Spring 2008 - Elliot Trap/Cage Trap
- Spring 2008 - Elliot Trap/Cage Trap/Hair Tube
- Spring 2008 - Spotlighting
- Spring 2008 - Spotlighting/Nocturnal Bird Survey
- Autumn 2009 - Bird survey
- Autumn 2009 - Cage Trap
- Autumn 2009 - Spotlighting
- Spring 2011 - Town Creek general survey and habitat assessments
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites
- Subject Site - Compound
- Subject Site - Stockpile
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- RoadNameExtent

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Figure 2.3.13: Location of fauna survey effort

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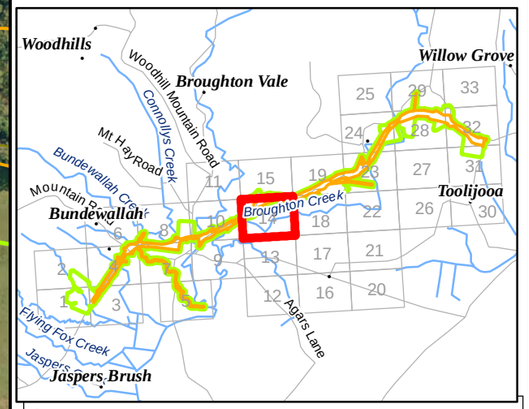
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Scale: 1: 4,000 at A3
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Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.3





Legend

Survey points
- Summer 2007, Anabat
- Summer 2007, Anabat/Harp Trap
- Summer 2007, Anabat/Owl Call Playback
- Summer 2007, Bird Survey
- Summer 2007, Habitat Assessment
- Summer 2007, Harp Trap
- Summer 2007, Owl Call Playback
- Summer 2007, Spotlighting
- Spring 2008, Anabat
- Spring 2008, Bird Survey
- Spring 2008, Frog Spotlight
- Spring 2008, Habitat Assessment
- Spring 2008, Owl Call Playback
- Autumn 2009, Bird Survey
- Autumn 2009, Call Playback
- Autumn 2009, Frog Spotlight
- Autumn 2009, Habitat Assessment
- Autumn 2009, Spotlighting

Survey transects
- Summer 2007 - Bird Survey
- Summer 2007 - Elliot Trap
- Summer 2007 - Cage Trap
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey/Spotlighting
- Summer 2007 - Spotlighting
- Summer 2007 - Spotlighting/Nocturnal Bird Survey
- Spring 2008 - Bird survey
- Spring 2008 - Elliot Trap/Cage Trap
- Spring 2008 - Elliot Trap/Cage Trap/Hair Tube
- Spring 2008 - Spotlighting
- Spring 2008 - Spotlighting/Nocturnal Bird Survey
- Autumn 2009 - Bird survey
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- Autumn 2009 - Spotlighting
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Ancillary Sites
- Subject Site - Compound
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Figure 2.3.14: Location of fauna survey effort

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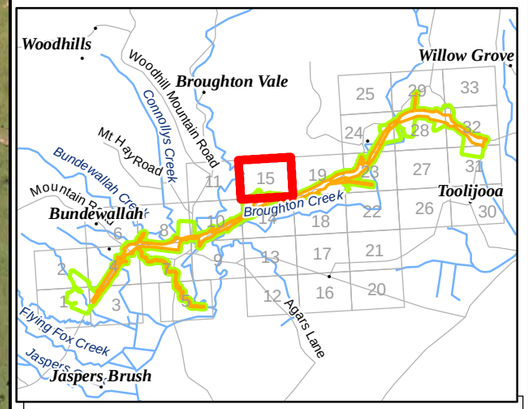
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Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.3





Legend

Survey points
- Summer 2007, Anabat
- Summer 2007, Anabat/Harp Trap
- Summer 2007, Anabat/Owl Call Playback
- Summer 2007, Bird Survey
- Summer 2007, Habitat Assessment
- Summer 2007, Harp Trap
- Summer 2007, Owl Call Playback
- Summer 2007, Spotlighting
- Spring 2008, Anabat
- Spring 2008, Bird Survey
- Spring 2008, Frog Spotlight
- Spring 2008, Habitat Assessment
- Spring 2008, Owl Call Playback
- Autumn 2009, Bird Survey
- Autumn 2009, Call Playback
- Autumn 2009, Frog Spotlight
- Autumn 2009, Habitat Assessment
- Autumn 2009, Spotlighting

Survey transects
- Summer 2007 - Bird Survey
- Summer 2007 - Elliot Trap
- Summer 2007 - Cage Trap
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey/Spotlighting
- Summer 2007 - Spotlighting
- Summer 2007 - Spotlighting/Nocturnal Bird Survey
- Spring 2008 - Bird survey
- Spring 2008 - Elliot Trap/Cage Trap
- Spring 2008 - Elliot Trap/Cage Trap/Hair Tube
- Spring 2008 - Spotlighting
- Spring 2008 - Spotlighting/Nocturnal Bird Survey
- Autumn 2009 - Bird survey
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- Autumn 2009 - Spotlighting
- Spring 2011 - Town Creek general survey and habitat assessments
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Ancillary Sites
- Subject Site - Compound
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Figure 2.3.15: Location of fauna survey effort

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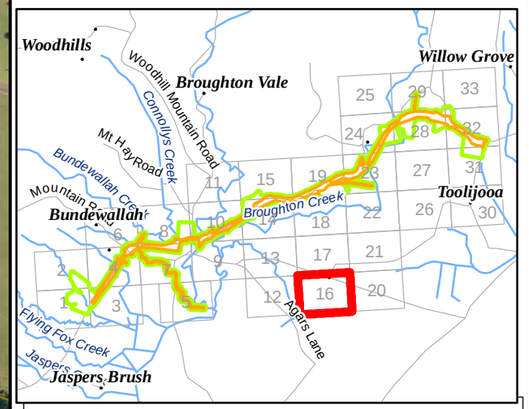
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Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.3





Legend

Survey points
- Summer 2007, Anabat
- Summer 2007, Anabat/Harp Trap
- Summer 2007, Anabat/Owl Call Playback
- Summer 2007, Bird Survey
- Summer 2007, Habitat Assessment
- Summer 2007, Harp Trap
- Summer 2007, Owl Call Playback
- Summer 2007, Spotlighting
- Spring 2008, Anabat
- Spring 2008, Bird Survey
- Spring 2008, Frog Spotlight
- Spring 2008, Habitat Assessment
- Spring 2008, Owl Call Playback
- Autumn 2009, Bird Survey
- Autumn 2009, Call Playback
- Autumn 2009, Frog Spotlight
- Autumn 2009, Habitat Assessment
- Autumn 2009, Spotlighting

Survey transects
- Summer 2007 - Bird Survey
- Summer 2007 - Elliot Trap
- Summer 2007 - Cage Trap
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey/Spotlighting
- Summer 2007 - Spotlighting
- Summer 2007 - Spotlighting/Nocturnal Bird Survey
- Spring 2008 - Bird survey
- Spring 2008 - Elliot Trap/Cage Trap
- Spring 2008 - Elliot Trap/Cage Trap/Hair Tube
- Spring 2008 - Spotlighting
- Spring 2008 - Spotlighting/Nocturnal Bird Survey
- Autumn 2009 - Bird survey
- Autumn 2009 - Cage Trap
- Autumn 2009 - Spotlighting
- Spring 2011 - Town Creek general survey and habitat assessments
- Subject Site - Temporary Creek Crossings
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Ancillary Sites
- Subject Site - Compound
- Subject Site - Stockpile
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- RoadNameExtent

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Figure 2.3.16: Location of fauna survey effort

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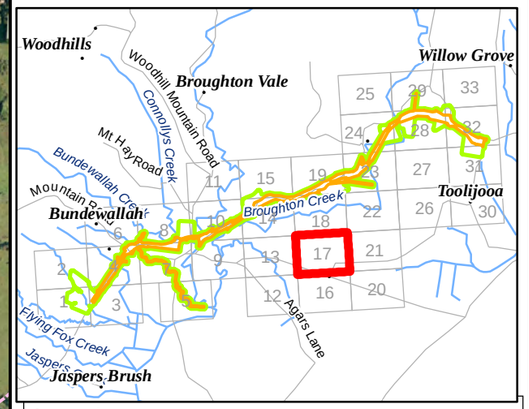
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Grid: Map Grid of Australia, Zone 56

N

Figure 2.3





Legend

Survey points
- Summer 2007, Anabat
- Summer 2007, Anabat/Harp Trap
- Summer 2007, Anabat/Owl Call Playback
- Summer 2007, Bird Survey
- Summer 2007, Habitat Assessment
- Summer 2007, Harp Trap
- Summer 2007, Owl Call Playback
- Summer 2007, Spotlighting
- Spring 2008, Anabat
- Spring 2008, Bird Survey
- Spring 2008, Frog Spotlight
- Spring 2008, Habitat Assessment
- Spring 2008, Owl Call Playback
- Autumn 2009, Bird Survey
- Autumn 2009, Call Playback
- Autumn 2009, Frog Spotlight
- Autumn 2009, Habitat Assessment
- Autumn 2009, Spotlighting

Survey transects
- Summer 2007 - Bird Survey
- Summer 2007 - Elliot Trap
- Summer 2007 - Cage Trap
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey/Spotlighting
- Summer 2007 - Spotlighting
- Summer 2007 - Spotlighting/Nocturnal Bird Survey
- Spring 2008 - Bird survey
- Spring 2008 - Elliot Trap/Cage Trap
- Spring 2008 - Elliot Trap/Cage Trap/Hair Tube
- Spring 2008 - Spotlighting
- Spring 2008 - Spotlighting/Nocturnal Bird Survey
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- Autumn 2009 - Spotlighting
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Figure 2.3.17: Location of fauna survey effort

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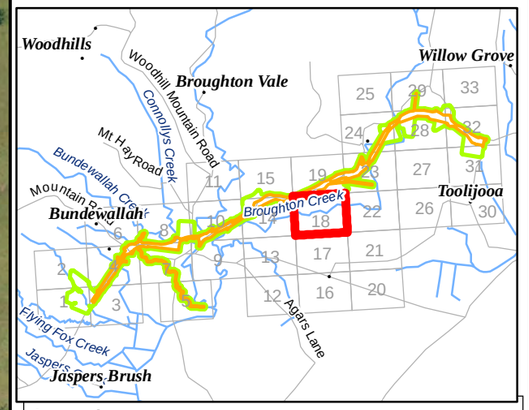
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Grid: Map Grid of Australia, Zone 56

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Figure 2.3





Legend

Survey points
- Summer 2007, Anabat
- Summer 2007, Anabat/Harp Trap
- Summer 2007, Anabat/Owl Call Playback
- Summer 2007, Bird Survey
- Summer 2007, Habitat Assessment
- Summer 2007, Harp Trap
- Summer 2007, Owl Call Playback
- Summer 2007, Spotlighting
- Spring 2008, Anabat
- Spring 2008, Bird Survey
- Spring 2008, Frog Spotlight
- Spring 2008, Habitat Assessment
- Spring 2008, Owl Call Playback
- Autumn 2009, Bird Survey
- Autumn 2009, Call Playback
- Autumn 2009, Frog Spotlight
- Autumn 2009, Habitat Assessment
- Autumn 2009, Spotlighting

Survey transects
- Summer 2007 - Bird Survey
- Summer 2007 - Elliot Trap
- Summer 2007 - Cage Trap
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey/Spotlighting
- Summer 2007 - Spotlighting
- Summer 2007 - Spotlighting/Nocturnal Bird Survey
- Spring 2008 - Bird survey
- Spring 2008 - Elliot Trap/Cage Trap
- Spring 2008 - Elliot Trap/Cage Trap/Hair Tube
- Spring 2008 - Spotlighting
- Spring 2008 - Spotlighting/Nocturnal Bird Survey
- Autumn 2009 - Bird survey
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- Autumn 2009 - Spotlighting
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Ancillary Sites
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Figure 2.3.18: Location of fauna survey effort

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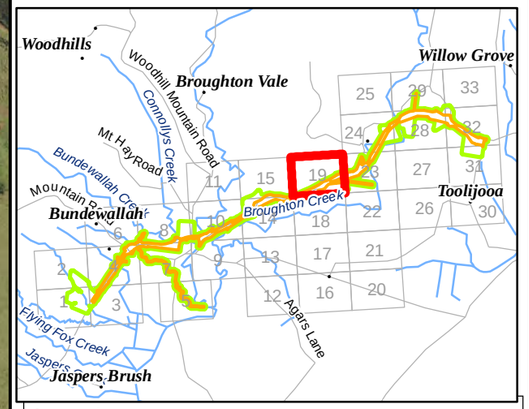
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Scale: 1: 4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.3





Legend

Survey points

- Summer 2007, Anabat
- Summer 2007, Anabat/Harp Trap
- Summer 2007, Anabat/Owl Call Playback
- Summer 2007, Bird Survey
- Summer 2007, Habitat Assessment
- Summer 2007, Harp Trap
- Summer 2007, Owl Call Playback
- Summer 2007, Spotlighting
- Spring 2008, Anabat
- Spring 2008, Bird Survey
- Spring 2008, Frog Spotlight
- Spring 2008, Habitat Assessment
- Spring 2008, Owl Call Playback
- Autumn 2009, Bird Survey
- Autumn 2009, Call Playback
- Autumn 2009, Frog Spotlight
- Autumn 2009, Habitat Assessment
- Autumn 2009, Spotlighting

Survey transects

- Summer 2007 - Bird Survey
- Summer 2007 - Elliot Trap
- Summer 2007 - Cage Trap
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey/Spotlighting
- Summer 2007 - Spotlighting
- Summer 2007 - Spotlighting/Nocturnal Bird Survey
- Spring 2008 - Bird survey
- Spring 2008 - Elliot Trap/Cage Trap
- Spring 2008 - Elliot Trap/Cage Trap/Hair Tube
- Spring 2008 - Spotlighting
- Spring 2008 - Spotlighting/Nocturnal Bird Survey
- Autumn 2009 - Bird survey
- Autumn 2009 - Cage Trap
- Autumn 2009 - Spotlighting
- Spring 2011 - Town Creek general survey and habitat assessments
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
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Figure 2.3.19: Location of fauna survey effort

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Location: P:\15000s\15039\Mapping\Variation 2\Variation 2 figures\15039_S2_F2-3_survey_fauna_010812.mxd	

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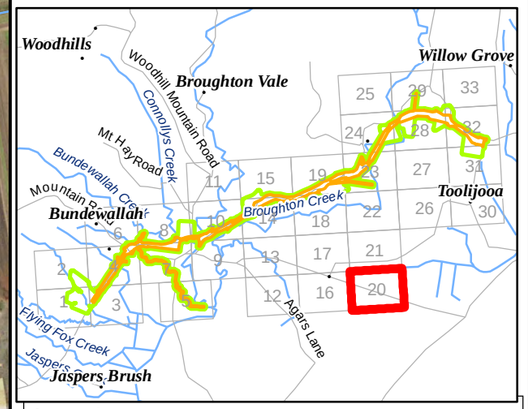
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Scale: 1: 4,000 at A3
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Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

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Figure 2.3





Legend

Survey points
- Summer 2007, Anabat
- Summer 2007, Anabat/Harp Trap
- Summer 2007, Anabat/Owl Call Playback
- Summer 2007, Bird Survey
- Summer 2007, Habitat Assessment
- Summer 2007, Harp Trap
- Summer 2007, Owl Call Playback
- Summer 2007, Spotlighting
- Spring 2008, Anabat
- Spring 2008, Bird Survey
- Spring 2008, Frog Spotlight
- Spring 2008, Habitat Assessment
- Spring 2008, Owl Call Playback
- Autumn 2009, Bird Survey
- Autumn 2009, Call Playback
- Autumn 2009, Frog Spotlight
- Autumn 2009, Habitat Assessment
- Autumn 2009, Spotlighting

Survey transects
- Summer 2007 - Bird Survey
- Summer 2007 - Elliot Trap
- Summer 2007 - Cage Trap
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey/Spotlighting
- Summer 2007 - Spotlighting
- Summer 2007 - Spotlighting/Nocturnal Bird Survey
- Spring 2008 - Bird survey
- Spring 2008 - Elliot Trap/Cage Trap
- Spring 2008 - Elliot Trap/Cage Trap/Hair Tube
- Spring 2008 - Spotlighting
- Spring 2008 - Spotlighting/Nocturnal Bird Survey
- Autumn 2009 - Bird survey
- Autumn 2009 - Cage Trap
- Autumn 2009 - Spotlighting
- Spring 2011 - Town Creek general survey and habitat assessments
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites
- Subject Site - Compound
- Subject Site - Stockpile
- Study Area
- RoadNameExtent

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Figure 2.3.20: Location of fauna survey effort

Date: 1 August 2012	Drawn by: RS/JMS/ANP
File: 13194	Checked by: JC
Location: P:\15000s\15039\Mapping\Variation 2\Variation 2 figures\15039_S2_F2-3_survey_fauna_010812.mxd	

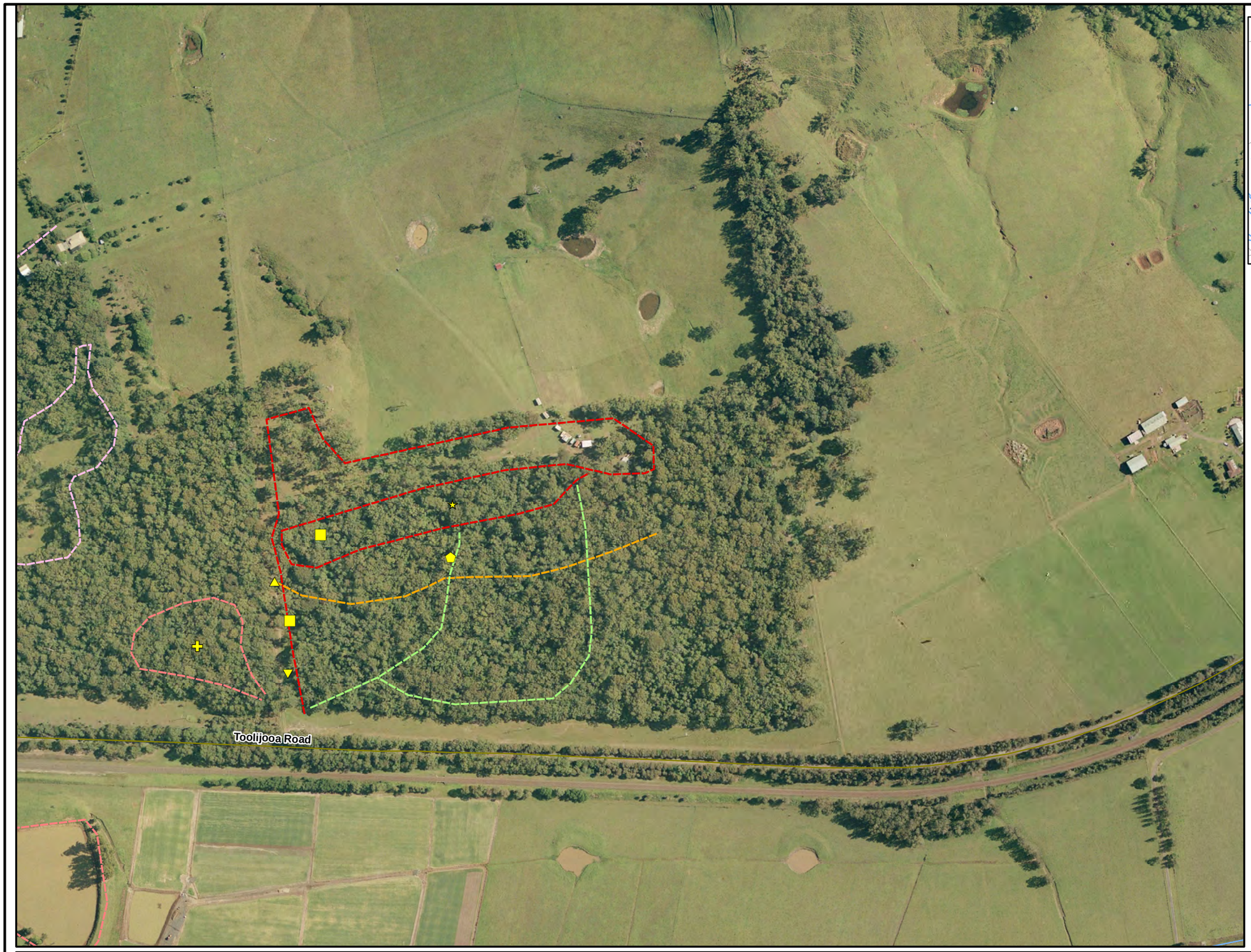
Acknowledgements:
Aerial imagery provided by ARUP
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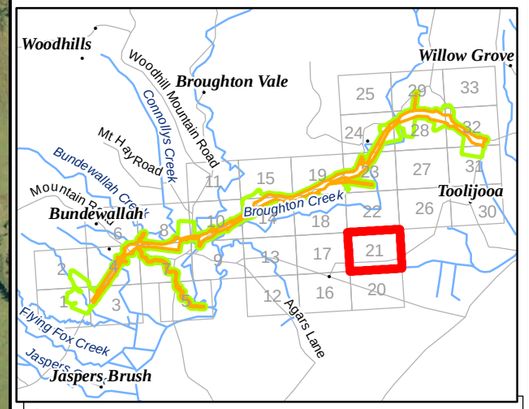
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Metres

Scale: 1: 4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.3





Legend

Survey points
- Summer 2007, Anabat
- Summer 2007, Anabat/Harp Trap
- Summer 2007, Anabat/Owl Call Playback
- Summer 2007, Bird Survey
- Summer 2007, Habitat Assessment
- Summer 2007, Harp Trap
- Summer 2007, Owl Call Playback
- Summer 2007, Spotlighting
- Spring 2008, Anabat
- Spring 2008, Bird Survey
- Spring 2008, Frog Spotlight
- Spring 2008, Habitat Assessment
- Spring 2008, Owl Call Playback
- Autumn 2009, Bird Survey
- Autumn 2009, Call Playback
- Autumn 2009, Frog Spotlight
- Autumn 2009, Habitat Assessment
- Autumn 2009, Spotlighting

Survey transects
- Summer 2007 - Bird Survey
- Summer 2007 - Elliot Trap
- Summer 2007 - Cage Trap
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey/Spotlighting
- Summer 2007 - Spotlighting
- Summer 2007 - Spotlighting/Nocturnal Bird Survey
- Spring 2008 - Bird survey
- Spring 2008 - Elliot Trap/Cage Trap
- Spring 2008 - Elliot Trap/Cage Trap/Hair Tube
- Spring 2008 - Spotlighting
- Spring 2008 - Spotlighting/Nocturnal Bird Survey
- Autumn 2009 - Bird survey
- Autumn 2009 - Cage Trap
- Autumn 2009 - Spotlighting
- Spring 2011 - Town Creek general survey and habitat assessments
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites
- Subject Site - Compound
- Subject Site - Stockpile
- Study Area
- RoadNameExtent

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Figure 2.3.21: Location of fauna survey effort

Date: 1 August 2012	Drawn by: RS/JMS/ANP
File: 13194	Checked by: JC
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Acknowledgements:
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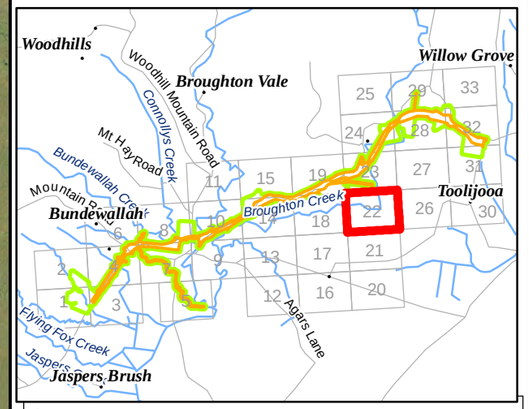
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Scale: 1: 4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.3





Legend

Survey points
- Summer 2007, Anabat
- Summer 2007, Anabat/Harp Trap
- Summer 2007, Anabat/Owl Call Playback
- Summer 2007, Bird Survey
- Summer 2007, Habitat Assessment
- Summer 2007, Harp Trap
- Summer 2007, Owl Call Playback
- Summer 2007, Spotlighting
- Spring 2008, Anabat
- Spring 2008, Bird Survey
- Spring 2008, Frog Spotlight
- Spring 2008, Habitat Assessment
- Spring 2008, Owl Call Playback
- Autumn 2009, Bird Survey
- Autumn 2009, Call Playback
- Autumn 2009, Frog Spotlight
- Autumn 2009, Habitat Assessment
- Autumn 2009, Spotlighting

Survey transects
- Summer 2007 - Bird Survey
- Summer 2007 - Elliot Trap
- Summer 2007 - Cage Trap
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey/Spotlighting
- Summer 2007 - Spotlighting
- Summer 2007 - Spotlighting/Nocturnal Bird Survey
- Spring 2008 - Bird survey
- Spring 2008 - Elliot Trap/Cage Trap
- Spring 2008 - Elliot Trap/Cage Trap/Hair Tube
- Spring 2008 - Spotlighting
- Spring 2008 - Spotlighting/Nocturnal Bird Survey
- Autumn 2009 - Bird survey
- Autumn 2009 - Cage Trap
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Ancillary Sites
- Subject Site - Compound
- Subject Site - Stockpile
- Study Area
- RoadNameExtent

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Figure 2.3.22: Location of fauna survey effort

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File: 13194	Checked by: JC
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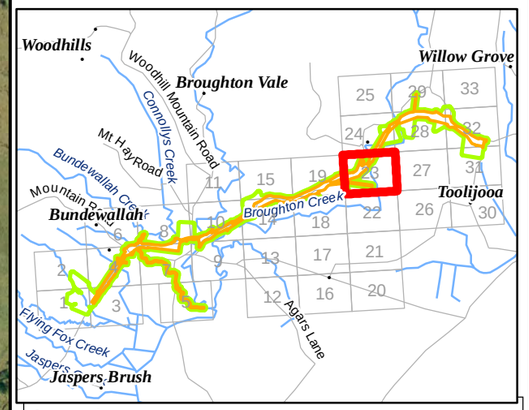
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Scale: 1: 4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.3





Legend

Survey points
- Summer 2007, Anabat
- Summer 2007, Anabat/Harp Trap
- Summer 2007, Anabat/Owl Call Playback
- Summer 2007, Bird Survey
- Summer 2007, Habitat Assessment
- Summer 2007, Harp Trap
- Summer 2007, Owl Call Playback
- Summer 2007, Spotlighting
- Spring 2008, Anabat
- Spring 2008, Bird Survey
- Spring 2008, Frog Spotlight
- Spring 2008, Habitat Assessment
- Spring 2008, Owl Call Playback
- Autumn 2009, Bird Survey
- Autumn 2009, Call Playback
- Autumn 2009, Frog Spotlight
- Autumn 2009, Habitat Assessment
- Autumn 2009, Spotlighting

Survey transects
- Summer 2007 - Bird Survey
- Summer 2007 - Elliot Trap
- Summer 2007 - Cage Trap
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey/Spotlighting
- Summer 2007 - Spotlighting
- Summer 2007 - Spotlighting/Nocturnal Bird Survey
- Spring 2008 - Bird survey
- Spring 2008 - Elliot Trap/Cage Trap
- Spring 2008 - Elliot Trap/Cage Trap/Hair Tube
- Spring 2008 - Spotlighting
- Spring 2008 - Spotlighting/Nocturnal Bird Survey
- Autumn 2009 - Bird survey
- Autumn 2009 - Cage Trap
- Autumn 2009 - Spotlighting
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Ancillary Sites
- Subject Site - Compound
- Subject Site - Stockpile
- Study Area
- RoadNameExtent

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Figure 2.3.23: Location of fauna survey effort

Date: 1 August 2012	Drawn by: RS/JMS/ANP
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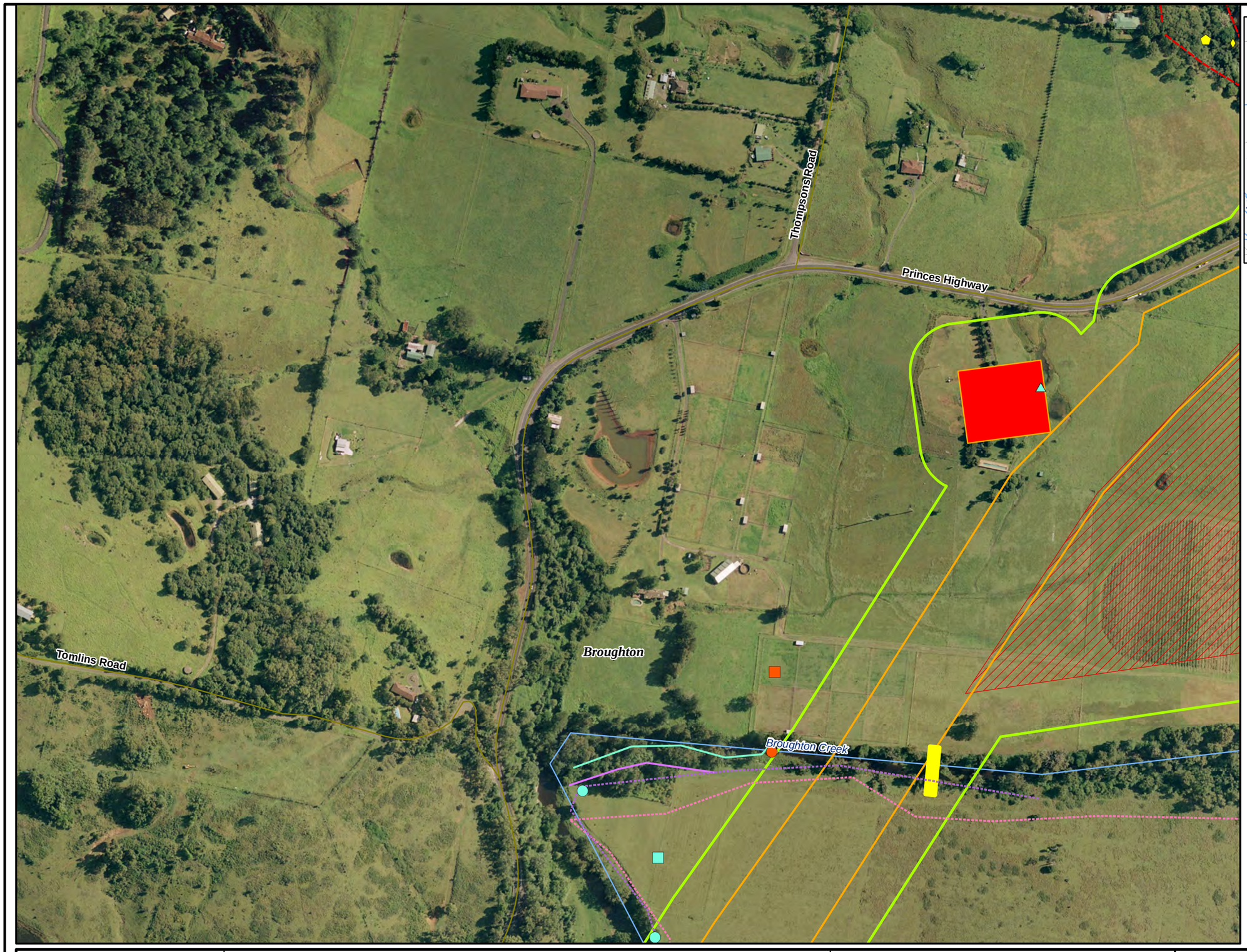
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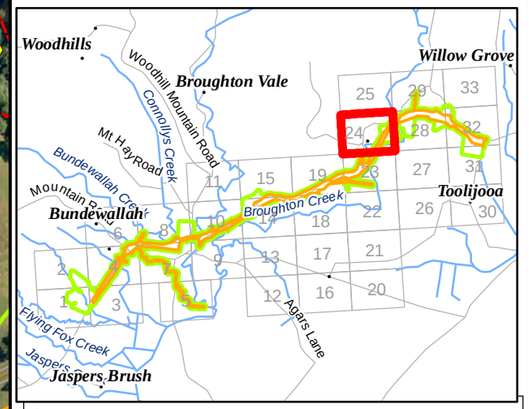
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Scale: 1: 4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.3





Legend

Survey points
- Summer 2007, Anabat
- Summer 2007, Anabat/Harp Trap
- Summer 2007, Anabat/Owl Call Playback
- Summer 2007, Bird Survey
- Summer 2007, Habitat Assessment
- Summer 2007, Harp Trap
- Summer 2007, Owl Call Playback
- Summer 2007, Spotlighting
- Spring 2008, Anabat
- Spring 2008, Bird Survey
- Spring 2008, Frog Spotlight
- Spring 2008, Habitat Assessment
- Spring 2008, Owl Call Playback
- Autumn 2009, Bird Survey
- Autumn 2009, Call Playback
- Autumn 2009, Frog Spotlight
- Autumn 2009, Habitat Assessment
- Autumn 2009, Spotlighting

Survey transects
- Summer 2007 - Bird Survey
- Summer 2007 - Elliot Trap
- Summer 2007 - Cage Trap
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey/Spotlighting
- Summer 2007 - Spotlighting
- Summer 2007 - Spotlighting/Nocturnal Bird Survey
- Spring 2008 - Bird survey
- Spring 2008 - Elliot Trap/Cage Trap
- Spring 2008 - Elliot Trap/Cage Trap/Hair Tube
- Spring 2008 - Spotlighting
- Spring 2008 - Spotlighting/Nocturnal Bird Survey
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- Autumn 2009 - Spotlighting
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- Subject Site - Temporary Creek Crossings
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Ancillary Sites
- Subject Site - Compound
- Subject Site - Stockpile
- Study Area
- RoadNameExtent

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Figure 2.3.24: Location of fauna survey effort

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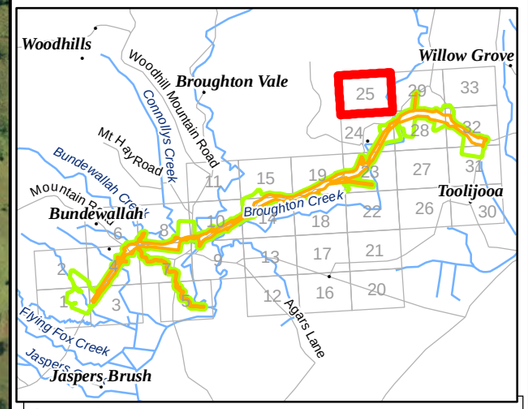
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Metres

Scale: 1: 4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.3





Legend

Survey points
- Summer 2007, Anabat
- Summer 2007, Anabat/Harp Trap
- Summer 2007, Anabat/Owl Call Playback
- Summer 2007, Bird Survey
- Summer 2007, Habitat Assessment
- Summer 2007, Harp Trap
- Summer 2007, Owl Call Playback
- Summer 2007, Spotlighting
- Spring 2008, Anabat
- Spring 2008, Bird Survey
- Spring 2008, Frog Spotlight
- Spring 2008, Habitat Assessment
- Spring 2008, Owl Call Playback
- Autumn 2009, Bird Survey
- Autumn 2009, Call Playback
- Autumn 2009, Frog Spotlight
- Autumn 2009, Habitat Assessment
- Autumn 2009, Spotlighting

Survey transects
- Summer 2007 - Bird Survey
- Summer 2007 - Elliot Trap
- Summer 2007 - Cage Trap
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey/Spotlighting
- Summer 2007 - Spotlighting
- Summer 2007 - Spotlighting/Nocturnal Bird Survey
- Spring 2008 - Bird survey
- Spring 2008 - Elliot Trap/Cage Trap
- Spring 2008 - Elliot Trap/Cage Trap/Hair Tube
- Spring 2008 - Spotlighting
- Spring 2008 - Spotlighting/Nocturnal Bird Survey
- Autumn 2009 - Bird survey
- Autumn 2009 - Cage Trap
- Autumn 2009 - Spotlighting
- Spring 2011 - Town Creek general survey and habitat assessments
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites
- Subject Site - Compound
- Subject Site - Stockpile
- Study Area
- RoadNameExtent

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Figure 2.3.25: Location of fauna survey effort

Date: 1 August 2012	Drawn by: RS/JMS/ANP
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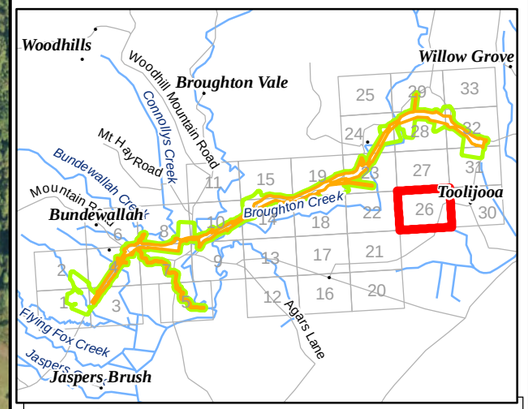
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Scale: 1: 4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.3





Legend

Survey points
- Summer 2007, Anabat
- Summer 2007, Anabat/Harp Trap
- Summer 2007, Anabat/Owl Call Playback
- Summer 2007, Bird Survey
- Summer 2007, Habitat Assessment
- Summer 2007, Harp Trap
- Summer 2007, Owl Call Playback
- Summer 2007, Spotlighting
- Spring 2008, Anabat
- Spring 2008, Bird Survey
- Spring 2008, Frog Spotlight
- Spring 2008, Habitat Assessment
- Spring 2008, Owl Call Playback
- Autumn 2009, Bird Survey
- Autumn 2009, Call Playback
- Autumn 2009, Frog Spotlight
- Autumn 2009, Habitat Assessment
- Autumn 2009, Spotlighting

Survey transects
- Summer 2007 - Bird Survey
- Summer 2007 - Elliot Trap
- Summer 2007 - Cage Trap
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey/Spotlighting
- Summer 2007 - Spotlighting
- Summer 2007 - Spotlighting/Nocturnal Bird Survey
- Spring 2008 - Bird survey
- Spring 2008 - Elliot Trap/Cage Trap
- Spring 2008 - Elliot Trap/Cage Trap/Hair Tube
- Spring 2008 - Spotlighting
- Spring 2008 - Spotlighting/Nocturnal Bird Survey
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- Spring 2011 - Town Creek general survey and habitat assessments
- Subject Site - Temporary Creek Crossings
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Ancillary Sites
- Subject Site - Compound
- Subject Site - Stockpile
- Study Area
- RoadNameExtent

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Figure 2.3.26: Location of fauna survey effort

Date: 1 August 2012	Drawn by: RS/JMS/ANP
File: 13194	Checked by: JC
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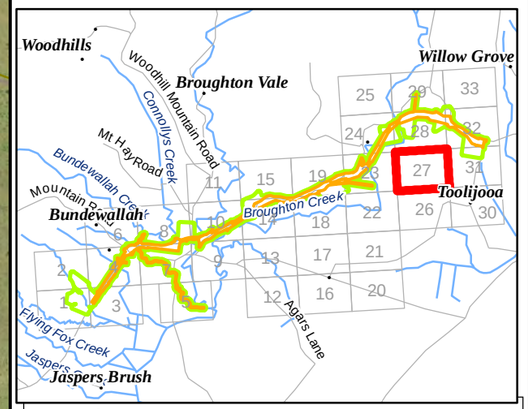
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Metres

Scale: 1: 4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.3





Legend

Survey points
- Summer 2007, Anabat
- Summer 2007, Anabat/Harp Trap
- Summer 2007, Anabat/Owl Call Playback
- Summer 2007, Bird Survey
- Summer 2007, Habitat Assessment
- Summer 2007, Harp Trap
- Summer 2007, Owl Call Playback
- Summer 2007, Spotlighting
- Spring 2008, Anabat
- Spring 2008, Bird Survey
- Spring 2008, Frog Spotlight
- Spring 2008, Habitat Assessment
- Spring 2008, Owl Call Playback
- Autumn 2009, Bird Survey
- Autumn 2009, Call Playback
- Autumn 2009, Frog Spotlight
- Autumn 2009, Habitat Assessment
- Autumn 2009, Spotlighting

Survey transects
- Summer 2007 - Bird Survey
- Summer 2007 - Elliot Trap
- Summer 2007 - Cage Trap
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey/Spotlighting
- Summer 2007 - Spotlighting
- Summer 2007 - Spotlighting/Nocturnal Bird Survey
- Spring 2008 - Bird survey
- Spring 2008 - Elliot Trap/Cage Trap
- Spring 2008 - Elliot Trap/Cage Trap/Hair Tube
- Spring 2008 - Spotlighting
- Spring 2008 - Spotlighting/Nocturnal Bird Survey
- Autumn 2009 - Bird survey
- Autumn 2009 - Cage Trap
- Autumn 2009 - Spotlighting
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- Subject Site - Temporary Creek Crossings
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Ancillary Sites
- Subject Site - Compound
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Figure 2.3.27: Location of fauna survey effort

Date: 1 August 2012	Drawn by: RS/JMS/ANP
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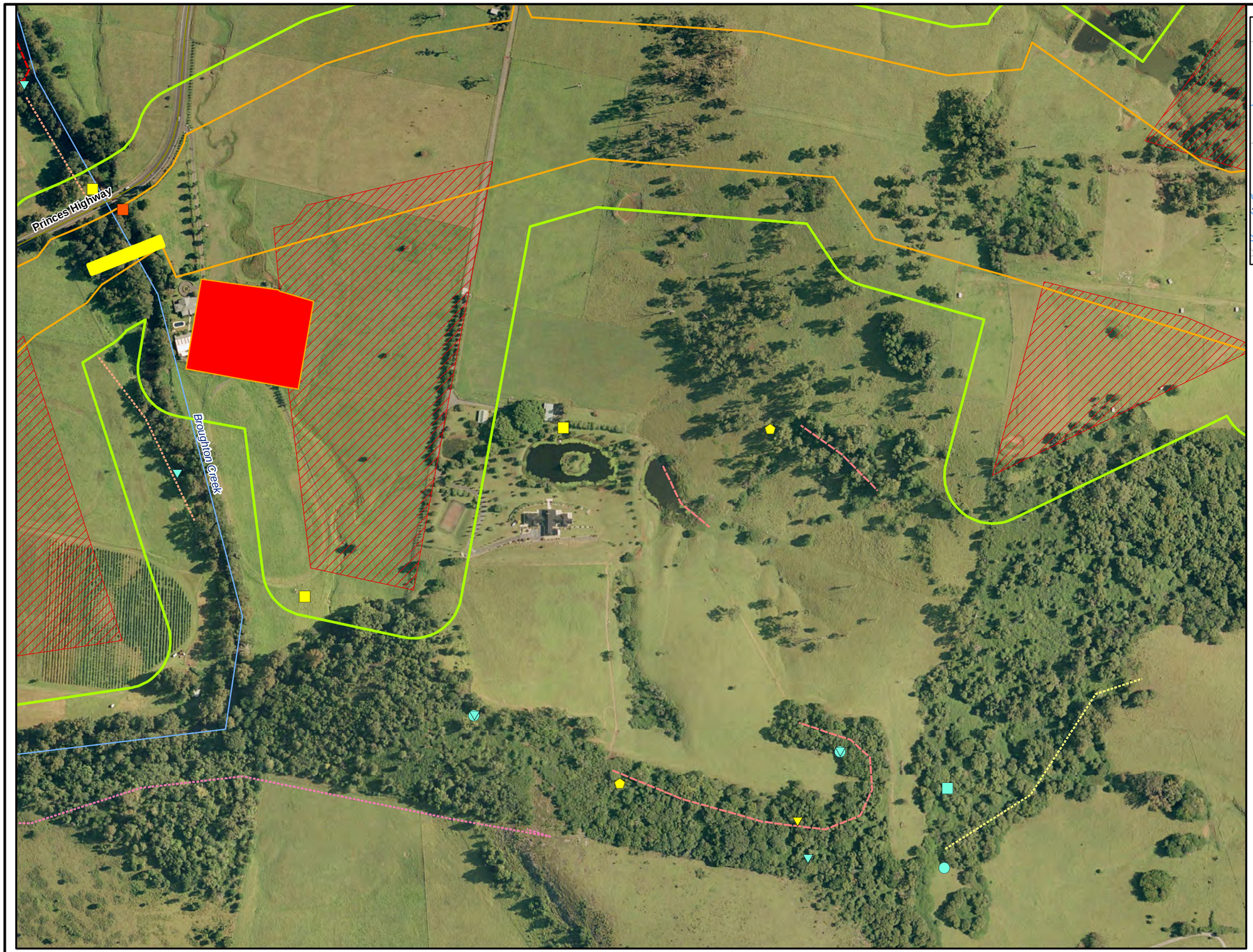
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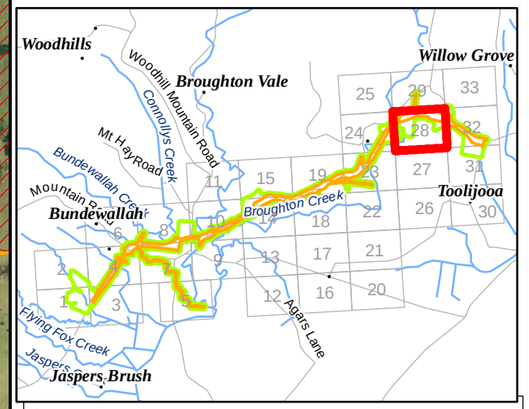
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Metres

Scale: 1: 4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.3





Legend

Survey points
- Summer 2007, Anabat
- Summer 2007, Anabat/Harp Trap
- Summer 2007, Anabat/Owl Call Playback
- Summer 2007, Bird Survey
- Summer 2007, Habitat Assessment
- Summer 2007, Harp Trap
- Summer 2007, Owl Call Playback
- Summer 2007, Spotlighting
- Spring 2008, Anabat
- Spring 2008, Bird Survey
- Spring 2008, Frog Spotlight
- Spring 2008, Habitat Assessment
- Spring 2008, Owl Call Playback
- Autumn 2009, Bird Survey
- Autumn 2009, Call Playback
- Autumn 2009, Frog Spotlight
- Autumn 2009, Habitat Assessment
- Autumn 2009, Spotlighting

Survey transects
- Summer 2007 - Bird Survey
- Summer 2007 - Elliot Trap
- Summer 2007 - Cage Trap
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey/Spotlighting
- Summer 2007 - Spotlighting
- Summer 2007 - Spotlighting/Nocturnal Bird Survey
- Spring 2008 - Bird survey
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- Spring 2008 - Elliot Trap/Cage Trap/Hair Tube
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- Autumn 2009 - Spotlighting
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Ancillary Sites
- Subject Site - Compound
- Subject Site - Stockpile
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- RoadNameExtent

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Figure 2.3.28: Location of fauna survey effort

Date: 1 August 2012	Drawn by: RS/JMS/ANP
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Location: P:\15000s\15039\Mapping\Variation 2\Variation 2 figures\15039_S2_F2-3_survey_fauna_010812.mxd	

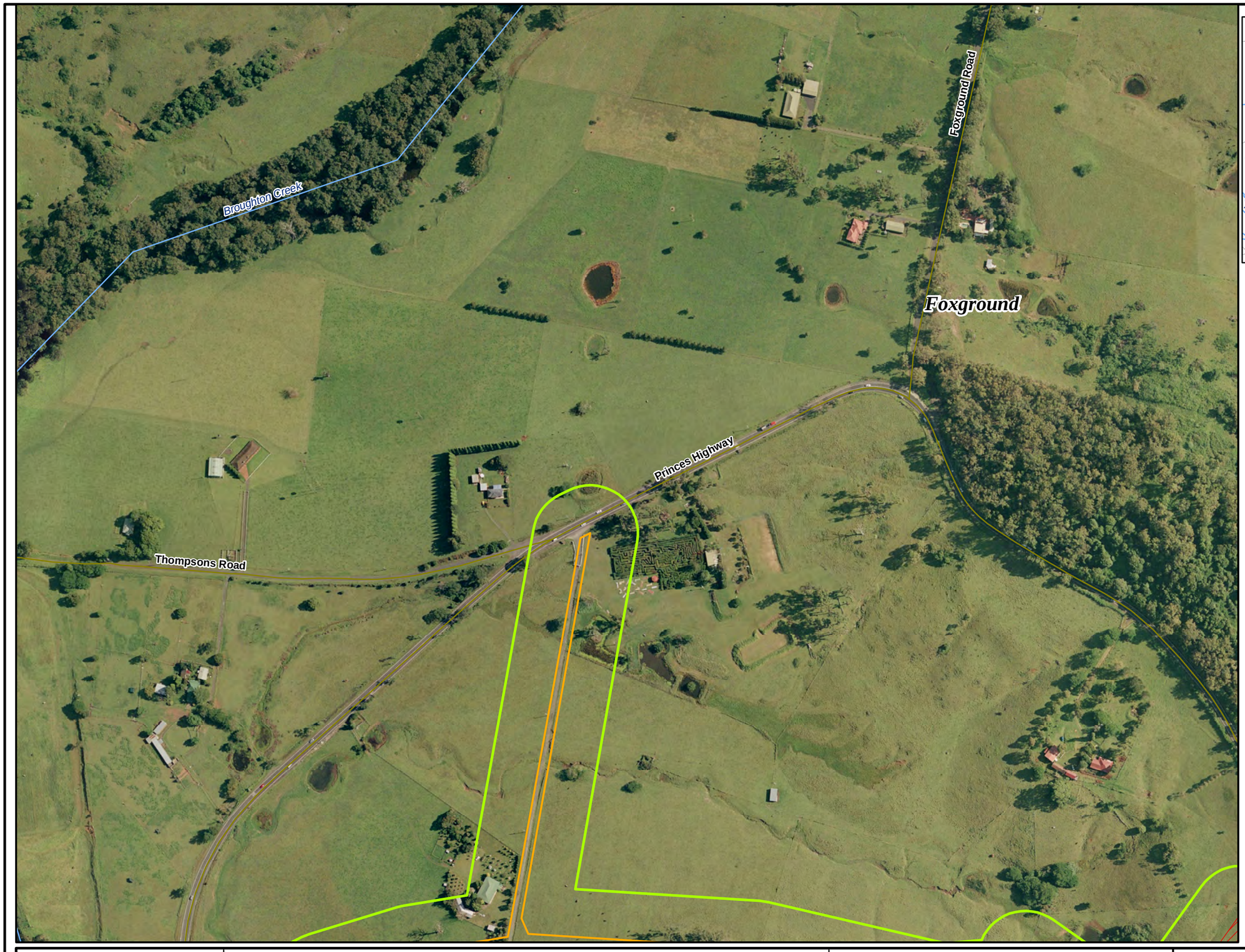
Acknowledgements:
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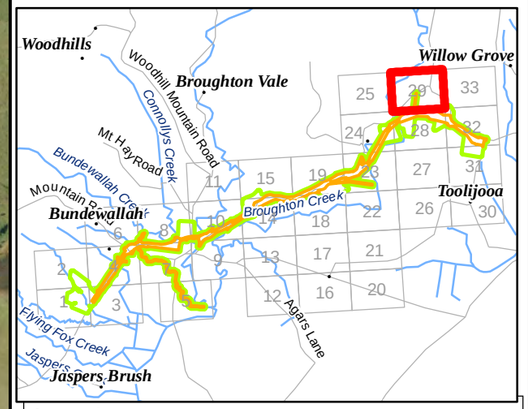
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Metres

Scale: 1: 4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.3





Legend

Survey points
- Summer 2007, Anabat
- Summer 2007, Anabat/Harp Trap
- Summer 2007, Anabat/Owl Call Playback
- Summer 2007, Bird Survey
- Summer 2007, Habitat Assessment
- Summer 2007, Harp Trap
- Summer 2007, Owl Call Playback
- Summer 2007, Spotlighting
- Spring 2008, Anabat
- Spring 2008, Bird Survey
- Spring 2008, Frog Spotlight
- Spring 2008, Habitat Assessment
- Spring 2008, Owl Call Playback
- Autumn 2009, Bird Survey
- Autumn 2009, Call Playback
- Autumn 2009, Frog Spotlight
- Autumn 2009, Habitat Assessment
- Autumn 2009, Spotlighting

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- Summer 2007 - Bird Survey
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- Summer 2007 - Cage Trap
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- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites
- Subject Site - Compound
- Subject Site - Stockpile
- Study Area
- RoadNameExtent

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Figure 2.3.29: Location of fauna survey effort

Date: 1 August 2012	Drawn by: RS/JMS/ANP
File: 13194	Checked by: JC
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Acknowledgements:
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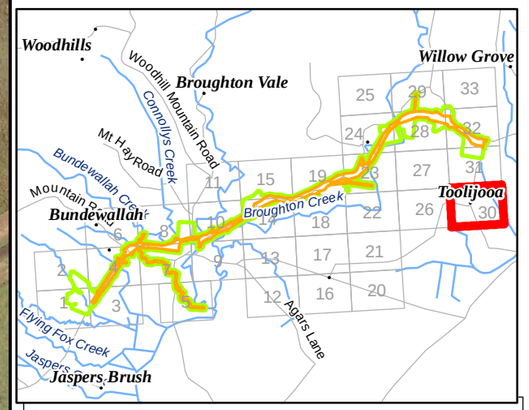
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Scale: 1: 4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.3





Legend

Survey points
- Summer 2007, Anabat
- Summer 2007, Anabat/Harp Trap
- Summer 2007, Anabat/Owl Call Playback
- Summer 2007, Bird Survey
- Summer 2007, Habitat Assessment
- Summer 2007, Harp Trap
- Summer 2007, Owl Call Playback
- Summer 2007, Spotlighting
- Spring 2008, Anabat
- Spring 2008, Bird Survey
- Spring 2008, Frog Spotlight
- Spring 2008, Habitat Assessment
- Spring 2008, Owl Call Playback
- Autumn 2009, Bird Survey
- Autumn 2009, Call Playback
- Autumn 2009, Frog Spotlight
- Autumn 2009, Habitat Assessment
- Autumn 2009, Spotlighting

Survey transects
- Summer 2007 - Bird Survey
- Summer 2007 - Elliot Trap
- Summer 2007 - Cage Trap
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey/Spotlighting
- Summer 2007 - Spotlighting
- Summer 2007 - Spotlighting/Nocturnal Bird Survey
- Spring 2008 - Bird survey
- Spring 2008 - Elliot Trap/Cage Trap
- Spring 2008 - Elliot Trap/Cage Trap/Hair Tube
- Spring 2008 - Spotlighting
- Spring 2008 - Spotlighting/Nocturnal Bird Survey
- Autumn 2009 - Bird survey
- Autumn 2009 - Cage Trap
- Autumn 2009 - Spotlighting
- Spring 2011 - Town Creek general survey and habitat assessments
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites
- Subject Site - Compound
- Subject Site - Stockpile
- Study Area
- RoadNameExtent

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Figure 2.3.30: Location of fauna survey effort

Date: 1 August 2012	Drawn by: RS/JMS/ANP
File: 13194	Checked by: JC
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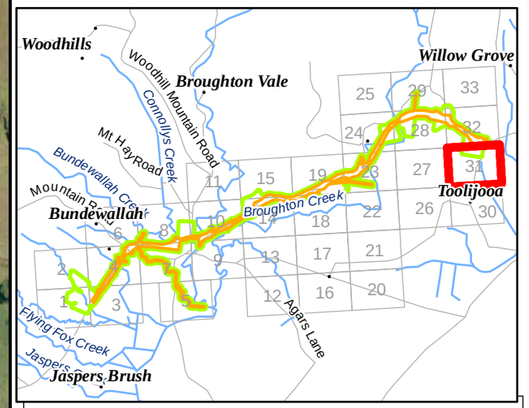
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Scale: 1: 4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.3





Legend

Survey points
- Summer 2007, Anabat
- Summer 2007, Anabat/Harp Trap
- Summer 2007, Anabat/Owl Call Playback
- Summer 2007, Bird Survey
- Summer 2007, Habitat Assessment
- Summer 2007, Harp Trap
- Summer 2007, Owl Call Playback
- Summer 2007, Spotlighting
- Spring 2008, Anabat
- Spring 2008, Bird Survey
- Spring 2008, Frog Spotlight
- Spring 2008, Habitat Assessment
- Spring 2008, Owl Call Playback
- Autumn 2009, Bird Survey
- Autumn 2009, Call Playback
- Autumn 2009, Frog Spotlight
- Autumn 2009, Habitat Assessment
- Autumn 2009, Spotlighting

Survey transects
- Summer 2007 - Bird Survey
- Summer 2007 - Elliot Trap
- Summer 2007 - Cage Trap
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey/Spotlighting
- Summer 2007 - Spotlighting
- Summer 2007 - Spotlighting/Nocturnal Bird Survey
- Spring 2008 - Bird survey
- Spring 2008 - Elliot Trap/Cage Trap
- Spring 2008 - Elliot Trap/Cage Trap/Hair Tube
- Spring 2008 - Spotlighting
- Spring 2008 - Spotlighting/Nocturnal Bird Survey
- Autumn 2009 - Bird survey
- Autumn 2009 - Cage Trap
- Autumn 2009 - Spotlighting
- Spring 2011 - Town Creek general survey and habitat assessments
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites
- Subject Site - Compound
- Subject Site - Stockpile
- Study Area
- RoadNameExtent

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Figure 2.3.31: Location of fauna survey effort

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File: 13194	Checked by: JC
Location: P:\15000s\15039\Mapping\Variation 2\Variation 2 figures\15039_S2_F2-3_survey_fauna_010812.mxd	

Acknowledgements:
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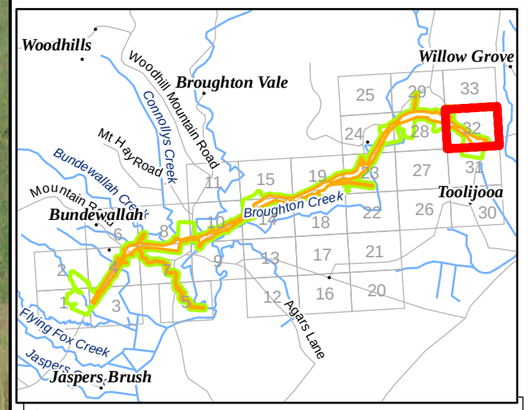
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Scale: 1: 4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.3





Legend

Survey points
- Summer 2007, Anabat
- Summer 2007, Anabat/Harp Trap
- Summer 2007, Anabat/Owl Call Playback
- Summer 2007, Bird Survey
- Summer 2007, Habitat Assessment
- Summer 2007, Harp Trap
- Summer 2007, Owl Call Playback
- Summer 2007, Spotlighting
- Spring 2008, Anabat
- Spring 2008, Bird Survey
- Spring 2008, Frog Spotlight
- Spring 2008, Habitat Assessment
- Spring 2008, Owl Call Playback
- Autumn 2009, Bird Survey
- Autumn 2009, Call Playback
- Autumn 2009, Frog Spotlight
- Autumn 2009, Habitat Assessment
- Autumn 2009, Spotlighting

Survey transects
- Summer 2007 - Bird Survey
- Summer 2007 - Elliot Trap
- Summer 2007 - Cage Trap
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey/Spotlighting
- Summer 2007 - Spotlighting
- Summer 2007 - Spotlighting/Nocturnal Bird Survey
- Spring 2008 - Bird survey
- Spring 2008 - Elliot Trap/Cage Trap
- Spring 2008 - Elliot Trap/Cage Trap/Hair Tube
- Spring 2008 - Spotlighting
- Spring 2008 - Spotlighting/Nocturnal Bird Survey
- Autumn 2009 - Bird survey
- Autumn 2009 - Cage Trap
- Autumn 2009 - Spotlighting
- Spring 2011 - Town Creek general survey and habitat assessments
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites
- Subject Site - Compound
- Subject Site - Stockpile
- Study Area
- RoadNameExtent

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Figure 2.3.32: Location of fauna survey effort

Date: 1 August 2012	Drawn by: RS/JMS/ANP
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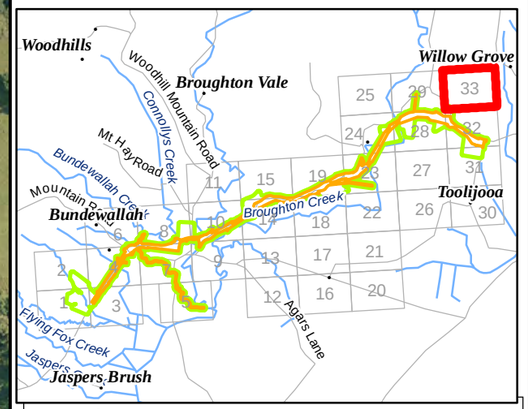
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Map Projection: Transverse Mercator
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Grid: Map Grid of Australia, Zone 56

N

Figure 2.3





Legend

Survey points
- Summer 2007, Anabat
- Summer 2007, Anabat/Harp Trap
- Summer 2007, Anabat/Owl Call Playback
- Summer 2007, Bird Survey
- Summer 2007, Habitat Assessment
- Summer 2007, Harp Trap
- Summer 2007, Owl Call Playback
- Summer 2007, Spotlighting
- Spring 2008, Anabat
- Spring 2008, Bird Survey
- Spring 2008, Frog Spotlight
- Spring 2008, Habitat Assessment
- Spring 2008, Owl Call Playback
- Autumn 2009, Bird Survey
- Autumn 2009, Call Playback
- Autumn 2009, Frog Spotlight
- Autumn 2009, Habitat Assessment
- Autumn 2009, Spotlighting

Survey transects
- Summer 2007 - Bird Survey
- Summer 2007 - Elliot Trap
- Summer 2007 - Cage Trap
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey
- Summer 2007 - Elliot Trap/Cage Trap/Bird Survey/Spotlighting
- Summer 2007 - Spotlighting
- Summer 2007 - Spotlighting/Nocturnal Bird Survey
- Spring 2008 - Bird survey
- Spring 2008 - Elliot Trap/Cage Trap
- Spring 2008 - Elliot Trap/Cage Trap/Hair Tube
- Spring 2008 - Spotlighting
- Spring 2008 - Spotlighting/Nocturnal Bird Survey
- Autumn 2009 - Bird survey
- Autumn 2009 - Cage Trap
- Autumn 2009 - Spotlighting
- Spring 2011 - Town Creek general survey and habitat assessments
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites
- Subject Site - Compound
- Subject Site - Stockpile
- Study Area
- RoadNameExtent

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Figure 2.3.33: Location of fauna survey effort

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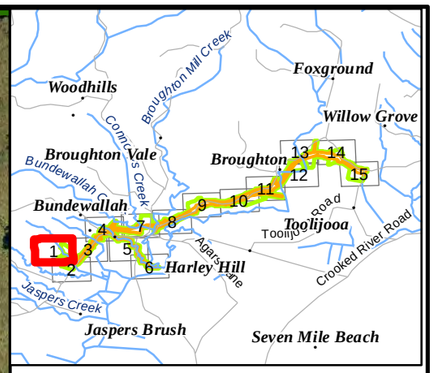
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Scale: 1: 4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 2.3



Legend

Vegatation communities

- Budderoo Temperate Rainforest
- Budderoo-Morton Plateau Forest
- Closed Grassland
- Closed Grassland/Sedgeland
- Coastal Foredune Scrub
- Coastal Freshwater Lagoon
- Coastal Sand Forest
- Coastal Sand Swamp Forest
- Coastal Warm Temperate Rainforest
- Constructed Wetland
- Currambene-Batemans Lowlands Forest
- Disturbed Riparian Open Woodland
- Escarpment Foothills Wet Forest
- Estuarine Creekflat Scrub
- Estuarine Mangrove Forest
- Floodplain Swamp Forest
- Illawarra Gully Wet Forest
- Illawarra Lowland Swamp Woodland
- Intermediate Temperate Rainforest
- Riverbank Forest
- South Coast Grassy Woodland
- Subtropical Complex Rainforest
- Subtropical Dry Rainforest
- Warm Temperate Layered Forest
- Yarrawarra Temperate Rainforest
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 3.1.1: Vegetation mapping of the study area (modified from DECCW, 2005)

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File: 13194	Checked by: JC
Location: P:\15000s\15039\Mapping\Variaition 1\Variation 1 Figures\13194_S2_F3-1_Veg_StripIndex_160712.mxd	

Acknowledgements:
Vegetation mapping from DECCW
Aerial imagery provided by ARUP
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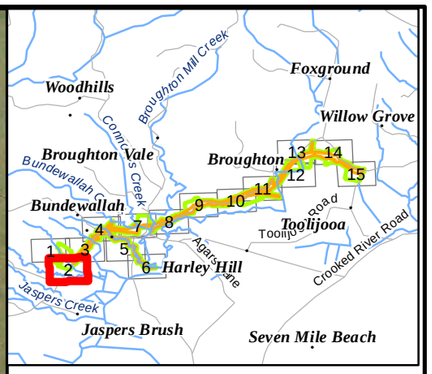
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Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 3.1





Legend

Vegatation communities

- Budderoo Temperate Rainforest
- Budderoo-Morton Plateau Forest
- Closed Grassland
- Closed Grassland/Sedgeland
- Coastal Foredune Scrub
- Coastal Freshwater Lagoon
- Coastal Sand Forest
- Coastal Sand Swamp Forest
- Coastal Warm Temperate Rainforest
- Constructed Wetland
- Currambene-Batemans Lowlands Forest
- Disturbed Riparian Open Woodland
- Escarpment Foothills Wet Forest
- Estuarine Creekflat Scrub
- Estuarine Mangrove Forest
- Floodplain Swamp Forest
- Illawarra Gully Wet Forest
- Illawarra Lowland Swamp Woodland
- Intermediate Temperate Rainforest
- Riverbank Forest
- South Coast Grassy Woodland
- Subtropical Complex Rainforest
- Subtropical Dry Rainforest
- Warm Temperate Layered Forest
- Yarrawarra Temperate Rainforest
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 3.1.2: Vegetation mapping of the study area (modified from DECCW, 2005)

Date: 16 July 2012	Drawn by: RS/JMS/ANP
File: 13194	Checked by: JC
Location: P:\15000s\15039\Mapping\Variaition 1\Variation 1 Figures\13194_S2_F3-1_Veg_StripIndex_160712.mxd	

Acknowledgements:
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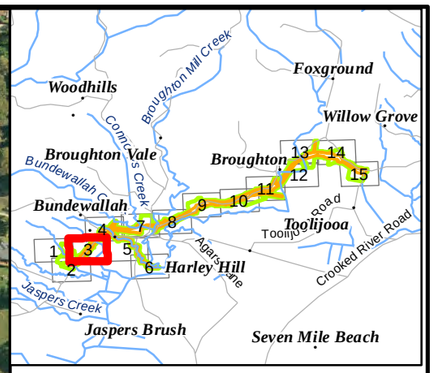
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Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 3.1



Legend

Vegatation communities

- Budderoo Temperate Rainforest
- Budderoo-Morton Plateau Forest
- Closed Grassland
- Closed Grassland/Sedgeland
- Coastal Foredune Scrub
- Coastal Freshwater Lagoon
- Coastal Sand Forest
- Coastal Sand Swamp Forest
- Coastal Warm Temperate Rainforest
- Constructed Wetland
- Currambene-Batemans Lowlands Forest
- Disturbed Riparian Open Woodland
- Escarpment Foothills Wet Forest
- Estuarine Creekflat Scrub
- Estuarine Mangrove Forest
- Floodplain Swamp Forest
- Illawarra Gully Wet Forest
- Illawarra Lowland Swamp Woodland
- Intermediate Temperate Rainforest
- Riverbank Forest
- South Coast Grassy Woodland
- Subtropical Complex Rainforest
- Subtropical Dry Rainforest
- Warm Temperate Layered Forest
- Yarrawarra Temperate Rainforest
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 3.1.3: Vegetation mapping of the study area (modified from DECCW, 2005)

Date: 16 July 2012	Drawn by: RS/JMS/ANP
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Location: P:\15000s\15039\Mapping\Variaition 1\Variation 1 Figures\13194_S2_F3-1_Veg_StripIndex_160712.mxd	

Acknowledgements:
Vegetation mapping from DECCW
Aerial imagery provided by ARUP
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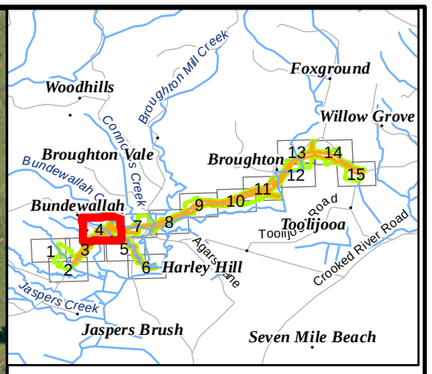
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Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 3.1





Legend

Vegatation communities

- Budderoo Temperate Rainforest
- Budderoo-Morton Plateau Forest
- Closed Grassland
- Closed Grassland/Sedgeland
- Coastal Foredune Scrub
- Coastal Freshwater Lagoon
- Coastal Sand Forest
- Coastal Sand Swamp Forest
- Coastal Warm Temperate Rainforest
- Constructed Wetland
- Currambene-Batemans Lowlands Forest
- Disturbed Riparian Open Woodland
- Escarpment Foothills Wet Forest
- Estuarine Creekflat Scrub
- Estuarine Mangrove Forest
- Floodplain Swamp Forest
- Illawarra Gully Wet Forest
- Illawarra Lowland Swamp Woodland
- Intermediate Temperate Rainforest
- Riverbank Forest
- South Coast Grassy Woodland
- Subtropical Complex Rainforest
- Subtropical Dry Rainforest
- Warm Temperate Layered Forest
- Yarrawarra Temperate Rainforest
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 3.1.4: Vegetation mapping of the study area (modified from DECCW, 2005)

Date: 16 July 2012	Drawn by: RS/JMS/ANP
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Location: P:\15000s\15039\Mapping\Variaition 1\Variation 1 Figures\13194_S2_F3-1_Veg_StripIndex_160712.mxd	

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Vegetation mapping from DECCW
Aerial imagery provided by ARUP
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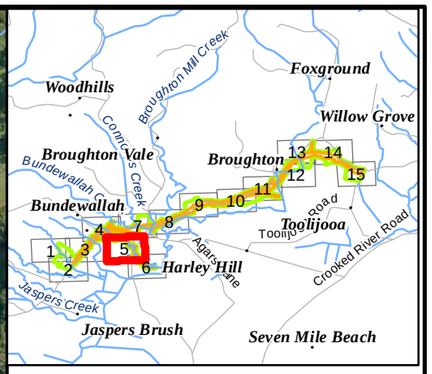
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Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 3.1





Legend

Vegatation communities

- Budderoo Temperate Rainforest
- Budderoo-Morton Plateau Forest
- Closed Grassland
- Closed Grassland/Sedgeland
- Coastal Foredune Scrub
- Coastal Freshwater Lagoon
- Coastal Sand Forest
- Coastal Sand Swamp Forest
- Coastal Warm Temperate Rainforest
- Constructed Wetland
- Currambene-Batemans Lowlands Forest
- Disturbed Riparian Open Woodland
- Escarpment Foothills Wet Forest
- Estuarine Creekflat Scrub
- Estuarine Mangrove Forest
- Floodplain Swamp Forest
- Illawarra Gully Wet Forest
- Illawarra Lowland Swamp Woodland
- Intermediate Temperate Rainforest
- Riverbank Forest
- South Coast Grassy Woodland
- Subtropical Complex Rainforest
- Subtropical Dry Rainforest
- Warm Temperate Layered Forest
- Yarrawarra Temperate Rainforest
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 3.1.5: Vegetation mapping of the study area (modified from DECCW, 2005)

Date: 16 July 2012	Drawn by: RS/JMS/ANP
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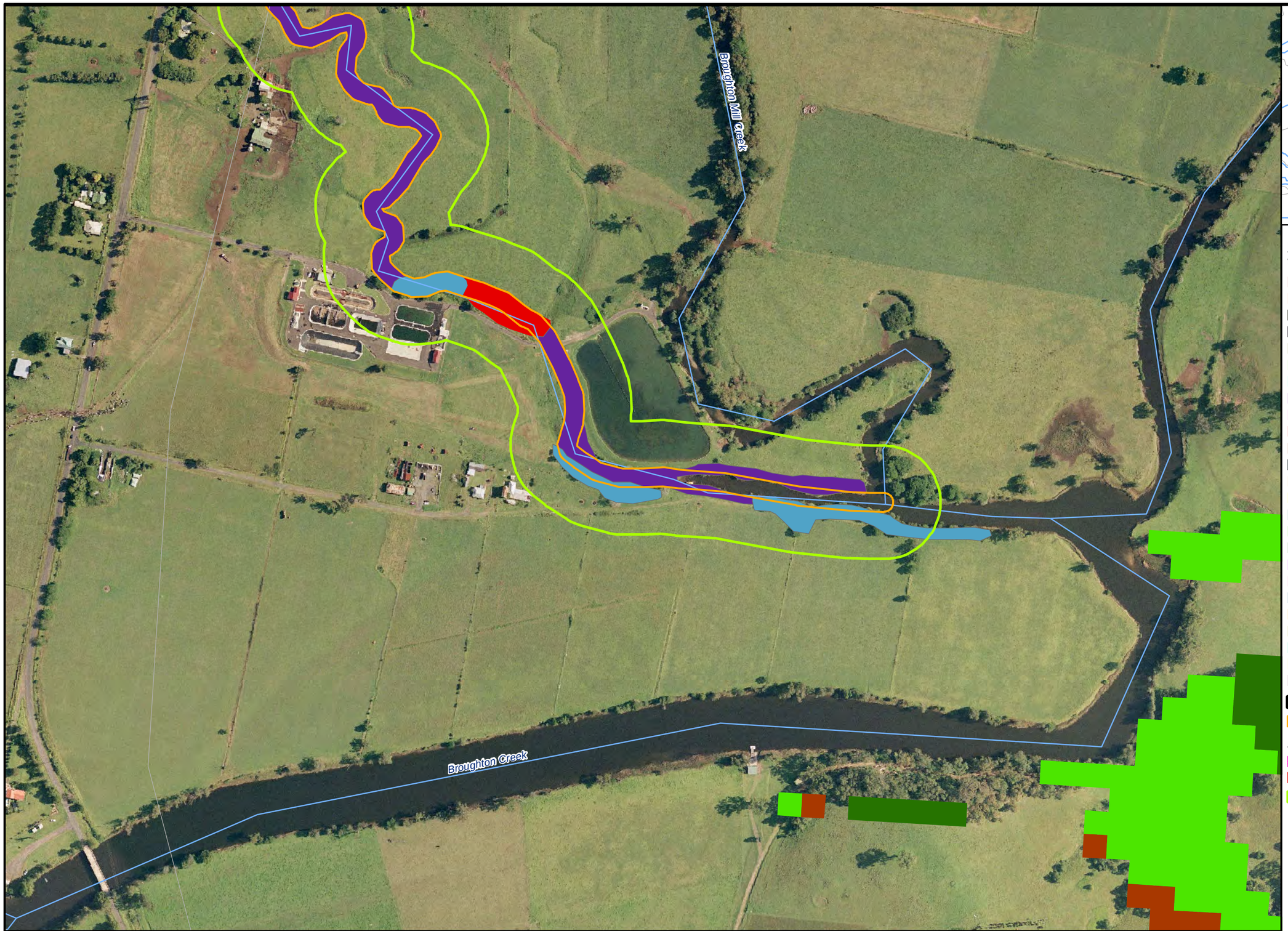
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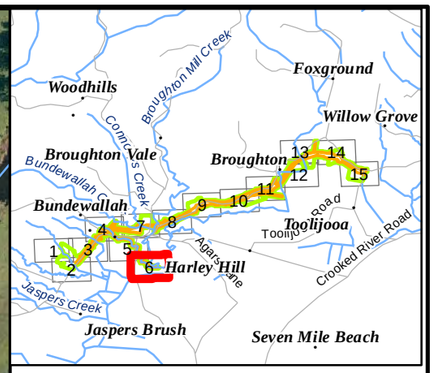
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Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 3.1





Legend

Vegatation communities

- Budderoo Temperate Rainforest
- Budderoo-Morton Plateau Forest
- Closed Grassland
- Closed Grassland/Sedgeland
- Coastal Foredune Scrub
- Coastal Freshwater Lagoon
- Coastal Sand Forest
- Coastal Sand Swamp Forest
- Coastal Warm Temperate Rainforest
- Constructed Wetland
- Currambene-Batemans Lowlands Forest
- Disturbed Riparian Open Woodland
- Escarpment Foothills Wet Forest
- Estuarine Creekflat Scrub
- Estuarine Mangrove Forest
- Floodplain Swamp Forest
- Illawarra Gully Wet Forest
- Illawarra Lowland Swamp Woodland
- Intermediate Temperate Rainforest
- Riverbank Forest
- South Coast Grassy Woodland
- Subtropical Complex Rainforest
- Subtropical Dry Rainforest
- Warm Temperate Layered Forest
- Yarrawarra Temperate Rainforest
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 3.1.6: Vegetation mapping of the study area (modified from DECCW, 2005)

Date: 16 July 2012	Drawn by: RS/JMS/ANP
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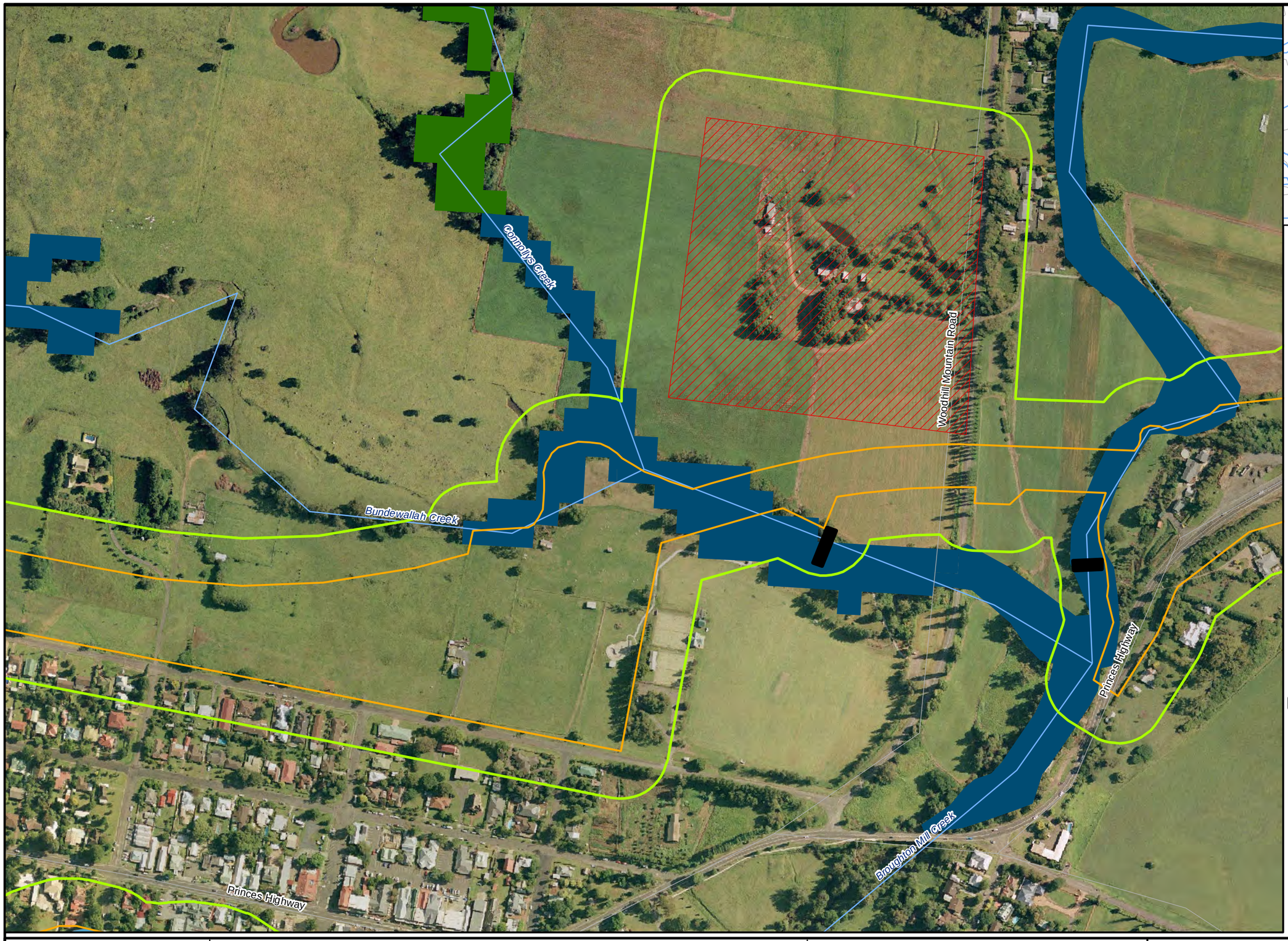
Acknowledgements:
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Aerial imagery provided by ARUP
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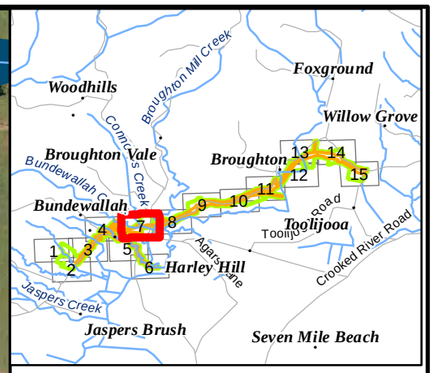
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Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 3.1





Legend

Vegatation communities

- Budderoo Temperate Rainforest
- Budderoo-Morton Plateau Forest
- Closed Grassland
- Closed Grassland/Sedgeland
- Coastal Foredune Scrub
- Coastal Freshwater Lagoon
- Coastal Sand Forest
- Coastal Sand Swamp Forest
- Coastal Warm Temperate Rainforest
- Constructed Wetland
- Currambene-Batemans Lowlands Forest
- Disturbed Riparian Open Woodland
- Escarpment Foothills Wet Forest
- Estuarine Creekflat Scrub
- Estuarine Mangrove Forest
- Floodplain Swamp Forest
- Illawarra Gully Wet Forest
- Illawarra Lowland Swamp Woodland
- Intermediate Temperate Rainforest
- Riverbank Forest
- South Coast Grassy Woodland
- Subtropical Complex Rainforest
- Subtropical Dry Rainforest
- Warm Temperate Layered Forest
- Yarrawarra Temperate Rainforest
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 3.1.7: Vegetation mapping of the study area (modified from DECCW, 2005)

Date: 16 July 2012	Drawn by: RS/JMS/ANP
File: 13194	Checked by: JC
Location: P:\15000s\15039\Mapping\Variaition 1\Variation 1 Figures\13194_S2_F3-1_Veg_StripIndex_160712.mxd	

Acknowledgements:
Vegetation mapping from DECCW
Aerial imagery provided by ARUP
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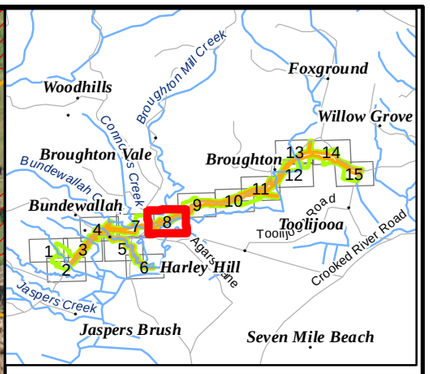
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Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 3.1





Legend

Vegatation communities

- Budderoo Temperate Rainforest
- Budderoo-Morton Plateau Forest
- Closed Grassland
- Closed Grassland/Sedgeland
- Coastal Foredune Scrub
- Coastal Freshwater Lagoon
- Coastal Sand Forest
- Coastal Sand Swamp Forest
- Coastal Warm Temperate Rainforest
- Constructed Wetland
- Currambene-Batemans Lowlands Forest
- Disturbed Riparian Open Woodland
- Escarpment Foothills Wet Forest
- Estuarine Creekflat Scrub
- Estuarine Mangrove Forest
- Floodplain Swamp Forest
- Illawarra Gully Wet Forest
- Illawarra Lowland Swamp Woodland
- Intermediate Temperate Rainforest
- Riverbank Forest
- South Coast Grassy Woodland
- Subtropical Complex Rainforest
- Subtropical Dry Rainforest
- Warm Temperate Layered Forest
- Yarrawarra Temperate Rainforest
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 3.1.8: Vegetation mapping of the study area (modified from DECCW, 2005)

Date: 16 July 2012	Drawn by: RS/JMS/ANP
File: 13194	Checked by: JC
Location: P:\15000s\15039\Mapping\Variaition 1\Variation 1 Figures\13194_S2_F3-1_Veg_StripIndex_160712.mxd	

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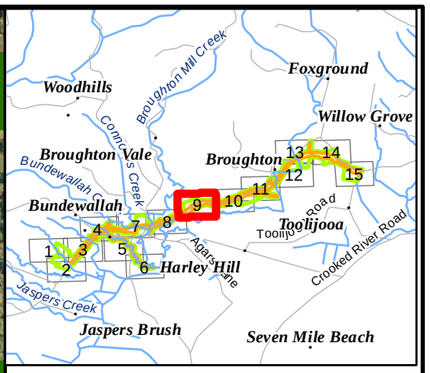
Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 3.1





Legend

Vegatation communities

- Budderoo Temperate Rainforest
- Budderoo-Morton Plateau Forest
- Closed Grassland
- Closed Grassland/Sedgeland
- Coastal Foredune Scrub
- Coastal Freshwater Lagoon
- Coastal Sand Forest
- Coastal Sand Swamp Forest
- Coastal Warm Temperate Rainforest
- Constructed Wetland
- Currambene-Batemans Lowlands Forest
- Disturbed Riparian Open Woodland
- Escarpment Foothills Wet Forest
- Estuarine Creekflat Scrub
- Estuarine Mangrove Forest
- Floodplain Swamp Forest
- Illawarra Gully Wet Forest
- Illawarra Lowland Swamp Woodland
- Intermediate Temperate Rainforest
- Riverbank Forest
- South Coast Grassy Woodland
- Subtropical Complex Rainforest
- Subtropical Dry Rainforest
- Warm Temperate Layered Forest
- Yarrawarra Temperate Rainforest
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 3.1.9: Vegetation mapping of the study area (modified from DECCW, 2005)

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Location: P:\15000s\15039\Mapping\Variaition 1\Variation 1 Figures\13194_S2_F3-1_Veg_StripIndex_160712.mxd	

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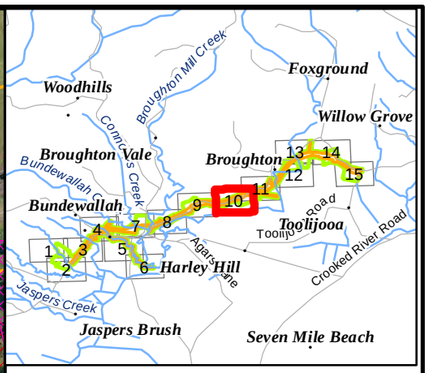
Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 3.1





Legend

Vegatation communities

- Budderoo Temperate Rainforest
- Budderoo-Morton Plateau Forest
- Closed Grassland
- Closed Grassland/Sedgeland
- Coastal Foredune Scrub
- Coastal Freshwater Lagoon
- Coastal Sand Forest
- Coastal Sand Swamp Forest
- Coastal Warm Temperate Rainforest
- Constructed Wetland
- Currambene-Batemans Lowlands Forest
- Disturbed Riparian Open Woodland
- Escarpment Foothills Wet Forest
- Estuarine Creekflat Scrub
- Estuarine Mangrove Forest
- Floodplain Swamp Forest
- Illawarra Gully Wet Forest
- Illawarra Lowland Swamp Woodland
- Intermediate Temperate Rainforest
- Riverbank Forest
- South Coast Grassy Woodland
- Subtropical Complex Rainforest
- Subtropical Dry Rainforest
- Warm Temperate Layered Forest
- Yarrawarra Temperate Rainforest
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 3.1.10: Vegetation mapping of the study area (modified from DECCW, 2005)

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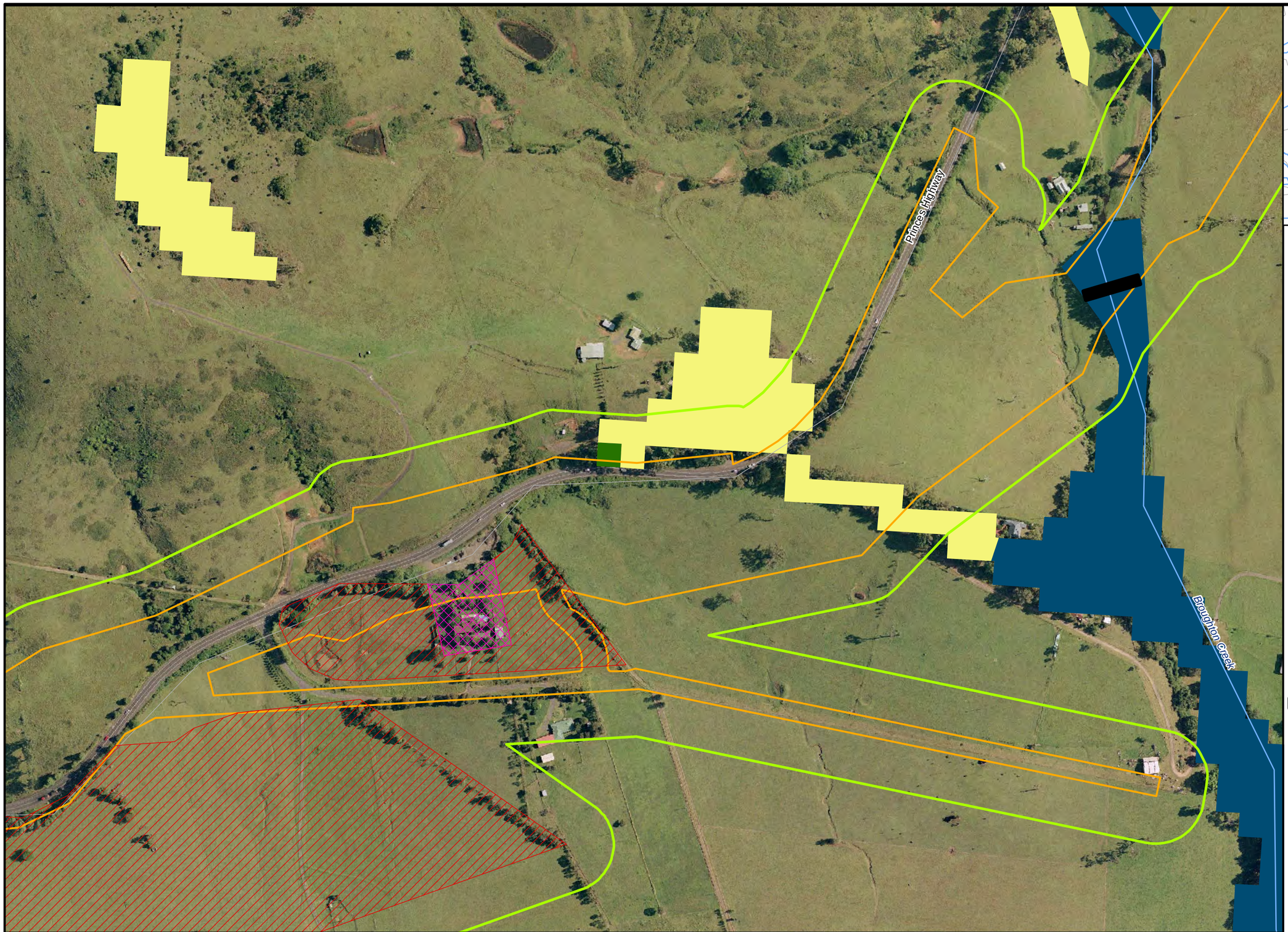
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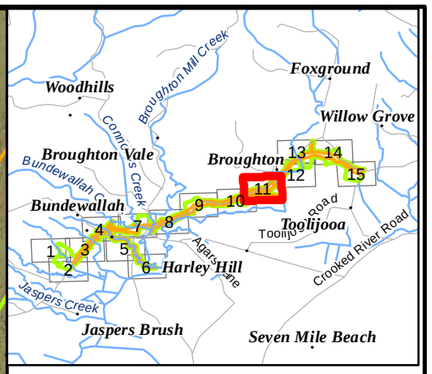
Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 3.1





Legend

Vegatation communities

- Budderoo Temperate Rainforest
- Budderoo-Morton Plateau Forest
- Closed Grassland
- Closed Grassland/Sedgeland
- Coastal Foredune Scrub
- Coastal Freshwater Lagoon
- Coastal Sand Forest
- Coastal Sand Swamp Forest
- Coastal Warm Temperate Rainforest
- Constructed Wetland
- Currambene-Batemans Lowlands Forest
- Disturbed Riparian Open Woodland
- Escarpment Foothills Wet Forest
- Estuarine Creekflat Scrub
- Estuarine Mangrove Forest
- Floodplain Swamp Forest
- Illawarra Gully Wet Forest
- Illawarra Lowland Swamp Woodland
- Intermediate Temperate Rainforest
- Riverbank Forest
- South Coast Grassy Woodland
- Subtropical Complex Rainforest
- Subtropical Dry Rainforest
- Warm Temperate Layered Forest
- Yarrawarra Temperate Rainforest
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 3.1.11: Vegetation mapping of the study area (modified from DECCW, 2005)

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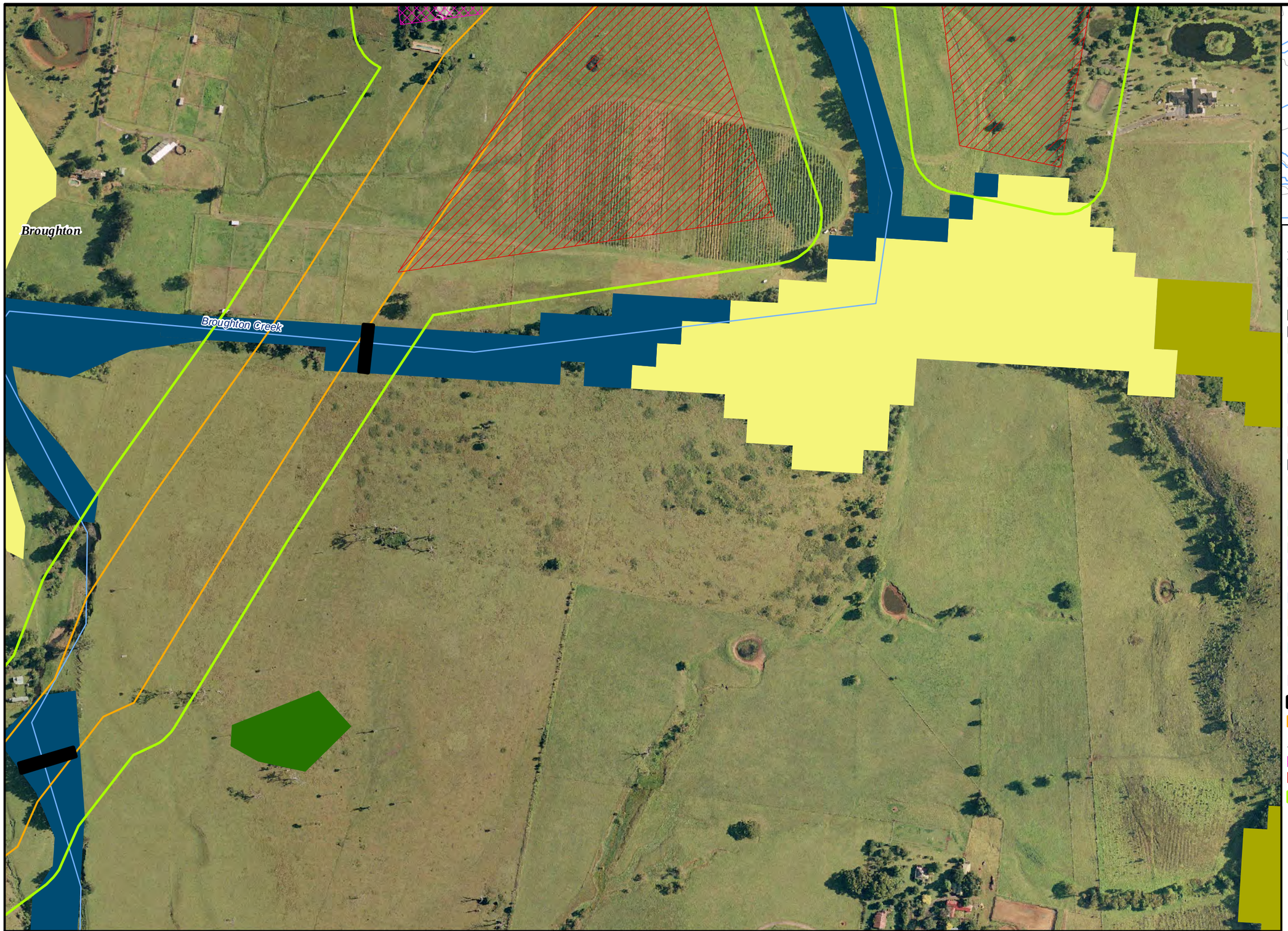
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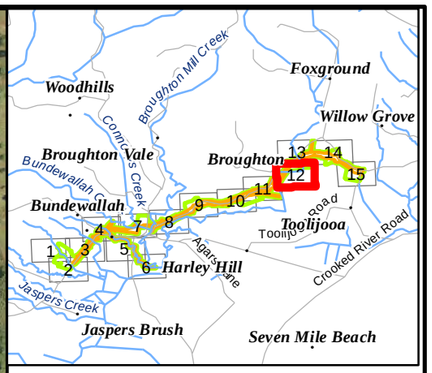
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Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 3.1





Legend

Vegatation communities

- Budderoo Temperate Rainforest
- Budderoo-Morton Plateau Forest
- Closed Grassland
- Closed Grassland/Sedgeland
- Coastal Foredune Scrub
- Coastal Freshwater Lagoon
- Coastal Sand Forest
- Coastal Sand Swamp Forest
- Coastal Warm Temperate Rainforest
- Constructed Wetland
- Currambene-Batemans Lowlands Forest
- Disturbed Riparian Open Woodland
- Escarpment Foothills Wet Forest
- Estuarine Creekflat Scrub
- Estuarine Mangrove Forest
- Floodplain Swamp Forest
- Illawarra Gully Wet Forest
- Illawarra Lowland Swamp Woodland
- Intermediate Temperate Rainforest
- Riverbank Forest
- South Coast Grassy Woodland
- Subtropical Complex Rainforest
- Subtropical Dry Rainforest
- Warm Temperate Layered Forest
- Yarrawarra Temperate Rainforest
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 3.1.12: Vegetation mapping of the study area (modified from DECCW, 2005)

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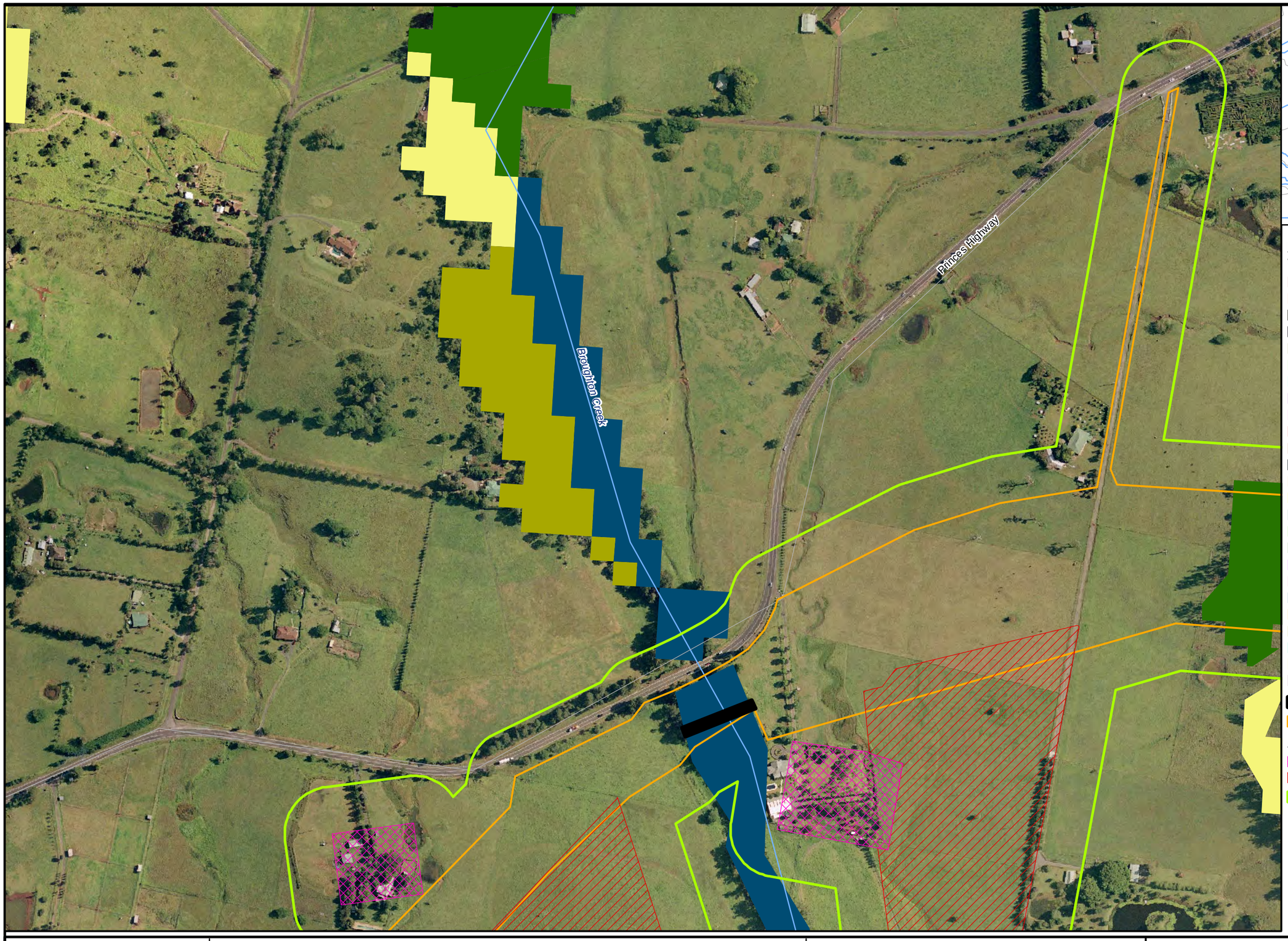
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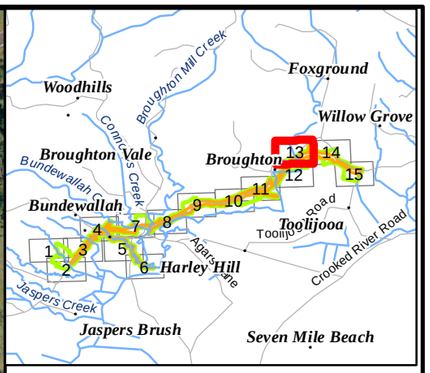
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Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 3.1





Legend

Vegatation communities

- Budderoo Temperate Rainforest
- Budderoo-Morton Plateau Forest
- Closed Grassland
- Closed Grassland/Sedgeland
- Coastal Foredune Scrub
- Coastal Freshwater Lagoon
- Coastal Sand Forest
- Coastal Sand Swamp Forest
- Coastal Warm Temperate Rainforest
- Constructed Wetland
- Currambene-Batemans Lowlands Forest
- Disturbed Riparian Open Woodland
- Escarpment Foothills Wet Forest
- Estuarine Creekflat Scrub
- Estuarine Mangrove Forest
- Floodplain Swamp Forest
- Illawarra Gully Wet Forest
- Illawarra Lowland Swamp Woodland
- Intermediate Temperate Rainforest
- Riverbank Forest
- South Coast Grassy Woodland
- Subtropical Complex Rainforest
- Subtropical Dry Rainforest
- Warm Temperate Layered Forest
- Yarrawarra Temperate Rainforest
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 3.1.13: Vegetation mapping of the study area (modified from DECCW, 2005)

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File: 13194	Checked by: JC
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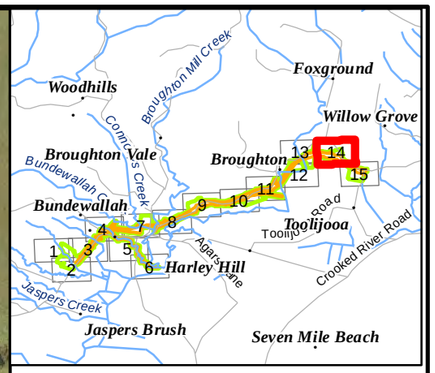
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Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 3.1



Legend

Vegatation communities

- Budderoo Temperate Rainforest
- Budderoo-Morton Plateau Forest
- Closed Grassland
- Closed Grassland/Sedgeland
- Coastal Foredune Scrub
- Coastal Freshwater Lagoon
- Coastal Sand Forest
- Coastal Sand Swamp Forest
- Coastal Warm Temperate Rainforest
- Constructed Wetland
- Currambene-Batemans Lowlands Forest
- Disturbed Riparian Open Woodland
- Escarpment Foothills Wet Forest
- Estuarine Creekflat Scrub
- Estuarine Mangrove Forest
- Floodplain Swamp Forest
- Illawarra Gully Wet Forest
- Illawarra Lowland Swamp Woodland
- Intermediate Temperate Rainforest
- Riverbank Forest
- South Coast Grassy Woodland
- Subtropical Complex Rainforest
- Subtropical Dry Rainforest
- Warm Temperate Layered Forest
- Yarrawarra Temperate Rainforest
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 3.1.14: Vegetation mapping of the study area (modified from DECCW, 2005)

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File: 13194	Checked by: JC
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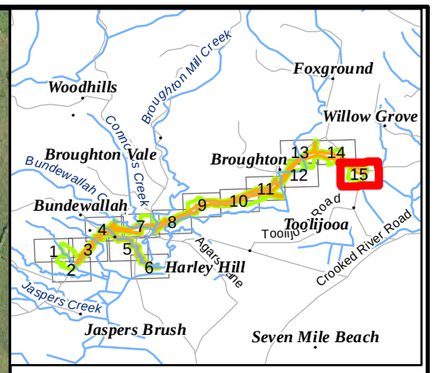
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Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Figure 3.1





Legend

Vegatation communities

- Budderoo Temperate Rainforest
- Budderoo-Morton Plateau Forest
- Closed Grassland
- Closed Grassland/Sedgeland
- Coastal Foredune Scrub
- Coastal Freshwater Lagoon
- Coastal Sand Forest
- Coastal Sand Swamp Forest
- Coastal Warm Temperate Rainforest
- Constructed Wetland
- Currambene-Batemans Lowlands Forest
- Disturbed Riparian Open Woodland
- Escarpment Foothills Wet Forest
- Estuarine Creekflat Scrub
- Estuarine Mangrove Forest
- Floodplain Swamp Forest
- Illawarra Gully Wet Forest
- Illawarra Lowland Swamp Woodland
- Intermediate Temperate Rainforest
- Riverbank Forest
- South Coast Grassy Woodland
- Subtropical Complex Rainforest
- Subtropical Dry Rainforest
- Warm Temperate Layered Forest
- Yarrawarra Temperate Rainforest
- Subject Site - Temporary Creek Crossings
- Subject Site - Footprint

Ancillary Sites

- Subject Site - Compound
- Subject Site - Stockpile
- Study Area

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Figure 3.1.15: Vegetation mapping of the study area (modified from DECCW, 2005)

Date: 16 July 2012	Drawn by: RS/JMS/ANP
File: 13194	Checked by: JC
Location: P:\15000s\15039\Mapping\Variaition 1\Variation 1 Figures\13194_S2_F3-1_Veg_StripIndex_160712.mxd	

Acknowledgements:
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Aerial imagery provided by ARUP
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0 60 120 180 240

Metres

Scale: 1:4,000 at A3
Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

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Figure 3.1