

## 7.3 Biodiversity

This chapter provides an assessment of terrestrial and aquatic ecology, which were nominated in the DGRs as a key environmental issue for the project. It represents a summary of the *Terrestrial Flora and Fauna Technical Paper* (Biosis, 2012) and the *Aquatic Ecology and Water Quality Management Technical Paper* (Cardno Ecology Lab, 2012), which were prepared for the project with consideration of the DGRs.

The technical papers are provided at **Appendix F** and **Appendix G**, respectively. The relevant extract from the DGRs is presented below.

| Director-General's requirements                                                                                                                                                                                                                                                                                                                       | Where addressed                                                                                                                                                                     |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b><i>Flora and Fauna – including but not limited to:</i></b>                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                     |
| <i>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.</i> | Section 7.3.1 and Section 7.3.3<br><br>Appendix F — Technical paper: Terrestrial flora and fauna<br><br>Appendix G — Technical paper: Aquatic ecology and water quality management. |
| <i>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.</i>                                                                                                            | Section 7.3.2 and Section 7.3.3<br><br>Appendix F — Technical paper: Terrestrial flora and fauna<br><br>Appendix G — Technical paper: Aquatic ecology and water quality management. |
| <i>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).</i>                                                                                               | Section 7.3.2 and Section 7.3.3<br><br>Appendix F — Technical paper: Terrestrial flora and fauna<br><br>Appendix G — Technical paper: Aquatic ecology and water quality management. |
| <i>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).</i>                                                                       | Section 7.3.3<br><br>Appendix F — Technical paper: Terrestrial flora and fauna<br><br>Appendix G — Technical paper: Aquatic ecology and water quality management.                   |
| <i>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.</i>                                                                                                                                 | Section 7.3.4<br><br>Appendix F — Technical paper: Terrestrial flora and fauna<br><br>Appendix G — Technical paper: Aquatic ecology and water quality management.                   |

| Director-General's requirements                                                                                                                                                                                                                                                                                                                                                                   | Where addressed                                                                                                                                                                                                       |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>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.</i> | <p>Section 7.3.4</p> <p>Appendix F — Technical paper: Terrestrial flora and fauna</p> <p>Appendix G — Technical paper: Aquatic ecology and water quality management.</p>                                              |
| <i>Identify potential risks of the project on groundwater resources including: impacts to groundwater-dependent ecological communities.</i>                                                                                                                                                                                                                                                       | <p>Section 7.3.3 and Section 7.4</p> <p>Appendix G — Technical paper: Aquatic ecology and water quality management.</p> <p>Appendix H – Technical paper: Surface water, groundwater and flooding.</p>                 |
| <i>Waterways to be modified as a result of the project, including ecological, hydrological and geomorphic impacts (as relevant) and measures to rehabilitate the waterways to pre-construction conditions or better.</i>                                                                                                                                                                          | <p>Section 7.3.3, Section 7.3.4 and Section 7.4.</p> <p>Appendix G — Technical paper: Aquatic ecology and water quality management.</p> <p>Appendix H – Technical paper: Surface water, groundwater and flooding.</p> |

### 7.3.1 Approach to assessment

The study area, for the purposes of the flora and fauna assessment, is defined as the project area and any additional areas that are likely to be directly or indirectly affected by the project. The study area used for the terrestrial ecology assessment includes the project and a 50 metre buffer either side of the project to account for any indirect impacts. The study area used for the aquatic ecology assessment includes aquatic habitat and biota upstream and downstream of the project.

### Methodology

Terrestrial and aquatic flora and fauna in the study area were assessed in accordance with Part 3A Guidelines for Threatened Species Assessment (Department of Environment and Conservation (DEC) and Department of Primary Industries (DPI, 2005). This included:

- Database searches and literature reviews.
- Field surveys to determine the presence or likelihood of threatened species, populations and endangered ecological communities (EEC) to occur.
- Significance assessments to evaluate the potential impacts on threatened species, populations, habitats and EEC likely to be affected by the project.
- Identification of measures to avoid, minimise and mitigate potential impacts, or the provision of an offset strategy where impacts could not be avoided or minimised.

### Terrestrial flora and fauna

Existing information about the terrestrial flora and fauna of the study area was obtained from a range of sources, including databases, aerial photographs, maps, previous studies carried out in the vicinity of the study area and consultation. The consultation was undertaken with experts, government agencies, land owners and land managers, local volunteer organisations and natural heritage clubs.

Threatened flora and fauna species, populations and EECs that occur, or are predicted to occur within the study area were identified by undertaking database searches. These included the OEH Atlas of NSW Wildlife, Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) Protected Matters Database, Birds Australia New Atlas of Australian Birds and OEH Illawarra sub-region database.

Field flora and fauna surveys were then used to ground truth and validate the information obtained during the desktop studies. Field survey sites were selected following a roadside inspection and examination of aerial photographs, topographic maps, existing vegetation maps and threatened species records. Survey sites within the study area included locations with stands of native vegetation and riparian vegetation along creeks and farm dams. Flora and fauna surveys involved random meanders and incidental observations throughout these sites, and opportunistically while travelling between these sites.

Seasonal surveys along the entire upgrade route were conducted in February 2007, November 2008 and May 2009. There were a total of 27 survey sites within the study area. The flora surveys were carried out by two botanists over a total of 22 days during three split survey periods conducted from 12 to 23 February 2007, 4 to 12 November 2008 and 18 to 22 May 2009. Further 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 and on 8 November 2011 to assess the proposed diversion of Town Creek. The flora surveys included targeted searches and plot based surveys, such as quadrats. Targeted species include 13 flora species with potential habitat in the study area (random meander surveys) and all flora species and communities (quadrat surveys).

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.

Habitat condition assessments were also carried out and involved the collection of data about the plant communities present at each survey site. Specific data that was collected included the dominant species within each stratum, the degree of vegetation cover and the relative condition of the plant community. The condition of the vegetation was assessed based on how it compared to relatively natural, undisturbed vegetation. The vegetation condition was classified as good, moderate, poor or unnatural landscape.

Targeted fauna surveys were conducted using Elliot traps, cage traps, hair tubes, harp traps, ultrasonic call recording, spotlighting and call playback. Diurnal bird surveys, nocturnal frog surveys and reptile surveys were carried out. Incidental fauna observations such as remains (including skins), scats, diggings, burrows and feeding scars were also recorded.

The condition of habitats was evaluated based on the presence of key habitat features, such as vegetation cover, tree hollows and potential foraging, nesting or roosting sites. Habitats were classified as good, moderate or poor.

The species considered in this assessment were defined as those threatened species that are known or considered likely to occur in the locality, based on desktop assessments, field surveys or as requested by OEH.

The locations for ancillary sites (not including temporary creek crossings) were unknown at the time of terrestrial field survey and for that reason have not all been directly surveyed in the field. Instead, a methodology for assessing the ancillary sites was developed. This methodology was based on using agreed criteria as the primary assessment tool to confirm 'no-go' areas for ancillary facilities and to identify worst case and representative potential impacts of these facilities on the receiving environment. The agreed criteria are discussed in **Section 4.4.7**.

## *Aquatic flora and fauna*

Threatened species, populations and endangered ecological communities (EECs) that occur or may occur within the study area were identified by reviewing published distributions and current listings on databases maintained by DSEWPaC, Department of Trade and Investment, Regional Infrastructure and Services (DTIRIS) and OEH. Results from a previous search of the NSW Government database 'BioNet' conducted on 7 September 2007 were also used<sup>1</sup>. DSEWPC, DTIRIS and OEH database searches were updated on 22 June 2011.

Aquatic habitats were assessed using three classification schemes, including riparian, channel and environmental (RCE) classification, riparian corridor management classification and fish habitat classification.

The RCE classification was used to understand the environmental state of waterways in the study area. The highest score (52) was assigned to a stream with little or no obvious physical disturbance. The lowest score (13) was assigned to a highly altered stream without any riparian vegetation.

The riparian habitat of each waterway in the study area was classified according to criteria provided in *Riparian Corridor Management Study (RCMS) in the Wollongong Local Government Area* (Department of Infrastructure Planning and Natural Resources (DIPNR) 2004). The classifications are informed by existing habitat conditions and also by the potential value of the habitat if it were rehabilitated. Classification categories are:

- *Category 1 – Environmental Corridor*: provides biodiversity linkages by maintaining connectivity for the movement of aquatic species along the riparian corridor and between key destinations.
- *Category 2 – Aquatic Habitat*: provides basic habitat and preserves or emulates, as much as possible, a naturally functioning stream.
- *Category 3 – Bank Stability and Water Quality*: may have limited habitat value but contributes to the overall basic health of a catchment.

Each waterway in the study area, upstream and downstream of the project, was classified for fish habitat in accordance with the *NSW Policy and Guidelines: Aquatic Habitat Management and Fish Conservation* (Smith and Pollard 1999) and guidelines and policies for fish friendly road crossings (Fairfull and Witheridge 2003). Fish habitat was classified from Class 1 – major fish habitat to Class 4 – unlikely fish habitat.

Fish and macroinvertebrate sampling were used to determine the fauna species present in the study area and to provide an understanding of the health of the ecosystems. Electrofishing was used in appropriate habitats at four sites to sample fish and large mobile macroinvertebrates. Surveys of fish were undertaken once during autumn (April 2009) and revealed the fish present at the time at each site. This survey provides no information on potential variation in fish populations through time; rather it presents an appropriate 'snapshot' of fish communities.

The Australian river assessment system (AusRivAS) protocol (Turak and Waddell 2004) was used to provide an assessment of ecosystem health. The protocol uses an internet-based software package to determine the environmental condition of a waterway. It is based on predictive models of the distribution of aquatic macroinvertebrates at undisturbed reference sites. Observed freshwater macroinvertebrate assemblages (meaning those collected in the field) were compared to macroinvertebrate assemblages expected from reference waterways of the same type, which provides a basis to assess the health of the stream.

The revised SIGNAL2 biotic index (Stream Invertebrate Grade Number Average Level) developed by Chessman (2003) was also used to determine the environmental quality of sites on the basis of the presence or absence of families of macroinvertebrates. This method assigns grade numbers between one and 10 to each macroinvertebrate family or taxa found, based largely on their responses to chemical pollutants. The sum of all grade numbers for that habitat is then divided by the total number of families recorded in each habitat to calculate the SIGNAL2 index.

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<sup>1</sup> The 'BioNet' database is no longer operational

The presence of instream macrophyte taxa was also recorded. The survey was done at an appropriate time to reveal a comprehensive range of macrophyte species present.

Water quality was measured at each waterway in the study area using a Yeo-Kal 611 probe. Physio-chemical properties measured included electrical conductivity, salinity, temperature, turbidity, dissolved oxygen, pH and oxidation reduction potential. Alkalinity was measured *in situ* using hand-held titration cells.

Temporary creek crossings were assessed using the above mentioned methodology as part of the aquatic ecology field surveys. Broad areas were identified as requiring temporary creek crossings. Within these areas, four sites were selected based on having the least possible impact on aquatic and terrestrial ecology and water quality.

### 7.3.2 Existing environment

The study area mainly comprises the existing Princes Highway road reserve as well as agricultural and rural properties. While most of the area outside the road reserve has been cleared for agricultural use, there are scattered patches of native vegetation and isolated remnant trees.

Conservation reserves in the area 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 would be directly impacted by the project.

The northern section of the project lies within the Crooked River catchment, however the project does not intersect any significant or ephemeral waterways in this catchment. As the project cuts through Toolijooa Ridge it crosses into the adjacent Broughton Creek catchment (which is part of the Shoalhaven River catchment). It crosses Broughton Creek on three occasions. Refer to **Section 7.4** for a description of the physical setting of these catchments.

There are several water quality issues facing watercourses within the Shoalhaven area due to past and present land-use practices. These include elevated nutrient levels, heavy metal contamination, suspended sediment resulting from erosion of soils, low dissolved oxygen, bacterial pollution and drainage of acid sulphate soils (ASS) (Environmental Protection Authority (EPA), 1997). Previous studies have found water quality within the study area to be typical of aquatic ecosystems that have been disturbed by agricultural practices (The Ecology Lab 1999, 2007). For further discussion on water quality within the study area, refer to Section 7.4.

#### Terrestrial flora

A total of 513 vascular flora species were recorded within the study and adjoining areas. About 78 per cent of these species were locally indigenous species and 22 per cent were exotic or environmental weed species. Two threatened flora species were recorded in areas adjoining the study area. Potential habitat for four threatened flora species may exist within the study area. A full list of flora species recorded is provided in **Appendix A** of the *Terrestrial Flora and Fauna Technical Paper* at **Appendix F**.

Most of the study area is covered by cleared land that is considered to have limited to no capacity for regeneration to a native plant community. Cleared land in the study area generally consists of grazed paddocks with little existing native vegetation.

#### Vegetation communities

As shown in **Figure 7-8**, 25 vegetation communities have been mapped as occurring within a five kilometre radius of the study area. Of these 25 communities, eight are mapped as occurring within the study area, including Illawarra gully wet forest, Currumbene-Batemans lowlands forest, riverbank forest, warm temperate layered forest, closed grassland, closed grassland / sedgeland, riparian open forest and constructed wetland.

One of the communities located within the study area, the riverbank forest, is consistent with the EEC *River-flat Eucalypt Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions* listed under the *Threatened Species Conservation Act 1995* (TSC Act). However, the community within the study area is considered to be highly disturbed and in poor condition as its species composition and structure have been altered and weed species are often dominant in the understorey. A total of 10 hectares of this community is mapped within the study area.

### *Threatened flora*

According to database search results, a total of 17 vascular flora species listed on the TSC Act and/or the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), or their habitat, have been previously recorded within a 10 kilometre radius of the study area. No threatened flora species were recorded in the study area during the field surveys.

Two threatened species, Illawarra Socketwood (*Daphnandra* sp. 'Illawarra') and Hill Zieria (*Zieria granulata*) were recorded in areas adjoining the study area. The closest records of these species were about 600 metres and 200 metres south of the study area, respectively.

Potential habitat may exist within the study area for four threatened flora species. This is based on the proximity of previous records and/or the presence of identified habitat preferences. These species include White-flowered Wax Plant (*Cynanchum elegans*), Illawarra Socketwood (*Daphnandra* sp. 'Illawarra'), Delicate Cress (*Irenepharsus trypherus*) and Hill Zieria (*Zieria granulata*). The OEH has specified five flora species to be assessed for the project including two of the species cited above and an additional three species. The additional three flora species are Illawarra Greenhood (*Pterostylis gibbosa*), Leafless Tongue Orchard (*Cryptostylis hunteriana*) and Bauer's Midge Orchard (*Genoplesium baueri*).

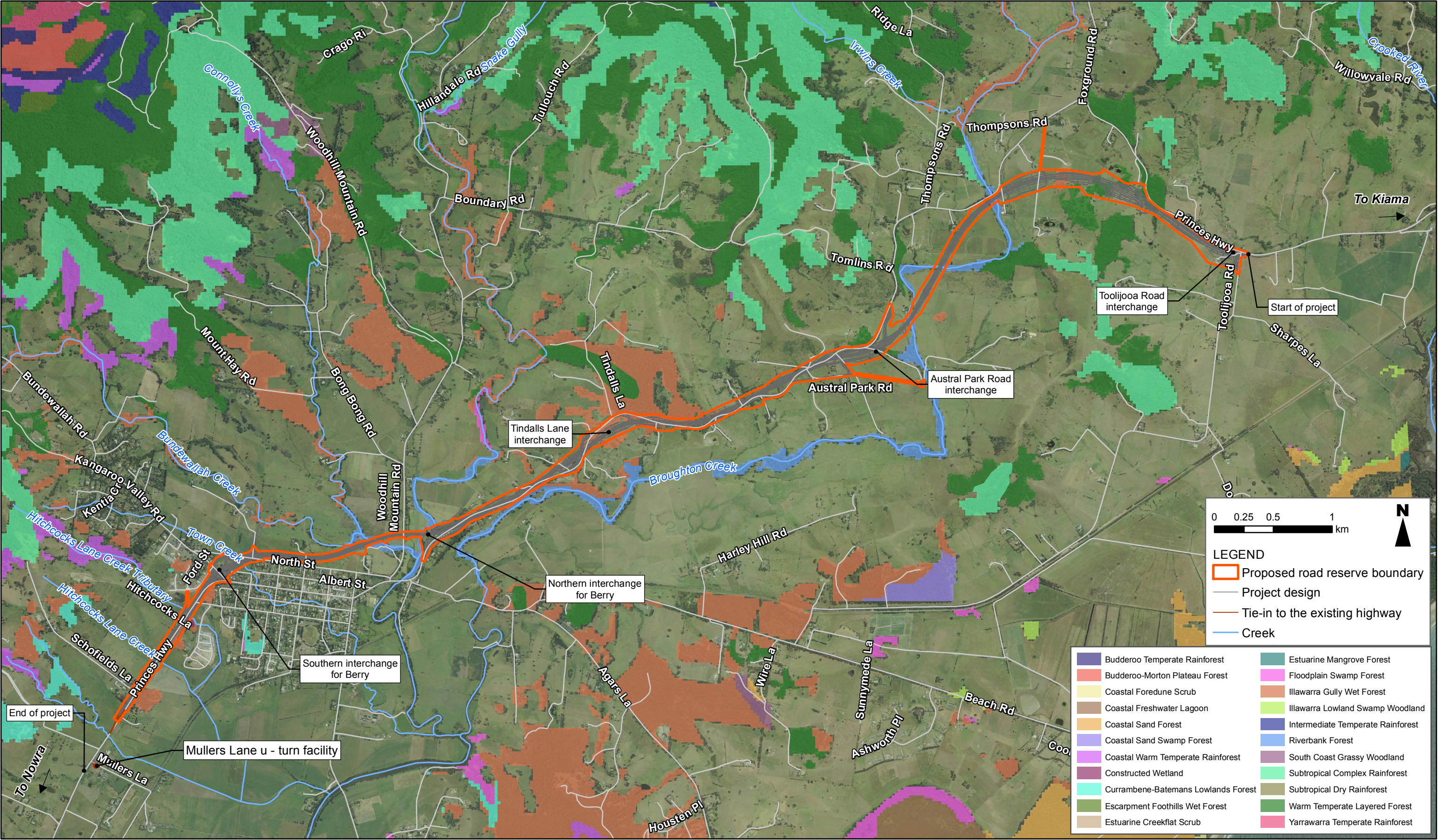


Figure 7-8 Vegetation communities within the study area

Note: Closed grassland, closed grassland / sedgeland and riparian open forest is not shown on this figure.

Source: AECOM (2012) ,LPMA (2011), OEH (2011)

### Exotic species

There were seven exotic species recorded in the study area and its surrounds that are listed as noxious weeds in the Shoalhaven local government areas (LGA). Three of these are also listed as noxious in the Kiama LGA. **Table 7-48** provides a list of the eight species and the noxious weed class to which they belong. Noxious weeds are non-native species declared under Section 7 of the *Noxious Weeds Act 1993*.

**Table 7-48 Noxious weeds recorded in the study area**

| Weed species                    | Common name         | Noxious weed class |
|---------------------------------|---------------------|--------------------|
| <i>Ageratina riparia</i>        | Mistflower          | 4                  |
| <i>Lantana camara</i> *         | Lantana             | 4                  |
| <i>Ligustrum lucidum</i>        | Large-leaved privet | 4                  |
| <i>Ligustrum sinense</i>        | Small-leaved privet | 4                  |
| <i>Lycium ferocissimum</i> *    | African boxthorn    | 4                  |
| <i>Rubus fruticosus</i> 8       | Blackberry complex  | 4                  |
| <i>Senecio madagascariensis</i> | Fireweed            | 4                  |

\*Listed as noxious in Kiama LGA

The regulatory requirements for the management of these noxious weed classes include:

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

Given that survey effort for noxious weeds 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.

Throughout Australia, 20 Weeds of National Significance (WONS) have been identified due to their invasiveness, impacts on primary production and the environment, potential for spread and socioeconomic impacts. Two WONS, Lantana (*Lantana camara*) and Blackberry complex (*Rubus fruticosus*), were recorded in the study area during the current surveys. Other than the requirements of the *Noxious Weeds Act 1993*, there are no additional regulatory obligations to control WONS. The invasion of lantana is also listed as a key threatening process under the TSC Act.

Environmental weeds were present in all areas of native vegetation that were surveyed and they dominated cleared and disturbed areas throughout the study area. The environmental weeds recorded during the field surveys included annual and perennial grasses and herbs. Some examples included Cobbler's Pegs (*Bidens pilosa*), Spear Thistle (*Cirsium vulgare*), Panic Veldtgrass (*Ehrharta erecta*), Kikuyu Grass (*Pennisetum clandestinum*), Paddy's Lucerne (*Sida rhombifolia*) and Curled Dock (*Rumex crispus*). Perennial species such as Sprengeri Fern (*Protasparagus aethiopicus*) and Madeira Winter Cherry (*Solanum pseudocapsicum*) had invaded areas under canopies and dense patches of groundcover. Species such as Creeping Buttercup (*Ranunculus repens*) and *Tradescantia fluminensis* were present in damp areas and riparian zones.

Woody environmental weeds such as Camphor Laurel (*Cinnamomum camphora*) and Wild Tobacco Bush (*Solanum mauritianum*) generally occur on the edges of native vegetation with cleared and disturbed areas as small stands or scattered individuals. Vines including *Araujia hortorum*, Cape Ivy (*Delairea odorata*) and White Passionflower (*Passiflora subpeltata*) are environmental weeds that occur on disturbed edges and under the canopy of patches of native vegetation.

## Terrestrial fauna

Fauna recorded within the study area included 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.

### *Threatened fauna*

According to database search results, a total of 114 threatened, migratory and/or preliminarily listed fauna species, or their habitats, 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 (CMA) region. Seventy-three of these fauna species are listed under the TSC Act and 69 fauna species are listed (or nominated for listing) under the EPBC Act (including 20 threatened species and 51 migratory species). Eighty-nine threatened and/or migratory species have been previously recorded within 10 kilometres of the study area.

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

Threatened fauna species recorded during the field surveys included:

- Gang-gang Cockatoo (*Callocephalon fimbriatum*).
- Powerful Owl (*Ninox strenua*).
- Yellow-bellied Sheath-tail 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 recorded during the field surveys included:

- 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*).

### *State Environmental Planning Policy (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. SEPP 44 identifies both 'potential' and 'core' Koala habitat. 'Potential' Koala habitat is defined in the SEPP as areas of native vegetation where the trees of the type listed in Schedule 2 of the policy constitute at least 15 per cent of the total number of trees in the upper and lower strata of the tree component. 'Core' Koala habitat is defined as an area of land with a resident population of Koalas.

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 and the absence of records of these 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.

### *Wildlife corridors*

Most 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. As a result, wildlife corridors in the study area are limited. The project does however cross the Seven Mile Beach National Park – Barren Grounds Nature Reserve wildlife corridor. Remnant native vegetation at Toolijooa Ridge, Broughton Creek, Broughton Mill Creek and Bundewallah Creek are discontinuous parts of this corridor and are important to wildlife in the area. Creeks provide dispersal habitat for aquatic fauna and vegetation. Other creeks (such as Town Creek) and some road reserves within the study area also provide limited value as local wildlife 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). **Figure 7-9** displays wildlife corridors located within the study area.

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 the Tindalls Lane interchange. It is mostly made up of cleared agricultural land and includes most of the wildlife corridors as shown in **Figure 7-9**.

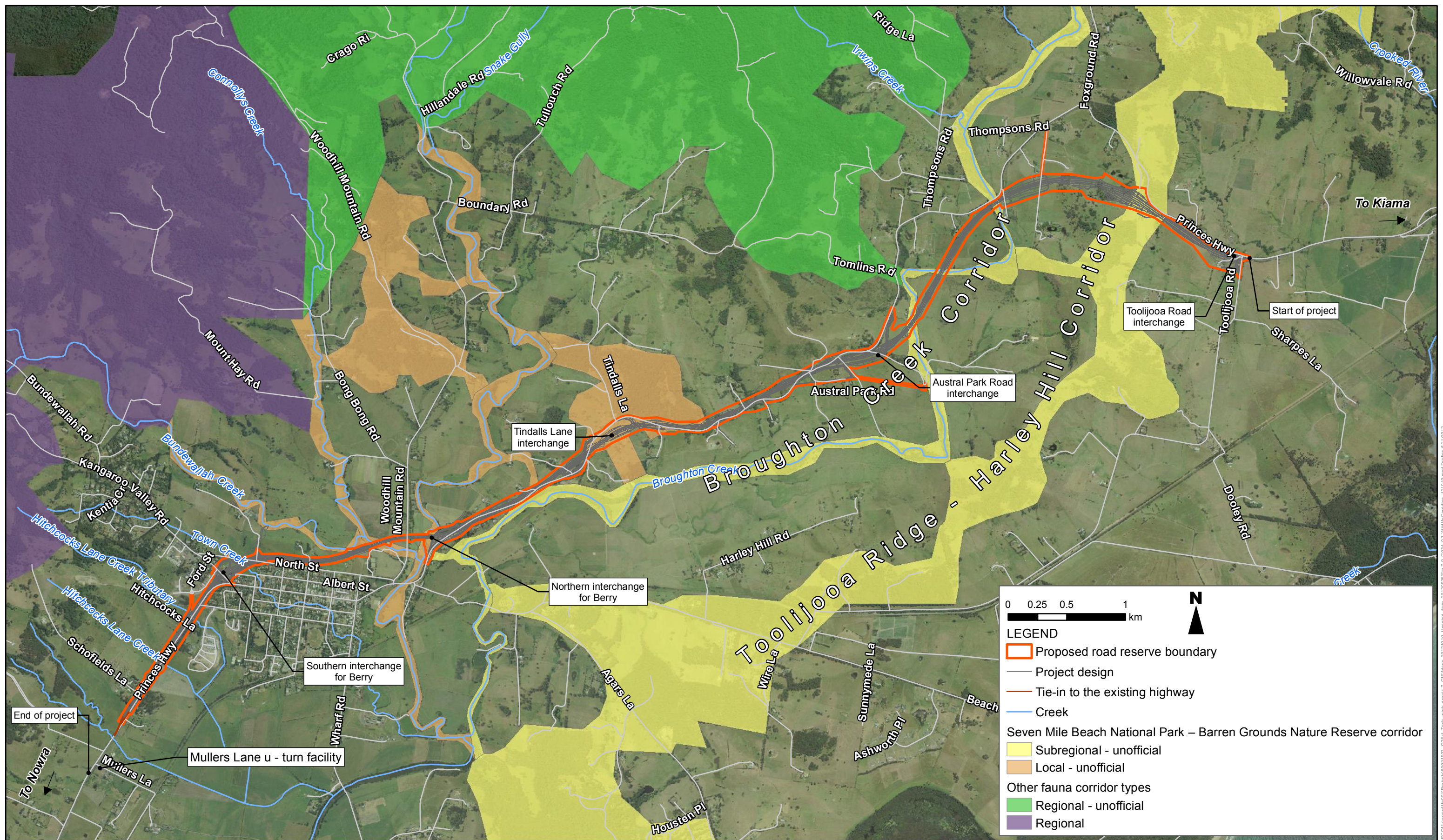


Figure 7-9 Wildlife corridors within the study area

Source: AECOM (2012), LPMA (2011), OEH (2011)

## Terrestrial habitats

The following section provides a description of the condition of flora and fauna habitats within the study area.

### *Toolijooa Ridge and Harley Hill*

Native vegetation along Toolijooa Ridge and Harley Hill was generally confined to 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 included subtropical complex rainforest which grades into warm temperate layered forest further down slope and along edges. Isolated stands of Illawarra gully wet forest were also present, sometimes represented by scattered remnant trees only. The dominant vegetation community at Harley Hill was the 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.

The native vegetation along Toolijooa Ridge and Harley Hill was generally considered to be in poor condition along edges where large infestations of the noxious weed Lantana were present and had displaced most native species. Some large hollow-bearing trees were present and provided potential nesting and roosting resources for birds, arboreal mammals and microchiropteran bats.

### *Broughton Creek*

Native vegetation along Broughton Creek was largely restricted to a thin riparian corridor with patches of remnant and regrowth vegetation. 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.

Vegetation alongside Broughton Creek was riverbank forest in poor condition. Each site had a tall native canopy of River Oak (*Casuarina cunninghamiana*) and an understorey completely dominated by a high density of environmental weeds. Natural structural layers of the riverbank forest were no longer intact and in most areas the mid storey and ground layers were completely dominated by environmental weed species. Obvious disturbances at each of these sites included heavy grazing and erosion.

At least six large hollow-bearing River Oaks and six large hollow-bearing Blackbutts (*Eucalyptus pilularis*) were located in the vicinity of Broughton Creek.

### *Princes Highway at Tindalls Lane*

Adjacent to Tindalls Lane and on the north and south sides of the existing Princes Highway was an area of remnant native vegetation that covered about 60 hectares. This was one of the largest areas of native vegetation present in the study area. Historic disturbances such as logging have altered the structure of these communities and environmental weeds were scattered throughout these areas.

The remnant native vegetation in these areas was Illawarra gully wet forest in a moderate to good condition. The native tree, shrub and ground layers were largely intact although woody weeds such as Lantana were present in dense patches. Where dense patches of lantana were absent, the native shrub layer remained 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.

### *Broughton Mill and Bundewallah Creeks*

Broughton Mill and Bundewallah Creeks lie immediately north-east of Berry township. Native vegetation along these creeks was largely restricted to a highly disturbed riparian corridor.

Vegetation in this part of the study area was represented by riverbank forest in a highly disturbed, poor condition. There was also a tall native canopy of River Oak and an understorey completely dominated by a high density of environmental weeds. Natural structural layers were not intact and in most areas the mid storey and ground layers were completely dominated by environmental weed species.

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

### *Bundewallah Creek (proposed receiving point for Town Creek diversion)*

The proposed Town Creek diversion would flow into Bundewallah Creek at the northern end of Rawlings Lane. Native vegetation within this riparian corridor was consistent with riverbank forest. Where the proposed diversion would connect to Bundewallah Creek, the riverbank forest included a sparse canopy of River Oak between 15 and 25 metres in height and woody weeds which formed a dense understorey in patches. Elsewhere the understorey was absent or had scattered woody weeds. Groundcover was dominated by exotic grasses and herbs with occasional patches of native groundcovers.

Bundewallah Creek at the proposed receiving point varied in width from around three 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 which would likely provide habitat for common frogs and ducks. Deposited concrete slabs provided basking and shelter habitat for common reptiles. Fauna habitats at this location range from poor to moderate in condition.

### *Town Creek*

Town Creek is a small ephemeral watercourse that passes directly through Berry, and originates to the north west of the town. The dominant vegetation type in the northern reaches of the creek, in the area north of North Street, was closed grassland which generally consists of introduced pasture species. There were also scattered occurrences of native herbs and rushes. The closed grassland represents a modified landscape and has established as a result of the substantial clearing of native vegetation and a long history of agriculture.

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

Town Creek south of North Street consisted of closed grassland, closed sedgeland and disturbed riparian open woodland. As with the closed grassland north of North Street, the closed grassland south of North Street was dominated by exotic species and patches of native vegetation. Disturbed riparian open woodland occurred along Town Creek through the Berry township. This vegetation community was characterised by areas of revegetation and regrowth of native vegetation, planted exotic trees, invasive woody weeds and areas of managed open space.

South of Berry, a wetland is located in the area immediately to the west of where Town Creek joins Broughton Mill Creek. This wetland formed following the construction of the access track causeway of the Berry sewage treatment works that encouraged the establishment of aquatic and semi aquatic vegetation. The wetland was characterised by patches of native rushes (*Typha*, *Typha orientalis*) and sparse cover of other emergent macrophytes. The banks were dominated by pasture grasses with exotic trees and shrubs occurring around the banks.

Fauna habitats along Town Creek south of North Street were disturbed, however they provide foraging and breeding resources for a range of common birds, frogs, reptiles and mammals. Town Creek itself and the wetland provide habitat for threatened and migratory birds. The wetland may offer potential habitat for the threatened Green and Golden Bell Frog. However, at the time of survey, the wetland was shallow and stagnant, limiting its habitat potential. Fauna habitats along Town Creek ranged from poor to moderate in condition.

#### *Broughton Mill Creek (confluence with Town Creek)*

Where Town Creek joins Broughton Mill Creek south-east of Berry, the vegetation consisted of riparian open woodland containing stands of exotic shrubs and trees. The groundcover was dominated by introduced pasture species. Fauna habitats were disturbed and subject to trampling by cattle (observed at time of survey). No sedges were present but patches of the reed would provide potential habitat for common frogs and birds.

#### *Hitchcocks Lane*

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

Vegetation opposite Hitchcocks Lane was Illawarra gully wet forest and included mature hollow-bearing Bangalay (*Eucalyptus saligna* X *botryoides*) and Blackbutt (*Eucalyptus pilularis*) with a patchy understorey including native shrubs and groundcovers, along with large patches of environmental weed species. The condition of Illawarra gully wet forest at the Hitchcocks Lane site was considered to be moderate.

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

Vegetation at the western end of Victoria Street included isolated remnant native trees with a mown grassy understorey. This area was considered to be highly modified and in poor condition. The only vegetation layer that remained undisturbed was the native canopy layer.

#### *Schofields Lane*

A native stand of Illawarra gully wet forest occurred south-west of Berry township and directly opposite Schofields Lane. This stand was considered to be in moderate condition, based on the number of mature eucalypt trees present. There were few logs and scattered stags (dead trees) with hollows on the site. There was potential for microbat breeding and roosting habitat.

### **Aquatic flora and fauna**

#### *Macrophytes*

Previous surveys of creeks within the Crooked River and Broughton Creek catchments recorded Cumbungi (*Typha* sp.), Spikerush (*Isolepis prolifera*), Starwort (*Aster* sp.), Duckweed (*Lemna* sp.), Water Ribbons (*Triglochin procerum*), Arum Lilies (*Zantedeschia aethiopica*), Tall Spikerush (*Eleocharis sphacelata*), River Clubrush (*Schoenoplectus validus*), Unidentified Rush (*Cyperus* sp.), Common Reed (*Phragmites australis*), Knotweed (*Persicaria* sp.), Water Plantain (*Alisma plantago-aquatica*), Watermilfoil (*Myriophyllum* sp.), Watercress (*Nasturtium officinale*) and Blunt Pondweed (*Potamogeton ochreatus*) (The Ecology Lab, 1999; 2007).

## Macroinvertebrates

A study of aquatic macroinvertebrates from slow-flowing 'pool edge' freshwater habitat in the Crooked River and adjacent Ooaree Creek catchments recorded 41 taxa (The Ecology Lab, 1999). The Crooked River and Ooaree Creek catchments are located to the south east of the project area. This study was located outside the project area and was used for comparative purposes. Consistent with results for water quality, the most common macroinvertebrates collected from pool habitat were midge fly larvae (family Chironomidae), which are tolerant to pollution or degraded habitat. Other relatively abundant taxa included the families; Leptophlebiidae, Hydroptilidae, Physidae, Tricladidae, Baetidae, Tasimiidae and the sub-family Orthocladiinae (The Ecology Lab, 1999).

## Fish

A literature and database search was conducted to obtain an inventory of freshwater fish fauna for the study area. There have been few formal fish surveys conducted in the study area, as discussed in **Section 7.3.1** (exceptions include the surveys documented by The Ecology Lab in 1999 and 2007).

Thirty-six fish species were identified as potentially existing or have historically existed within the study area. Of these, 33 are native species and three are exotic species. Three of the native species are listed as threatened. The *Fisheries Management Act 1994* (FM Act) lists the Macquarie Perch (*Macquaria australasica*) as an endangered species, the Black Cod (*Epinephelus daemeli*) as a vulnerable species and the Australian Grayling (*Prototroctes maraena*) as a protected species. The Macquarie Perch and the Australian Grayling are also listed under the EPBC Act as endangered and vulnerable respectively. The Australian Grayling has been recorded by the Australian Museum from Broughton Mill Creek, to the south-east of Berry and from the lower section of Jaspers Creek, just upstream of its confluence with Broughton Creek.

It is likely that not all 36 species identified as potentially or historically existing within the study area would actually occur within the study area. This is because the 36 species were obtained by including surveys from a wider area, including the larger Shoalhaven River system. The Shoalhaven River provides considerable fish habitat and ranges in altitude from sea level to over 500 metres AHD. Like the Shoalhaven River, Broughton Creek supports an estuarine floodplain at lower altitudes. It is likely that fish species that inhabit the lower reaches of the Shoalhaven River would also inhabit the lower reaches of Broughton Creek. However, the freshwater habitats that occur at higher altitudes within the Broughton Creek catchment are generally small and ephemeral. These streams would be unlikely to provide fish habitat and as a result some species found in the upper reaches of the Shoalhaven River may not be present in Broughton Creek.

The Macquarie Perch generally inhabits higher freshwater areas than those commonly found in the study area (NSW DPI 2005). However, Gehrke et al., (2001) claim that Macquarie Perch was historically present (prior to the construction of the Tallowa dam) in sections of the Shoalhaven River as low as 30 metres above sea level. Similar low elevations existed in the study area, although they were smaller and more degraded.

A previous survey of waterways intersecting the study area recorded nine species of freshwater and estuarine fish (The Ecology Lab, 2007). Four species were recorded within freshwater habitat from the Broughton Creek catchment, including Longfinned Eel (*Anguilla reinhardtii*), Flathead Gudgeon (*Phylloptodon grandiceps*), Striped Gudgeon (*Gobiomorphus australis*) and Empire Gudgeon (*Hypseleotris compressa*). In addition to Flathead Gudgeon, another five species were recorded at the downstream extent of freshwater in Broughton Creek, which occurs at the Coolangatta Road bridge crossing. These species included Australian Smelt (*Retropinna semoni*), Pacific Blue-eye (*Pseudomugil signifer*), Estuary Perchlet (*Ambassis marianus*), Sea Mullet (*Mugil cephalus*) and the introduced Mosquito Fish (*Gambusia holbrooki*) (The Ecology Lab, 2007).

Field surveys conducted for the project recorded seven native fish species. These species were Bullrout (*Notesthes robusta*), Australian Bass (*Macquaria novemaculeata*), Australian Smelt, Longfinned Eel, Common Jollytail (*Galaxias maculatus*), Flathead Gudgeon and Striped Gudgeon. Australian bass is an important species to recreational fishers and is a common large predator within the study area. Its presence also influences the presence or absence of other fish species. For example, if Australian bass are found in a watercourse, then typically Macquarie perch would only be found upstream of them (McDowall, 1996).

The Shoalhaven/Crookhaven estuary, which is located downstream of the study area, supports a significant fish population. The estuary supports commercial fishing. Fish likely to occur include luderick, whiting (*Sillaginidae*), mullet (*Mugilidae*), flathead (*Platycephalidae*), bream (*Sparidae*) and crab species. A number of threatened and protected species either occur, or suitable habitat for them may occur, in the region of the estuary.

### *Syngnathiformes*

All Syngnathiformes (seahorses, seadragons, pipefish, pipehorses, ghost pipefish and seamoths) that may inhabit the study area are listed as protected species under the FM Act. There are currently 31 syngnathids (seahorse, pipefish, pipehorses and seadragon), four solenostomids (ghost pipefish) and two species of pegasids (seamoths) known to exist in NSW waters. Syngnathiformes are found in a variety of habitats, including seagrass beds, coastal embayments and artificial structures such as jetties or mesh nets.

Some Syngnathiformes inhabit coastal embayments and estuarine habitats, are often associated with seagrass habitat, and can be found in the Crooked River lagoon, downstream of the study area.

### *Invasive species*

The Environmental Reporting Tool identified alligator weed (*Alternanthera philoxeroides*) as potentially occurring in the region. Alligator weed is a WONS. It poses a significant environmental and economic threat and is highly invasive. Alligator weed is a Class 2 noxious weed in the Shoalhaven and Kiama LGAs, and as such the land must be kept free of alligator weed and it must be eradicated when identified.

### *Migratory marine species*

An expanded search which included the distant downstream Shoalhaven/Crookhaven estuary identified 49 aquatic fauna species that are given general protection and listed under Section 248 of the EPBC Act, as migratory marine species, listed marine species, or whales and other cetaceans.

Twelve species are listed as migratory marine species, comprising six mammals, four reptiles and two sharks. There are 26 listed marine species, comprising two mammals, four reptiles and 20 ray-finned fish from the order Syngnathiformes (including pipefish, pipehorses, seahorses, seadragons, and ghost pipefish). Eleven species are listed as whales and other cetaceans.

### **Aquatic habitats**

As discussed in **Section 7.3.1**, the existing quality of aquatic habitats has been assessed using three different measures:

- RCE classification – to provide a measure of habitat disturbance.
- Fish habitat – measured as Class 1 to Class 4 waterways.
- Riparian habitat – measured as category 1 to category 3 waterways.

### *Broughton Creek*

The section of Broughton Creek upstream of Berry was mostly surrounded by cleared agricultural land. There were also large upstream sections with intact native riparian vegetation. Large sections of the creek also alternated between riffle and pool habitats and in-stream fish habitat, such as snags, rocks and deep holes. Closer to Berry, riparian vegetation became sparse and there was greater livestock access to the creek. The channel also became wider and there were longer, deep pool sections with cleared steep banks. Previous surveys have found that Broughton Creek provides major fish habitat (Class 1 waterway). The ephemeral tributaries of upper Broughton Creek have been considered unlikely to provide fish habitat (Class 4 waterways), as they only flow during larger rain events, have poorly defined channels with few standing pools and are often colonised by pasture grasses (The Ecology Lab 2007).

Broughton Creek was moderately disturbed (meaning it had a moderate RCE score) at the location of each of the three proposed highway bridges that would cross the creek. The results of the AusRivAS assessment showed that Broughton Creek was moderately impacted due to pollution and/or damage to the local habitat. However, Broughton Creek was considered to provide major fish habitat and it is a Category 1 waterway meaning that it provides biodiversity linkages along the riparian corridor.

The Coolangatta Road bridge crossing of Broughton Creek marks the downstream extent of freshwater habitat. This crossing is about 1.7 kilometres south of Berry. Further downstream the creek became considerably wider (up to 50 metres) and was estuarine. It meandered through the Broughton floodplain which has been cleared for agricultural use and the riparian vegetation was thin and sparse. There have been historical flood mitigation works in this area and a number of tributaries of Broughton Creek have been straightened and contain tidal gates. The estuarine section of Broughton Creek has been previously classed as major fish habitat (Class 1 waterway) (The Ecology Lab, 2007).

### *Broughton Mill Creek and Bundewallah Creek*

Habitats within the Broughton Mill Creek and Bundewallah Creek catchments were relatively degraded (The Ecology Lab, 2007). Riparian vegetation was sparse or dominated by River Oak and mixed exotic species. The creek banks often had loose and eroded soils. Assessments completed during a prolonged dry period in Bundewallah Creek and Connollys Creek found minimal fish habitat (Class 3 waterway). The sections of Broughton Mill Creek just above and below the point where it joins Bundewallah Creek provided moderate fish habitat (Class 2 waterway). This watercourse had a sequence of pools and riffles, with some large snags and deeper holes.

At the location of the proposed crossing of Broughton Mill Creek, the waterway provided moderate fish habitat and had a moderate RCE score. It is a Category 2 waterway, meaning that it provided some riparian corridor but does not link to other destinations. The results of the AusRivAS assessment showed that Broughton Mill Creek was relatively healthy but showed some signs of pollution and/or local habitat damage.

At the location of the proposed crossing of Bundewallah Creek, the waterway provided moderate fish habitat and had a moderate RCE score. It was also a Category 2 waterway and the results of the AusRivAS assessment showed that Bundewallah Creek was relatively healthy but had some signs of pollution and/or local habitat damage.

### *Town Creek*

At the location of the proposed diversion of Town Creek, the waterway was ephemeral, had a low RCE score and was unlikely to provide fish habitat. The catchment was urbanised with riparian habitat that was highly degraded and the creek is classed as a Category 3 waterway. Reaches of the creek to the north and south of the urbanised reaches had poorly defined channels, with few standing pools and were often colonised by pasture grasses.

## **SEPP 14 wetlands**

The SEPP 14 listed Coomonderry Swamp lies behind Seven Mile Beach National Park on the eastern side of the ridge that separates the Broughton Creek valley and floodplain from the coast.

Coomonderry Swamp is a 670 hectare semi-permanent freshwater swamp fed by surface and groundwater from the eastern slopes of Harley hill, Moeyan hill and Coolangatta Mountain (NSW NPWS 1998). The drainage catchments of Coomonderry Swamp, which is about five kilometres southeast of Berry are not within the study area, and would be unaffected by the project.

The Shoalhaven/Crookhaven estuary is located downstream of the Broughton Creek and Shoalhaven River confluence. It supports a number of significant estuarine wetlands, many of which are SEPP 14 listed, including the Comerong Island Nature Reserve.

## **Groundwater dependent ecosystems**

Shallow alluvial groundwater systems have been identified upstream in the Broughton Creek floodplain and in the area immediately north of Berry, where Broughton Mill Creek, Bundewallah Creek and Connollys Creek converge (RTA, 2010). In these areas, groundwater levels are typically between 0.37 metres and 2.5 metres below ground level. Shallow alluvial groundwater systems are often in direct connection with surface water bodies, such as coastal waterways. These systems can be quickly recharged and water levels restored when droughts break (DLWC, 2002). The groundwater system in the study area is likely to support surface flows, hyporheic ecosystems and terrestrial vegetation such as riparian forests. The hyporheic zone is a fluctuating region where water exchanges between the surface and groundwater and is an important habitat for many aquatic invertebrates and a refuge during droughts and floods.

Shallow groundwater can support riparian vegetation either permanently or seasonally. The groundwater needs to be sufficiently high to sustain the vegetation therefore the sections of riparian habitat most dependent on groundwater within the study area most likely occur in areas where the water table is closest to the surface. However, the relationship between groundwater and survival of riparian vegetation in the study area is not known.

Groundwater can also be important for the persistence of aquatic macrophytes during periods when waterways are not flowing. An example would be Cumbungi, whose roots penetrate beneath creek beds.

Groundwater flow can be an important part of maintaining instream flow to support shallow aquatic habitat, such as riffles. At the surface, groundwater flow is often seen as springs or waterlogged soil. Shallow habitats were common within the major waterways of the study area. Each habitat supports a unique variety of aquatic flora and fauna. Groundwater contribution to surface water flows can also be important to the long term survival of unconnected pools. This is especially the case during droughts as pools function as a refuge for aquatic flora and fauna. The importance of groundwater to base flow of waterways within the study area is not known. There are no known significant springs in the study area.

Coomonderry Swamp is a well known groundwater dependent ecosystem (GDE) within the region. Its groundwater inflows come from a catchment outside the study area (to the east of Harley hill, Moeyan hill and Coolangatta Mountain) and therefore would be unaffected by the project.

### 7.3.3 Assessment of potential impacts

Potential impacts to terrestrial and aquatic flora and fauna within the study area during the construction and operation of the project could potentially include:

- Vegetation clearance and terrestrial habitat loss, including loss of EEC.
- Fragmentation and loss of connectivity.
- Loss of threatened species and their habitats.
- Loss of aquatic habitats.
- Loss of habitat for migratory species.
- Mortality of individuals.
- Invasion of exotic species.
- Reduction of water quality.
- Alterations of natural flow regimes.
- Impacts due to temporary creek crossings and ancillary facilities (construction only).
- Impacts to GDEs.
- Cumulative impacts.

#### **Vegetation clearance and terrestrial habitat loss, including loss of endangered ecological communities**

The project would have direct and indirect impacts as a result of vegetation clearance within the study area. Direct impacts would include the removal of vegetation to construct the roadway, temporary creek crossings and to provide areas for ancillary facilities. They would also include the loss of fauna habitat features such as nesting habitat and roosting hollows, as well as feeding and shelter resources.

**Table 7-49** shows that 57.1 hectares of native vegetation would potentially be impacted directly or indirectly by the project. This includes an EEC and five different vegetation communities that provide potential habitats for threatened species. Around 0.9 hectares of closed grassland, which is not considered to be a native or derived native plant community, would also be directly or indirectly impacted by the project.

Table 7-49 Area of each plant community potentially impacted by the project

| Plant community                     | Impacted area (hectare) |                      |                     |                      |                         |
|-------------------------------------|-------------------------|----------------------|---------------------|----------------------|-------------------------|
|                                     | Direct                  |                      |                     |                      | Indirect (edge effects) |
|                                     | Roadway                 | Ancillary facilities | Temporary crossings | Town Creek diversion |                         |
| Closed grassland*                   | -                       | -                    | -                   | 0.4                  | 0.5                     |
| Closed grassland/sedgeland          | 0.1                     | -                    | -                   | 2.1                  | 0.3                     |
| Constructed wetland                 | 0.2                     | -                    | -                   | 0.2                  | 0.3                     |
| Currambene-Batemans lowlands forest | -                       | 0.0002               | -                   | -                    | 2.4                     |
| Disturbed riparian open woodland    | -                       | -                    | -                   | 2.6                  | 1.2                     |
| Illawarra gully wet forest          | 13.7                    | 1.7                  | -                   | -                    | 10.05                   |
| River-flat eucalypt forest**        | 2.6                     | -                    | 0.2                 | 0.1                  | 7.1                     |
| Warm temperate layered forest       | 5.0                     | 1.9                  | -                   | -                    | 5.3                     |
| <b>Total</b>                        | <b>21.6</b>             | <b>3.6</b>           | <b>0.2</b>          | <b>5.4</b>           | <b>27.2</b>             |

\* Closed grassland is not considered to be native plant or derived native plant community

\*\*River-flat Eucalypt Forest is an EEC

Indirect impacts on native vegetation and habitats due to edge effects would be caused by vegetation clearance for the project. Indirect impacts have been assumed to occur within a 50 metre zone from the proposed edge of vegetation clearance. Edge effects would likely include the degradation of adjacent habitat through changes in microclimate, changes in hydrology, changes in floristics, alteration to the pattern and frequency of fire, invasion by exotic flora and fauna species, increase in sedimentation, increase in tree death, increase in rubbish and water pollution and improved access for predators (Bali 2000).

Native riparian vegetation within the study area (being River-flat Eucalypt Forest) would be subject to direct and indirect impacts as a result of the project. This includes the loss of 2.9 hectares of riparian vegetation. This includes the clearance of 0.1 hectares of riparian vegetation for the diversion of Town Creek. Around 7.1 hectares of riparian vegetation would be subject to edge effects. Native riparian vegetation within the study area forms part of 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. As shown in **Figure 7-8**, areas where this EEC would be directly or indirectly impacted would include:

- The junction of Bundewallah Creek and Connollys Creek and downstream to Broughton Mill Creek.
- Broughton Creek to the east of Berry on the southern side of the Princes Highway.
- Broughton Creek to the south east and east of the intersection of Tomlins Road and Princes Highway, at Broughton.
- Broughton Creek to the east of the intersection of Thompson Road and Princes Highway, at Broughton.
- Bundewallah Creek at the Town Creek diversion.

The diversion of flows from Town Creek would see the degradation of about 2.9 kilometres of existing vegetation and habitat along the existing channel. However, vegetation along the existing Town Creek is highly degraded and dominated by exotic species. With the planting of appropriate riparian vegetation communities along the diversion channel, about 0.4 kilometres of higher quality habitat would be created along the channel.

Removal or degradation of native vegetation within riparian areas would also have the potential to impact on aquatic ecology. Riparian vegetation is important ecologically because it provides a source of organic matter, shade and a source of large woody debris. Riparian vegetation also stabilises the beds and banks of watercourses, protecting them against erosion and acts as a filter for sediments and nutrients entering watercourses.

Riparian vegetation at Broughton Creek, Broughton Mill Creek and Bundewallah Creek, which are all classified as Category 1 (Environmental Corridors) was generally intact but was highly edge affected.

Along smaller waterways, the riparian vegetation that would be removed as a result of the project was already extremely degraded and highly edge affected. Within these communities, large woody vegetation was often absent and they were often dominated by exotic species. Therefore, it is unlikely that the project at these locations would further degrade riparian habitat and cause a significant impact on aquatic ecology, subject to the implementation of the recommended mitigation measures.

An assessment of significance has been carried out for the River-flat Eucalypt Forest EEC following the Guidelines for Threatened Species Assessment under Part 3A of the *Environmental Planning and Assessment Act 1979* (EP&A Act) (refer to **Appendix G** of the *Terrestrial Flora and Fauna Technical Paper* at **Appendix F**). This assessment concluded that the impacts to the EEC are not considered to be significant, on the basis that:

- River-flat Eucalypt Forest in the study area is highly fragmented.
- River-flat Eucalypt Forest that would 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 (refer to **Section 7.3.4**).

However, there would remain an unavoidable loss of River-flat Eucalypt Forest as a result of the project, which would have residual impacts on terrestrial and aquatic ecology.

## Fragmentation and loss of connectivity

The project would have some impact on local and regional wildlife corridors, particularly where the project crosses Toolijooa Ridge and Broughton Creek, despite the existing degree of clearing and fragmentation.

The existing Princes Highway crosses Toolijooa Ridge, however the project would widen the existing highway and deviate to the west. This would result in a wider barrier to fauna movement along the ridge. While the existing highway crosses Broughton Creek once, the project would cross Broughton Creek on three occasions. Construction of the project would also require three temporary crossings of Broughton Creek and temporary crossings of Broughton Mill Creek and Bundewallah Creek. Vegetation removal for the creek crossings would fragment riparian connectivity along Broughton Creek, Broughton Mill Creek and Bundewallah Creek. Movements of non-threatened terrestrial and arboreal mammals and birds may also be limited by the project.

The diversion of Town Creek would require the removal of riparian vegetation along Bundewallah Creek. It would also cause the degradation of vegetation along the existing Town Creek channel where the overall flow speed and volume would be reduced. This would potentially remove any wildlife connectivity along the existing Town Creek. However, an alternative wildlife corridor would be provided along the Town Creek diversion channel and Bundewallah Creek with the planting and rehabilitation of appropriate riparian vegetation.

Fragmentation of wildlife corridors would create barrier effects which would occur where particular species are either unable or unwilling to move between suitable areas of fragmented habitat. Even a small reduction in movements can reduce genetic continuity within a population and reduce the population size. Species most vulnerable to barrier effects include rare species, smaller ground-dwelling species and species with low mobility.

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. These species would include the Black Bittern, Bush Stone-curlew, Eastern Pygmy-possum, Spotted-tailed Quoll, Yellow-bellied Glider, Koala and Long-nosed Potoroo.

The worst case scenario would see the project being undertaken without the implementation of mitigation measures to minimise impacts to flora and fauna or the mitigation measures implemented fail to achieve the desired outcome, for example fauna may not use the provided mitigation which leads to extinction of local populations. This scenario would likely result in significant impacts to the above mentioned fauna species due to fragmented corridors and connectivity. However, with the implementation of mitigation measures detailed in **Section 7.3.4**, it is considered unlikely that the project would significantly impact flora and fauna corridors and connectivity and likely that the worst case would be ameliorated by the implementation of the appropriate mitigation measures, as outlined at **section 7.3.4**.

Potential impacts on the Southern Rivers CMA corridor have been assessed throughout **Section 7.3.3**. The assessment concentrates on connectivity impacts associated with the most vulnerable areas within this corridor. These are located along creeks and ridgelines which have existing remnant vegetation.

There is potential that the project would impact on fish passage in the study area as a result of bridge structures, culverts and the diversion of Town Creek. Barriers to fish passage have been discussed in alterations to natural flow regimes in this section of the environmental assessment.

## **Loss of threatened species and their habitats**

### *Terrestrial flora*

No threatened flora species, as listed under the TSC Act or EPBC Act, were recorded in the study area. The project would not be expected to impact threatened species listed under the TSC Act or EPBC Act that may potentially occur in the study area.

Assessments of significance following the Guidelines for Threatened Species Assessment under Part 3A of the EP&A Act were carried out for seven flora species listed as threatened under the TSC Act as a precautionary measure. These species were identified previously in **Section 7.3.2** and include the White-flowered Wax Plant, Leafless Tongue Orchard, Illawarra Socketwood, Delicate Cress, Hill Zieria, Illawarra Greenhood and Bauer's Midge Orchid.

The assessments of significance for each species considered the worst case impacts for the project, including:

- Is likely to reduce the long-term viability of a local population of the species, population or ecological community.
- Is likely to accelerate the extinction of the species, population or ecological community or place it at risk of extinction.
- Would adversely affect critical habitat.

The assessments also considered whether or not the project would maintain or improve biodiversity values, after considering actions to avoid, mitigate or compensate or to prevent unavoidable impacts.

The assessments of significance concluded that the project would have a minimal impact on flora species and 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.

As discussed in **Section 7.3.2**, five species listed as endangered under the EPBC Act were considered to have potential habitat and a likelihood of occurrence in the study area. These included White-flowered Wax Plant, Illawarra Socketwood, Delicate Cress, Hill Zieria and Illawarra Greenhood. An additional species, Leafless Tongue Orchard (a vulnerable species), was considered to have potential habitat in the study area but was not expected to occur given the absence of recordings for this species. All six species have been assessed against the relevant significant impact criteria in accordance with the EPBC Act Policy Statement 1.1 Significant Impact Guidelines: Matters of National Environmental Significance (DEWHA 2009) (refer to **Appendix I** of the *Terrestrial Flora and Fauna Technical Paper* at **Appendix F**).

This assessment considered the worst case impacts on these species that would potentially occur as a result of the project, including:

- 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.

This assessment concluded that the project is unlikely to have a significant impact on these species. Based on the outcomes of the assessment against the relevant significant impact criteria, referral to the Federal Minister for Sustainability, Environment, Water, Population and Communities is not required for the project in terms of potential impacts on listed flora.

### *Terrestrial fauna*

The project may impact on threatened fauna species. In a worst case scenario the project may cause death or injury of individuals, loss or disturbance of limiting foraging resources or loss or disturbance of limiting breeding resources. A number of threatened fauna species listed under the TSC Act and EPBC Act were recorded or were considered to have potential habitat within the study area. The project may impact the foraging habitat and habitat connectivity of these species. However, it is unlikely that the project would have a significant impact on the survival of these species. It is likely that the worst case scenario would be ameliorated by the implementation of appropriate mitigation measures, as outlined at **section 7.3.4**.

Nine threatened species were recorded during the field surveys, including the Gang-gang Cockatoo, Powerful Owl, Yellow-bellied Sheath-tail 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 assessed. Eighteen of the 51 species were also specified by the OEH as requiring an assessment.

Eleven species listed as critically endangered, endangered or vulnerable under the EPBC Act have potential habitat in the study area. These include the Regent Honeyeater, Eastern Bristlebird, Swift Parrot, Orange-bellied Parrot, Spotted-tailed Quoll, Green and Golden Bell Frog, Australian Painted Snipe, Long-nosed potoroo, Grey-headed Flying Fox, Koala and the Large-eared Bat.

**Table 4.3** of the *Terrestrial Flora and Fauna Technical Paper* at **Appendix F** summarises the possible impacts from the project on threatened or endangered species listed under the TSC Act and EPBC Act with known and/or potential habitat in the study area, and determines the need for further assessments.

After considering information sourced from databases, literature reviews and field surveys, 27 of the 51 fauna species listed under the TSC Act were considered unlikely to be negatively impacted as a result of the project. As such, assessments of significance have not been prepared for these species (refer to **Appendix F**).

Assessments of significance completed for the remaining 24 terrestrial fauna species (refer to **Appendix G** of the *Terrestrial Flora and Fauna Technical Paper* at **Appendix F**), concluded that the project would be unlikely to have a significant impact on any of the species assessed.

Of the eleven terrestrial fauna species listed under the EPBC Act, it was considered that the project may have an impact on the Swift Parrot, Spotted-tailed Quoll, Green and Golden Bell Frog, Long-nosed Potoroo and the Grey-headed Flying-fox and the Koala. Therefore assessments in accordance with the Significant Impact Criteria (DEWHA, 2009) would be required. This was based on the potential for the project to limit foraging habitat and/or impacts on habitat connectivity. For the five remaining species, it was concluded that assessments in accordance with the Significant Impact Criteria (DEWHA, 2009) would not be required.

Of the six fauna species carried forward for assessment against the Significant Impact Criteria, it was concluded that the project would be unlikely to have a significant impact on the species, provided the mitigation measures detailed in **Section 7.3.4** are implemented. Consequently, referral to the Federal Minister for Sustainability, Environment, Water, Population and Communities is not required for the project.

### *Aquatic flora and fauna*

No aquatic threatened or protected species or populations listed under the FM Act or the EPBC Act were observed in the study area during field surveys. The project would not be expected to impact threatened species listed under the FM Act or EPBC Act that may potentially occur in the study area.

Based on literature reviews, databases and survey data (as discussed in **Section 7.3.2**), potential impacts on the following aquatic fauna species were assessed due to the possibility that they might occur in the study area:

- Macquarie Perch, which is listed as vulnerable under the FM Act and endangered under the EPBC Act.
- Australian Grayling, which is listed as protected under the FM Act and vulnerable under the EPBC Act.
- Black Cod, which is listed as a vulnerable species under the FM Act.

These assessments were completed as a precautionary measure and to assess the worst case scenario, even though it is considered that the study area would not support viable populations of the Macquarie Perch or the Australian Grayling. Similarly, a significance assessment was also completed for the Black Cod, as it is possible that Crooked River and Shoalhaven/Crookhaven estuary are habitat for juveniles of this species.

All assessments found that the project would be unlikely to impact on each species, particularly following the implementation of mitigation measures presented in **Section 7.3.4**. A referral to the Federal Minister for Sustainability, Environment, Water, Population and Communities is not required for the project.

It is anticipated that the project would not have any significant impacts on surface or groundwater hydrology that might affect sensitive Syngnathiformes inhabiting distant downstream habitats. Similarly, appropriate erosion and stormwater control measures would eliminate potential downstream impacts related to sedimentation and pollution. Therefore, the project would not be expected to have any impact on Syngnathiformes.

### *Aquatic communities*

No aquatic threatened or protected communities were observed in the study area during field surveys.

Assessments of significance were carried out for two aquatic communities (coastal saltmarsh and freshwater wetlands on coastal floodplains) as a precautionary measure and to assess the worst case scenario. The assessments found that the project would be unlikely to impact these communities given that they do not occur within the study area. A referral to the Federal Minister for Sustainability, Environment, Water, Population and Communities is not required for the project.

### **Loss of aquatic habitats**

In-stream woody debris provides habitat for macroinvertebrates and fish, including refuge from predation, habitat for prey and as damming structures that create pools. Large woody debris was present within the larger watercourses, such as Broughton Creek, Broughton Mill Creek and Bundewallah Creek, and has the potential to be impacted by the project.

Temporary crossings would be constructed near each bridge site and would potentially involve in-stream works. In a worst case scenario it is possible that project works could lead to the removal of large woody debris. However, with the implementation of mitigation measures presented in **Section 7.3.4**, the impact to aquatic habitats would be expected to be minimal. Other than the bridge at Berry, no permanent bridge abutments or piers would be placed within these waterways meaning that the long term removal of woody debris would not be expected at most locations.

Temporary construction pads are likely to be required during the construction phase of the project to assist with bridge construction. Construction pads may involve the temporary placement of rocks or other construction materials within waterways.

There was little large woody debris in many of the smaller waterways that intersect the project, including Town Creek. Therefore it is unlikely that the project would further degrade large woody debris habitat at these locations such that it would cause a significant impact on aquatic ecology.

### **Loss of habitat for migratory species**

The project would not be expected to impact terrestrial or aquatic migratory species with known or potential habitat within the study area. This is because habitat for these species occurs well outside the project area or because habitat within the project area is not considered to be important for these species.

In a worst case scenario habitat for migratory species within the study area would be reduced. This has the potential to limit migratory species from visiting the region or to reduce the viability of migratory species. It is unlikely that the worst case scenario would occur with the implementation of appropriate mitigation measures, as outlined at **section 7.3.4**.

Fifty-one migratory species (or their habitats) have been previously recorded within 10 kilometres of the study area. Six of these species were recorded during the field surveys including, 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 21 migratory species.

Migratory waders are the most common migratory species recorded in the locality. Coomonderry Swamp, Seven Mile Beach National Park, Crooked River Estuary and Black Head are used on occasion or regularly by these species. However, 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 (such as 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 these migratory species. Habitat and 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, assessments in accordance with the Significant Impact Criteria (DEWHA, 2009) have not been carried out.

It is unlikely that the project would cause significant effects on the aquatic habitats and biota of the Shoalhaven/Crookhaven estuary, including aquatic and marine migratory species identified in the expanded EPBC Act search. Impacts are considered unlikely given:

- Their distance downstream.
- The implementation of mitigation measures to control water quality.
- That the species are mostly coastal or oceanic species.
- The Shoalhaven/Crookhaven estuary does not constitute critical habitat for any of these species.
- It is likely that the species would only use the estuary intermittently (if at all), as demonstrated by the limited records of these species in the estuary.

As such, no formal assessments of significance were completed for these species.

### **Mortality of individuals**

Fauna injury or death may occur during the construction phase of the project, when all vegetation has been removed. Many species, such as nocturnal species and smaller ground-dwelling species, would be vulnerable to predators as they are unable to move rapidly over large distances. Fauna mortality may also occur as a result of road kill during the operation of the project. The effects of mortality on general populations of species are difficult to predict. More detailed population data for species in the study area would be required.

RMS has policies and guidelines in place to manage the risk of fauna mortality during construction and operation of the highway (refer to **Section 7.3.4**). While road kill may still occur during operation, these mitigation measures would reduce the likelihood of road kill causing a significant impact on a species.

In a worst case scenario, there would be potential for a higher rate of mortality (of threatened or non-threatened species) as a result of the project. This may be as a result of additional vegetation clearance and associated habitat loss and removal or changes to proposed fauna crossing structures. However, it is likely that the worst case scenario would be ameliorated by the implementation of appropriate mitigation measures, as outlined at **section 7.3.4**.

## Invasion of exotic species

### *Terrestrial species*

The project would change the environmental conditions of adjoining native vegetation that may encourage weed invasion. However, all areas of native vegetation recorded in the study area are characterised by existing weed infestation. This is especially the case in areas adjoining Broughton and Bundewallah Creeks, where the understorey of riverbank forest is completely dominated by weed species, including Small Leaved Privet, Lantana, Wild Tobacco Bush, Mistflower and *Tradescantia fluminescens*.

A worst case scenario would see the introduction of WONS or noxious weed species that do not currently occur in the region. In particular the introduction of a Class 1 or Class 2 noxious weed species.

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

The implementation of mitigation measures provided in **Section 7.3.4** would decrease the likelihood of increased weed invasion in the impacted patches and the worst case impact is unlikely to occur.

### *Aquatic species*

Alligator weed was not observed at any site within the study area and no records were found for its occurrence. Notwithstanding, this species is known to be present within the Illawarra region. In a worst case scenario, if alligator weed became established within the study area, it is possible that its distribution could be increased by construction activities associated with the project.

Alligator weed would have the potential to impact the viability of native aquatic flora and fauna, if it became established within the study area. The mitigation measures presented in **Section 7.3.4** would be implemented to reduce the potential for the introduction and spread of alligator weed.

## Reduction of water quality

Potential water quality impacts to aquatic ecology during the construction and operation of the project would include sedimentation, pollution and disturbance of ASS.

### *Sedimentation*

There is potential for the mobilisation of sediments into the study area's aquatic habitats. Sediment mobilisation may arise from earthworks required for construction of the project and from ongoing erosion of disturbed areas during operation.

In a worst case scenario, an increase in sediment load can degrade water quality and important habitat features resulting in a loss of biodiversity and altered biotic assemblages. Sedimentation has the potential to lead to mortality and decreased growth in flora and fauna, degradation of habitat and reduced water quality. It is likely that the worst case scenario would be ameliorated by the implementation of appropriate mitigation measures, as outlined at **section 7.3.4**.

Increased sedimentation would be a concern for local freshwater habitats and biota downstream of the construction works, such as Broughton Creek, Broughton Mill Creek and Bundewallah Creek. There are also downstream sections of these waterways with relatively intact riparian vegetation and aquatic habitat.

The diversion of Town Creek would have the potential to increase sedimentation in both Bundewallah Creek and Town Creek. The excavation of a new creek bed would potentially facilitate erosion of the creek bed and banks due to the diverted flows. This would increase sedimentation in Bundewallah Creek. The decrease in flow in Town Creek south of the diversion point would increase sediment accumulation within the creek as a result of the decrease in overall flows and flushing flows during flood events.

A large amount of freshwater habitat within the study area is relatively degraded, particularly the smaller, more ephemeral streams. Nevertheless, increasing sediment loads could further degrade existing habitat and impact biotic assemblages. The likelihood and scale of impacts would be greater closer to the construction sites, with aquatic habitat furthest downstream, particularly the Shoalhaven/Crookhaven estuary, least likely to be affected.

The concept design for the project includes a number of strategies designed to mitigate sediment mobilisation into waterways. Construction erosion and sediment control measures outlined in **Section 7.3.4** would also be implemented to reduce the mobilisation of sediments. Combined, these measures would minimise the impact of the project to aquatic ecology within the study area.

### *Pollution*

In general, the project would be expected to have a relatively minor impact on water quality due to pollution. In a worst case scenario the construction and operation of the project has the potential to mobilise contaminants into aquatic habitat. Possible pollution may include (but would not be limited to):

- Pollutants associated with materials used in the process of road construction.
- Pollutants associated with heavy vehicles used on site during construction and from ongoing traffic use of the project, such as aromatic hydrocarbons and heavy metals.
- Contaminant spills of materials transported via the highway.
- Leachate from waste dumps established onsite.
- Overflow from dams/ponds used to trap and recycle contaminated water onsite.
- Organic pollutants in stormwater runoff (such as nitrogen and phosphorus).
- Mobilisation of pollutants bound to disturbed sediments into aquatic habitat.

The project may result in increased pollution, which would be a concern for water quality downstream of the construction. Waterways that may be impacted would include Broughton Creek, Broughton Mill Creek and Bundewallah Creek. These are major waterways which represent major to moderate fish habitat and function as significant environmental corridors.

Previous studies have suggested that regional agricultural land use has had a negative impact on water quality within the study area. However, further pollution would increase the stress on these aquatic ecosystems and may cause a loss of biodiversity, a shift towards biotic assemblages dominated by pollution-tolerant taxa and degradation in ecological function.

Strategies designed to mitigate contamination of aquatic habitat and biota (refer to **Section 7.3.4**) have been included in the concept design for the project. As a result the project would have a relatively minor impact on water quality through careful design and best practice environmental management.

### *Acid sulfate soils*

Floodplain areas within the study area were assessed as having a low risk of disturbing ASS or Potential Acid Sulfate Soils (PASS). In a worst case scenario, if ASS was uncovered in the project area, it would have major environmental impacts and constrain development and construction in affected areas. The worst case impacts on aquatic ecology would include habitat degradation, fish kills, reduced aquatic food resources, reduced migration potential of fish, reduced fish recruitment, altered macrophyte communities, weed invasion by acid-tolerant plants and secondary water quality changes. ASS can also increase the susceptibility of fish to fungal infections which may lead to diseases such as epizootic ulcerative syndrome or 'red spot disease'. Red spot disease is considered a threat to Macquarie Perch.

Construction methodologies, including those used for the diversion of Town Creek, would be carefully considered in order to avoid or minimise the potential impacts of ASS on the aquatic ecology in the study area and in downstream environments. Proposed mitigation strategies described in **Section 7.3.4** would be implemented in order to minimise potential impacts and ameliorate the worst case impact.

### **Alterations of natural flow regimes**

The construction of structures within the floodplain, riparian areas or waterways may alter natural flow regimes in the short-term (in the case of construction) or permanently. This includes piers, abutments, temporary bridge crossings, temporary construction pads and culverts. Potential alterations to natural flow regimes of rivers, streams, floodplains and wetlands have been discussed in **Section 7.4**. There is potential that these alterations would have minor impacts on aquatic ecology.

In a worst case scenario, impacts to aquatic ecology would result from changes to flooding regimes, including:

- Changes to overbank flows that provide infrequent but important passages between different aquatic habitats and can drive temporary booms in the growth of populations. These are important for long term population persistence.
- Changes to seasonal flood flows which a number of native aquatic species require to spawn. Juveniles of these species benefit from the increased productivity during the seasonal flood flows.

The worst case scenario would be ameliorated by the implementation of appropriate mitigation measures, as outlined at **section 7.3.4**.

The four proposed bridge structures, including the three Broughton Creek bridges and the bridge at Berry, would slightly impede channel flow due to the presence and location of bridge abutments and piers and the associated embankments.

The changes to hydrology caused by Broughton Creek bridges 1 and 3 and the bridge at Berry would be negligible for flow events less than the 100 year ARI. Therefore these bridges would have an insignificant effect on aquatic ecology and water quality.

The project would have minor impacts on aquatic ecology as a result of changes to flood hydrology at Broughton Creek bridge 2 and Bundewallah Creek from the diversion of Town Creek flows and the placement of piers associated with the bridge at Berry. This is because:

- Broughton Creek bridge 2 and the raised earth embankment would increase flood levels upstream and reduce floodplain storage and capacity. This could result in some productivity decreases for aquatic assemblages.
- Placement of pier structures in Bundewallah Creek would alter the hydrology of the creek. A general decrease in velocity (0.1 to 0.2 m/s) immediately upstream of the piers would be observed, with a corresponding slight increase in water levels. There would also be localised increases in velocity downstream of the piers, of a similar magnitude to those identified above. The increases in velocity would not extend across the entire flow width at the pier cross section and are relative to predevelopment velocities.
- The diversion of Town Creek flows into Bundewallah Creek would:
  - Decrease flow and increase sediment accumulation in Town Creek, altering the aquatic ecology of the creek. However, the impact is expected to be minor when compared to the existing conditions within Town Creek.
  - Increase flow volumes in Bundewallah Creek during large flood events, having a minor effect on aquatic ecology and water quality.

The decrease in flow and associated sediment accumulation within Town Creek south of the diversion would alter the aquatic ecology of the creek. Aquatic habitats nearest the diversion point would be reduced to isolated pools and would experience associated declines in water quality. However, alterations in aquatic habitats, the loss of connected aquatic habitat and reductions in overall flows in Town Creek may have little additional impact on aquatic ecology and water quality. This is because the waterway is currently ephemeral and has been extremely degraded by agricultural and residential land uses. It is also not considered important as fish habitat.

Alterations to aquatic habitats downstream of the diversion, where Town Creek re-joins Broughton Mill Creek, would not be expected. These habitats would continue to receive stormwater inflow from the existing Town Creek.

There is currently no aquatic ecological benefit to overbank flooding in large flood events within the Berry township. As a result, there would be no loss of ecological function caused by the diversion of flooding flows into Bundewallah Creek.

The proposed culverts and bridges would also conform to the 'minimum' recommended crossing types outlined in *'Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings'* (Fairfull and Witheridge, 2003). As such they would have little or no impact on fish passage and aquatic ecology. Where culverts would be required, there would be a residual impact of reduced longitudinal connectivity during low flows. However, these impacts would be temporary in nature.

During construction, the use of bridges as temporary crossings would have an insignificant effect on aquatic ecology given that support structures would be located landward of the creek banks and no other in-stream structures would be used. The use of inappropriate structures for temporary crossings, such as restrictive culverts or fords may obstruct upstream fish passage and reduce longitudinal connectivity. Temporary structures would have minimal impact on aquatic ecology, providing recommended crossing types, discussed in **Section 7.3.4**, are used.

## Impacts due to temporary creek crossings, construction pads and ancillary facilities

### *Temporary creek crossings*

Temporary creek crossings are required at each proposed bridge structure during the construction period. Each proposed bridge location was surveyed and preferred temporary crossing sites were identified. Preferred sites for temporary creek crossings were located such that impacts to terrestrial and aquatic ecology and water quality were minimised.

In a worst case scenario, potential impacts associated with temporary creek crossings include alterations of water flow regimes, sedimentation of waterways, aquatic and terrestrial habitat loss and degradation of riparian vegetation. These impacts have been discussed in the relevant assessment sections above.

### *Temporary construction pads*

Temporary construction pads are likely to be required during the construction phase of the project to assist with bridge construction. Construction pads may involve the temporary placement of rocks or other construction materials within waterways. The main potential aquatic ecology impact would be the blockage of fish passage, in particular for Australian Bass.

The construction method employed should avoid complete blockage of the stream, be of minimum possible duration and involve full removal of all construction material from the waterway.

### *Ancillary facilities*

Impacts due to vegetation clearing and construction activities at ancillary facility sites have been discussed as part of the broader consideration of impacts on the study area provided above.

As discussed in **Section 4.4.7**, ancillary facilities have been located within areas of low conservation significance, which include built-up areas, mown lawns and heavily grazed exotic pastures (with no shrub layer, no trees, no rocks, no logs and no water). Therefore, impacts to terrestrial and aquatic flora and fauna as a result of the establishment and operation of ancillary facility sites are considered unlikely.

## Impacts to groundwater dependent ecosystems

Works associated with the project that have the potential to impact on GDEs within the study area include ground conditioning in areas where settlement has been assessed as a geotechnical issue, such as alluvial soils of floodplain areas, and cuttings at various locations along the alignment. As discussed in **Section 7.4**, it is anticipated that the project would have a minor and localised effect on groundwater flows.

The shallow alluvial groundwater systems within the study area support GDEs such as hyporheic habitats, base flows to significant waterways such as Broughton Creek, Broughton Mill Creek, Bundewallah Creek and Connollys Creek and riparian forest areas. The hyporheic zone is a region where there is mixing of groundwater and surface water. Native riparian forest within the study area is generally the EEC River-flat Eucalypt Forest on Coastal Floodplains.

The natural variability of shallow alluvial groundwater systems can make them more robust and able to tolerate fluctuating water levels but in the worst case, significant changes to groundwater hydrology can lead to ecosystem damage (DLWC, 2002). The exact importance of groundwater to GDEs is unknown and therefore it is difficult to accurately predict impacts associated with the project. GDEs most sensitive to changes in the groundwater regime would be hyporheic ecosystems, shallow aquatic habitat (and associated biota) such as riffles and discontinuous pool refuges and low-lying riparian forest.

Groundwater seepage into road cuttings would be collected by a longitudinal drainage system and transferred to vegetated swales or sediment basins within the Broughton Creek catchment. As discussed in **Section 7.4**, the treatment of soft-soils may cause some reduction in the permeability of underlying soils but groundwater would still flow, particularly through the sandy soil horizon.

### **Cumulative impacts**

The project area occurs in a largely rural landscape. Much of the native vegetation in the local area has been cleared and many of the remaining native vegetation remnants are small, isolated and fragmented. A large area of land in the locality is within the floodplain, which restricts further development, reducing the likelihood of simultaneous developments and cumulative construction impacts.

Existing and proposed development projects are mostly located on already cleared land within or adjacent to existing development, such as near Berry township and to the north of Bomaderry. Recent residential development within the study area at Berry includes the Arbor Retirement Village and Huntingdale Park Estate, both of which are located in previously cleared areas.

### *Sand quarry, Gerroa*

Approved development in the locality includes expansion of an existing sand quarry at Gerroa, 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.

### *Princes Highway upgrade*

The project itself forms one part of the RMS's overall upgrade of the Princes Highway to four lanes from Waterfall to the Jervis Bay Road junction, to provide increased road safety and traffic efficiency in the south coast region and needs to be considered in this context. Remaining sections of the highway still to be upgraded include a section between Kinghorne Street and Forest Road, South Nowra and a section between Mount Pleasant and Bomaderry.

The Princes Highway upgrade at South Nowra is located about 20 kilometres south west of Schofields Lane (via the highway). The South Nowra project extends from Kinghorne Street to Forest Road. It involves about 6.3 kilometres of upgrade works, including the construction of a four lane divided carriageway (RTA 2009a; RTA 2009b). This project was approved under Part 5 of the EP&A Act in 2011 and is currently under construction.

Flora and fauna assessments were undertaken for the project in two sections, the Kinghorne Street to Warra Warra Road section (NGH 2009) and the Warra Warra Road to Forest Road section (Hayes Environmental cited in RTA 2009a). Based on these two assessments the following native vegetation would be cleared between Kinghorne Street and Forest Road:

- 2.2 hectares of Currumbene-Batemans lowlands forest.
- 2.6 hectares of Southern lowland wet forest.
- 0.05 hectares of Floodplain swamp forest, which is an EEC.
- 0.08 hectares of South Coast lowland swamp woodland, which is an EEC.
- 1.3 hectares of Disturbed edge vegetation.
- 9 hectares of Open eucalypt forest.

Minor cumulative impacts would occur for Currumbene-Batemans lowlands forest. Currumbene-Batemans lowlands forest is not an EEC but it provides potential habitat for three threatened flora species, including the Leafless Tongue Orchard (*Cryptostylis hunteriana*), the Thick Lip Spider Orchid (*Caladenia tessellata*) and the Austral Toadflax (*Thesium australe*). Only 0.0002 hectares of Currumbene-Batemans lowland forest would be directly impacted by this project, which equates to less than 0.01 per cent of the total to be cleared by both projects. including, (*Caladenia tessellate*) and (*Thesium austral*).

Known habitat for the Green and Golden Bell Frog occurs within the South Nowra project (Currumbene-Batemans lowland forest) and potential habitat occurs for this species within this project (constructed wetlands). Only 0.4 hectares of potential habitat would be directly impacted by this 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 within about 30 kilometres of the project (which includes all of the South Nowra project area). Given the lack of habitat connectivity and distance between the project and the South Nowra project, the magnitude of cumulative impacts on threatened fauna populations is considered to be low.

Consideration of the cumulative impacts on vegetation and fauna habitat for the three remaining sections between Mount Pleasant and Bomaderry does not change the conclusions of impact assessments undertaken for threatened biota either occurring or potentially occurring in the study area. This is because the project is considered to include the greatest vegetation losses (about 80 per cent) of all sections to be upgraded. These impacts would be managed in accordance with the mitigation measures that have been proposed in **Section 7.3.4**, which are specific to the Foxground and Berry bypass project.

### 7.3.4 Environmental management measures

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 through 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).

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

Mitigation and management measures would be implemented to avoid, minimise or manage impacts to biodiversity and to improve and/or maintain biodiversity. These mitigation and management measures are listed in **Table 7-50** and have been incorporated in the draft statement of commitments in **Chapter 10**.

Table 7-50 Mitigation and management measures

| Potential impacts                                       | Mitigation and management measures                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|---------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Pre-construction</b>                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| General construction impacts on flora and fauna         | <p>Prepare a Flora and Fauna Management Plan, including weed management, and ensure that it is integrated with the landscape plan for the project.</p> <p>Prepare a Vegetation Management Plan (VMP) detailing restoration, regeneration and rehabilitation of areas of native vegetation in the vicinity of the project. Preparation of the VMP should involve consultation with local Landcare groups and the CMA.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <b>Construction</b>                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| Removal of native vegetation and increased edge effects | <p>Implement the Flora and Fauna Management Plan including all weed management measures.</p> <p>Clear vegetation in accordance with RMS 'Biodiversity Guidelines: Guide 1 – The Pre-clearing process' and 'Guide 4 – Clearing of vegetation and removal of bushrock' (RTA 2011).</p> <p>Ensure that locally indigenous species are used for rehabilitation and revegetation of habitat areas.</p> <p>Seek opportunities to reduce the removal of native vegetation in the detailed design phase.</p> <p>Where clearing would 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).</p> <p>Ensure that ancillary facilities and stockpiles are sited on land that has been previously cleared or disturbed, and is 50 metres away from waterways*.</p> <p>Ensure that environmentally sensitive areas are fenced off and signage erected in accordance with the RMS <i>Biodiversity guidelines: Guide 2 – Exclusion Zones</i> (RTA, 2011).</p> <p>Conduct a hollow-bearing tree/stag survey prior to construction. Undertake stag-watching to identify the number and type of nest boxes required and where to install them. The optimal season for stag-watching is spring; a hollow-bearing tree/stag survey however, can be conducted any time of year.</p> <p>Install bat roost and nest boxes at a ratio of 1:1 for each hollow removed by the project. Installation of bat roost and nest boxes would take place at least one month prior to the commencement of construction.</p> <p>Install nest boxes in accordance with RMS 'Biodiversity Guidelines: Guide 8 - Nest Boxes' (RTA 2011)</p> <p>Prior to construction, conduct a survey of any bridges or culverts scheduled for removal in order to detect roosting microbats. If detected, prepare and implement a Bat Management Plan.</p> |

| Potential impacts                                 | Mitigation and management measures                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|---------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                   | <p>Where possible, locate temporary waterway crossings immediately downstream of the proposed bridge alignments and within the existing footprint. This would minimise the clearing of additional riparian habitat for approaches to the temporary crossings.</p> <p>Progressively revegetate and landscape batters and other cleared areas as construction is completed.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| Mortality of individuals                          | Ensure that vegetation clearance complies with RMS <i>Biodiversity Guidelines</i> : Guide 4 - Clearing of vegetation and removal of bushrock (RTA, 2011),                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| Fragmentation of habitat and loss of connectivity | <p>Enhance the existing fauna corridor along Broughton Creek through revegetation including connection to Toolijooa Ridge vegetation.</p> <p>Retain roadside vegetation in the vicinity of rope bridges for arboreal fauna crossings (possums and gliders) and fauna underpasses.</p> <p>Revegetate or augment vegetation in the vicinity of all fauna crossings where vegetation is cleared.</p> <p>Retain riparian vegetation under bridges and at temporary creek crossing sites where feasible. If vegetation clearance is necessary, undertake revegetation as soon as practicable after construction.</p> <p>Implement the following fauna management structures. The location of these structures are presented in <b>Figures 4-1 to 4-3</b> and further details are provided in <b>Section 5.3</b> of the <i>Terrestrial Flora and Fauna Technical Paper</i> at <b>Appendix F</b>.</p> <ul style="list-style-type: none"> <li>• Provide fauna underpasses at Toolijooa Ridge and near Tindalls Lane. The chainages and dimensions of these are presented in <b>Table 4-3</b>.</li> <li>• Provide fauna 'furniture' such as rocks, raised log railings and refuge poles where appropriate.</li> <li>• Provide rope crossings for arboreal species 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 proposed highway bridges.</li> <li>• Provide fauna fencing extending at least 200 metres either side of the underpass to funnel fauna towards the crossings structures, where appropriate.</li> <li>• Install fauna fencing at the western end of the bridge at Berry but not at the Broughton Creek crossings. Should road kill become an issue at these crossings after the project is opened, fauna fencing may be reconsidered.</li> </ul> |
| Loss of aquatic habitats                          | <p>Consider lopping or relocation of large woody debris in streams as a first priority before removal.</p> <p>Should removal of large woody debris be necessary, consider the introduction of engineered woody debris as compensation within the offset strategy for residual impacts. Subject to relevant approvals and conditions, there is potential for trees removed as a consequence of the project to be utilised for fish habitat and bank stability within the creeks of the project area.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |

| Potential impacts                       | Mitigation and management measures                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|-----------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                         | <p>Consult with the DPI, Fisheries for input, in relation to matters relevant to Fisheries, into relocation of Town Creek.</p> <p>Maintain the flow along the current Town Creek alignment through appropriate design.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| Loss of fish passage                    | Where feasible use low hollow-core bridges or short lengths of pipe culverts for temporary crossings to maintain fish passage with reference to guidelines for the design and construction of waterway crossings to maintain fish passage (Smith and Pollard 1999, Fairfull and Witheridge 2003).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| Invasion of exotic species: Terrestrial | <p>Control noxious and environmental weeds in the existing road corridor, construction areas and ancillary facilities during construction in accordance with <i>RMS Biodiversity Guidelines</i>: Guide 6 - Weed management and Guide 10 - Aquatic habitats and riparian zones (RTA 2011). This would be achieved by:</p> <ul style="list-style-type: none"> <li>• Restricting the area of native vegetation disturbed during construction works.</li> <li>• Restricting stockpiling to areas already cleared of vegetation.</li> <li>• Controlling drainage that may contain weed seeds or high levels of nutrients.</li> <li>• Using weed-free topsoil in landscaping and revegetating 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.</li> <li>• Monitoring and controlling weed populations that establish in disturbed areas.</li> </ul> |
| Invasion of exotic species: Aquatic     | <p>Train staff in the identification and disposal of alligator weed and inspect heavy machinery regularly to ensure that the species is not spread to new areas. This should be conducted in accordance with <i>RMS Biodiversity Guidelines</i>: Guide 10 – Aquatic habitats and Riparian Zones (RTA 2011)</p> <p>Report positive identifications of alligator weed within the construction area to Kiama and Shoalhaven Council</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| Reduction of water quality              | <p>Implement erosion and scour protection in the design and construction of bridges and culverts. This would include energy dissipaters and/or batter treatments to ensure that the diversion of flows from Town Creek to Bundewallah Creek does not cause scour and erosion.</p> <p>Manage erosion and sedimentation impacts during construction in line with the erosion and sediment control plan and measures detailed in <b>Section 8.1.4</b>, conduct surface water quality monitoring during construction of the project and incorporate results into the CEMP with protocols to address detected levels above water quality criteria.</p> <p>Implement management measures to minimise the potential impacts of ASS as proposed and detailed in <b>Section 8.1.4</b>.</p> <p>Manage any on-site waste dump to prevent leaching of contaminants.</p>                                                                                                                                                 |

| Potential impacts          | Mitigation and management measures                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
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|                            | Document procedures for the proper handling, transport, storage and disposal of hazardous substances and include in site inductions for staff. Site all refuelling areas and least 50 metres away from waterways and properly bund.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| Alteration of flow regime  | <p>Design transverse drainage structures to allow unrestricted passage of most natural flows and allow for changes in the natural flow regime as a result of climate change. This would be achieved by designing bridges and culverts to provide flood immunity from the 100 year flood event and the 50 year flood event respectively.</p> <p>Do not position bridge piers or abutments within the section of waterway channels (wetted width) that carry median flows, where practicable.</p> <p>Implement scour protection to assist with upstream fish passage to mitigate the impacts of localised velocity and water level changes as a result of bridge pier placement in waterways.</p> <p>Structure the layout of the RMS stockpile straddling the southern end of the project area between Schofield's Lane and Andersons Lane to minimise effects on the flow regime of waterways that run through the property. A culvert providing flood immunity from the 50 year flood event would allow sufficient protection to the natural flow regime for this waterway, should the need for a crossing be identified during detailed design phase of the project.</p> |
| <b>Operation</b>           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| Reduction in water quality | <p>Minimise impacts to water quality during operation of the project through the combination of swales, water quality basins and biofiltration. Further detail on these measures can be found in <b>Section 7.4</b> and <b>Section 8.1</b>.</p> <p>In areas close to or upstream from sensitive receiving waters, implement additional treatment measures to ensure no net increase in pollutant load from road runoff. Biofiltration swales or trenches would likely be used to remove dissolved nitrogen from runoff through biological processes (refer to <b>Section 7.4</b>). The configuration and location of the biofiltration systems would be confirmed during the detailed design phase of the project. Locations where the biofiltration systems would be most effective would include areas where runoff would discharge directly to permanent waterways.</p>                                                                                                                                                                                                                                                                                                |
| Mortality of individuals   | <p>Remove vegetation overhanging fauna fences. Overhanging vegetation may allow fauna to enter the road reserve.</p> <p>Consider providing vegetation in the verges and median strip which does not attract fauna.</p> <p>Avoid the use of barbed wire fencing at glider crossing zones.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| Fish passage               | Design bridges and culverts to maintain fish passage with reference to the guidelines contained in ' <i>Guidelines and Policies for Aquatic Habitat Management and Fish Conservation</i> ' (Smith and Pollard 1999) and ' <i>Why do fish need to cross the road? Fish passage requirements for waterway crossings</i> ' (Fairfull and Witheridge, 2003).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |

| Potential impacts                                                               | Mitigation and management measures                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
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| <b>Monitoring</b>                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| Monitoring impacts during pre-construction, construction and operational phases | <p>Prepare pre-construction, construction and operational monitoring programs which would use the 'Before and After at Control and Impact sites' approach and set out the type and frequency of monitoring to be carried out, allocate responsibilities and monitoring parameters where relevant.</p> <p>Ensure a qualified ecologist is present for staged habitat removal in accordance with the RMS' Biodiversity Guidelines (RTA 2011) and fauna rescue/relocation.</p> <p>Undertake monitoring of sediment and erosion control measures during construction. This would form part of the Erosion and Sediment Control Plan (refer to <b>Section 7.4</b>).</p> <p>Undertake monitoring of edge effects and weed management measures as outlined in the Flora and Fauna Management Plan.</p> <p>Undertake bi-annual monitoring of nest boxes and bat roost boxes by a qualified and licensed ecologist during construction and annual monitoring for a period of three years post completion of construction with the provision to review the continuation and/or frequency of monitoring after the completion of three years monitoring.</p> <p>Undertake bi-annual monitoring of dedicated fauna underpasses and rope bridges (using equipment such as remote cameras) by a qualified and licensed ecologist for a period of three years post completion of construction with the provision to review the continuation and/or frequency of monitoring for a further two years.in the event a negative impact on species is detected.</p> <p>Conduct regular checks of fauna fencing to identify and fix any damage.</p> <p>Conduct road kill monitoring during operation of the project over a 12 month period at weekly intervals. The monitoring would include a record of the species (if possible) and the GPS location. The local council road cleansing teams or Wildlife Rescue South Coast may be contracted to undertake the monitoring or alternatively RMS Southern Region would undertake the monitoring.</p> <p>Conduct regular water quality monitoring focusing on wet weather events during pre-construction, construction and operational periods of the project in accordance with the surface water quality monitoring program outlined in Appendix F of the <i>Aquatic Ecology and Water Quality Management Technical Paper</i> provided at <b>Appendix G</b> of this environmental assessment.. For construction, the frequency of monitoring would be based on a monthly sampling program for minor wet weather events, and event based sampling after major wet weather events. A maximum of three major events would be sampled per year for the duration of the construction phase. During operation, the program would be based on minor wet weather events for one years, or 12 sampling events, whichever is greater.</p> |

| Potential impacts | Mitigation and management measures                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
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|                   | <p>Conduct aquatic ecology monitoring during the pre-construction, construction and operational periods of the project in accordance with the aquatic ecology monitoring program outlined in Appendix G of the <i>Aquatic Ecology and Water Quality Management Technical Paper</i> provided at <b>Appendix G</b> of this environmental assessment. Sampling would be undertaken during Spring and Autumn, with the monitoring to continue for a minimum of one year after the project is opened to traffic. Monitoring locations would include the created diversion channel between Town Creek and Bundewallah Creek in order to provide an indication of the successful establishment of a natural creek ecosystem.</p> <p>In accordance with the aquatic ecology monitoring program, periodically review and evaluate the results of the monitoring to identify improvements to existing mitigation measures or maintenance regimes. Use the results of the monitoring to identify the need for additional mitigation or management responses to address any unforeseen impacts on biodiversity.</p> |

\* 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.

### 7.3.5 Residual impacts and offsetting

It is unlikely that there would be a significant impact on threatened flora and fauna species that are known to occur in the study area, subject to the implementation of mitigation measures described in **Section 7.3.4**. However, there would be remaining residual impacts following the construction of the project. The residual impacts would include:

- Direct impact to 30.4 hectares of native vegetation, including the loss of 2.9 hectares of River-flat Eucalypt Forest and indirect impact to 26.7 hectares of native vegetation, including 7.1 hectares of River-flat Eucalypt Forest within the project corridor, Town Creek diversion, ancillary infrastructure and temporary crossing footprint. Direct residual impacts to River-flat Eucalypt Forest would be offset as detailed below. Direct residual impacts to other native vegetation and all indirect impacts to native vegetation would be avoided or managed in accordance with the mitigation measures presented in **Table 7-50**.
- Reduced floodplain storage, productivity and lateral connectivity in the region of the Broughton Creek bridge 2 embankment. This could result in some residual productivity decreases for aquatic assemblages. The design of the bridge would be refined during the detailed design phase to in order minimise potential flood impacts associated with the construction of new infrastructure in the floodplain (refer to **Section 7.5.4** for further details).
- Potential reduced longitudinal connectivity at temporary crossings during low flows. As discussed in **Table 7-50**, where feasible, temporary crossings would be designed to maintain fish passage with reference to 'Guidelines and Policies for Aquatic Habitat Management and Fish Conservation' (Smith and Pollard 1999) and 'Why do fish need to cross the road? Fish passage requirements for waterway crossings' (Fairfull and Witheridge, 2003). Impacts related to temporary creek crossing would only be expected during the construction period and would be temporary in nature.
- Permanent diversion of Town Creek. The project would cause a residual loss of overall flows and flushing flows from Town Creek which would potentially increase sedimentation in both Town Creek and Bundewallah Creek. However, the diversion would also have the positive residual impact of reducing flood impacts within Berry.

- Changes to flood hydrology at Town Creek, Bundewallah Creek and Broughton Creek from installation of transverse drainage structures. There is potential that the presence and location of bridge abutments, piers and culverts and associated embankments would impede channel flow. However, proposed culverts and bridges would conform to the 'minimum' recommended crossing types outlined in *'Why do fish need to cross the road? Fish passage requirements for waterway crossings'* (Fairfull and Witheridge, 2003) and as such residual aquatic ecology impacts would be minor.

## Offsetting

To meet the 'improve or maintain' outcomes required by the DGRs, offsetting would be required. 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.' As such the residual direct impact on 2.9 hectares of River-flat Eucalypt Forest would require offsetting. While River-flat Eucalypt Forest in the project area is generally in poor condition, it requires offsetting as it is an EEC and therefore has a high conservation status.

A Biodiversity Offset Strategy has been prepared and is provided in Appendix E of the *Terrestrial Flora and Fauna Technical Paper (Appendix F)*. The area of restoration would be guided by a simulated assessment of the project impacts and potential offsets using the BioBanking Assessment Methodology with a minimum of 2:1 for riparian vegetation to meet DTIRIS requirements.

A simulated BioBanking assessment undertaken for the project determined that native vegetation removed would need to be offset at an average ratio of 5.3:1 in order to achieve the 'improve or maintain' standard.

The following offset actions are proposed in order to achieve this ratio and 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 (located in Appendix E of the terrestrial flora and fauna technical paper, **Appendix F**). Action 1 focuses on the strategic revegetation of River-flat Eucalypt Forest that addresses improvements to both terrestrial and aquatic biodiversity. It would enhance native riparian vegetation connectivity at a locality scale, with a focus on River-flat Eucalypt Forest, other coastal plain EECs or closely associated non-threatened plant communities.

Desktop mapping has been carried out to identify areas that would be suitable for restoration and rehabilitation of riparian vegetation. In accordance with the RMS' *Biodiversity Guidelines* (RTA 2011), an investigation area of five kilometres from the project was adopted and a standardised riparian zone of 50 metres either side of drainage lines was applied. Suitable areas have been classified into three priorities (refer to Figures C1 to C7 of the Biodiversity Offset Strategy, in Appendix E of the terrestrial flora and fauna technical paper, **Appendix F**).

Action 1 would also consider:

- Restoration of riparian habitat to Category 1 creeks on RMS owned land to enhance connectivity for terrestrial and aquatic habitats. The RMS owns land with large frontages on Broughton Creek, Broughton Mill Creek, Bundewallah Creek and Connollys Creek.
- Ongoing financial support for existing riparian restoration works within the region (such as programs run by Southern Rivers CMA, Shoalhaven City Council or DTIRIS).

Finalisation of the exact locations for restoration of riparian vegetation 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 Berry Landcare Group and consideration of the strategic priorities or actions of Berry Nature Corridor – Escarpment to Sea (Berry Landcare Group, in preparation).

Action 2 would only be considered if there were residual offset requirements after Action 1 offset measures have been exhausted. 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. This includes areas of floodplain swamp forest.

Areas of riparian vegetation types that may be suitable for further investigation in the delivery of Action 2 have been identified in the Biodiversity Offset Strategy, and include areas of swamp oak floodplain forest. This includes stands close to Broughton Creek, Kangaroo Valley River and Shoalhaven River (refer to Figures D1 to D6 of the Biodiversity Offset Strategy, in Appendix E of the *Terrestrial Flora and Fauna Technical Paper*, **Appendix F**).

Whether Action 1 or 2 were to be further investigated, 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.

A biodiversity offset package would be submitted to DP&I within 12 months of the approval. 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 the Biodiversity Offset 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.