

NSW Roads and Maritime Services

WOOLGOOLGA TO BALLINA | PACIFIC HIGHWAY UPGRADE ENVIRONMENTAL IMPACT STATEMENT

MAIN VOLUME 1A

Chapter 10 – Biodiversity

Chapter summary

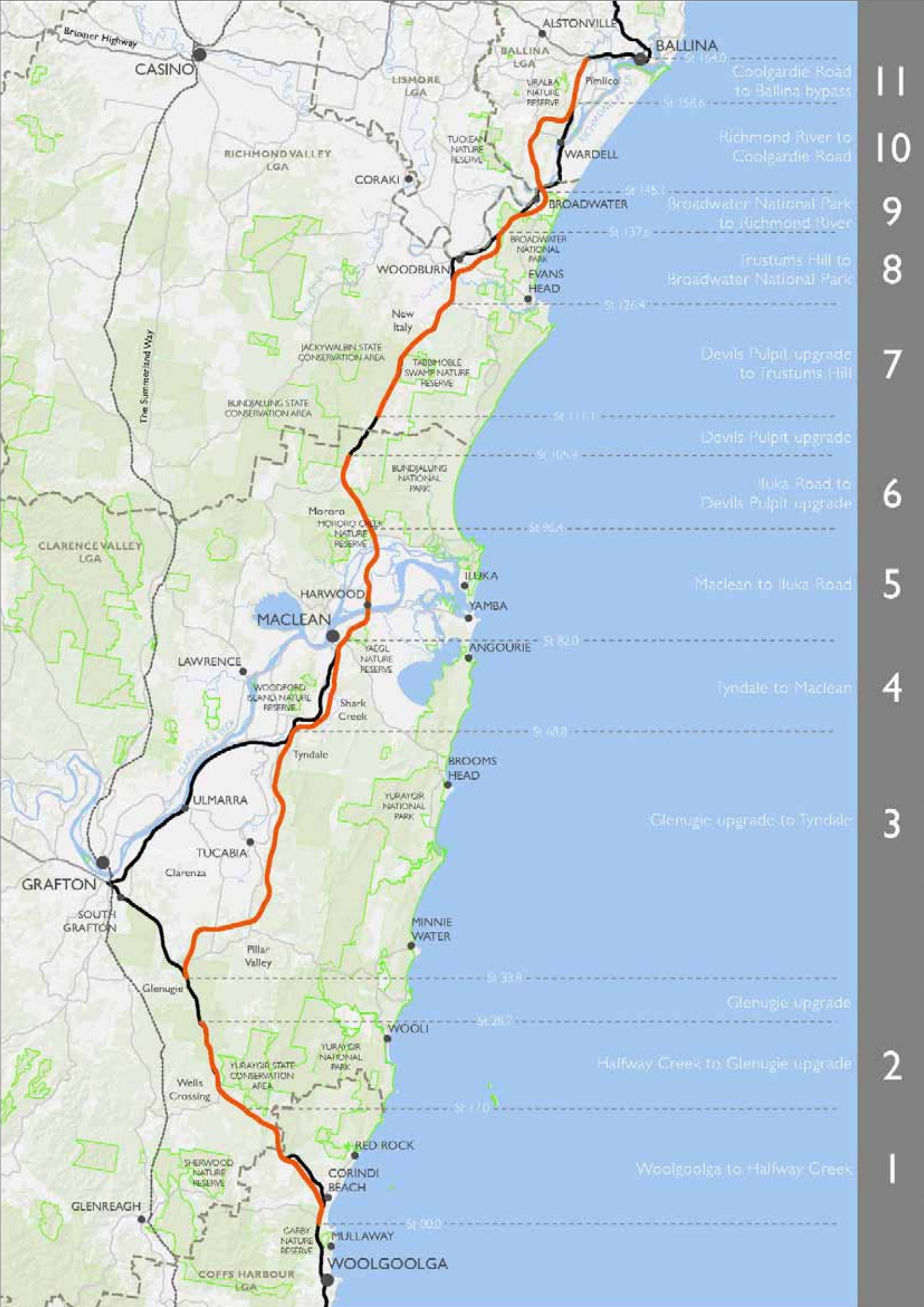
This chapter presents a summary of the biodiversity assessment that was undertaken to assess the direct and indirect impacts of the project. The main impacts of the project are:

- Loss of 948 hectares of native vegetation (including 337.7 hectares of threatened ecological communities). A further 25 hectares of remnant native vegetation could potentially be removed should identified ancillary facilities outside the project boundary, be required.
- Impacts on a range of threatened fauna species including significant impacts to 24 fauna species
- Direct impacts on a range of threatened flora species including a significant impact to 12 flora species
- Removal of breeding and/or sheltering habitat for threatened fauna, in particular, the loss of hollow-bearing trees. This impact is likely to be greatest where the project deviates from the existing Pacific Highway in sections 3, 9 and 10
- Loss of connectivity for threatened flora and fauna species and populations with the degradation of wildlife and habitat corridors (including links to national parks and State forests)
- Edge effects from road noise and light over an area of around 431 hectares
- Loss of foraging resources for fauna, particularly forest-dependent species such as Squirrel Glider, Yellow-bellied Glider, Brush-tailed Phascogale, Koala, Rufous Bettong, and insectivorous bats
- Direct mortality of fauna from construction activities and vehicle strike on the highway
- Potential impacts from construction to water quality and alterations to natural hydrological flows resulting in impacts to several freshwater fish species, such as the Oxleyan Pygmy Perch
- Potential impacts on groundwater-dependant ecosystems and wetlands (including SEPP 14 and nationally important wetlands).

To minimise and mitigate these impacts, the project incorporates a biodiversity management framework that includes a monitoring strategy, a Connectivity Strategy, threatened fauna management plan and a strategy to offset residual impacts on biodiversity.

The Connectivity Strategy includes provision for dedicated and combined fauna underpass and overpass structures. It would have a high degree of effectiveness for a wide range of fauna groups as determined by scientific research and documented design standards.

The Biodiversity Offset Strategy would deliver a package of offsets to achieve a neutral or net beneficial biodiversity outcome for the region.



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10 Biodiversity

This chapter presents a summary of the biodiversity assessment that was undertaken to assess the direct and indirect impacts of the project. The full assessment is provided in Working paper – Biodiversity (SKM 2012). The Director-General's requirements and the supplementary requirements from the Commonwealth Minister for Sustainability, Environment, Water, Population and Community (DSEWPoC) have been addressed in the assessment and are provided below. This chapter outlines the methods used in the assessment and summarises the key findings.

Reference	Director General's requirements	Where addressed
Biodiversity	The Environmental Impact Statement must include:	
	Impacts on the biodiversity values of the site and adjoining areas, including flora and fauna and their habitat (terrestrial, riparian and aquatic).	Section 10.3
	Impacts on Endangered Ecological Communities, critical habitat, threatened and protected species, populations and their habitats, listed under both State and Commonwealth legislation that have been recorded or considered likely to occur on the site and surrounding land based on the presence of suitable habitat, and whether the proposal or specific aspects of the proposal constitute Key Threatening Processes in terms of the <i>Threatened Species Conservation Act 1995</i> .	Section 10.3
	Targeted surveys of threatened flora and fauna species and their habitat that are known or likely to occur within the project's study area based on the presence of suitable habitat. The targeted surveys must include but not limited to the following species: • Oxleyan Pygmy Perch (<i>Nannoperca oxleyana</i>), Purple Spotted Gudgeon (<i>Mogurnda adspersa</i>), • Squirrel Glider, Yellow-bellied Glider, Brush-tailed Phascogale, Eastern Pygmy-possum, • Wallum Froglet, Olongburra Frog, Pouched Frog, Giant-barred Frog, Green-thighed Frog, Green and Golden Bell Frog, • White-crowned Snake, Pale Headed Snake, Stephen's Banded Snake, • Microbats – all threatened species, • Forest Owls – Masked, Sooty, Barking, Powerful, Grass Owl, • Brolga, Black-necked Stork, Comb-crested Jacana, Magpie Goose, Black Bittern, • Bush Stone – curlew, Albert's Lyrebird, Grey-crowned Babbler, • Koala, Long-nosed Potoroo, Common Planigale, Rufous Bettong, and • Emu (<i>Dromaius novaehollandiae</i>). Details of the survey methodology employed, including survey effort and timing and representativeness for the species targeted, should be identified.	Section 10.1.3
	Impacts on wildlife and habitat corridors, and habitat fragmentation and details of mitigation measures, having regard to the range of fauna species and opportunities for connectivity (terrestrial, arboreal and aquatic) across the project.	Sections 10.3.4, 10.3.5 and 10.4
	Impacts on/from vegetation loss, weed infestation (terrestrial and aquatic), edge effects, groundwater dependent ecosystems, wetlands including State Environmental Planning Policy No. 14 – Coastal Wetlands, and aquatic and riparian species and their habitats.	Section 10.3
	Consideration of regional scale cumulative impacts and the significance of the biodiversity impacts of the project in the context of the Pacific Highway Upgrade Program.	Section 10.3.11
	Details of how impacts would be managed during construction and	Section 10.4.2

Reference	Director General's requirements	Where addressed
	operation for project components (including ancillary facilities), the suitability of measures and adaptive management and maintenance protocols and monitoring programs.	
	The details of available offset measures to compensate the biodiversity impacts of the proposal where offset measures are proposed to address residual impacts, consistent with the Principles for the use of biodiversity offsets in NSW.	Section 10.4.2
	Taking into account the Draft Guidelines for Threatened Species Assessment (Department of Environment and Conservation, 2005); Threatened Species Survey and Assessment Guidelines: Field Survey Methods for Fauna - Amphibians (DECC, 2009); and Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities – Working Draft (DEC, 2004).	Section 10.1

Reference	Supplementary Director General's requirements	Where addressed
	The following matters must be addressed in the environmental assessment of the action:	
3. A description of the existing environment and relevant matters of national environmental significance	A description of the existing environment including:	Section 10.2
	- A description of the nature, location and extent of: - All vegetation types occurring on-site and immediately adjacent to the site(s); and - Aquatic and riparian environment that is likely to provide suitable habitat for threatened species.	
	- A description and map of the nature, location and extent of likely suitable habitat, and known records for migratory species, threatened species and ecological communities (including breeding, foraging, roosting habitat, habitat critical to the survival of the relevant species and ecological communities, movement corridors and migration paths) within the site and in surrounding areas that may be impacted by the proposal; and - A detailed description of the methodology, timing, effort and results of all targeted surveys undertaken for all relevant matters, in accordance with any relevant guidelines and a description of any limitations and constraints of the surveys undertaken; and	Section 10.1
	- Details of relevant baseline conditions to be used to assess the impacts of the action and the performance and effectiveness of proposed mitigation measures, including water quality, road kill data and habitat parameters for relevant areas that support migratory species, listed threatened species and ecological communities; or - Details of the monitoring programs to be implemented before, during and after construction to determine these baseline conditions.	Section 9.2.2 Section 10.1 Section 10.4.2
4. An assessment of the relevant impacts of the action	An assessment of the relevant impacts of the action including: - A detailed description and assessment of the nature and extent of all relevant impacts, including direct, indirect and facilitated impacts that the action will have or is likely to have on: - Threatened species and ecological communities listed under sections 18 and 18A of the EPBC Act; and - Migratory species listed under sections 20 and 20A of the EPBC Act.	Section 10.3

Reference	Supplementary Director General's requirements	Where addressed
	This must include, but not be limited to, an assessment of any habitat loss, degradation, fragmentation as a result of the action, as well as likely impacts from road strike; • Whether any relevant impacts are likely to be unknown, unpredictable or irreversible; and • Any technical data and other information used or needed to make a detailed assessment of the relevant impacts.	
5. Proposed safeguards, mitigation and offset measures	A description of changes to the action and feasible mitigation measures, that are intended to avoid, minimise or compensate for relevant impacts, including: • A description of how the action has been designed to avoid impacts to migratory species, threatened species and ecological communities; • A consolidated list of mitigation measures proposed to be undertaken to prevent or minimise the relevant impacts of the action, before, during and after construction and during operation; • A description and an assessment of the expected or predicted effectiveness of, the mitigation measures, including a justification of the location and design of mitigation measures to be implemented to ensure their effectiveness. This analysis should be based on best available knowledge and baseline data for the relevant areas; • A description of the objectives of the mitigation measures, thresholds for corrective actions, and the corrective actions to be implemented should these thresholds be exceeded; • Any statutory or policy basis for the mitigation measures; • Details of environmental management plans that set out the framework for continuing management, mitigation and monitoring programs for the relevant impacts of the action, including the person or agency responsible for implementing these programs and provisions for independent environmental auditing; • The name of the agency responsible for endorsing or approving each mitigation measure or monitoring program; In the event that impacts cannot be avoided or mitigated, a description of any offsets to compensate for any predicted or potential residual impacts on migratory species, threatened species and ecological communities. This should be in accordance with the department's draft Offsets Policy and include: • An assessment of how any proposed offset compensates for the residual impacts on migratory species, threatened species and ecological communities which remain following avoidance and mitigation measures to be implemented; • The location of any proposed offset; • The timing of the delivery of any offset; and • How the offset will be secured and managed in perpetuity.	Section 10.4

10.1 Assessment methodology

10.1.1 Terminology

The following terminology is used in this chapter:

- Study area: The study area encompasses the project boundary and any adjoining or adjacent habitat where potential indirect impacts may occur
- Project boundary: As defined in Chapter 5, this is the area that encompasses the project.

10.1.2 Assessment approach

The biodiversity assessment was undertaken in a number of different phases and included:

- Preliminary assessment: Database reviews and background information (including previous ecological studies) to identify known or likely to occur threatened or migratory species, populations and ecological communities within the study area. Data gaps from previous field surveys undertaken for the project were identified to provide a focus for additional targeted surveys. Key stakeholders including State and federal government agencies were consulted
- Field surveys and assessment of species predicted to occur in the study area: field surveys (including those done previously) aimed to provide an assessment of the presence of threatened and migratory species, populations and ecological communities in the study area. In addition, habitat searches identified a list of other State and federally listed threatened species that had the potential to be present but not found on site.
- Evaluation of impacts: Key design measures implemented as part of the project were identified that avoided and minimised potential biodiversity impacts. The residual impacts from the project were then identified including direct and indirect impacts. These impacts are then assessed (under the significance assessment) for threatened and migratory species, populations and ecological communities in the context of the *Threatened Species Conservation Act 1995*, *Fisheries Management Act 1994* and *Environment Protection and Biodiversity Conservation Act 1999* including significance assessments and identification of key threatening processes.
- Mitigation and management: Mitigation and management measures to be applied during construction and operation of the project have been identified. A framework has been identified and provides a mitigation strategy including a Connectivity Strategy and a monitoring strategy
- Offset strategy: As a final step in the biodiversity assessment process, a strategy for offsetting the residual impacts has been developed, with a focus on identifying objectives and a framework to achieve these objectives.

10.1.3 Preliminary assessment

The preliminary assessment involved a review of biodiversity literature, previous studies and government databases covering the study area and consultation with key agency stakeholders.

Consulting key stakeholders

Key stakeholders were consulted through a series of meetings and workshops. A number of issues were raised and clarified throughout through this consultation including:

- The technical objectives of the study
- Identify important factors such as habitats and corridors for the NSW North Coast Bioregion, specifically in relation to biodiversity connectivity workshops
- Any specific survey requirements for targeted species
- The level of reporting and reporting format
- A strategy for identifying knowledge gaps for the endangered emu population
- Issues around biodiversity offsets, monitoring programs and management measures.

Key stakeholders consulted were:

- Commonwealth Department of Sustainability, Environment, Water, Populations and Communities (DSEWPaC)
- NSW Office of Environment and Heritage (NSW Office of Environment and Heritage) / Environment Protection Authority (EPA) including the NSW National Parks and Wildlife Service (NPWS)
- NSW Department of Primary Industries (NSW Fishing and Aquaculture)
- Relevant local councils
- National Herbarium
- Forests NSW
- Clarence Valley Wildlife Information Rescue and Education Service (WIRES).

In addition numerous property owners were consulted during the field survey to identify local knowledge of flora and fauna, road kill sites and wildlife movements in the study area.

Collation and review of existing information

Existing information on the presence and distribution of threatened species and populations in the study area was obtained from a variety of data sources including:

- Atlas of NSW Wildlife Database (NSW Office of Environment and Heritage, 2012b)
- NPWS (2002a and 2002b) Threatened Species of the Upper North Coast of New South Wales: (i) Fauna; and (ii) Flora
- Records published in scientific journals, reports and general flora and fauna distribution texts
- Results of local environmental studies, including studies prepared by consultants, local government authorities, biological organisations, universities and other sources (Steenbeeke, 1998)
- Discussions with personnel from the NSW Office of Environment and Heritage and DPI (Forests NSW and Fisheries) and Coffs Harbour, Clarence Valley, Richmond Valley and Ballina councils
- Anecdotal reports from authorities and local ecologists / naturalists and local landowners
- National Directory of Important Wetlands
- Road kill records provided by Clarence Valley WIRES and RMS
- NSW Office of Environment and Heritage Threatened Species Profile Search for species population and ecological communities of NSW (accessed online January 2012)
- Protected Matters Search Tool (DSEWPaC 2009)
- Species profile and threats databases (NSW Office of Environment and Heritage and DSEWPaC) (accessed online January – November 2012:)

Previous development projects ecological assessments

The biodiversity assessments undertaken as part of the previous development projects were reviewed to obtain information on the vegetation, habitats, species and populations confirmed from systematic field-based investigations.

10.1.4 Field surveys

The body of ecological data contributing to the biodiversity assessment of the preferred routes has been gathered over a period of six years (2006-2012). Field surveys undertaken for the previous development projects between 2006 and 2009 were comprehensive and consistent with survey guidelines outlined in the *Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities* (Department of Environment and Conservation 2004). These studies were conducted to a level sufficient to inform an EIS. These studies were used as the framework for the biodiversity assessment, with a review identifying knowledge gaps that required additional survey work based on survey timing and effort and representativeness for the species targeted. Additional field surveys were then undertaken in 2010-2012 to address these gaps. The field survey information has provided a range of data over various seasons, with a focus on a range of different species.

Surveys were conducted using a combination of sampling techniques in general accordance (where relevant) with the *Threatened Biodiversity Survey and Assessment: Guidelines for developments and activities - Working draft* (DEC, 2004), *Draft Guidelines for Threatened Species Assessment* (DEC, 2005); *Threatened Species Survey and Assessment Guidelines: Field Survey Methods for Fauna - Amphibians* (DECC, 2009). The majority of the surveys preceded the release of the Commonwealth guidelines for survey of threatened species in 2010 and 2011. Survey techniques applied through the course of the study (2006-2012) are considered to comply with these guidelines in terms of the planning requirements; equipment used, and survey technique.

A summary of all the field surveys undertaken within the project boundary and their purpose is detailed in Table 10-1. During all surveys, threatened flora searches were conducted continuously while traversing habitats in the study area. All threatened flora species encountered were recorded along with similar common species. This equated to a survey effort of 117 days across all seasons.

Further details on methods used during these surveys are detailed in section 2.4 of the Working paper - Biodiversity. Limitations of these surveys have been identified in Table 2-2, Table 2-7 and Table 2-5 of Working paper – Biodiversity.

Table 10-1: Summary of field surveys

Project section	Survey period	Purpose
1-2	16-21 Oct 2006 18-24 Feb 2007	- Mapping of vegetation communities - Targeted searches for threatened flora species - Surveys for arboreal and terrestrial mammals, reptiles, frogs, microchiropteran bats, nocturnal birds and mammals and birds - Targeted searches for quolls, bandicoots and Koalas.
	10-15 March 2007	Aquatic fauna surveys
	19-24 Aug 2010	- Targeted survey to map <i>Eucalyptus tetrapleura</i> distribution between Halfway Creek and Glenugie - Opportunistic observations of other threatened flora.
	Nov 2011	Habitat surveys (including identification of hollow bearing trees).
	5-9 Dec 2011	- Re-survey previously identified flora populations to identify any changes in distribution - Targeted searches for <i>Lindsaea incisa</i>, <i>Maundia triglochinoides</i> and cryptic summer flowering species - Vegetation mapping in areas not covered in previous surveys.

Project section	Survey period	Purpose
3-5	July-Aug 2005 Oct 2005	• Surveys for arboreal and terrestrial mammals, frogs, microchiropteran bats, nocturnal birds and mammals, birds and reptiles • Targeted searches for quolls, bandicoots and Koala.
	5-8 June 2007 25-29 June 2007	• Aquatic fauna surveys.
	2-7 July 2007 6-11 Aug 2007 14-19 Oct 2007	• Mapping of vegetation communities • Targeted searches for threatened flora species • Targeted survey to map <i>Eucalyptus tetrapleura</i> distribution between Glenugie and Pillar Valley • Targeted searches to map the extent and distribution of <i>Angophora robur</i> • Surveys for arboreal and terrestrial mammals, microchiropteran bats, birds (including emus), nocturnal birds and mammals, frogs and reptiles • Targeted surveys for quolls and bandicoots.
	23-27 Aug 2010	• Vegetation mapping and flora species at soft soil areas • Targeted searches for threatened flora species at soft soil areas • Additional flora surveys.
	16-19 Nov 2010	• Targeted survey to map the extent and distribution of <i>Angophora robur</i> from Pillar Valley to Tyndale • Opportunistic observations of threatened flora species.
	21-25 Oct 2011	• Supplementary surveys to map the extent and distribution of <i>Angophora robur</i> from Pillar Valley to Tyndale.
	12-16 Dec 2011	• Re-survey previously identified flora populations to identify any changes in distribution • Targeted searches for <i>Lindsaea incisa</i>, <i>Maundia triglochinoides</i> and cryptic summer flowering species • Targeted surveys for frogs, reptiles and Koalas • Habitat survey (including identification of hollow bearing trees).
	Jan 2012	• Targeted surveys for mammals, microchiropteran bats, nocturnal mammals and birds, frogs, reptiles and Koalas • Habitat survey (including identification of hollow bearing trees).
6-8	March 2005	• Habitat survey (including identification of hollow bearing trees).
	May-June 2005	• Mapping of vegetation communities • Targeted searches for threatened flora • Surveys for arboreal and terrestrial mammals, microchiropteran bats, nocturnal birds and mammals, birds, frogs and reptiles • Targeted surveys for quolls, bandicoots and Koalas.
	2-7 Dec 2007	• Targeted surveys for <i>Melaleuca irbyana</i> at New Italy.
	13-15 Sept 2011	• Aquatic fauna survey.
	16-20 Jan 2012	• Re-survey previously identified flora populations to identify any changes in distribution • Targeted searches for threatened cryptic summer flowering species including <i>Cyperus aquatilis</i>, <i>Oberonia titania</i>, <i>Lindsaea incisa</i>, <i>Arthraxon hispidus</i> and <i>Prostanthera cineolifera</i> • Targeted surveys for arboreal and terrestrial mammals, reptiles and frogs.
9-11	14-25 March 2005	• Mapping of vegetation communities • Threatened flora species surveys.
	11-16 March 2006	• Survey for arboreal and terrestrial mammals, microchiropteran bats, nocturnal birds and mammals, birds, frogs, reptiles and invertebrates • Targeted surveys for quolls, bandicoots and Koalas • Habitat survey (including identification of hollow bearing trees). • Aquatic fauna survey.

Project section	Survey period	Purpose
	15 - 18 May 2006	Aquatic fauna survey.
	15-18 Aug 2006	Mapping for vegetation communities.
	12-14 Sept 2006	Aquatic fauna survey.
	Jan 2007	- Surveys for arboreal and terrestrial mammals, microchiropteran bats, nocturnal birds and mammals, birds, frogs and reptiles - Targeted surveys for quolls, bandicoots and Koalas - Habitat survey (including identification of hollow bearing trees).
	16 - 20 Aug 2010	Aquatic fauna survey.
	30-3 Aug-Sept 2010	- Mapping of vegetation communities - Targeted searches for threatened flora species.
	16-20 Jan 2012 13-16 March 2012	- Re-survey previously identified flora populations to identify any changes in distribution - Targeted searches for threatened cryptic summer flowering species including <i>Cyperus aquatilis</i>, <i>Oberonia titania</i>, <i>Lindsaea incisa</i>, <i>Arthraxon hispidus</i> and <i>Prostanthera cineolifera</i> - Targeted survey of the Lowland Rainforest Critically Endangered Ecological Community (recently listed on the EPBC Act) - Targeted survey for small terrestrial mammals.
	Feb 2012	Targeted survey for invertebrates.

Fauna field surveys

The fauna survey techniques and effort varied across the study area according to the species being targeted and the habitat types in which each species occurs. Surveys for terrestrial fauna used a range of techniques aimed at identifying the type and distribution of fauna habitats in the project boundary, and fauna species richness, distribution and abundance. The fauna surveys targeted those threatened species and their habitat that were identified as having a moderate to high likelihood of occurring in the study area.

Surveys included diurnal and nocturnal surveys and opportunistic observations using a stratified sampling approach that aimed to sample the range of habitats present. Surveys were conducted within the project boundary and where possible within adjacent habitats that extended beyond the project boundary. Further details on survey techniques are identified in section 2.4 of the Working paper – Biodiversity.

KEY TERM – Terrestrial fauna

Animals that live on land.

10.1.5 Impact assessment methodology

Full references to technical data and other information sources used in the impact assessment for the project may be found in the Working paper – Biodiversity.

Vegetation removal

To assess the amount of vegetation needed to be removal for the project, the construction footprint (as shown in Chapter 6 – Description of the project- construction) was used. The construction footprint is defined as:

- An offset of 10 metres from the top of the cutting or base of the embankments with cuttings over 20 metres deep having a setback of 25 metres
- An offset of 10 metres off the edge of the bridge structures
- The area along the existing local road boundary (where outside of the project boundary); or an offset of 10 metres
- An offset of 10 metres around sedimentation and water quality control basins, including space for access.

The construction footprint also includes ancillary facilities – both those sites within and outside of the project boundary. The use of ancillary facilities is subject to landowner consent and further investigation. As such, some ancillary facilities may not be used. Therefore, vegetation removal required for ancillary facilities outside of the project boundary was identified separately. This ensured the separation of these sites from the main calculation to avoid ‘double-counting’ of vegetation removal.

All vegetation to be removed either for the permanent project infrastructure or for temporary ancillary facilities was calculated and this presented a ‘worst case’ impact footprint.

Edge effects

In a review of edge effects for a diversity of habitat types, Bali (2000; 2005) estimated that average edge effects can generally be identified up to 50 metres from the road edge. The potential indirect impacts associated with edge effects for this project have been calculated using this estimate.

However, as edge effect areas retain some value for biodiversity and can be used by some threatened species such as Rufous Bettong, the calculation was discounted by 60 per cent. The estimate of edge effects (indirect impacts) for the project was applied where the highway would create a new edge through contiguous forest. It did not include existing edge affected fragments that adjoin the project boundary (such as along the existing highway) or small fragmented areas of modified habitat.

10.1.6 Threatened species assessment

All NSW and Commonwealth listed flora and fauna threatened species were assessed to identify their likelihood of occurrence within the project boundary based on known habitat requirements and habitat present within the study area (refer to Appendix D of the Working paper – Biodiversity). The following information was consulted to determine the likelihood of species occurrence:

- NSW Office of Environment and Heritage Threatened Species Profile Database
- Atlas of NSW Wildlife (NSW Office of Environment and Heritage)
- Surveys undertaken for the project
- DSEWPac Commonwealth listed Species Profile and Threat (SPRAT) Database (*Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)).

TERM –Threatened species, populations and ecological communities

A species, population or ecological community listed as ‘vulnerable’, ‘endangered’ or ‘critically endangered’ under the NSW *Threatened Species Conservation Act 1995* and/or Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.

The likelihood of species occurrence was classified from unlikely to high. Unlikely occurrence is where a species is restricted to a specific geographical area that is not within the study area and no suitable habitat is present in the study area.

Species that have a high likelihood of occurring in the study area are those that have been confirmed during the field surveys or species not confirmed that fit one or more of the following criteria:

- Have frequently been recorded previously in the study area/surrounds
- Use habitat types or resources that were present in the study area that are abundance and/or in good condition within the study area

- Known or likely to maintain resident populations surrounding the study area
- Known or likely to visit the site during regular seasonal movements or migration.

The impact assessment of the project focused on those threatened flora and fauna species which were confirmed as being present in the study area or had a moderate to high likelihood of occurring in the study area. Those species that are unlikely or have a low possibility of being present in the study area were not assessed. These include a number of targeted species as indicated in Table 10-2 and Table 10-3 and are:

- Diamond Firetail
- Hooded Robin
- Painted Honeyeater
- Albert's Lyrebird
- Rufous Scrub-bird
- Black-breasted Button-quail
- Speckled Warbler
- White-eared Monarch
- Collared Kingfisher
- Turquoise Parrot
- Olive Whistler
- Eastern Chestnut Mouse
- Hastings River Mouse
- Green and Golden Bell Frog
- Stuttering Frog
- Fleay's Barred Frog
- Pouched Frog
- Booroolong Frog
- White-crowned Snake
- Three-toed Snake-tooth Skink
- Mitchells Rainforest Snail
- Shorter Rainforest Ground Beetle.

10.1.7 Significance assessment

Significance assessments were carried out for threatened species, populations or communities listed under the *Threatened Species Conservation Act 1979*, *Fisheries Management Act 1994* or *Environmental Protection Biodiversity Conservation Act 1999* that were confirmed during field survey or predicted to have a medium to high likelihood of occurrence (refer to section 10.1.6) within the study area.

Significance assessments for species or communities listed under the *Threatened Species Conservation Act 1979* were prepared by following the *Guidelines for Threatened Species Assessment* (DEC & DPI, 2005). For species or communities listed under the *Environmental Protection Biodiversity Conservation Act 1999*, significance assessments were completed in accordance with the *EPBC Act Policy Statement 1.1 Significant Impact Guidelines* (DEWHA, 2009). For species or communities listed under both TSC and EPBC Acts, assessments of significance were completed separately under the two guidelines.

Groups of species with similar ecological and habitat requirements or life-cycle patterns that are affected by many of the same key threatening processes (for example tree roosting microbats and large forest owls) were assessed together in a combined significance assessment. All significance assessments are detailed in Appendix E of the Working paper – Biodiversity.

Where there is reasonable doubt regarding the likely impacts, or where detailed information is not available, a significant impact has been assumed as a precautionary approach.

10.1.8 Summary of methodology for targeted threatened species

The biodiversity assessment focused on those threatened flora and fauna species that were confirmed (ie identified during field survey) or had a moderate to high likelihood of occurring in the study area. A summary of assessment methodology (including field surveys, modelling and mapping) undertaken for targeted threatened flora species is provided in Table 10-2. A summary of field surveys undertaken for targeted threatened fauna species is provided in Table 10-3.



Photo 1: Coastal Emu (*Dromaius novaehollandiae*) in sugar cane fields near Shark Creek (Section 4)

Table 10-2: Summary of assessment methodology for targeted threatened flora

Target species, listing status and project location	Survey methods
Sandstone Rough Barked Apple (<i>Angophora robur</i>) Vulnerable (TSC Act, EPBC Act) Confirmed. Section 3-4.	The species was first confirmed in 2009 (SKM (2009)) in the area between Pillar Valley and Tyndale as part of the route selection and preferred route surveys. Targeted surveys were conducted in summer of 2010 and spring-summer 2011 to identify the size and extent of the local population, in addition to a wider mapping of the regional population. Mapping occupied habitat General observations of the distribution of <i>Angophora robur</i> in the study area indicated that the species most commonly occurred on the Summervale Range and Richmond Range landscape units (Mitchell 2003). The distribution of the species was initially mapped at a fine scale following extensive ground truthing along the footslopes of the Summervale Range between Pillar Valley and Tyndale near the project boundary. The extent of each of the populations was mapped using a Trimble Yuma handheld GPS to identify the approximate edge of the distribution of the species, as well as recording point data for individual plants and groups of trees. Predictive mapping of the extent of the species was undertaken in areas to the west of the study area in the Copmanhurst and Coaldale regions and also to the east in Newfoundland State Forest. Predictive mapping used information on landscape (including Mitchell Landscapes), elevation data, broad-scale vegetation mapping, aerial photography and field observations where access was available. Rapid habitat assessment Rapid habitat assessments were undertaken within habitats where <i>Angophora robur</i> occurred within and adjacent to the project boundary. A range of environmental variables were confirmed including dominant flora species and broad structural vegetation community type, the extent of disturbance including clearing, grazing and fire, the presence of rocky outcrops basic soil attributes, the reproductive health of the population including the population structure and subjective assessments of the health of trees, and potential hybridisation in the population. Population estimates The size of the local and regional population was estimated using a combination of several methods including ground-truthed mapping of the distribution of the species and direct counts within these populations, and predictive mapping based on soil landscape data, rapid field observations, direct counts and government-maintained databases. Direct counts were undertaken in each of the populations using belt transects of various lengths in which every tree was counted in a 20 m wide area (10 m either side). A total of 32 transects were undertaken in each of the larger populations and the average number of plants per hectare was extrapolated across the entire extent of the population. Two different estimates were calculated: based on the known extent of <i>Angophora robur</i> and the predicted extent as detailed in Table 10-8).

Target species, listing status and project location	Survey methods
Square-fruited Ironbark (<i>Eucalyptus tetrapleura</i>) Vulnerable (TSC Act, EPBC Act) Confirmed. Section 1-2.	The species was first confirmed in Glenugie State Forest as part of the Glenugie upgrade between Sections 2 and 3 (SKM 2010). Previously identified populations occurring within state forests and conservation reserves were surveyed to assess the overall distribution and abundance of the regional population. The approximate extent of each population was mapped using a hand-held GPS to mark the boundaries of the population. Within each extent the density of trees per hectare was confirmed. At each locality standardised transects were traversed, recording details on the number of trees 10 m either side of the centreline, with the start and finish of the transect recorded using a hand-held GPS so the exact length of the transect could be calculated. Trees were characterised into size classes based on the Diameter at Breast Height (DBH). The density of trees per hectare was calculated based on the average density from all transects undertaken within that population and extrapolated across the entire distribution of the population cluster. Follow-up surveys were conducted in 2010 to establish accurately the distribution and abundance of the species from Halfway Creek to the start of the Glenugie upgrade including Wells Crossing Flora Reserve and this data was added to the overall knowledge of the local species population at Glenugie.
Weeping Paperbark (<i>Melaleuca irbyana</i>) Endangered (TSC Act) Confirmed. Section 7.	A population of the species was first confirmed in the project boundary for Section 7 in 2006 (Eco 2006). A survey of the population was conducted in 2006 and spatial data was recorded with a hand-held GPS, which generally displayed an accuracy of 5-10 metres. Point co-ordinates were recorded every 5-10 metres and a tally kept of the number of individuals. Polygons within the population were defined by recording individuals on the edge of the polygon, then counts made of individuals within the polygon to identify the overall population distribution and abundance. The population was re-surveyed in summer 2012 to assess any change in distribution and abundance since the original survey and to establish an accurate depiction of the distribution and abundance of the species, direct counts were also undertaken at this time focused on the project boundary.
Slender Screw Fern (<i>Lindsaea incisa</i>) (SF) Endangered (TSC Act) Confirmed. Sections 1, 2, 3 and 6. <i>Maundia triglochinos</i> Vulnerable (TSC Act) Confirmed. Sections 2, 3 and 7.	Both <i>Lindsaea incisa</i> and <i>Maundia triglochinos</i> were found to be restricted to narrow riparian habitats associated with creeks and drainage swales in varying abundance. Targeted surveys concentrated on these suitable habitat types where crossed by the project using a general traverse approach. The species are readily detectable irrespective of season and reproductive status. The survey of population size and abundance was based on a systematic survey of the entire population at the site and was not designed on stratification or representative sampling. Where encountered the distribution of the species was mapped using a pre-determined abundance scale through the collection of a series of waypoints. For larger distributions an area was attributed to the point data (ie around 20 m x 10 m area). In some areas where larger populations were observed polygons were mapped using aerial photography interpretation.

Target species, listing status and project location	Survey methods
Four-tailed Grevillea (<i>Grevillea quadricauda</i>) Vulnerable (TSC Act, EPBC Act) Confirmed. Section 3.	Both <i>Grevillea quadricauda</i> and <i>Prostanthera cineolifera</i> were recorded at two locations in the project boundary in low-moderate abundance. Targeted population surveys involved direct counts of the species in the project boundary. Surveys of the species were also conducted outside the project boundary to gain an appreciation of the distribution and abundance of the species and assess the impact on the population. These involved direct counts of plants using a large plot (50 x 50 m) or where large aggregations were encountered population numbers were estimated.
Singleton Mint Bush (<i>Prostanthera cineolifera</i>) Vulnerable (TSC Act, EPBC Act) Confirmed. Section 7.	
Water Nutgrass (<i>Cyperus aquatilis</i>) Endangered (TSC Act) Confirmed. Section 6-7.	Water Nutgrass is an annual species which grows in ephemerally wet situations, and is dependent upon summer rainfall for germination and some level of soil disturbance, with populations being found in roadside drainage swales, deep tyre ruts on disturbed trails and depressions in grazed paddocks. Targeted surveys were conducted in summer (2011-12) over period of 20 days. Considering the large area of potential habitat for this species across the project, representative survey sites were selected, focusing on at least one site per 50 hectare in suitable habitat. In addition, known locations (confirmed from preferred route studies and the Atlas of NSW Wildlife) were targeted using direct counts of individuals and a general meandering technique.
Hairy-joint Grass (<i>Arthraxon hispidus</i>) Vulnerable (TSC Act, EPBC Act) Confirmed. Section 10.	For <i>A. hispidus</i>, two surveys were conducted in February-March 2012 in Section 10 and 11 targeting the flowering period of the species over a period of 8 days. The survey aimed to record the distribution of the populations within and adjacent to the project boundary by mapping the outer perimeters of the population to develop a series of polygon patches for the species. Due to the numerous and widespread plant counts, representative plots of known size were used to sample the number of plants in an area. This provided the extent of occupied habitat in the study area. Population estimates were then derived by multiplying the mean number of plants in a known area (plot) by the total area of occupied habitat. The plot size for counts were 50 m x 2 m along fence lines or 5x5 m in other areas. This data was then extrapolated across the entire confirmed group of polygons to estimate the population size within and adjacent to the project boundary.

Table 10-3: Summary of assessment methodology for targeted threatened fauna

Target species, listing status and status on project	Survey method and effort
Wetland and migratory bird species	
Australasian Bittern <i>Botaurus poiciloptilus</i> Endangered (TSC Act and EPBC Act). Confirmed.	Area and time-based bird surveys were conducted in representative wetlands, wet forest, swamp forests, wet heaths and riparian habitats. The survey periods varied from 5-20 minutes at each site depending on the condition and size of the site, location and noise of traffic. Surveys were conducted across swamp forests, wet heaths, wetland habitat and modified lands covering a total of 20 sites and 130 person hours over four seasons. Systematic bird surveys were also conducted at the small areas of floodplain wetlands near the project boundary. This involved a point census from wetland edge or vantage point along nearby road during early morning and dusk census for a total of one person hour at each site including at Chaffin Swamp, the Coldstream wetland near Tucabia and north of Sandy Crossing (Wants Lane) in Section 3. Additionally, the Australasian Bittern <i>Botaurus poiciloptilus</i> was targeted in spotlighting surveys around wetlands and riparian sites (16 sites) and targeted searches for nest sites of Black-necked Stork <i>Ephippiorhynchus asiaticus</i> were undertaken, particularly in Sections 3-5. Birds were also recorded opportunistically during all fauna survey activities.
Australian Painted Snipe <i>Rostratula australis</i> (Endangered TSC Act, Vulnerable, Migratory EPBC Act) Predicted	
Black-necked Stork <i>Ephippiorhynchus asiaticus</i> (Endangered TSC Act) Confirmed.	
Pale-vented Bush Hen <i>Amauornis molucanna</i> (Vulnerable TSC Act) Predicted	
Magpie Goose <i>Anseranas semipalmata</i> (Vulnerable (TSC Act) Confirmed: Wants Lane, Coldstream wetland	
Comb-crested Jacana <i>Irediparra gallinacea</i> (Vulnerable (TSC Act) Predicted	
Black Bittern <i>Ixobrychus flavicollis</i> (Vulnerable (TSC Act) Predicted	
Brolga <i>Grus rubicundus</i> (Vulnerable (TSC Act) Confirmed.	
Freckled Duck <i>Stictonetta naevosa</i> (Vulnerable (TSC Act) Predicted	
Other migratory listed wetland species including but not limited to Latham's Snipe, Cattle Egret, Great Egret (Migratory, EPBC Act) Predicted	
Pied Oystercatcher <i>Haematopus longirostris</i> (Endangered TSC Act) Not predicted	

Target species, listing status and status on project	Survey method and effort
Large forest owls and other nocturnal birds	
Barking Owl <i>Ninox connivens</i> (Vulnerable TSC Act) Predicted across a range of habitats	Targeted surveys were conducted at 38 individual sites over 53 survey nights. Calls of target species were broadcast through a 15-20W loudspeaker for 5 minute periods, followed by periods of listening and spotlighting. Sooty Owl and Grass Owl were only played at sites with suitable habitat. Playback sessions were repeated at each site in all sections and varied from 2 nights per site in Sections 1-2, 4 nights per site in Section 3-5, 8 nights per site in Section 6-7. In section 9-11, 5 nights per site were repeated for Powerful Owl, Barking Owl and Grass Owl, 6 nights for Sooty Owl and 7 nights for Masked Owl. Surveys were conducted all year round and were widely spaced to account for different home range areas.
Powerful Owl <i>Ninox strenua</i> (Vulnerable TSC Act) Confirmed at a number of locations	
Grass Owl <i>Tyto longimembris</i> (Vulnerable TSC Act) Predicted in restricted habitats	
Masked Owl <i>Tyto novaehollandiae</i> (Vulnerable TSC Act) Confirmed.	
Sooty Owl <i>Tyto tenebricosa</i> (Vulnerable TSC Act) Confirmed in restricted habitats	
Searches for owl pellets were conducted at all 129 habitat assessment sites.	
Spotlighting searches were conducted at 56 sites for a total of 138 person hours, covering all habitat strata. The spotlighting searches targeted nocturnal birds.	
Birds were also recorded opportunistically during all fauna survey activities.	
Woodland birds	
Brown Treecreeper <i>Climacteris picumnus</i> (Vulnerable TSC Act) Confirmed. Section 2	Suitable habitat includes a range of dry sclerophyll forest types, predominantly with open or grassy understorey. Systematic bird surveys targeting these habitats were conducted at a total of 24 sites. These surveys were conducted across a full range of seasons and generally time-based consisting of direct observations of birds and identification from calls using either a line transect or random meander search technique for between 20 and 60 minutes at each site depending on the area and site accessibility.
Diamond Firetail <i>Stagonopleura guttata</i> (Vulnerable TSC Act) Not predicted	
Speckled Warbler <i>Pyrholaemus sagittatus</i> (Vulnerable TSC Act) Not predicted	
Black-chinned Honeyeater (eastern subsp.) <i>Melithreptus gularis gularis</i> (Vulnerable TSC Act) Confirmed. Section 2	
Hooded Robin <i>Melanodryas cucullata</i> (Vulnerable TSC Act) Not predicted	
Painted Honeyeater <i>Grantiella picta</i> (Vulnerable TSC Act) Not predicted	
Bush Stone-curlew <i>Burhinus grallarius</i> (Endangered TSC Act) Confirmed.	
A total of 226 person hours were spent surveying woodland birds. In general, these surveys covered an average two hectares search area at each of the 24 sites. Birds were also recorded opportunistically during all fauna survey activities.	
The Bush Stone-curlew was also subject to a call playback survey, conducted in sections 1-9 in areas of suitable dry sclerophyll forest habitats.	

Target species, listing status and status on project	Survey method and effort
Rainforest birds	
Double-Eyed Fig-Parrot <i>Cyclopsitta diophthalma coxeni</i> (Critically endangered TSC Act, endangered EPBC Act) Predicted	Systematic bird surveys for rainforest species were conducted at 31 sites stratified by broad habitat types where this intersects with the project boundary. These include wet forest/floodplain rainforests (11 sites), swamp forest (13 sites). These surveys were conducted across a full range of seasons and generally time-based consisting of direct observations of birds and identification from calls using either a line transect or random meander search technique for between 20 and 60 minutes at each site depending on the area and site accessibility. A total of 485 person hours were spent surveying all birds. In general, these surveys covered an average two hectares search area at each site. Birds were also recorded opportunistically during all fauna survey activities.
Albert’s Lyrebird <i>Menura albertii</i> (Vulnerable TSC Act) Not predicted	
Wompoo Fruit-dove <i>Ptilinopus magnificus</i> (Vulnerable TSC Act) Predicted	
Rose-crowned Fruit Dove <i>Ptilinopus regina</i> (Vulnerable TSC Act) Predicted all sections	
Superb Fruit-dove <i>Ptilinopus superbus</i> (Vulnerable TSC Act) Predicted	
Rufous Scrub-Bird <i>Atrichornis rufescens</i> (Vulnerable TSC Act) Not predicted	
White-eared Monarch <i>Monarcha leucotis</i> (Vulnerable TSC Act) Not predicted	
Black-breasted Button-quail <i>Turnix melanogaster</i> (Critically endangered TSC Act, Vulnerable EPBC Act) Not predicted	
Forest birds	
Little Eagle <i>Hieraaetus morphnoides</i> (Vulnerable TSC Act) Predicted.	Systematic bird surveys were conducted at a total of 55 sites stratified by broad habitat types where this intersects with the project boundary. Dry forest (24 sites), wet forest/floodplain rainforests (11 sites), swamp forest (13 sites), and heath (2 sites). These surveys were conducted across a full range of seasons and generally time-based consisting of direct observations of birds and identification from calls using either a line transect or random meander search technique for between 20 and 60 minutes at each site depending on the area and site accessibility. General searches for nest sites were undertaken for Little Eagle, Square-tailed Kite and Eastern Osprey. General searches for dormitories of the Grey-crowned Babbler were also undertaken near bird and mammal survey sites. A total of 485 person hours were spent surveying birds. In general, these surveys covered an average two hectares search area at each site. Birds were also recorded opportunistically during all fauna survey activities.
Square-tailed Kite <i>Lophoictinia isura</i> (Vulnerable TSC Act) Predicted.	
Eastern Osprey <i>Pandion haliaetus</i> (Vulnerable TSC Act, Migratory EPBC Act) Confirmed	
Red Goshawk <i>Erythrotriorchis radiatus</i> (Critically endangered TSC Act, vulnerable EPBC Act) Predicted	

Target species, listing status and status on project	Survey method and effort
Glossy Black-cockatoo <i>Calyptorhynchus lathami</i> (Vulnerable TSC Act) Confirmed.	A habitat assessment was also conducted for the Allocasuarina species, a favoured feeding resource for Glossy Black-cockatoo. The density of this species was surveyed at 129 sites.
Little Lorikeet <i>Glossopsitta pusilla</i> (Vulnerable TSC Act) Predicted.	
Mangrove Honeyeater <i>Lichenostomus fascioculari</i> (Vulnerable TSC Act) Predicted	
Turquoise Parrot <i>Neophema pulchella</i> (Vulnerable TSC Act) Not predicted	
Olive Whistler <i>Pachycephala olivacea</i> (Vulnerable TSC Act) Not predicted	
Ground Parrot (eastern subsp.) <i>Pezoporus wallicus wallicus</i> (Vulnerable TSC Act) Predicted	
Barred Cuckoo-shrike <i>Coracina lineata</i> (Vulnerable TSC Act) Predicted	
Grey-crowned Babbler (eastern subsp.) <i>Pomatostomus temporalis temporalis</i> (Vulnerable TSC Act) Confirmed.	
Collared Kingfisher <i>Todiramphus chloris</i> (Vulnerable TSC Act) Not predicted	
Ratites	
Coastal Emu <i>Dromaius novaehollandiae</i> (Endangered population TSC Act) Confirmed.	To gain a better understanding of the coastal emu endangered population, a number of different studies were undertaken, including: population surveys, interviews with landowners on emu movements through properties, scat and feather collections, genetic study and road kill investigation. A genetic pilot study was undertaken to collect scats and feathers in 31 transects. Two observers walked along each transect and recorded all samples and details. Samples were dried and then sent for DNA extraction. The road kill investigation consisted of a total 26 kill sites and 15 control sites. These were surveyed for habitat characteristics to determine temporal and spatial patterns, movement features and predicted locations to inform the mitigation strategy.

Target species, listing status and status on project	Survey method and effort
Microchiropteran bats	
Large-eared Pied Bat <i>Chalinolobus dwyeri</i> (Vulnerable TSC Act and EPBC Act) Predicted	Three methods were used: harp trapping, call surveys and roost surveys. Standard two-bank 4.2 m ² harp traps were used to sample for microchiropteran bats at 50 sites stratified by dry (28), moist (10) and swamp forest (12) over 108 trap nights. This resulted in a total of one site per 15 hectares in dry forest, 1 site per 33 hectares in moist forest and one site per 12 hectares in swamp forest. Trapping sessions were conducted over a minimum of two consecutive nights. This resulted in 11 traps nights per 100 hectares in dry forest, eight trap nights per 100 hectares in moist forests, and 21 trap nights per 100 hectares in swamp forest. The surveys aimed to sample representative vegetation associations. Ultrasonic call recording was conducted at 72 sites for a total of 552 recording hours. Roost surveys were conducted for the Duck Creek and Emigrant Creek bridges (project sections 10 and 11) during the summer season.
Hoary Wattled Bat <i>Chalinolobus nigrogriseus</i> (Vulnerable TSC Act) Confirmed in Sections 1-3 & 6-8	
Eastern False Pipistrelle <i>Falsistrellus tasmaniensis</i> (Vulnerable TSC Act) Confirmed in Sections 1-3	
Golden-tipped Bat <i>Kerivoula papuensis</i> (Vulnerable TSC Act) Confirmed in Sections 9-11	
Little Bent-wing Bat <i>Miniopterus australis</i> (Vulnerable TSC Act) Confirmed in Sections 1-11	
Eastern Bent-wing Bat <i>Miniopterus schreibersii oceanensis</i> (Vulnerable TSC Act) Confirmed in Sections 1-2 & 6-11	
Beccari's Freetail-Bat <i>Mormopterus beccarii</i> (Vulnerable TSC Act) Predicted	
Eastern Freetail-Bat <i>Mormopterus norfolkensis</i> (Vulnerable TSC Act) Confirmed in Sections 6-11	
Southern Myotis <i>Myotis macropus</i> (Vulnerable TSC Act) Confirmed in Sections 1-2 and 6-11	
Eastern Long-Eared Bat <i>Nyctophilus bifax</i> (Vulnerable TSC Act) Confirmed in Sections 6-11	
Yellow-bellied Sheath-tail-bat <i>Saccolaimus flaviventris</i> (Vulnerable TSC Act) Confirmed in Sections 9-11	

Target species, listing status and status on project	Survey method and effort
Greater Broad-nosed Bat <i>Scoteanax rueppellii</i> (Vulnerable TSC Act) Confirmed in Sections 9-11	
Eastern Cave Bat <i>Vespadelus troughtoni</i> (Vulnerable TSC Act) Confirmed in Sections 6-11	
Arboreal mammals	
Eastern Pygmy-possum <i>Cercartetus nanus</i> (Vulnerable TSC Act) Predicted.	Trapping for arboreal mammals used Elliott type B traps attached to tree trunks 3 - 3.5 metres above ground and also used a combination of trap numbers and transect configurations. Trapping was conducted at 34 sites stratified by dry forests (19 sites), wet forests (6 sites), swamp forests (6 sites) and heath (3 sites), resulting in a total of one site per 23 hectares in dry forest, one site per 55 hectares for wet forests, one site per 24 hectares for swamp forest and one site per 3 hectares in heath. Trapping sessions (including pitfall and ground traps) were conducted over 3-4 consecutive nights resulting in a total of 1182 trap nights in dry forest or 135 trap nights per 50 hectares. Sixty eight trap nights were conducted in wet forests (10 trap nights per 50 hectares), 234 trap nights in swamp forest (78 trap nights per 50 hectares) and 240 trap nights in heath over 10 hectares. Spotlighting and dusk census for arboreal mammals was conducted during the trapping periods and at 46 sites across the range of habitat types. Spotlighting was generally foot-based and comprised a concentrated survey across the entire trapping grid and general survey through adjacent areas, using hand-held spotlights. Two or three observers conducted the survey for a minimum period of 30 minutes per site following dusk for a search area up to 2 hectares. Pitfall trapping was employed to target Common Planigale and other small mammal species such as Eastern Pygmy Possum and Antechinus spp. Pits consisted of four or five metal or plastic buckets (400-500 millimetres deep) set at each site and connected with drift fencing for a total of three to five consecutive nights. Loose bark and leaves were added to each pit to provide protection and cover for captured animals. Pitfall trapping tended to coincide with sandy soils for ease of installation and were used in project sections 1-7. Call playback was used for Yellow-bellied Glider, Squirrel Glider in suitable habitat.
Yellow-bellied Glider <i>Petaurus australis</i> (Vulnerable TSC Act) Confirmed.	
Squirrel Glider <i>Petaurus norfolcensis</i> (Vulnerable TSC Act) Confirmed.	
Brush-tailed Phascogale <i>Phascogale tapoatafa</i> (Vulnerable TSC Act) Confirmed.	
Koala <i>Phascolarctos cinereus</i> (Vulnerable TSC Act and EPBC Act) Confirmed in Section 3, predicted in all sections	Surveys for Koala were conducted between 2006 and 2012 and preceded the listing of the species on the EPBC Act and subsequent release of the <i>Interim Koala Referral Advice for Proponents</i> released in June 2012 (DSEWPaC 2012). However, the method for assessing potential impacts of the project on the Koala was consistent with these guidelines. Koala surveys involved a combination of the Spot Assessment Technique (SAT) to indicate how much or frequently the area of habitat is being used by Koalas and identify the relative importance of the habitat. In addition, to call playback surveys and spotlighting were undertaken. Area searches for Koala scats were conducted during the habitat assessment method in 2011 and 2012 as part of the additional surveys and involved a traverse across the entire habitat plot (50 x 20

Target species, listing status and status on project	Survey method and effort
	metres) and searching the base of all larger trees (>20 centimetres DBH) with particular focus paid to any known Koala feed trees species for the north coast region as confirmed in the Recovery Plan for the Koala (DECC 2008c). This included primary, secondary and supplementary trees species. The locations of any scats found were recorded with a Global Positioning System. A total of 120 plots were searched using this method across the entire project. An additional 12 plots were sampled using with same plot size and method in 2008 between Wells Crossing and Iluka Road (SKM 2009) and 27 plots of 20 x 20 metres in area were searched over the remainder of the project (Geolyse 2007; Ecotone 2007, Connell Wagner 2008). The total number of Koala scat search plots surveyed over the entire project boundary was 159. Spotlighting and dusk census for Koala was conducted during the trapping periods and at 46 sites across the range of habitat types. Spotlighting was generally foot-based and comprised a concentrated survey across the entire trapping grid and general survey through adjacent areas, using hand-held spotlights. Two or three observers conducted the survey for a minimum period of 30 minutes per site following dusk for a search area up to two hectares. Call playback was also used for Koala during the forest owl playback sessions.
Ground-dwelling mammals	
Rufous Bettong <i>Aepyprymnus rufescens</i> (Vulnerable TSC Act) Confirmed in Section 1-3	Ground-based trapping was used to target small and medium sized ground-dwelling mammals. The technique used a combination of aluminium folding traps (Elliott type A, 33 x 10 x 9 cm, and Elliott type B, 15 x 16 x 45 cm), and cage traps (30 x 30 x 60 cm) and hair-tubes using different trap densities and transect configurations. The numbers of traps at each site varied between 10 and 25, for a period of between three to four consecutive nights. Pitfall trapping was employed to target Common Planigale and other small mammal species such as Eastern Pygmy Possum and Antechinus spp. Pits consisted of four or five metal or plastic buckets (400-500 millimetres deep) set at each site and connected with drift fencing for a total of three to five consecutive nights. Loose bark and leaves were added to each pit to provide protection and cover for captured animals. Pitfall trapping tended to coincide with sandy soils for ease of installation and were used in project sections 1-7. Searches for scats and signs of mammals were conducted over 129 habitat assessment sites. Spotlighting and dusk census was conducted during the trapping periods and at 46 sites across the range of habitat types. Spotlighting was generally foot-based and comprised a concentrated survey across the entire trapping grid and general survey through adjacent areas, using hand-held spotlights. Two or three observers conducted the survey for a minimum period of 30 minutes per site following dusk for a search area up to 2 hectares.
Common Planigale <i>Planigale maculata</i> (Vulnerable TSC Act) Confirmed in Section 1-2	
Long-nosed Potoroo <i>Potorous tridactylus tridactylis</i> (Vulnerable TSC Act and EPBC Act) Predicted	
Eastern Chestnut Mouse <i>Pseudomys gracilicaudatus</i> (Vulnerable TSC Act) Not predicted	
Hastings River Mouse <i>Pseudomys oralis</i> (Endangered TSC Act and EPBC Act) Not predicted	
Spotted-tailed Quoll <i>Dasyurus maculatus maculatus</i> (SE population) (Vulnerable TSC Act and Endangered EPBC Act) Predicted	

Target species, listing status and status on project	Survey method and effort
Megachiropteran bats	
Grey-headed Flying-fox <i>Pteropus poliocephalus</i> (Vulnerable TSC Act and EPBC Act) Confirmed in Sections 1-2, 4-6, & 8-11	The primary focus of this survey was to identify the distribution and quality of potential foraging habitat for these species within the study area and in the case of the Grey-headed Flying-fox identify the location of known roost camps for the species from the EPA Grey-headed Flying-fox database. The assessment used vegetation mapping for the project and region to identify the distribution and extent of critical foraging habitat for the species with reference to DECCW (2009). Spotlighting and dusk census was conducted during the trapping periods and at 46 sites across the range of habitat types. Spotlighting was generally foot-based and comprised of a concentrated survey across the entire trapping grid and general survey through adjacent areas, using hand-held spotlights. Two or three observers conducted the survey for a minimum period of 30 minutes per site following dusk for a search area up to 2 hectares. Concentrated searches were conducted for this species where flowering trees were noted.
Common Blossom-bat <i>Syconycteris australis</i> (Vulnerable TSC Act) Confirmed in Section 10	
Black Flying-fox <i>Pteropus alecto</i> (Vulnerable TSC Act) Not predicted	
Wetland and swamp dwelling frogs	
Wallum Froglet <i>Crinia tinnula</i> (Vulnerable TSC Act) Confirmed in Sections 1, 2 and between 6 and 11.	Potential habitats for all these frog species were confirmed from stratification and during the initial field survey design. Targeted frog surveys conducted between 2006 and 2012 included spotlighting in suitable habitats, pitfall traps, diurnal and nocturnal searches and call playback. Spotlighting targeted timed based wetland surveys depending on the size of the area and were conducted across spring and summer seasons. Survey timing varied between 20-60 minutes and involved a minimum of two people using head torches and spotlights searching for adult frogs and tadpoles in the water column. A total of 80 sites were surveyed using this technique over 69 person hours. Call playback involved an initial five-minute listening period, after which calls of the species were broadcast for a period of around five minutes, followed by a five minute listening period for a response. After completion of the call playback surveys, the immediate area was searched by spotlight for any species that approached the broadcast site without eliciting calls. Frog were searched for under rocks, by the edge of the water, on floating vegetation, in fringing grass or other vegetation, under logs and other debris. Call playback was used at 16 sites. Pit traps were deployed to target a range of fauna including frogs and were used at 14 sites in total, seven of which were within suitable habitat for the target species. On three occasions during the summer survey programs, high rainfall periods were experienced (in 2006, 2007 and 2011). This prompted additional targeted frog surveys for Green-thighed Frog in particular to coincide with the breeding biology of the species which breeds during heavy rainfall and associated flood events. These rainfall events were also viewed as an optimal survey period for other target species including the Wallum Froglet, Olongburra Frog and Booroolong Frog.
Green and Golden Bell Frog <i>Litoria aurea</i> (Endangered TSC Act, Vulnerable EPBC Act) Not predicted.	
Booroolong Frog <i>Litoria booroolongensis</i> (Endangered TSC Act and EPBC Act) Not predicted.	
Green-thighed Frog <i>Litoria brevipalmata</i> (Vulnerable TSC Act) Confirmed in Sections 2, 6 and 7.	
Olongburra Frog <i>Litoria olongburensis</i> (Vulnerable TSC Act and EPBC Act) Predicted in Sections 9-11.	

Target species, listing status and status on project	Survey method and effort
Stream dwelling frogs	
Stuttering Frog <i>Mixophyes balbus</i> (Endangered TSC Act, Vulnerable EPBC Act) Not predicted	Survey methods and effort were conducted in accordance with the guidance of DEC (2004). Targeted field surveys for stream-dwelling frogs were typically the same as wetland and swamp-dwelling frogs with the use of spotlighting, diurnal and nocturnal searches and call playback in different but suitable habitat. However in addition, streams were also surveyed using a combination of the time interval searches or alternatively traversing a 500 metre transect along the targeted creek depending on the length of waterway and ease of traversing. A total of 22 sites and over 20 person hours were spent searching in suitable habitat using this technique. Creeks targeted using this methods included Section 1 (Arrawarra Gully, Corindi River); Section 2 (Blackadder Gully, Redbank Creek); Section 3 (Champion Creek , Black Snake Hole (Pillar Valley Creek); Section 6 (Mororo Creek, Tabbimoble Creek); Section 7 (Oakey Creek); Section 8 (Macdonalds Creek). In addition to this, numerous wetlands, drains and unnamed watercourses were sampled. The high rainfall events in January and February 2006, January 2007 and January 2011 resulted in optimal survey conditions for the Giant Barred Frog and Stuttering Frog that breed in summer, usually after flood events.
Fleay's Barred Frog <i>Mixophyes fleayi</i> (Endangered TSC Act and EPBC Act) Not predicted	
Giant Barred Frog <i>Mixophyes iterates</i> (Endangered TSC Act and EPBC Act) Confirmed in Section 1 and 7.	
Pouched Frog <i>Assa darlingtoni</i> (Vulnerable TSC Act) Not predicted	
Reptiles	
White-crowned Snake <i>Cacophis harriettae</i> (Vulnerable TSC Act) Not predicted	Targeted surveys consisted of dry pitfall traps, spotlighting diurnal and nocturnal searches during the same periods of frog surveys. The diurnal component of the reptile surveys consisted of hand searches for active and resting individuals under rocks, logs, bark, leaves and timber and artificial debris when encountered. The surveys were both time-based and area-based and varied in duration according to the size of the habitat, wetland. Reptile surveys were conducted at all trap sites and involved a 30-minute general traverse. Systematic reptile searches were conducted at the habitat assessment sites. This involved an active area search across the habitat plot (20 x 50 metres). A total of 129 habitat plots were sampled of these reptile searches were conducted at 83 plots.
Three-toed Snake-tooth Skink <i>Coeranoscincus reticulatus</i> (Vulnerable TSC Act and EPBC Act) Not predicted	
Pale-headed Snake <i>Hoplocephalus bitorquatus</i> (Vulnerable TSC Act) Predicted	
Stephens' banded snake <i>Hoplocephalus stephensii</i> (Vulnerable TSC Act) Confirmed in Section 3. Predicted in Sections 1, 2 and 6-8.	
Fish	
Oxleyan Pygmy Perch <i>Nannoperca oxleyana</i> (OPP)(Endangered TSC Act and EPBC Act) Confirmed in Section 7-9	Investigations were done at 67 different sites covering 36 different waterways (named and unnamed), this includes 43 sites surveyed for the preferred route studies and an additional 24 sites surveyed to address gaps in the fish survey data particularly to target the Oxleyan Pygmy Perch and Purple-spotted Gudgeon.
Purple-spotted Gudgeon <i>Mogurnda adspersa</i> (Endangered TSC	

Target species, listing status and status on project	Survey method and effort
Act) Predicted Eastern Freshwater Cod <i>Maccullochella ikei</i> (Endangered TSC Act and EPBC Act) Predicted	The named creeks surveys were: Section 1 (Arrawarra Gully, Corindi River); Section 2 (Blackadder Gully, Redbank Creek); Section 3 (Champion Creek, Black Snake Hole (Pillar Valley Creek), Coldstream River, Pheasants Creek); Section 4 (Edwards Creek, Shark Creek); Section 5 (Clarence River - at two locations); Section 6 (Mororo Creek, Tabbimoble Creek); Section 7 (Oakey Creek); Section 8 (Macdonalds Creek, Richmond River at two locations); Section 9 (Richmond River at two locations), Section 9 (Evan's River, Rocky Mouth River, Tuckean Broadwater, Bingil Creek); Section 10 (Garretts Creek); Section 11 (Duck Creek and Emigrant Creek). In addition to this, numerous wetlands, drains and unnamed watercourses were sampled. Additional targeted surveys were undertaken in September 2011, in consultation with the Department of Fisheries, and in accordance with the Survey Guidelines for Australia's Threatened Fish (DSEWPaC 2012). These surveys for Oxleyan Pygmy Perch were undertaken during the optimal period before the onset of the breeding season, to prevent disturbance to breeding populations and breeding habitats. Fish sampling methods involved the use of electrofishing, bait traps and dip netting. Where habitat and site access allowed, backpack electrofishing was undertaken with an electrical output of 500b, 60Hz pulsed DC to allow capture but without causing muscle rigidity. Unbaited bait traps were set for a period of 30-60 minutes (as baiting does not improve the probability of attracting fish (Knight et al. 2007). Up to 40 nets were deployed at each site, set around 1.5-2 metres apart. Dip-netting was undertaken in areas where it was too shallow to trap.
Invertebrates	
Pink Underwing Moth <i>Phyllodes imperialis</i> southern subsp. (Vulnerable TSC Act and EPBC Act) Confirmed in Section 10	Suitable habitat was confirmed at 10 sites in Sections 9-11. A wide representation of potential habitat was surveyed using a variety of techniques including random meander searches, active ground searches and opportunistic observations. A random meander search was carried out to find host plants in a 30 minute meander through each hectare of suitable habitat. An active ground search was also used to intensely observe the ground layer at each site for 30 minutes per hectare depending on the complexity of ground debris. Opportunistic observations were undertaken in 20 minute searches at suitable habitats in wetlands and swamps to find invertebrates in transit. Host plants were also searched and used as indicators for suitable habitat. A second stage survey was undertaken in Section 10 to search for the Pink Underwing Moth (<i>Phyllodes imperialis</i>).
Coastal Petaltail <i>Petalura litorea</i> (Endangered TSC Act) Predicted in sections 8-9	
Atlas Rainforest Ground Beetle <i>Nurus atlas</i> (Endangered TSC Act) Confirmed in Section 10	
Shorter Rainforest Ground Beetle <i>Nurus brevis</i> (Endangered TSC Act) Not predicted	

Target species, listing status and status on project	Survey method and effort
Other fauna	
Mitchells Rainforest Snail <i>Thersites mitchellae</i> (Endangered TSC Act and Critically endangered EPBC Act) Not predicted	Geolyse (2007) and Stanisc (2007) undertook surveys 10-11 March 2006. A meandering transect method was used to search for live animals and empty shells in preferred habitat (lowland rainforest and riparian habitat). A total of seven transects were searched over 11.5 hours, each transect having a 20 metre search area in the same vegetation type. Weather and moisture conditions were excellent for snail collecting. Rain had fallen before the survey and on one of the survey days frequent rainstorms (high humidity) occurred, these are optimal conditions to search for these species. The ground surveys revealed that the vegetation was not key habitat preferred by the species (Geolyse 2007). The absence of a known co-habitant, the Large Camaenid (<i>Sphaerospira fraseri</i>) also led to the conclusion that the species was unlikely to occur in the study area (Stanisc 2007).
Swift Parrot <i>Lathamus discolor</i> (Endangered TSC Act, Endangered, Migratory EPBC Act) Predicted	As both the Regent Honeyeater and Swift Parrot are semi-nomadic species that move large distances in search of flowering resources, their presence in a particular area of coastal NSW is unpredictable. This makes targeted surveys difficult without previous knowledge of known sites. The primary focus of this study was to identify the distribution and quality of potential foraging habitat for both species within the study area. As a secondary aim, targeted searches were conducted for both species where flowering trees were noted. Aggregations of other nectivorous birds, particularly Scaly-breasted Lorikeet (<i>Trichoglossus chlorolepidotus</i>) and Rainbow Lorikeet (<i>T. haematodus</i>), which can often be heard from a distance, were also used as a guide to locate flowering trees and search for the target species, as Swift Parrot are found with these species. Systematic bird surveys were conducted at a total of 55 sites stratified by broad habitat types where this intersects with the project boundary. Dry forest (24 sites), wet forest/floodplain rainforests (11 sites), swamp forest (13 sites), heath (2 sites). Surveys in section 3-11 included autumn and winter surveys which coincide with the peak presence of these migratory species in the study area. These surveys were conducted across a full range of seasons and generally time-based consisting of direct observations of birds and identification from calls using either a line transect or random meander search technique for between 20 and 60 minutes at each site depending on the area and site accessibility. A total of 485 person hours were spent surveying birds. In general, these surveys covered an average two hectares search area at each site. Birds were also recorded opportunistically during all fauna survey activities.
Regent Honeyeater <i>Xanthomyza phrygia</i> (Endangered TSC Act and endangered and migratory EPBC Act) Predicted	

10.2 Existing environment

10.2.1 Bioregional context

The project is located in the NSW North Coast Bioregion, which is one of the most ecologically diverse bioregions in NSW. The variety of ecosystems within the bioregion includes sub-tropical and warm temperate rainforests, a wide variety of wet and dry sclerophyll eucalypt forests, heathland, paperbark swamps, and freshwater and estuarine wetlands and waterways.

10.2.2 Key habitats and corridors

The project intersects with 30 key fauna movement habitat corridors and climate change corridors (listed in Table 10-4 and shown in Figure 10-1 and Figure 10-2). Key habitat corridors were identified from the *Key Habitats and Corridors project* (DEC, 2003) and climate change corridors from the *Climate Change Corridors project* (DECC, 2007). Key fauna habitats are distributed throughout the study area.

Table 10-4: Key habitats and corridors

Regional corridor	Location description	Focal species in corridor
NSW Office of Environment and Heritage climate change corridors - moist corridors		
Corindi Connector	Crosses Section 1. Connects with the Yamba - Nymboida corridor. Fully intersected by project.	Yellow-bellied Glider, Grey-headed Flying-fox
Yamba - Nymboida	Crosses Section 1. Connects with the Corindi Connector corridor. Fully intersected by project.	Yellow-bellied Glider, Grey-headed Flying-fox
Iluka - Richmond Range	Crosses Sections 6 and 7. Fully intersected by project.	Grey-headed Flying-fox, Black-striped Wallaby
Alstonville Plateau Link	Intersects with western side of Sections 10 and 11. Not Fully intersected by project.	Rose-crowned Fruit Dove, Pouched Frog
NSW Office of Environment and Heritage climate change corridors - coastal corridors		
Coffs Coast	Intersects with Section 1. Partly intersected by project.	Grey-headed Flying-fox, Koala, Spotted- tailed Quoll
Yuraygir	Intersects with eastern side of Section 1. Partly intersected by project.	Emu, Ground Parrot, Spotted-tailed Quoll
Lower Clarence	Crosses Sections 3, 4, 5 and 6. Fully intersected by the project at several locations.	Wetland waterbirds, Emu
Broadwater - Bungawalbin	Crosses Devils Pulpit Upgrade and Sections 7, 8 and 9. Fully intersected by project.	Koala, Emu
Ballina	Intersects with Sections 10 and 11. Partly intersected by project.	Grey-headed Flying-fox, Rose-crowned Fruit Dove
Uralba-Tuckean Swamp	Crosses Sections 10 and 11. Fully intersected by project.	Albert's Lyrebird, Koala
NSW Office of Environment and Heritage climate change corridors - dry corridors		
Coastal Range	Intersected by Sections 1, 2 and 3 and the Glenugie upgrade. Intersects with western edge of Sections 3 and 4.	Coastal Emu
Richmond Range-Bungawalbin	Intersects with western side of Sections 6 and 7 and the Devils Pulpit upgrade. Partly intersected by project.	Squirrel Glider, Spotted-tailed Quoll
NSW Office of Environment and Heritage key corridors (listed from south north)		
Corindi (Corindi River)	Links with Redbank Creek corridor and key habitat areas across existing highway. Corindi River is fully intersected by Section 1.	Brolga, Black-necked Stork,

Regional corridor	Location description	Focal species in corridor
Dirty Creek	Links to Yuraygir National Park, state forests, key habitats and Redbank Creek corridor. Intersected by Section 1.	Yellow-bellied Glider, Rufous Bettong, Spotted-tailed Quoll
Lazyman Creek	Crosses Section 1 at Lazyman Creek. Links state forest areas and key habitats.	All fauna
New-Sherwood	Crosses Section 1. Links to state forest areas, Sherwood Nature Reserve and key habitats. Fully intersected by project.	Yellow-bellied Glider, Rufous Bettong, Spotted-tailed Quoll
Yuraygir (Yuray-Sherwood, Yuraygir_CR)	Crosses Section 1. Links Sherwood Nature Reserve to Yuraygir National Park. Partly intersected by project.	Yellow-bellied Glider, Rufous Bettong
Halfway Creek	Crosses section 2 at Halfway Creek (Section 2). Links Sherwood Nature Reserve to Yuraygir National Park. Fully intersected by project.	Rufous Bettong, Koala, Spotted-tailed Quoll
Snake Creek	Crosses Section 2. Connects areas of state forest and key habitats across the existing highway.	All fauna
Newfoundland State Forest	Western boundary intersects Section 2 of the project. Partly intersected by project.	All fauna
Glenugie State Forest	Occurs both sides of Section 2 and the Glenugie upgrade. Project boundary intersects eastern patches in Section 2 and the Glenugie upgrade. Fully intersected in Section 3.	All fauna
Pine Brush	Crosses Section 3. Partly intersected by project.	Brush-tailed Phascogale
Mororo – Gibberage (Bundjalung, Mororo SF, Moro-Bundj)	Crosses project in Section 6. Connects to several other corridors, state forests and key habitats. Fully intersected by project	Yellow-bellied Glider
Bundjalung - Devils Pulpit (Bundjalung, Devils Pulpit, Devils_sf)	Crosses the Devils Pulpit upgrade. Connects areas of state forest and key habitats across the existing highway. Fully intersected.	Yellow-bellied Glider, Brush-tailed Phascogale
Bundjalung-Tabbimoble (Tabbimoble_nr, Tabbimoble-Bundjalung, Doubleduke State Forest, Tabbimoble_sf)	Crosses project in multiple places in Section 7. Links key habitat areas across the existing highway at several locations. Fully intersected by project.	Long-eared Bat, Yellow-bellied Glider, Brush-tailed Phascogale, Spotted-tailed Quoll
Broadwater (Broadwater Ck, Broadwater NP)	Crosses Sections 9 and 10. Connects to several other corridors and key habitats to the west of project. Fully intersected by project.	Eastern Long-eared Bat, Black Bittern, Brush-tailed Phascogale
Wardell - Blackwall	Crosses Section 10 near Wardell. Fully intersected by project.	Eastern Long-eared Bat, Black Flying-fox
Wardell-Tuckean (Wardell)	Crosses Section 10 near Wardell. Fully intersected by project.	Eastern Long-eared Bat, Black Flying-fox
Wardell-Uralba	Intersects Section 11 and crosses project in Section 10 near Wardell. Fully intersected by project.	Eastern Long-eared Bat, Black Flying-fox
Emigrant Creek	Crosses Section 11. Connects to the Uralba-Ballina corridor to the northwest and the Richmond River to the east. Fully intersected by project.	All fauna



Figure 10-1: Key habitats and corridors found in the study area and surrounds

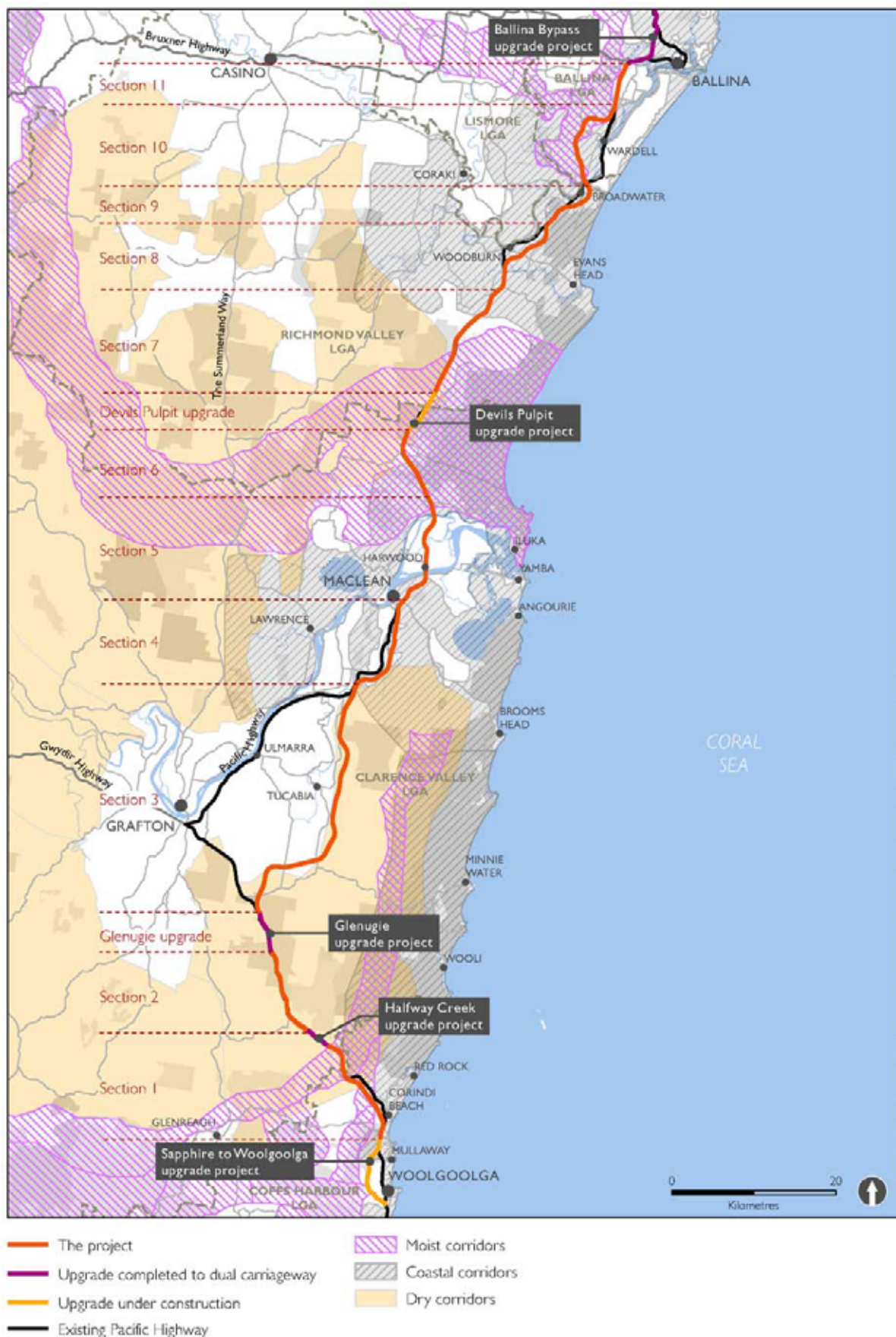


Figure 10-2: Climate change corridors found in the study area and surrounds

10.2.3 Vegetation communities

The vegetation types that dominate the study area include:

- Dry sclerophyll open forests and woodlands
- Wet sclerophyll forests
- Swamp forests
- Floodplain forests
- Rainforests
- Freshwater wetlands
- Estuarine wetlands
- Heathlands
- Modified habitats.

These vegetation types can be classified into 57 plant communities and 24 bioMetric vegetation types (Gibbons et al., 2008) based on the dominant canopy and understorey flora, landscape position and geographic location.

Table 10-5 provides a summary of the Catchment Management Authority biometric vegetation types present and equivalent vegetation types as described in the specialist studies. Where applicable these are matched to Threatened Ecological Communities as listed under the *Threatened Species Conservation Act 1979* and the *Environmental Protection Biodiversity Conservation Act 1999* and an estimate of the percentage of each vegetation community cleared to date within NSW. The distribution of the bioMetric vegetation types in relation to the project boundary are shown in Figure 10-4 to Figure 10-29.

Table 10-5: Summary of vegetation types in the study area.

Equivalent bioMetric vegetation type (CMA)	Threatened Ecological Community type ¹	Amount cleared to date in NSW (%) ²
Black Bean - Weeping Lilly Pilly riparian rainforest of the North Coast	Lowland Rainforest in NSW North Coast and Sydney Basin Bioregion (E)	75
Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast	Not applicable	40
Blackbutt grassy open forest of the lower Clarence Valley of the North Coast	Not applicable	30
Coast Cypress Pine shrubby open forest of the North Coast Bioregion	Coast Cypress Pine shrubby open forest of the North Coast Bioregion (E)	40
Coastal floodplain sedgeland, rushlands, and forblands	Freshwater Wetlands on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East bioregions (E)	80
Coastal heath on sands of the North Coast	Not applicable	10
Flooded Gum - Tallowwood - Brush Box moist open forest of the coastal ranges of the North Coast	Not applicable	40
Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast	Sub-tropical Coastal Floodplain Forest of the NSW North Coast bioregion (E)	60
Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast	Not applicable	20
Hoop Pine – Yellow tulipwood dry rainforest of the North Coast	Lowland Rainforest on Coastal Floodplains (E) Lowland Rainforest of Subtropical Australia (CE)	30

Equivalent bioMetric vegetation type (CMA)	Threatened Ecological Community type ¹	Amount cleared to date in NSW (%) ²
Mangrove - Grey Mangrove low closed forest of the NSW Coastal Bioregion	Not applicable	75
Narrow-leaved Red Gum woodlands of the lowlands of the North Coast	Sub-tropical Coastal Floodplain Forest of the NSW North Coast bioregion (E)	40
Needlebark Stringybark - Red Bloodwood heathy woodland on sandstones of the lower Clarence of the North Coast	Not applicable	20
Orange Gum (<i>Eucalyptus bancroftii</i>) open forest of the North Coast	Not applicable	75
Paperbark swamp forest of the coastal lowlands of the North Coast	Swamp Sclerophyll Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions (E)	75
Red Mahogany open forest of the coastal lowlands of the North Coast	Not applicable	30
Scribbly Gum - Needlebark Stringybark heathy open forest of coastal lowlands of the northern North Coast	Not applicable	40
Spotted Gum – Grey Box – Grey Ironbark dry open forest of the Clarence Valley lowlands of the North Coast	Not applicable	40
Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast	Not applicable	50
Swamp Box swamp forest of the coastal lowlands of the North Coast	Sub-tropical Coastal Floodplain Forest of the NSW North Coast bioregion (E)	70
Swamp Mahogany swamp forest of the coastal lowlands of the North Coast	Swamp Sclerophyll Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions (E)	75
Swamp Oak swamp forest of the coastal lowlands of the North Coast	Swamp Oak Floodplain Forest of the NSW North Coast, Sydney Basin and South East Corner bioregions (E)	75
Tallowood dry grassy forest of the far northern ranges of the North Coast	Not applicable	15
Turpentine moist open forest of the coastal hills and ranges of the North Coast	Not applicable	55
Wet heathland and shrubland of coastal lowlands of the North Coast	Not applicable	75
White Booyong - Fig subtropical rainforest of the North Coast	Lowland Rainforest on Coastal Floodplains (E) Lowland Rainforest of Subtropical Australia (CE)	75

¹ Endangered (E) (TSC Act), Critically Endangered (CE) (EPBC Act)

² According to the Northern River Catchment Management Authority (NRCMA) bioMetric database

Threatened Ecological Communities

Six Threatened Ecological Communities listed under the Threatened Species Conservation Act 1979 are present (Table 10-6). These are listed under Schedule 1 Part 3 of the Act as Threatened Ecological Communities. One of these communities, Lowland Rainforest in subtropical Australia, has also been listed as Critically Endangered under the *Environmental Protection Biodiversity Conservation Act 1999*. There are no other *Environmental Protection Biodiversity Conservation Act 1999* listed endangered ecological communities within the study area. The distribution of *Threatened Species Conservation Act 1979* and *Environmental Protection Biodiversity Conservation Act 1999* listed ecological communities in the region is widespread, although heavily fragmented. They are generally associated with coastal and floodplain habitats that have been cleared for agriculture and development.

TERM – ecological communities

An assemblage of species occupying a particular area.

The distribution of NSW and Commonwealth listed ecological communities in the study area is shown in Figure 10-4 to Figure 10-29. Figure 10-3 provides the legend for the series of figures.

Legend sheet A

Threatened flora species

-  *Angophora robur*
-  *Cyperus aquatilis*
-  *Melaleuca irbyana*
-  *Olaix angulata*
-  Various threatened flora species include:
Archidendron hendersonii
Cryptocarya foetida
Endiandra hayesii
Endiandra muelleri subsp. *bracteata*
Syzygium hodgkinsoniae
-  *Angophora robur*
-  *Arthaxon hispidus*
-  *Eucalyptus tetrapleura*
-  *Grevillea quadricauda*
-  *Lindsaea incisa*
-  *Moundia triglochneoides*
-  *Melaleuca irbyana*
-  *Prostanthera cuneolifera*

Threatened ecological communities

-  Coastal Cypress Pine Forest in NSW North Coast Bioregion (Endangered, TSC Act)
-  Freshwater Wetlands on Coastal Floodplains (Endangered, TSC Act)
-  Lowland Rainforest on Coastal Floodplains (Endangered, TSC Act)
-  Lowland Rainforest of Subtropical Australia (Critically Endangered, EPBC Act) and Lowland Rainforest on Coastal Floodplains (Endangered, TSC Act)
-  Subtropical Coastal Floodplain Forest on Coastal Floodplains (Endangered, TSC Act)
-  Swamp Oak Floodplain Forest on Coastal Floodplains (Endangered, TSC Act)
-  Swamp Sclerophyll Forest on Coastal Floodplains (Endangered, TSC Act)

Vegetation communities

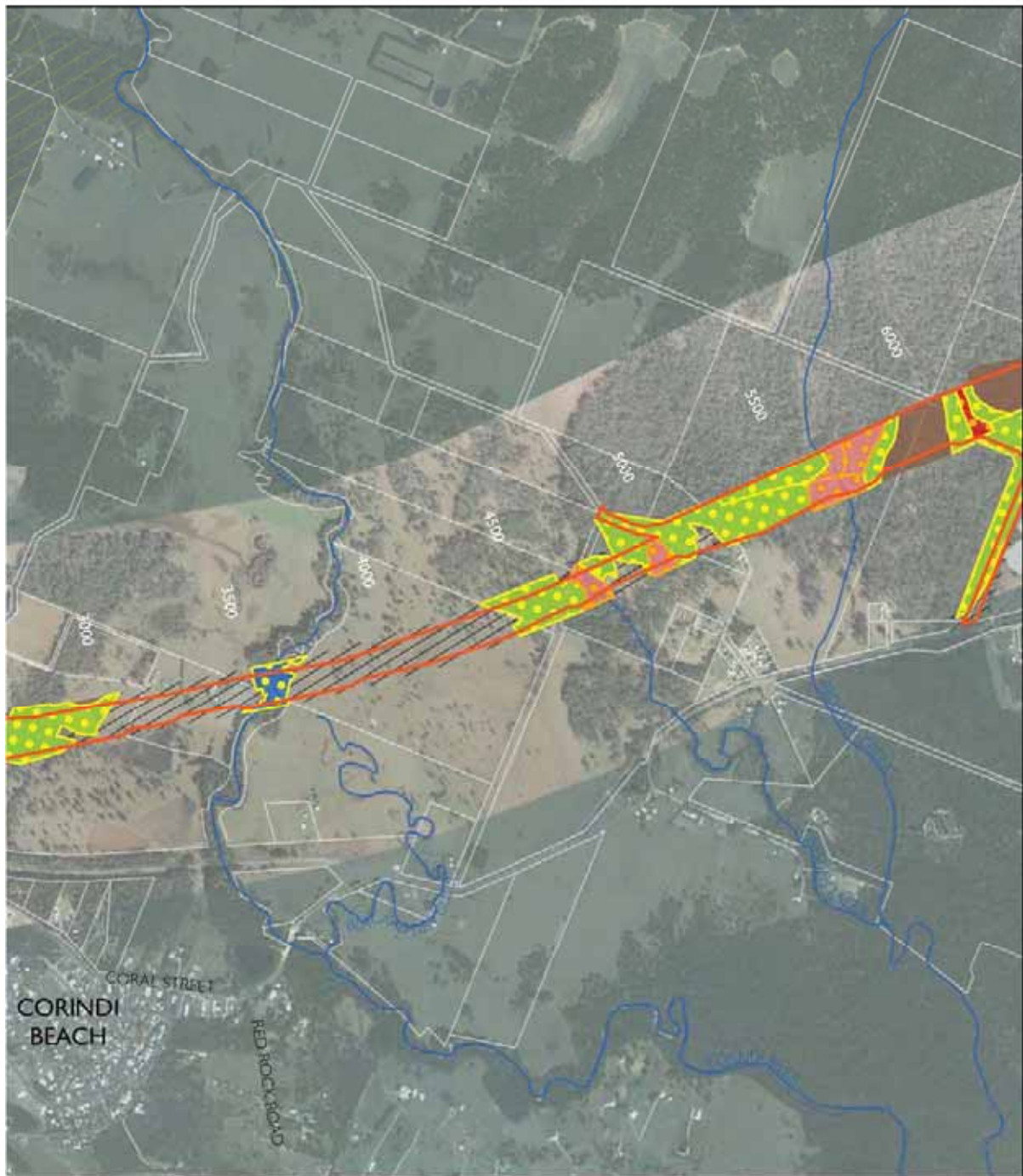
-  Blackbutt grassy open forest of the lower Clarence Valley of the North Coast
-  Swamp Box swamp forest of the coastal lowlands of the North Coast
-  Red Mahogany open forest of the coastal lowlands of the North Coast
-  Narrow-leaved Red Gum woodlands of the lowlands of the North Coast
-  Blackbutt - Paperbark Moist Open Forest

-  Brush Box tall moist forest of the northern ranges of the North Coast
-  Flooded Gum - Tallowwood - Brush Box moist open forest of the coastal ranges of the North Coast
-  Tallowwood dry grassy forest of the far northern ranges of the North Coast
-  Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast
-  Turpentine moist open forest of the coastal hills and ranges of the North Coast
-  Wet heathland and shrubland of coastal lowlands of the North Coast
-  Coastal heath on sands of the North Coast
-  Paperbark swamp forest of the coastal lowlands of the North Coast
-  Swamp Mahogany swamp forest of the coastal lowlands of the North Coast
-  Swamp Oak swamp forest of the coastal lowlands of the North Coast
-  Hoop Pine - Yellow Tulipwood dry rainforest of the North Coast
-  Black Bean - Weeping Lilly Pilly riparian rainforest of the North Coast
-  White Booyong - Fig subtropical rainforest of the North Coast
-  Coastal floodplain sedgelands, rushlands, and forblands
-  Mangrove - Grey Mangrove low closed forest of the NSW Coastal Bioregions
-  Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast
-  Coast Cypress Pine shrubby open forest of the North Coast Bioregion
-  Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast
-  Orange Gum (*Eucalyptus bancroftii*) open forest of the North Coast
-  Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast
-  Scribbly Gum - Needlebark Stringybark heathy open forest of coastal lowlands of the northern North Coast
-  Spotted Gum - Grey Box - Grey Ironbark dry open forest of the Clarence Valley lowlands of the North Coast
-  Needlebark Stringybark - Red Bloodwood heathy woodland on sandstones of the lower Clarence of the North Coast
-  Cleared/modified

Figure 10-3: Legend for ecological communities and threatened flora species



Figure 10-4: Ecological communities and threatened flora species in the study area (Station 0.0 to 6.0)



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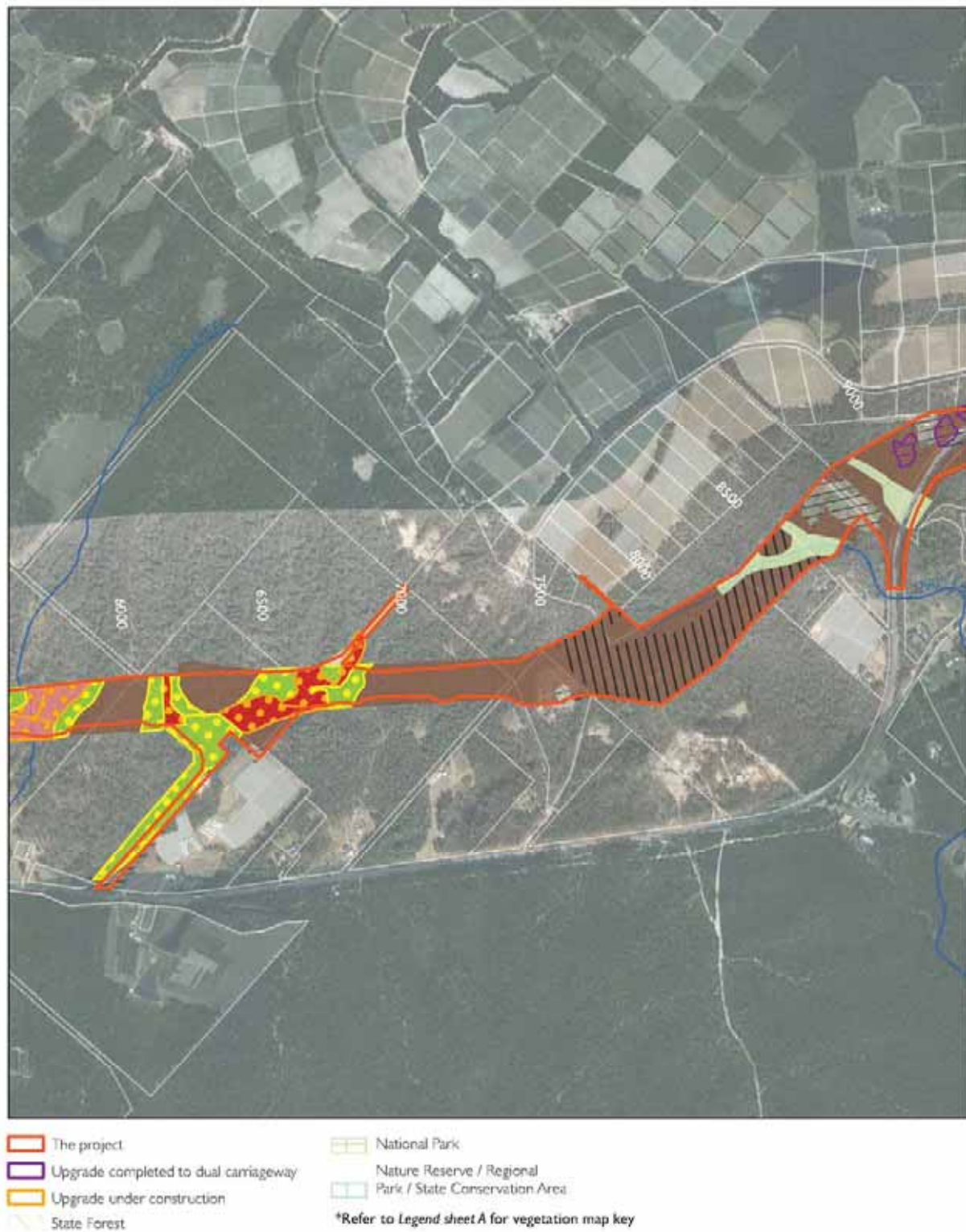
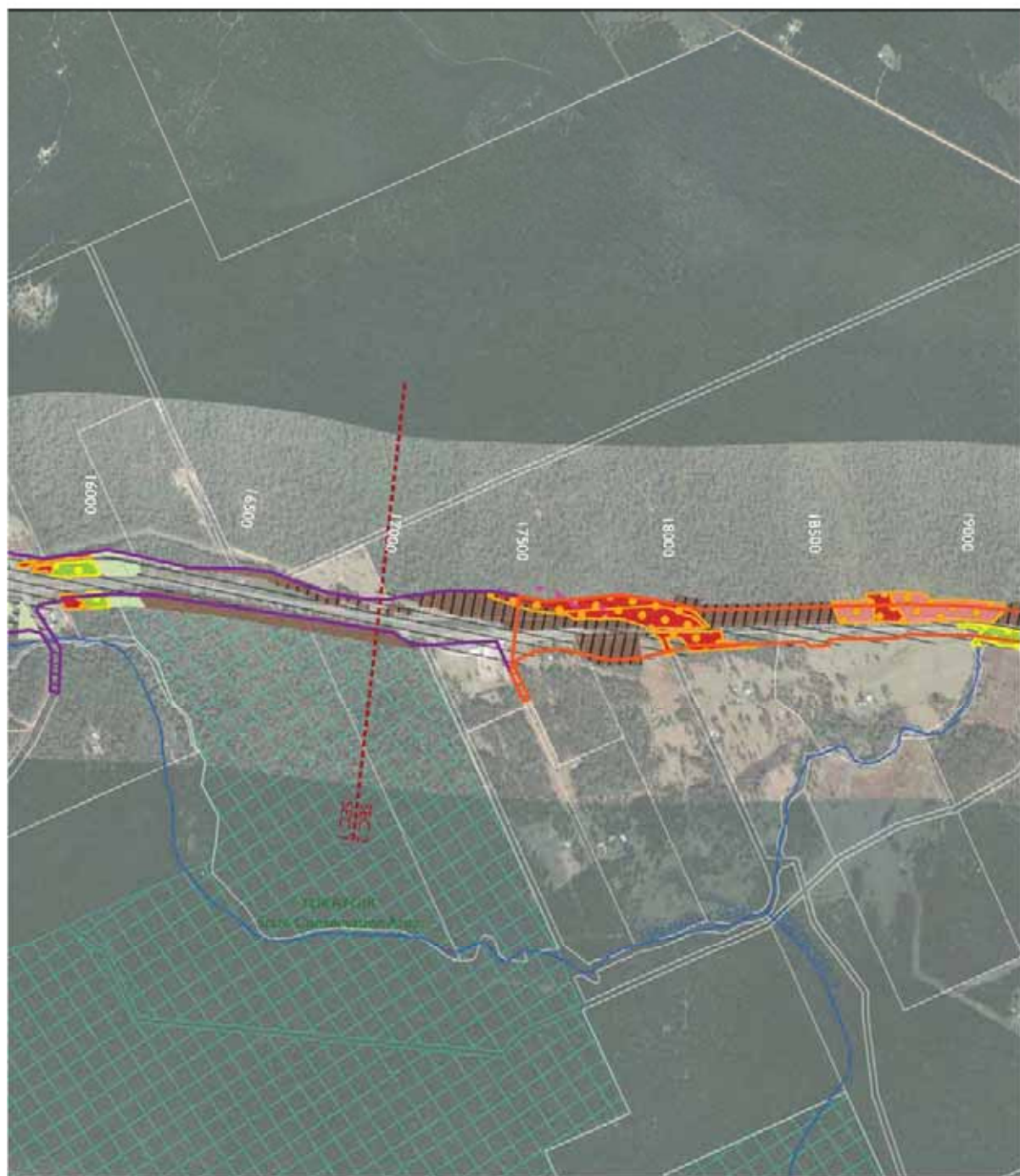


Figure 10-5: Ecological communities and threatened flora species in the study area (Station 6.0 to 12.5)





Figure 10-6: Ecological communities and threatened flora species in the study area (Station 12.5 to 19.0)



0 500
Metres



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Figure 10-7: Ecological communities and threatened flora species in the study area (Station 18.5 to 25.0)

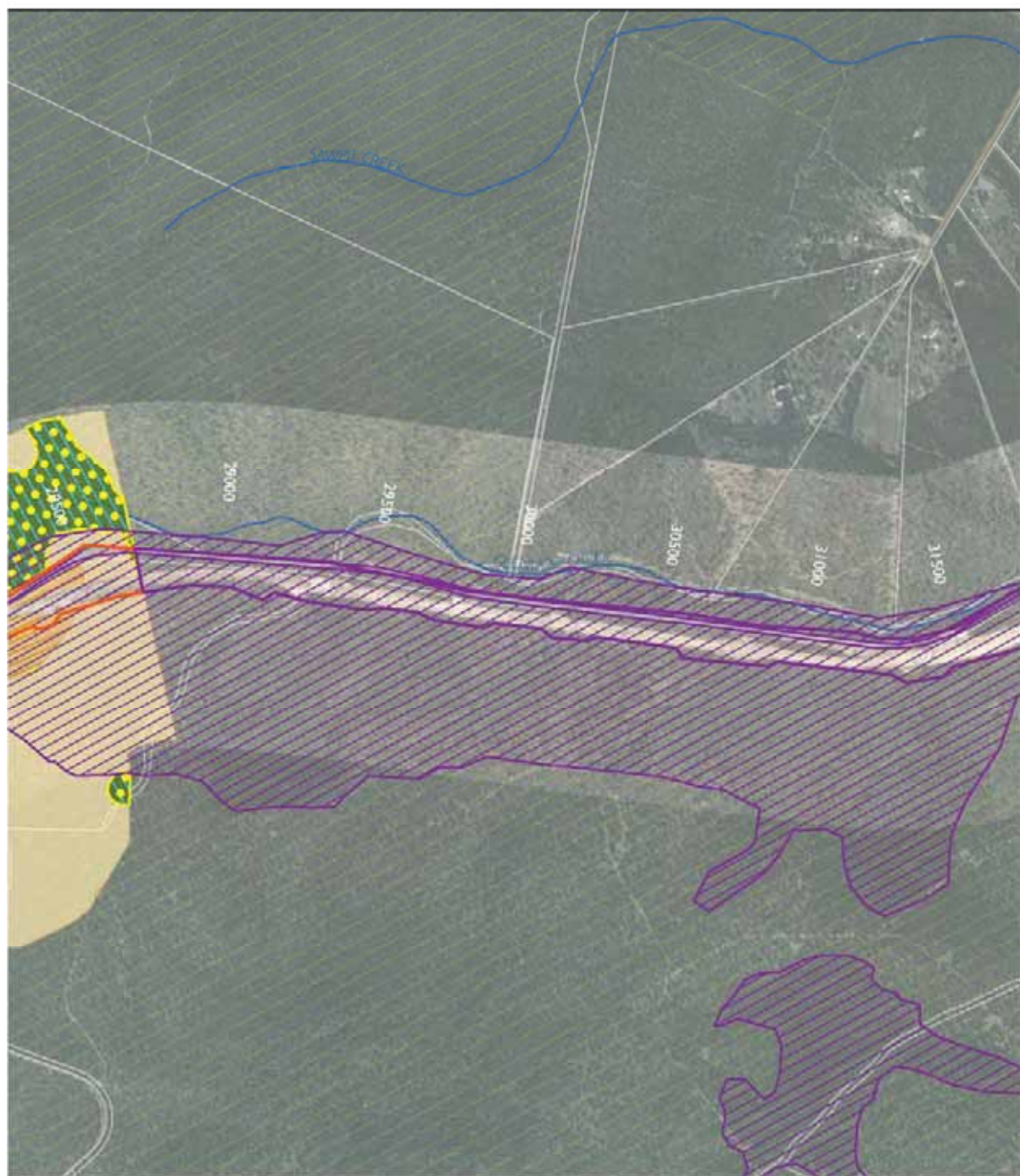


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Figure 10-8: Ecological communities and threatened flora species in the study area (Station 25.0 to 31.5)



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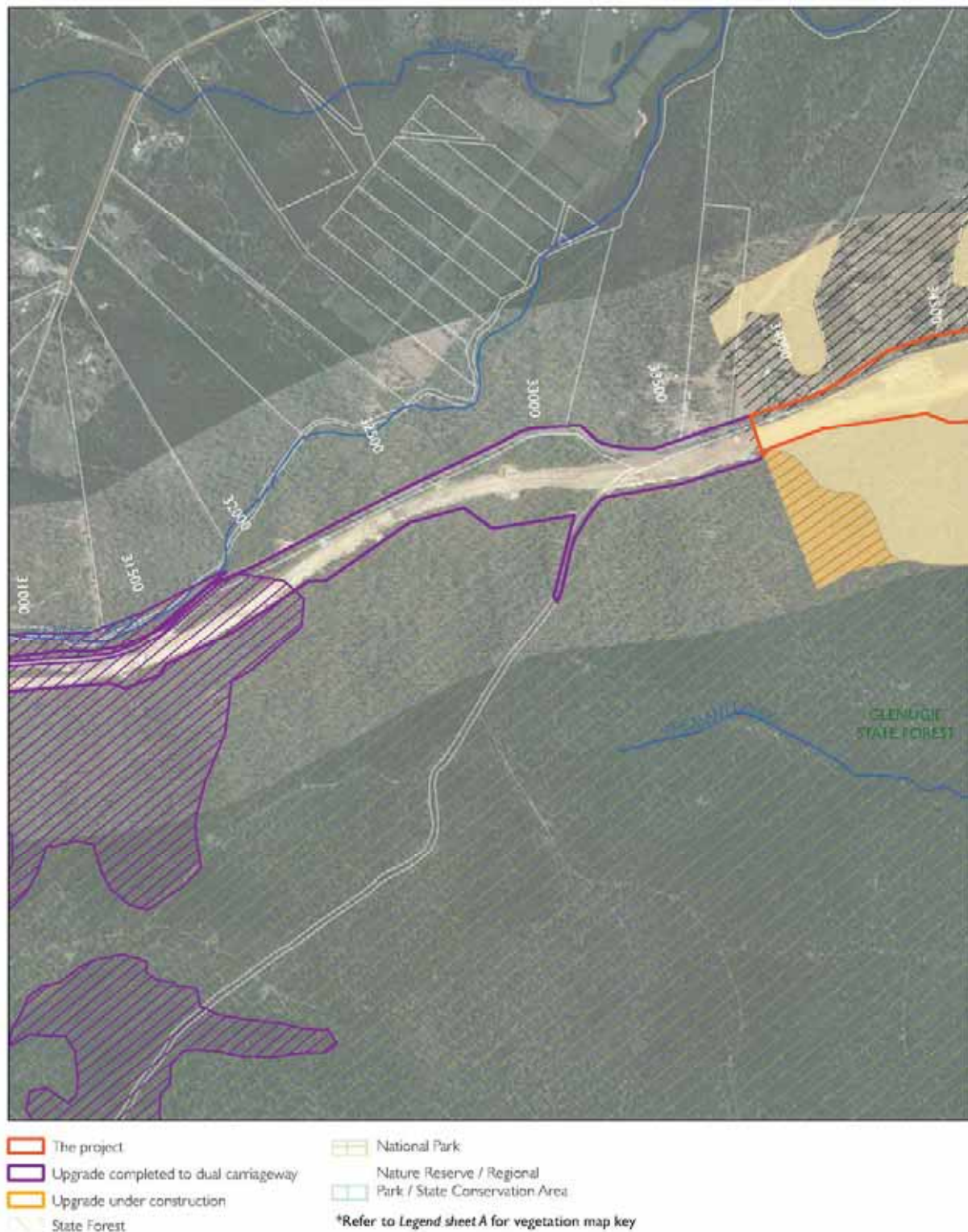
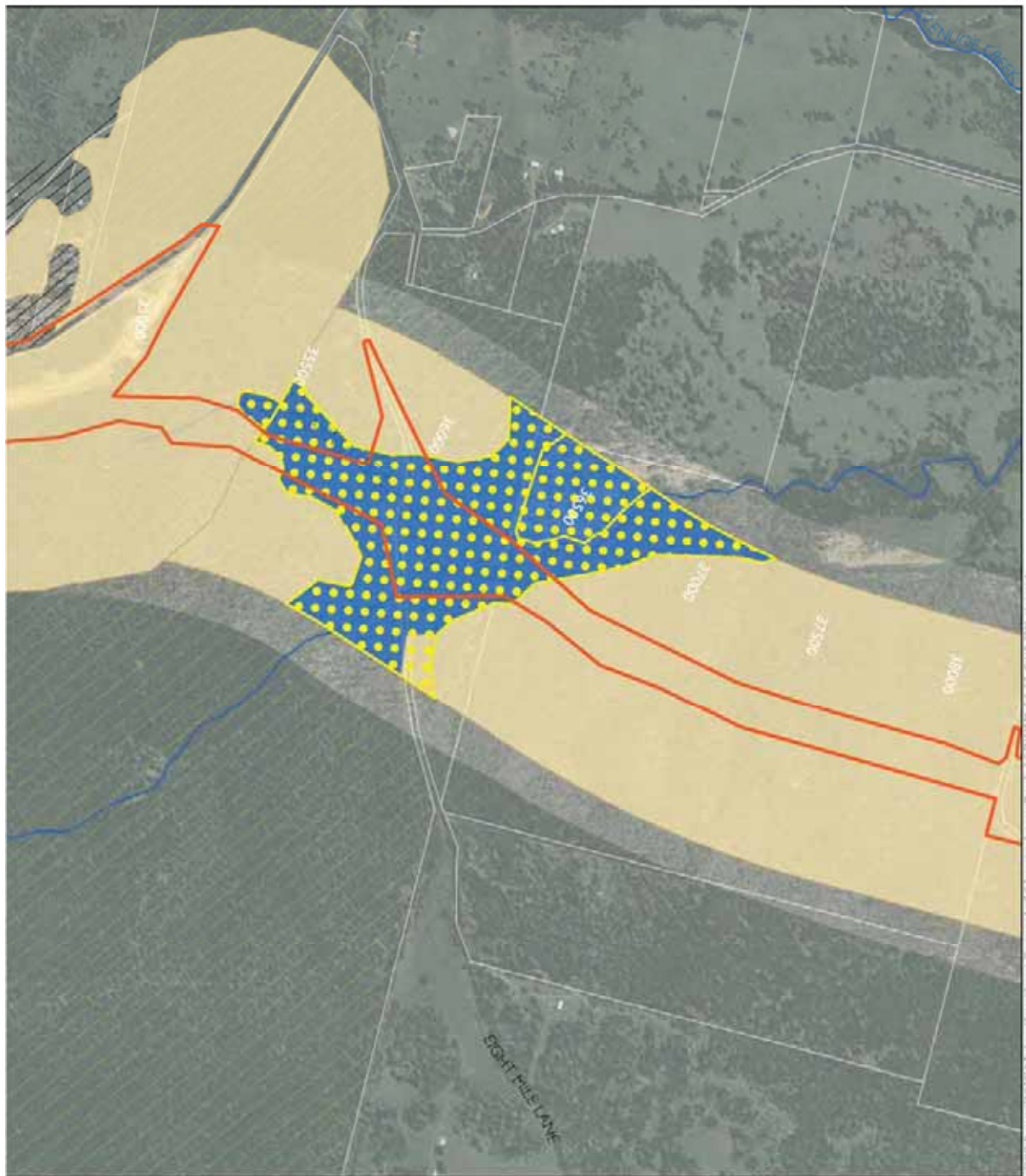


Figure 10-9: Ecological communities and threatened flora species in the study area (Station 31.0 to 38.0)



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Metres

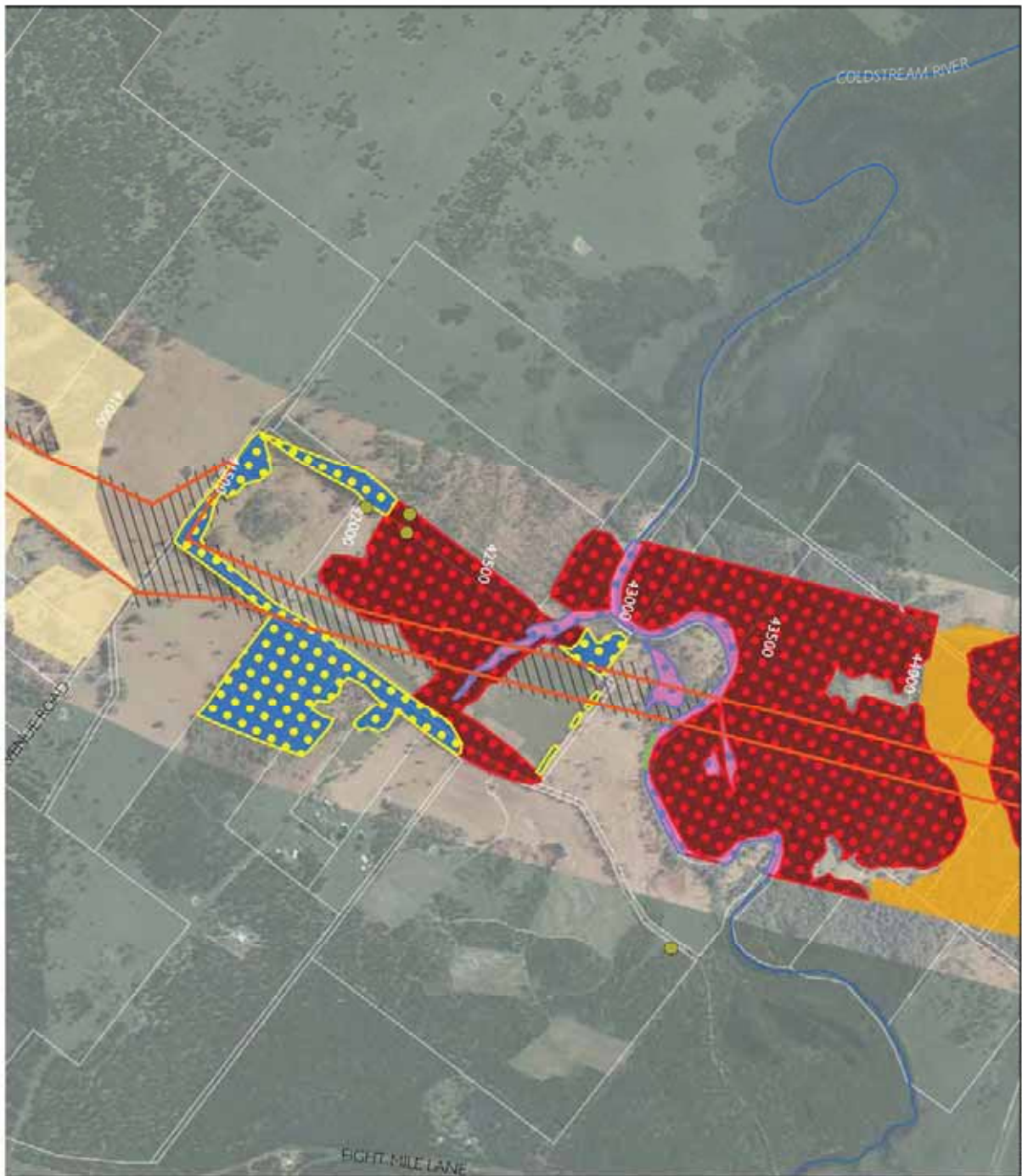


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Figure 10-10: Ecological communities and threatened flora species in the study area (Station 37.0 to 44.0)



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Metres



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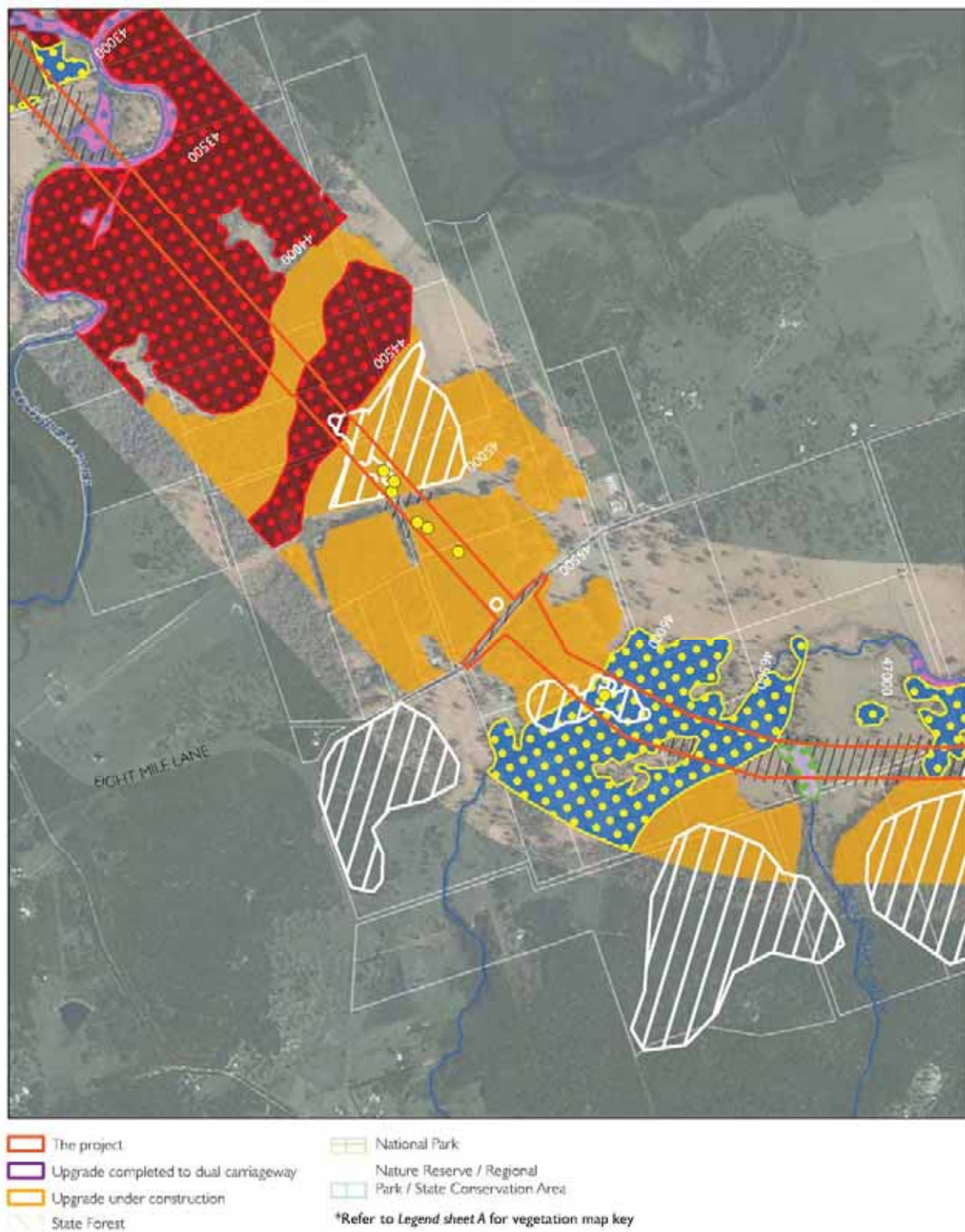


Figure 10-11: Ecological communities and threatened flora species in the study area (Station 43.0 to 51.0)



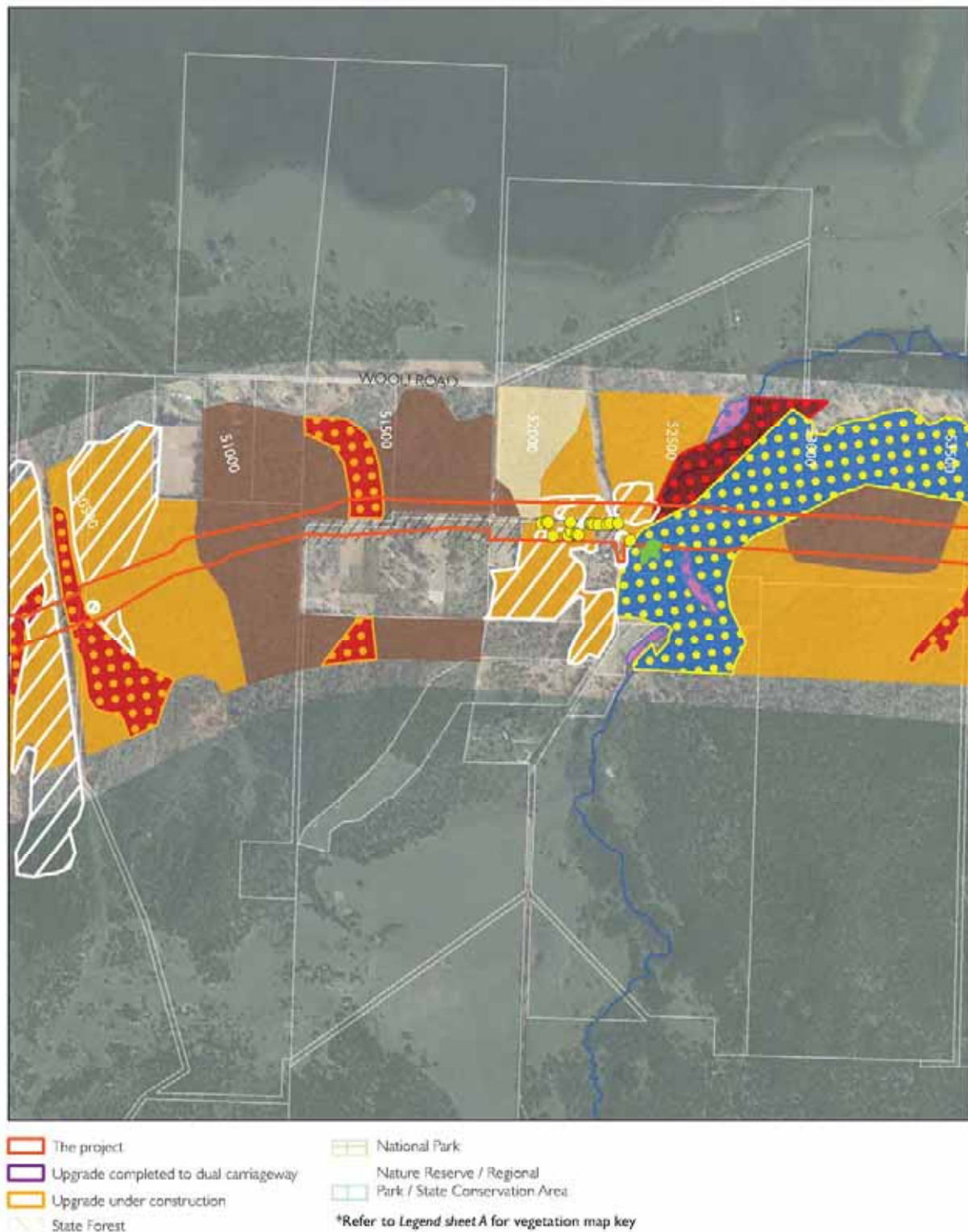
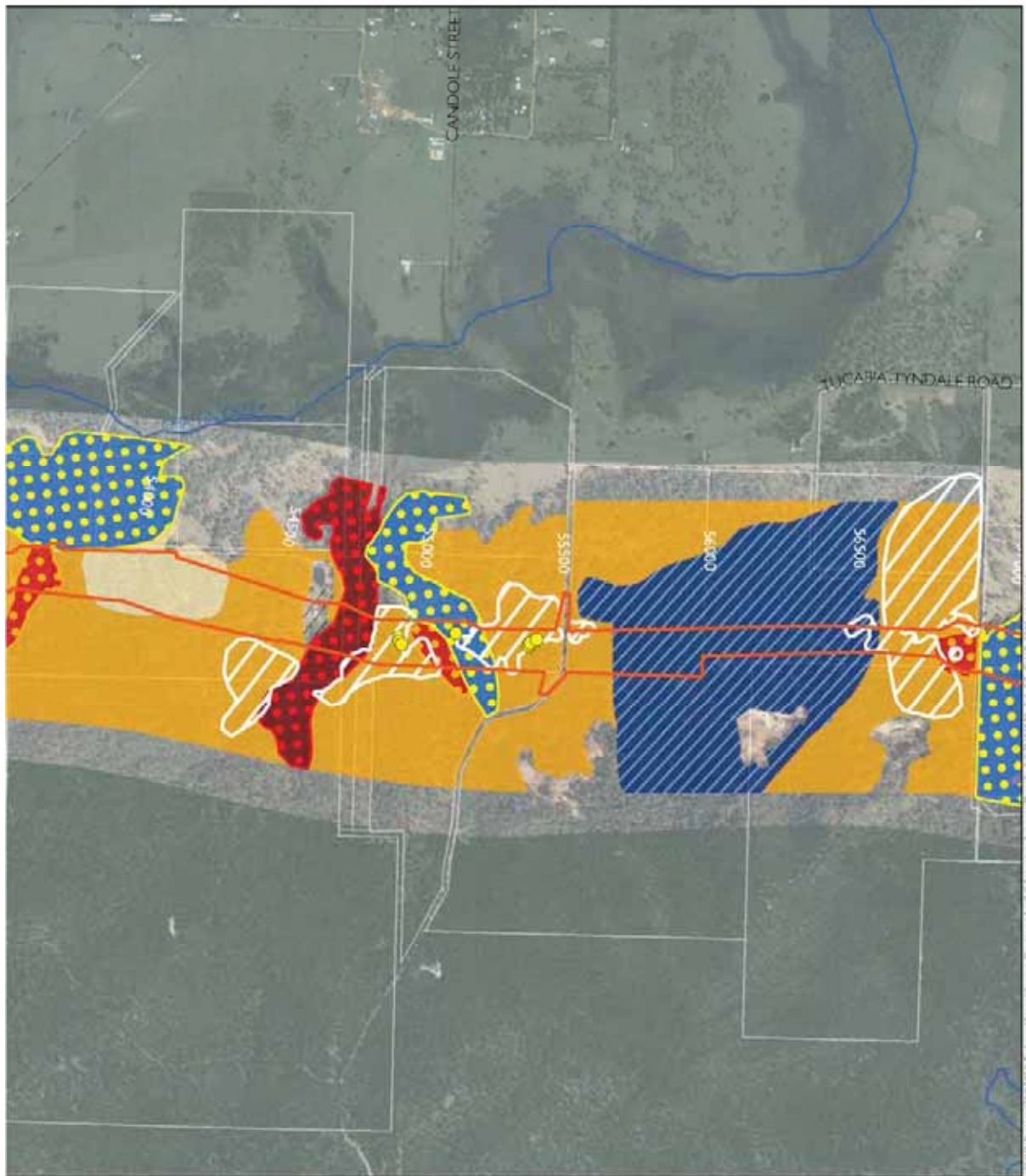


Figure 10-12: Ecological communities and threatened flora species in the study area (Station 50.5 to 56.5)



0 500
Metres



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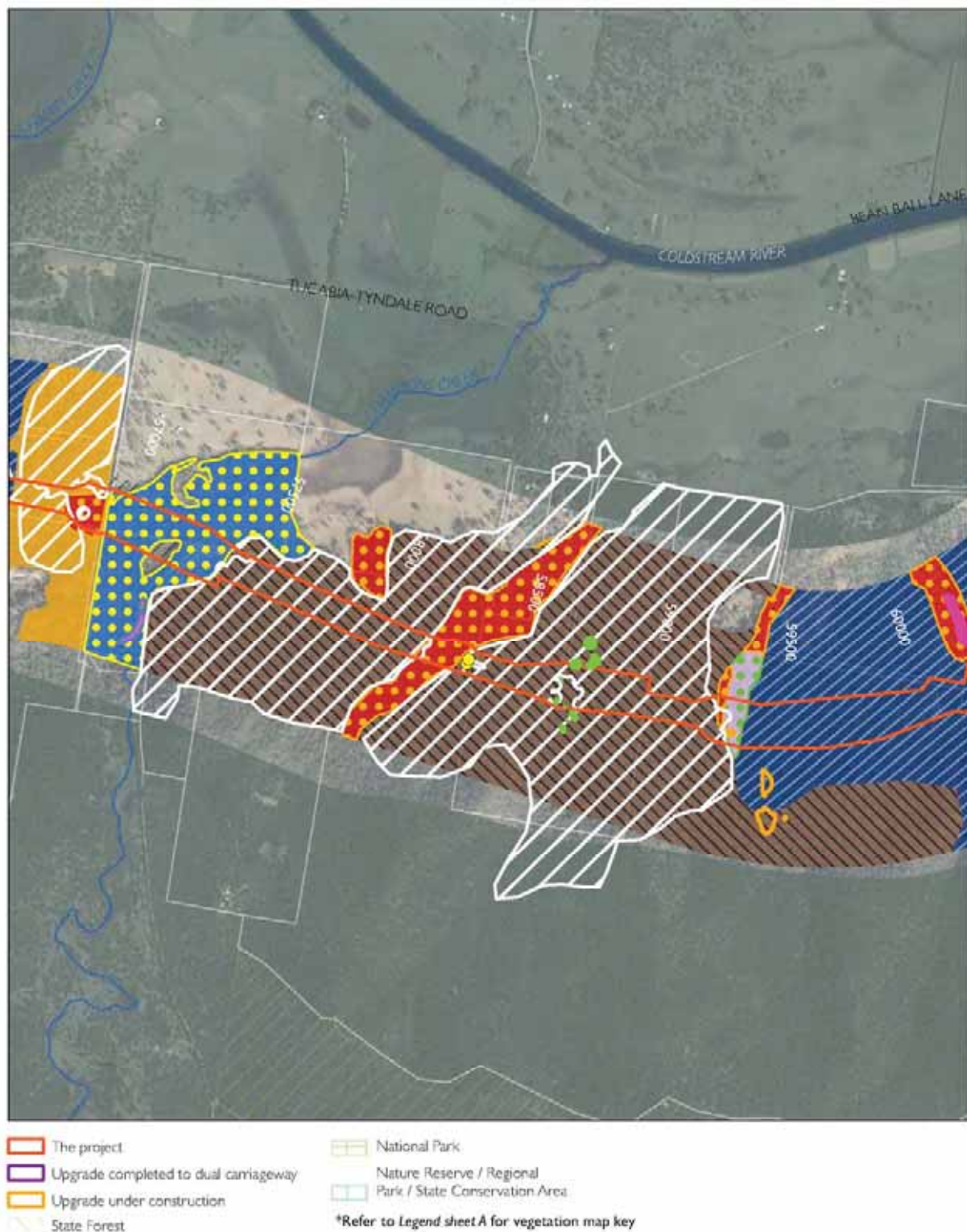
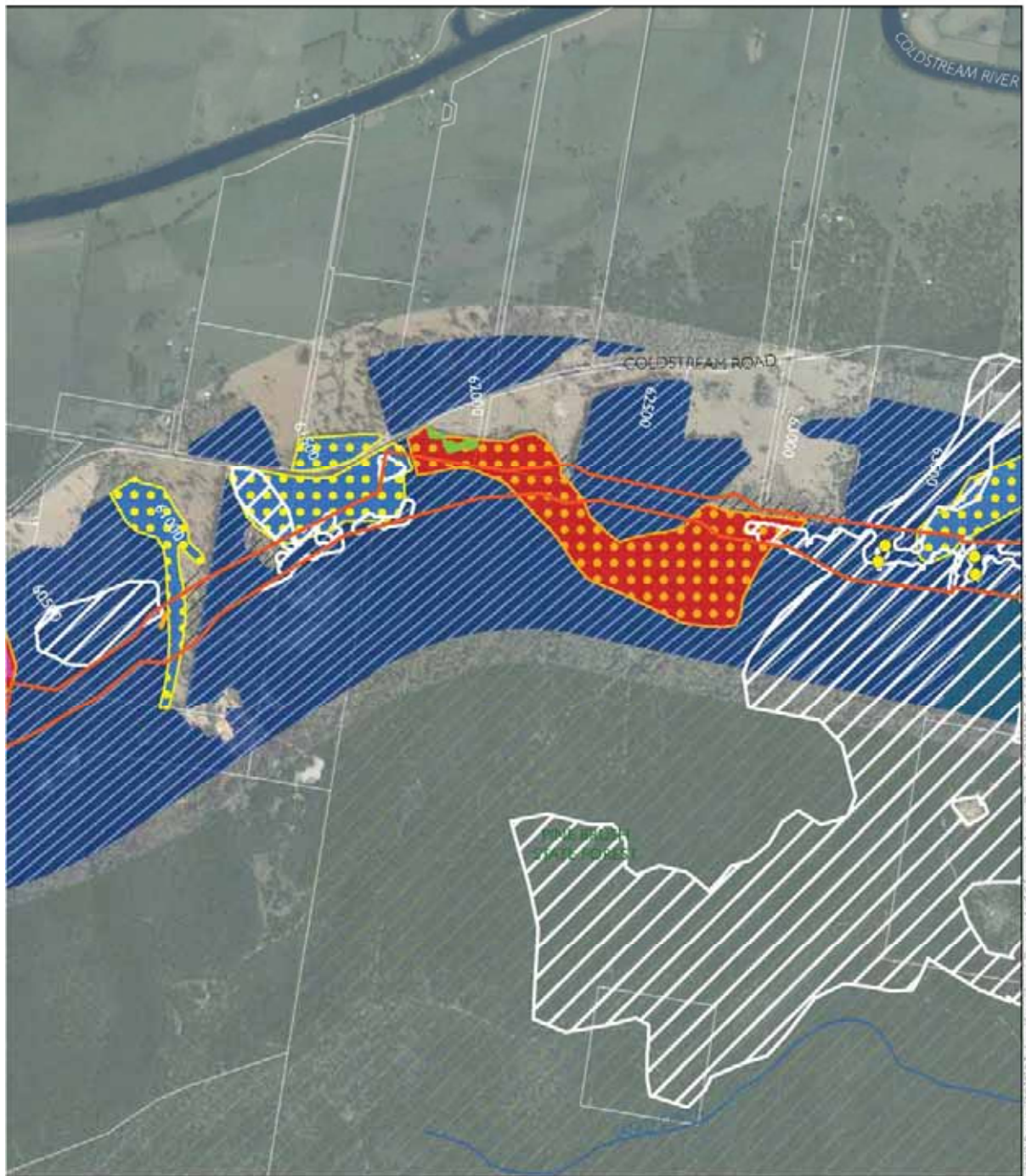


Figure 10-13: Ecological communities and threatened flora species in the study area (Station 57.0 to 63.5)



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Metres

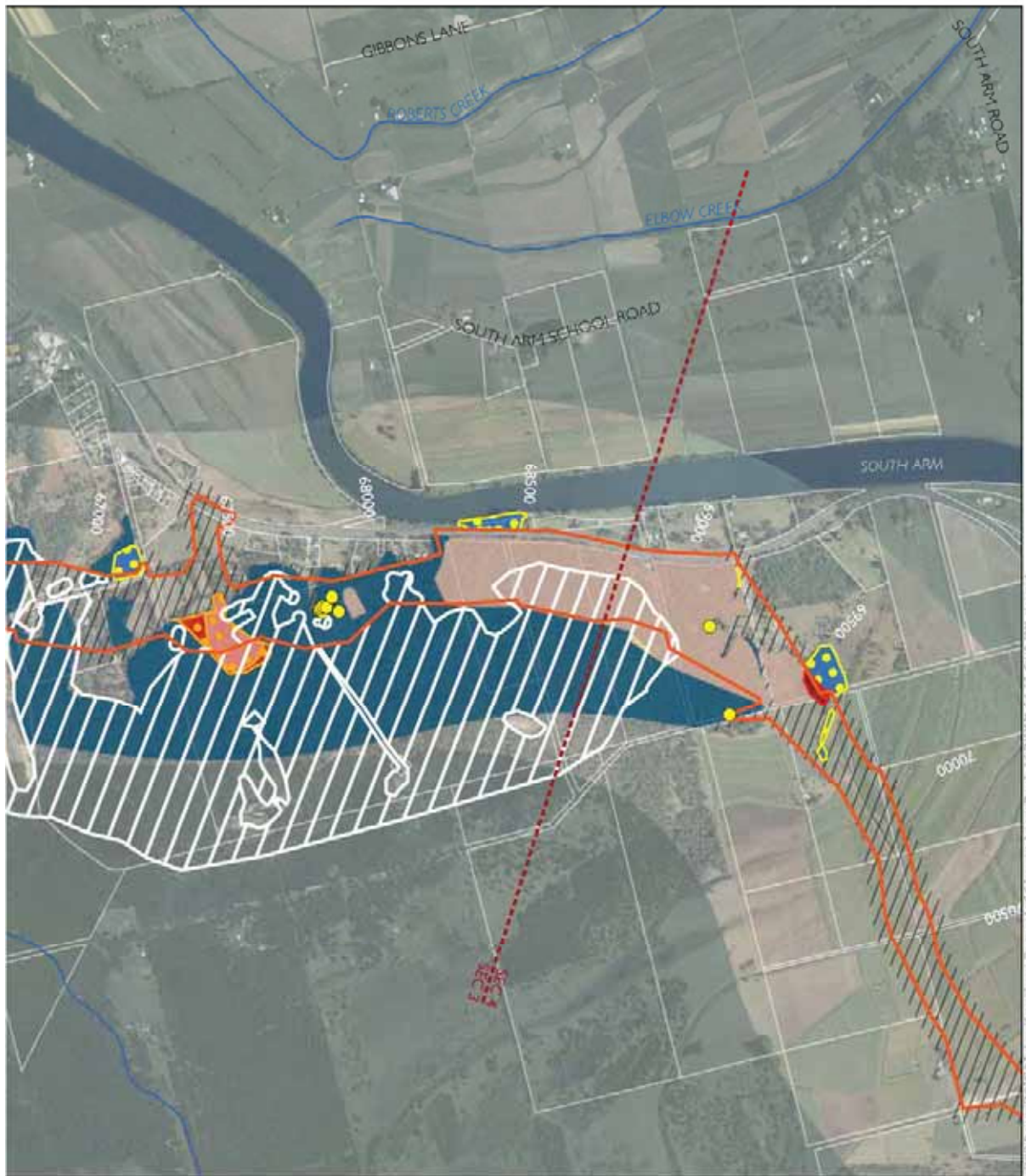


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Figure 10-14: Ecological communities and threatened flora species in the study area (Station 63.5 to 70.0)



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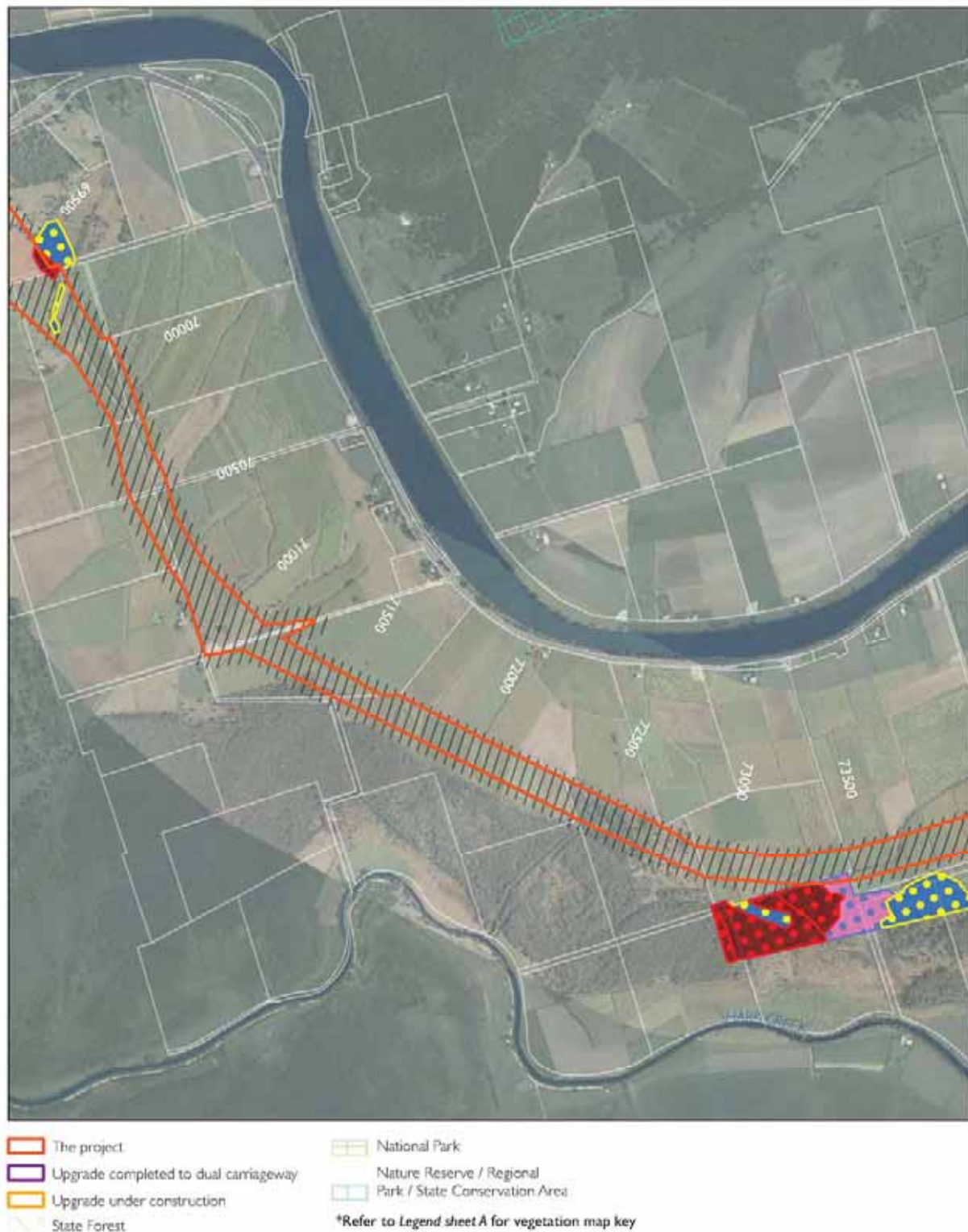
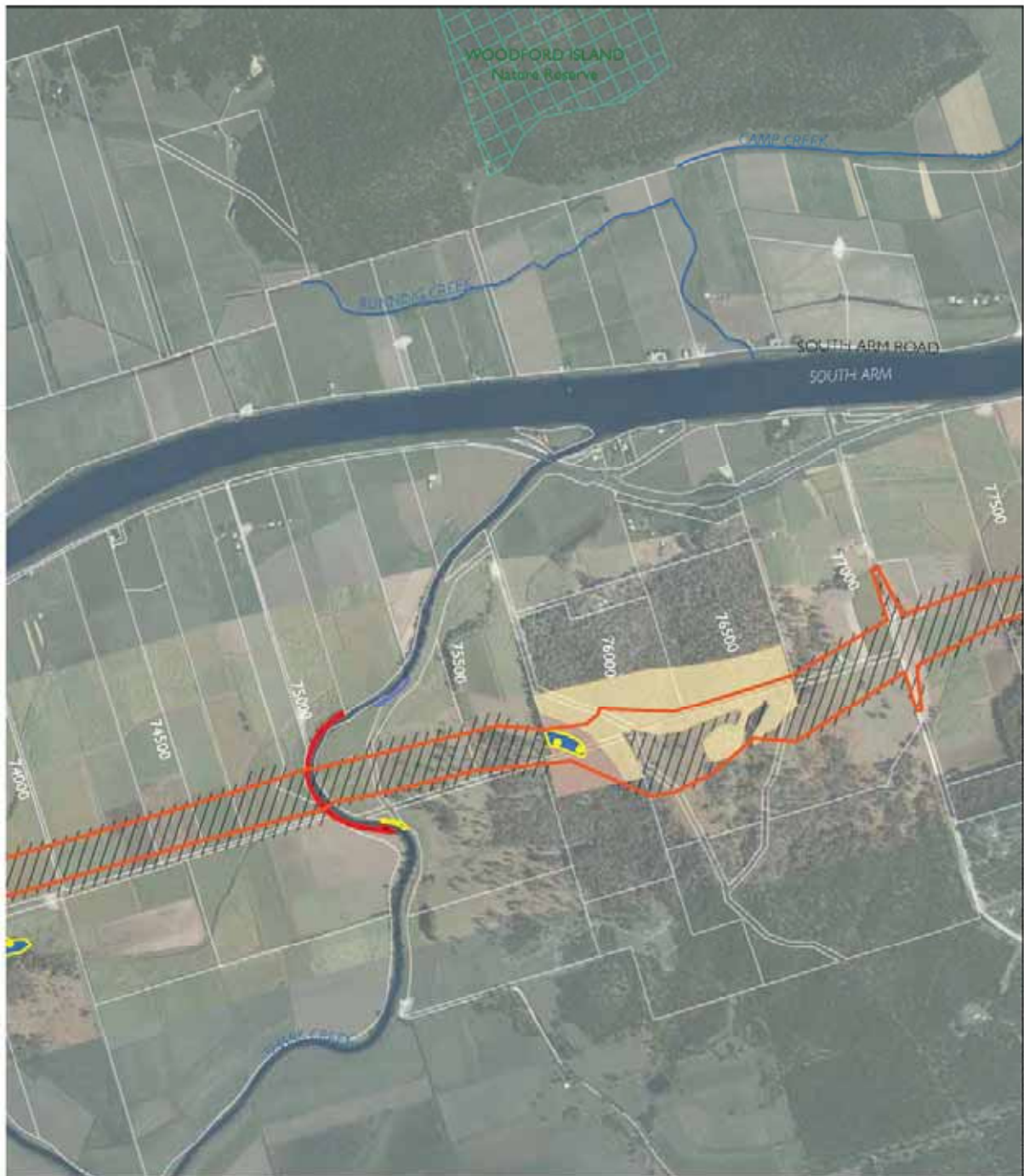


Figure 10-15: Ecological communities and threatened flora species in the study area (Station 69.5 to 77.5)



0 500
Metres



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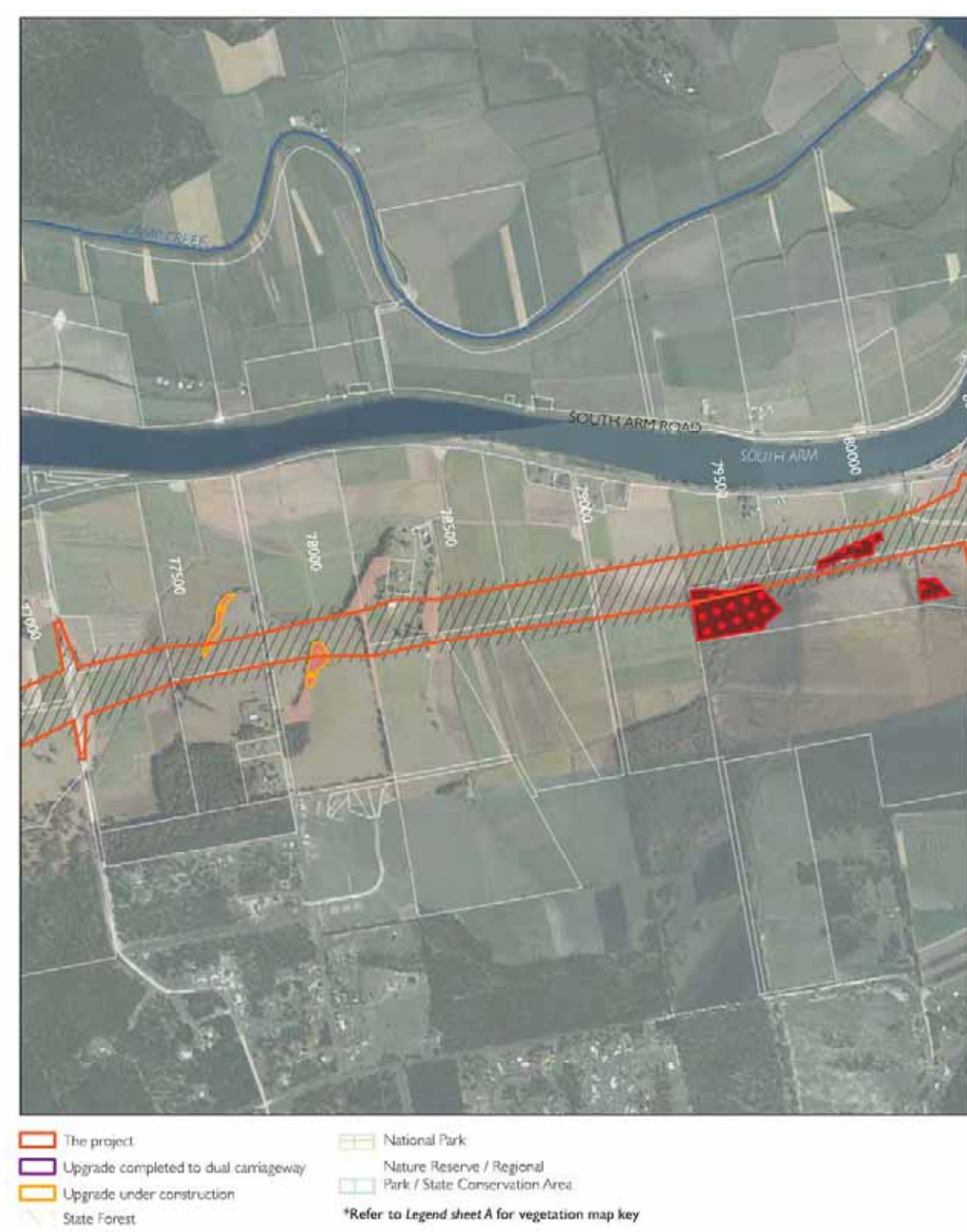


Figure 10-16: Ecological communities and threatened flora species in the study area (Station 77.5 to 83.5)



0 500
Metres



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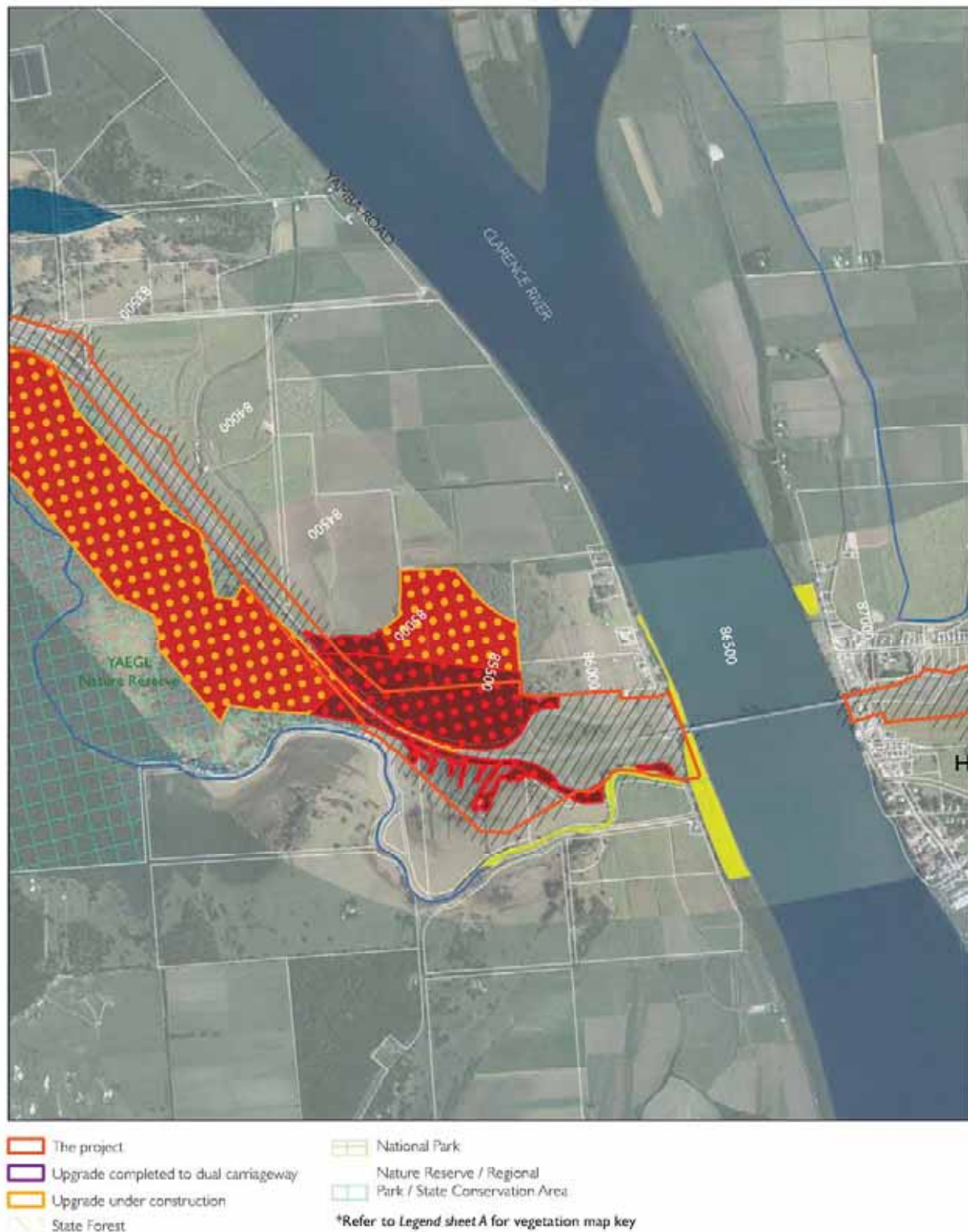


Figure 10-17: Ecological communities and threatened flora species in the study area (Station 83.5 to 90.5)



0 500
Metres



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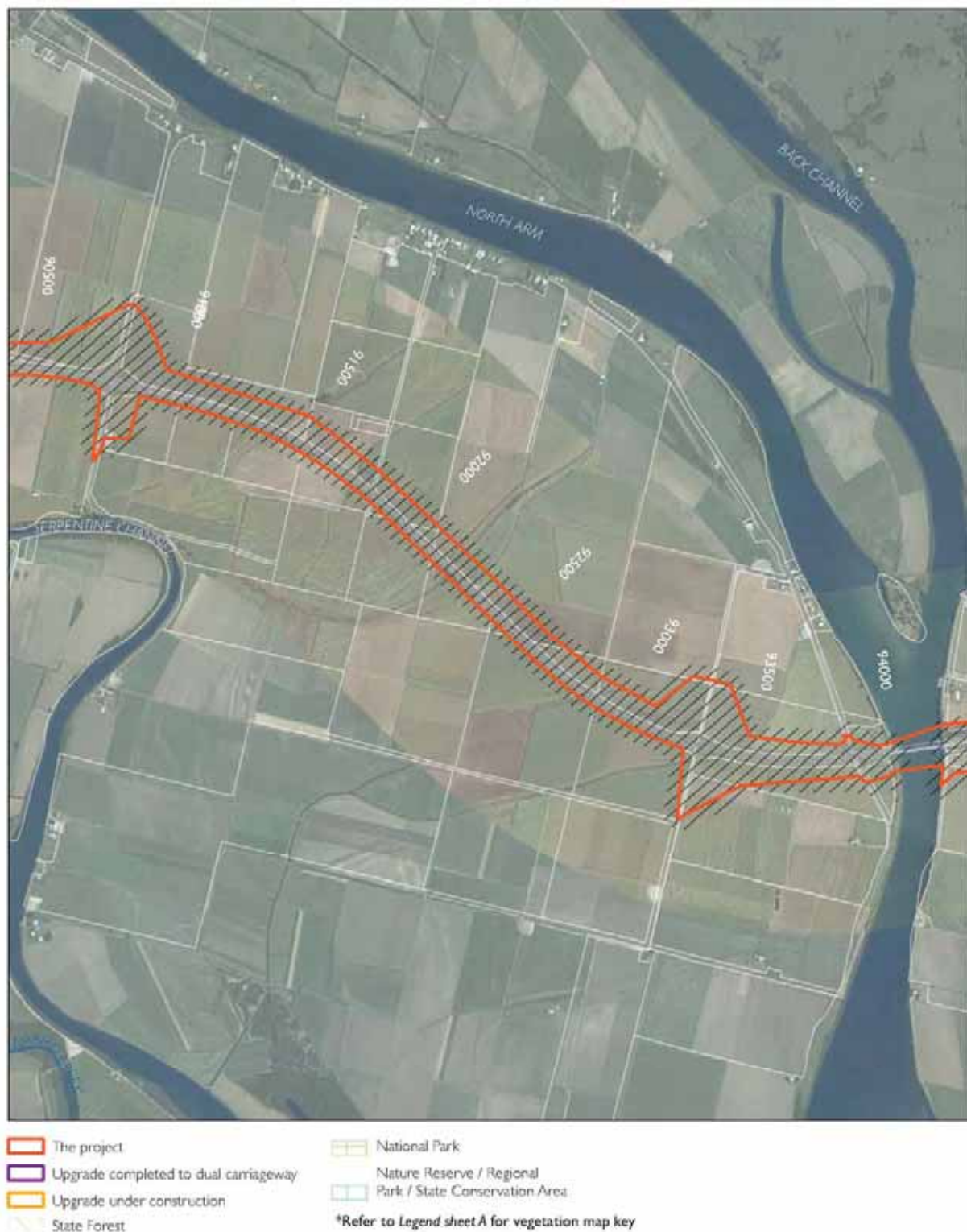
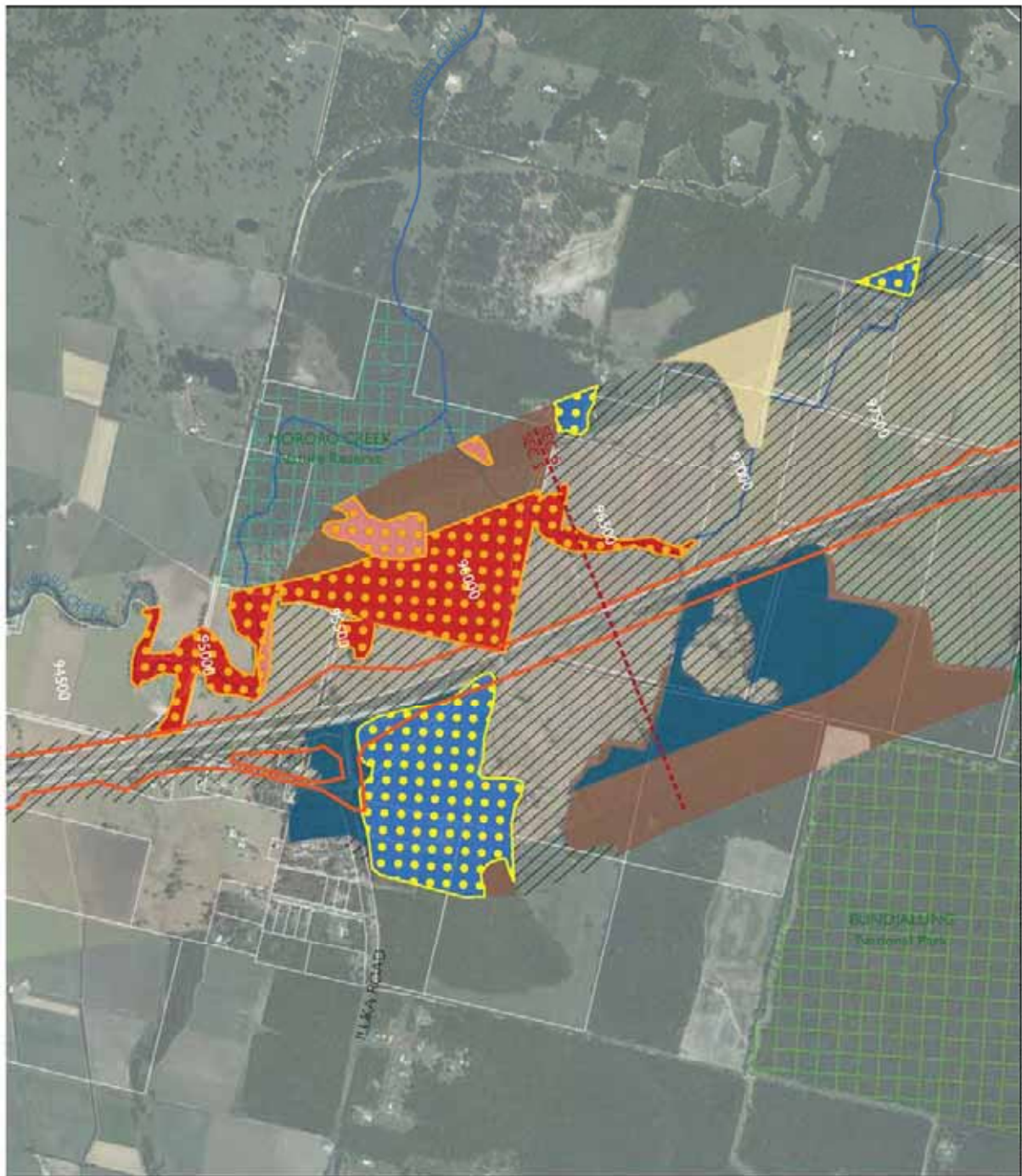


Figure 10-18: Ecological communities and threatened flora species in the study area (Station 90.5 to 97.5)



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Metres



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Figure 10-19: Ecological communities and threatened flora species in the study area (Station 97.5 to 104.0)

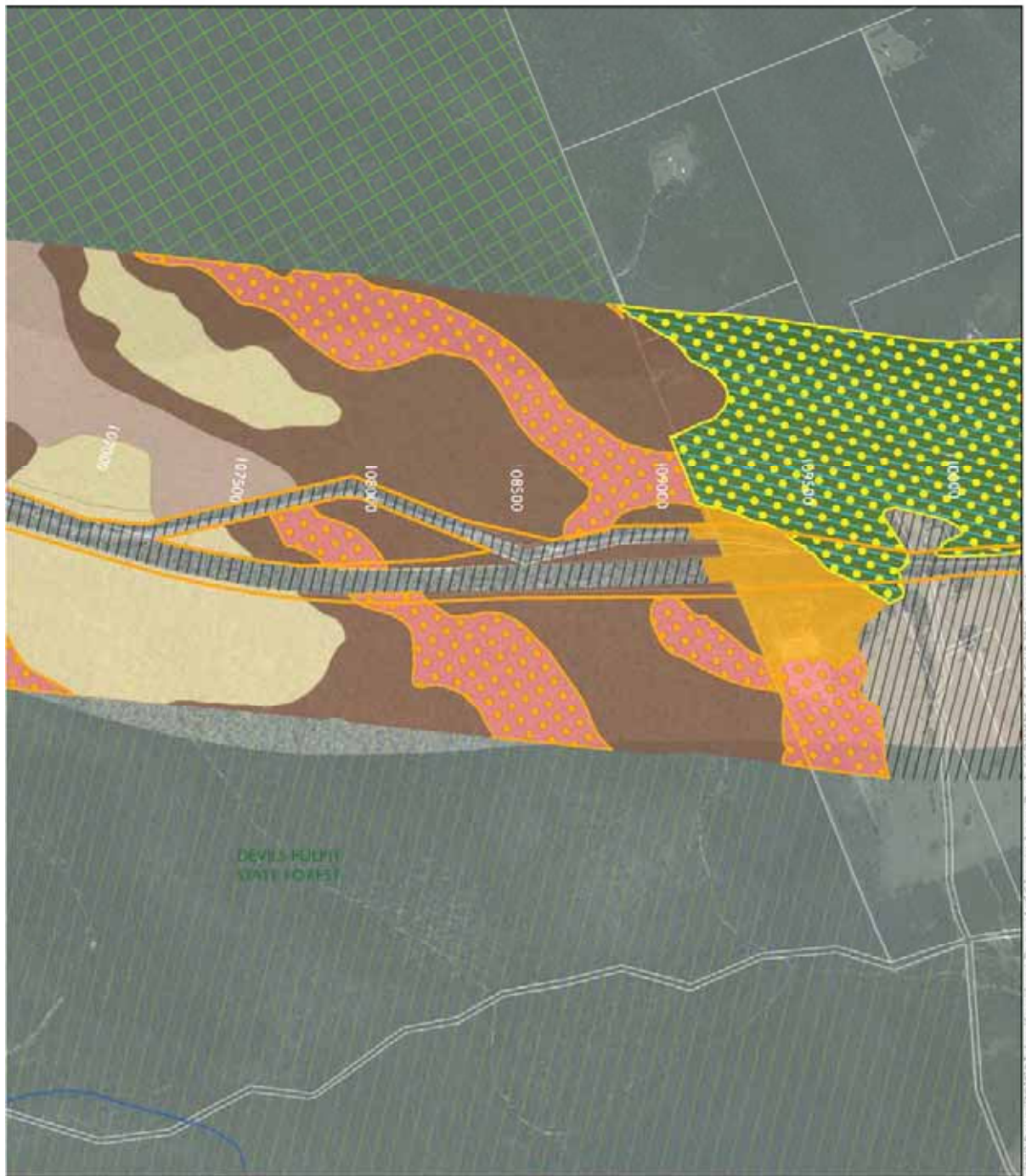


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Figure 10-20: Ecological communities and threatened flora species in the study area (Station 103.5 to 110.0)



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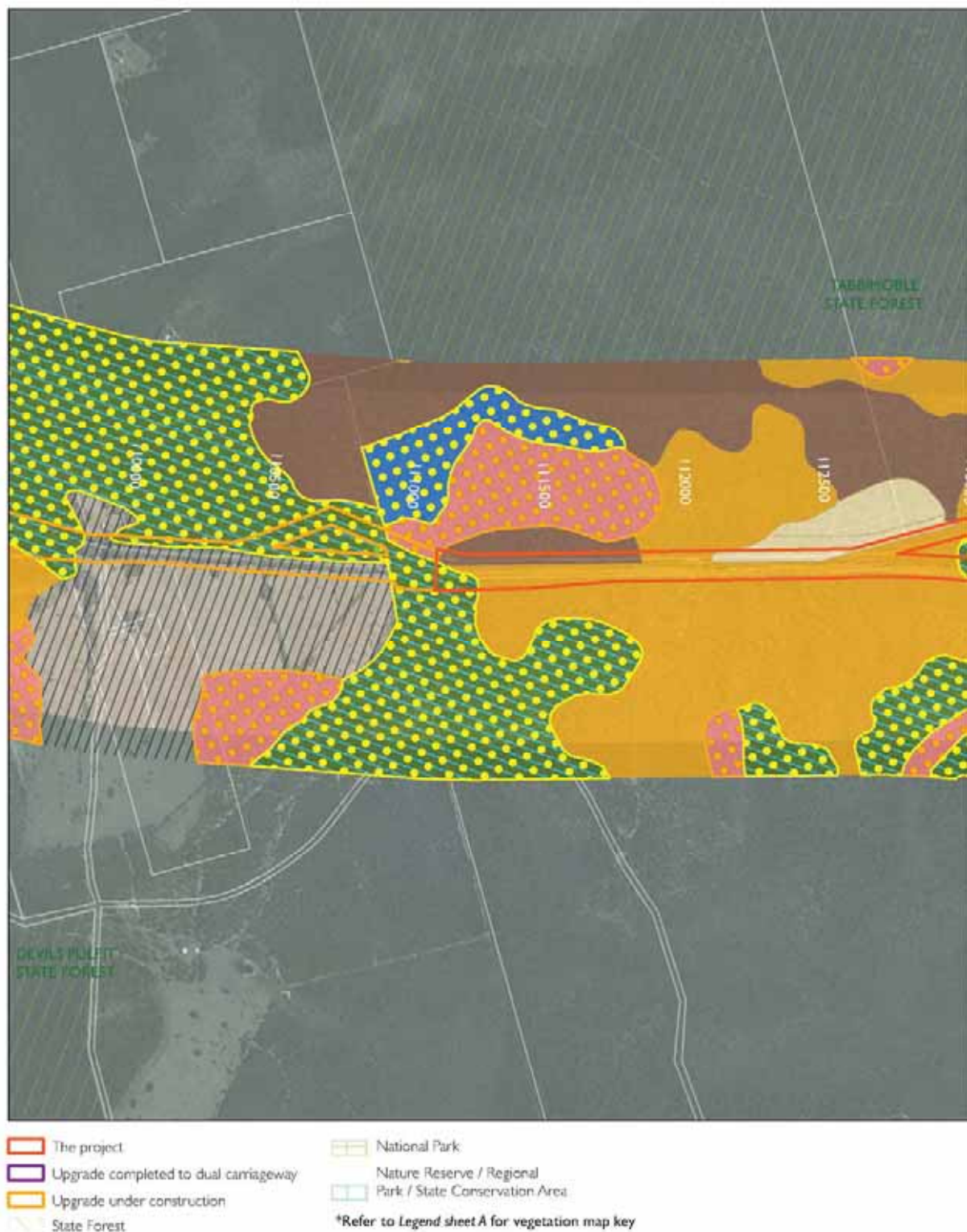


Figure 10-21: Ecological communities and threatened flora species in the study area (Station 110.0 to 116.0)



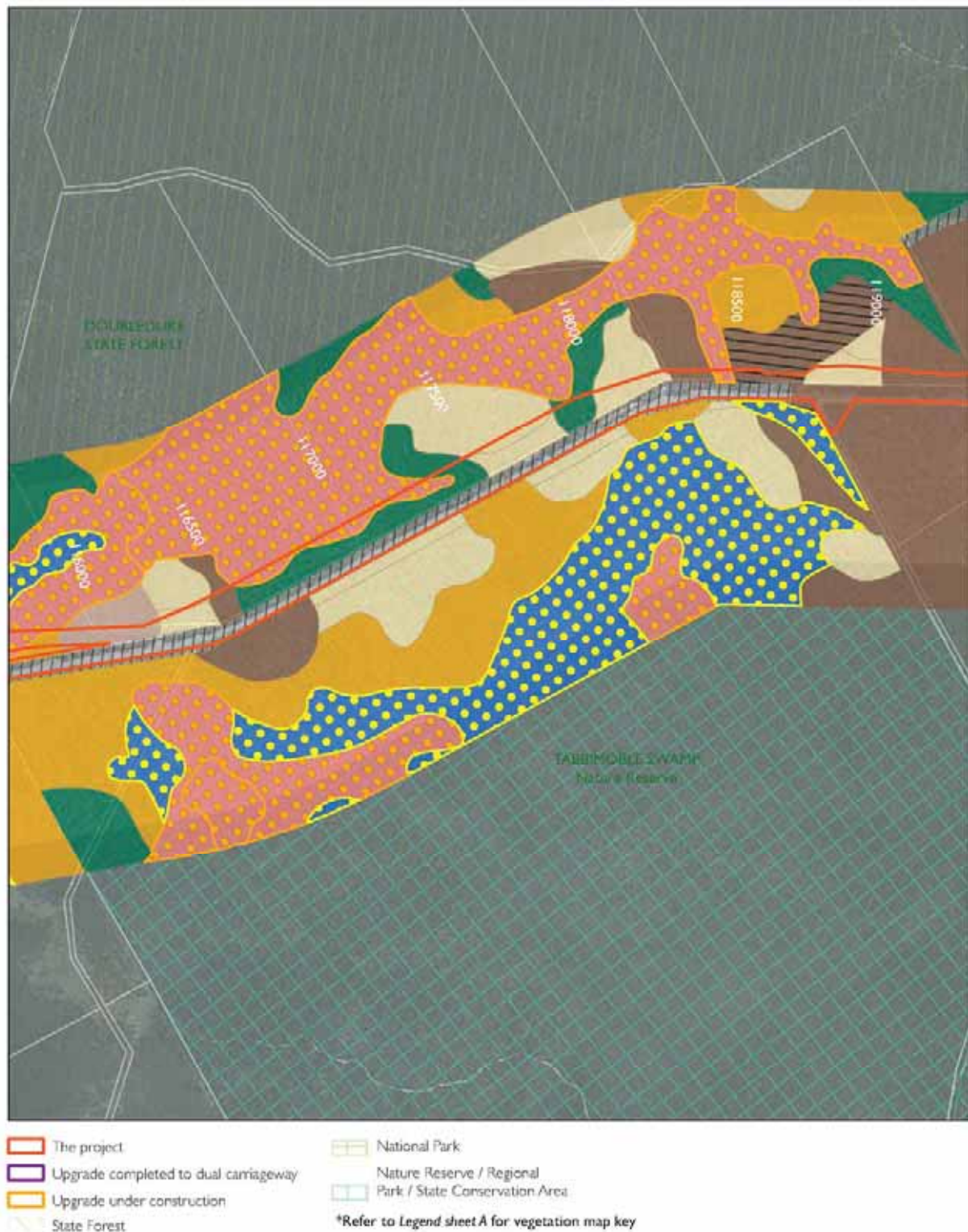
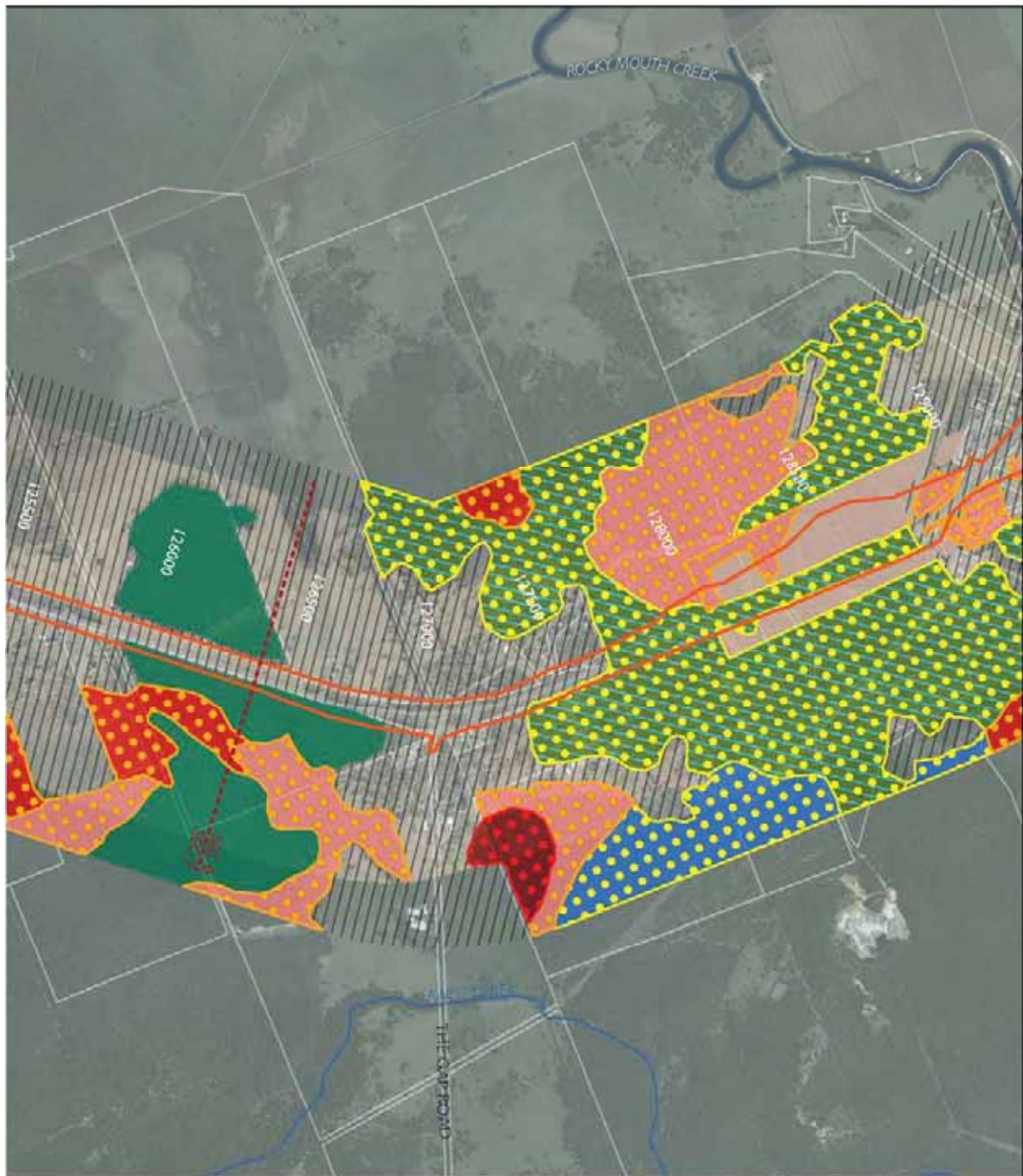


Figure 10-22: Ecological communities and threatened flora species in the study area (Station 116.0 to 122.5)





Figure 10-23: Ecological communities and threatened flora species in the study area (Station 122.0 to 129.0)



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Metres



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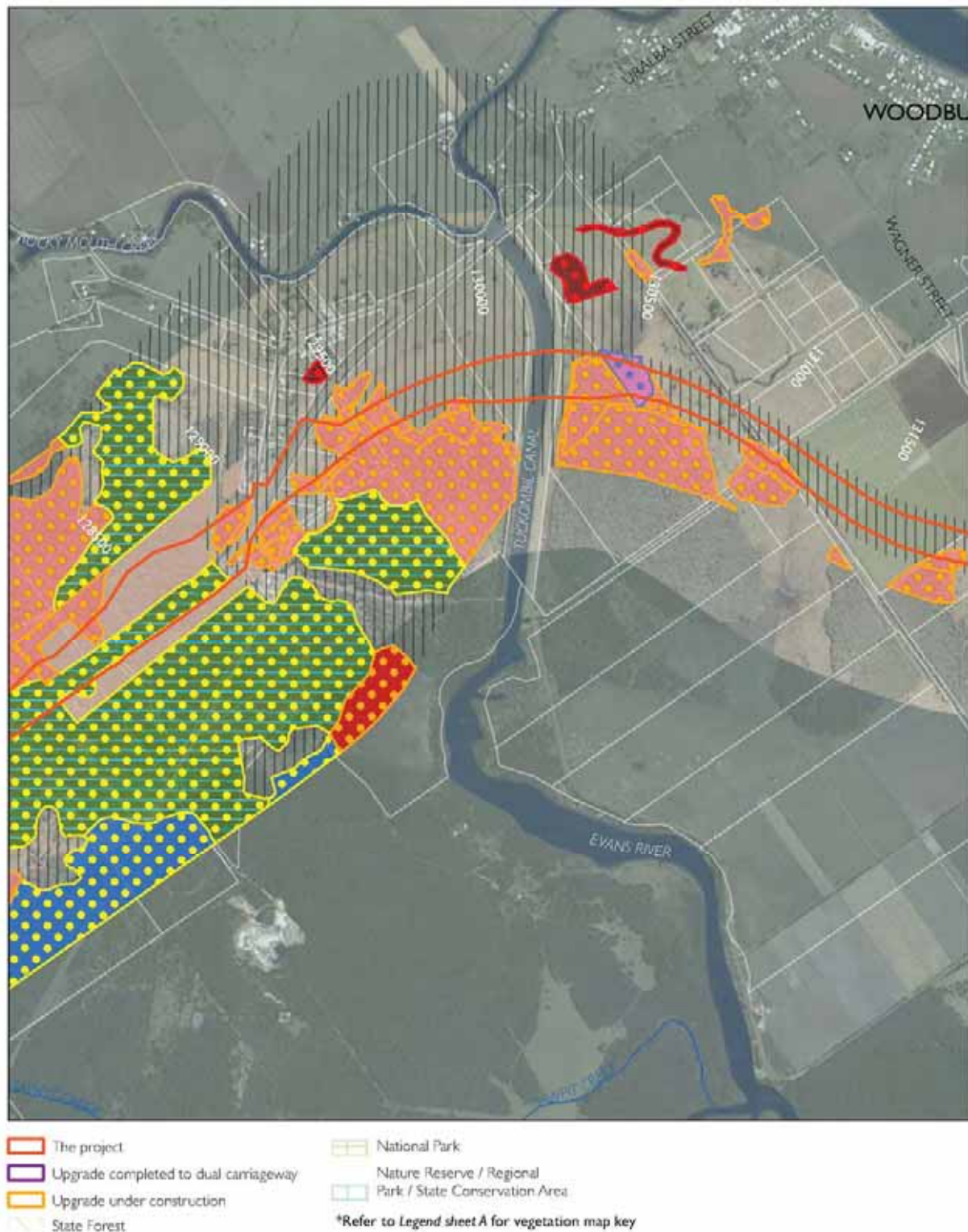
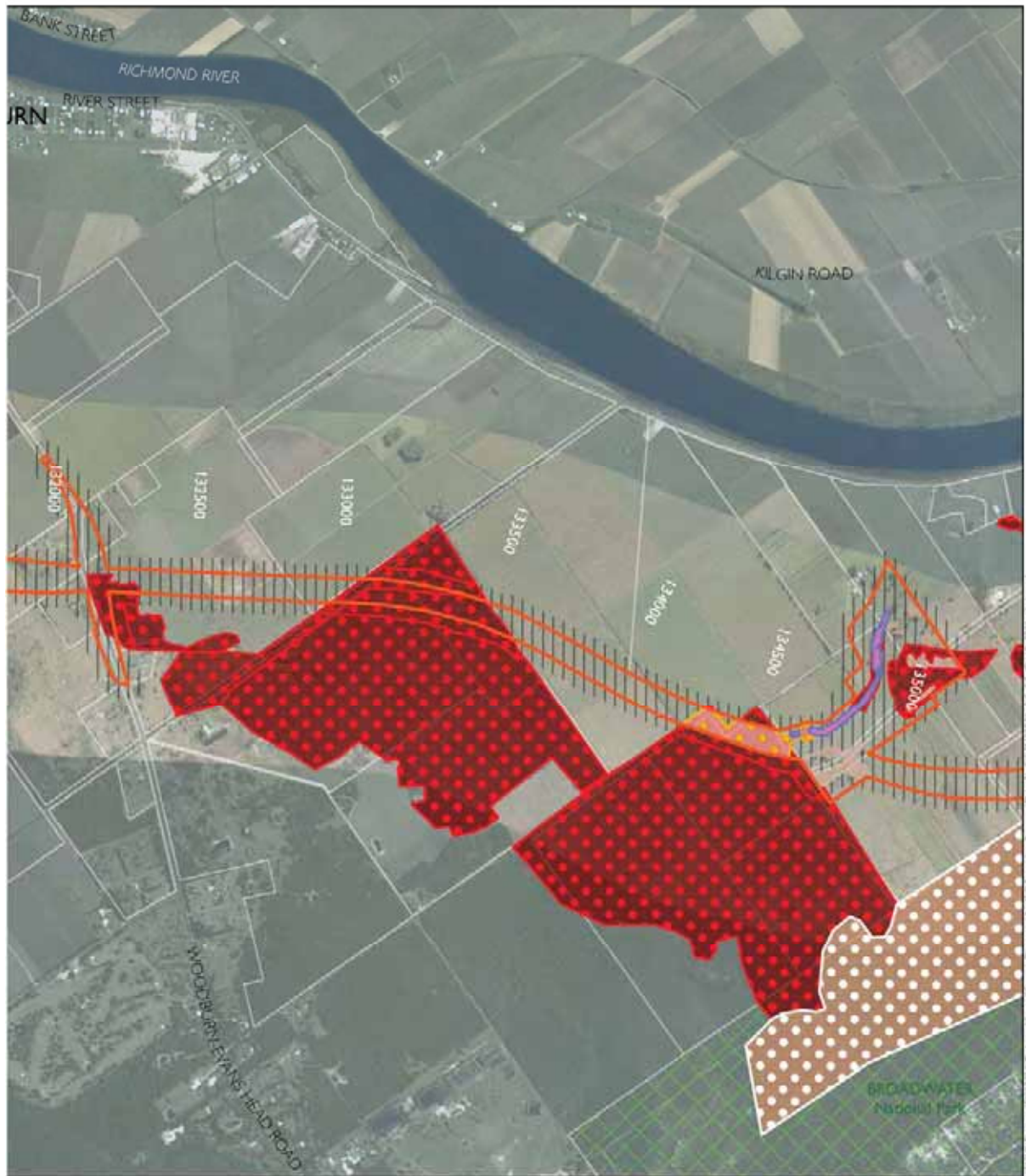


Figure 10-24: Ecological communities and threatened flora species in the study area (Station 128.5 to 135.0)



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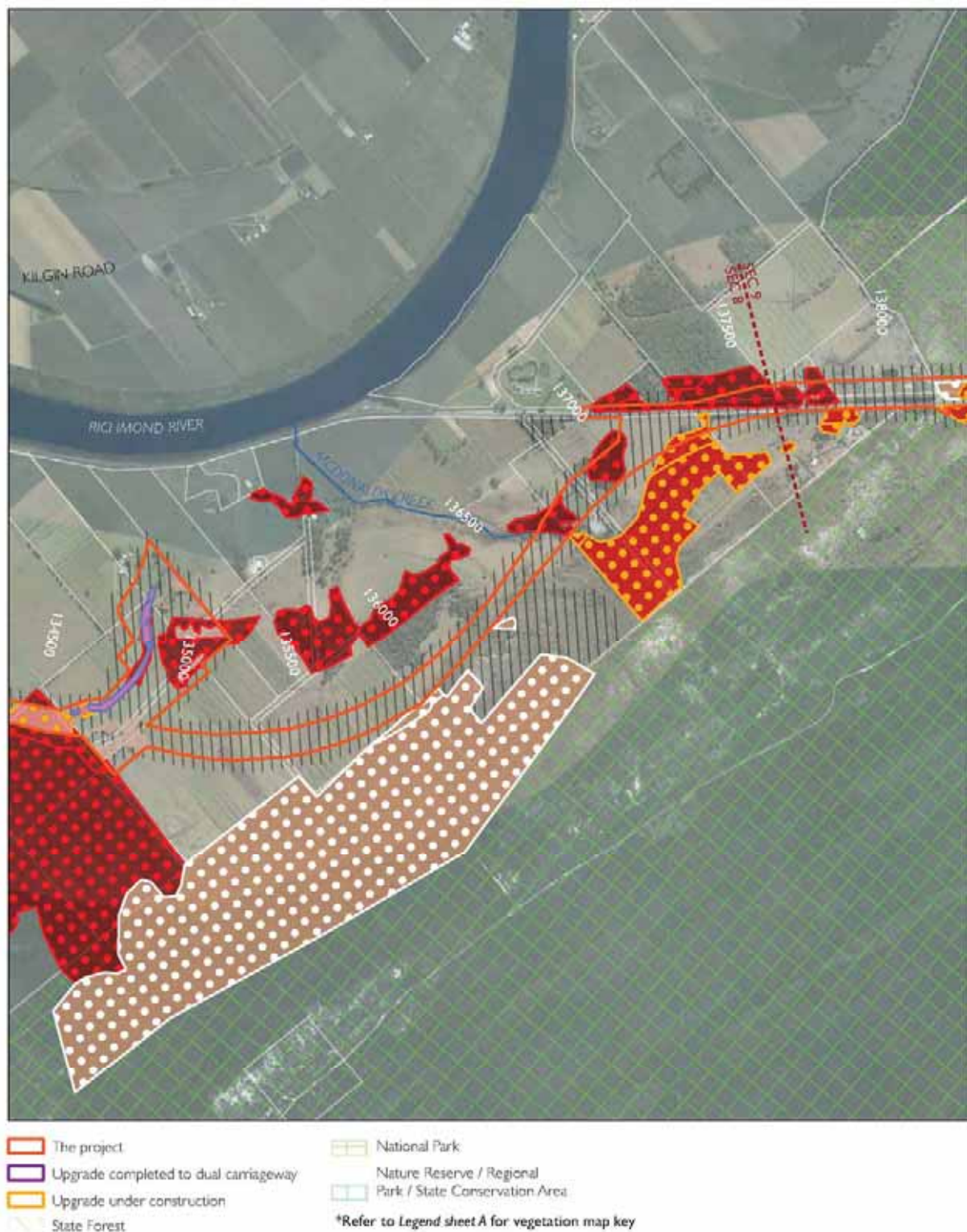


Figure 10-25: Ecological communities and threatened flora species in the study area (Station 134.5 to 141.5)



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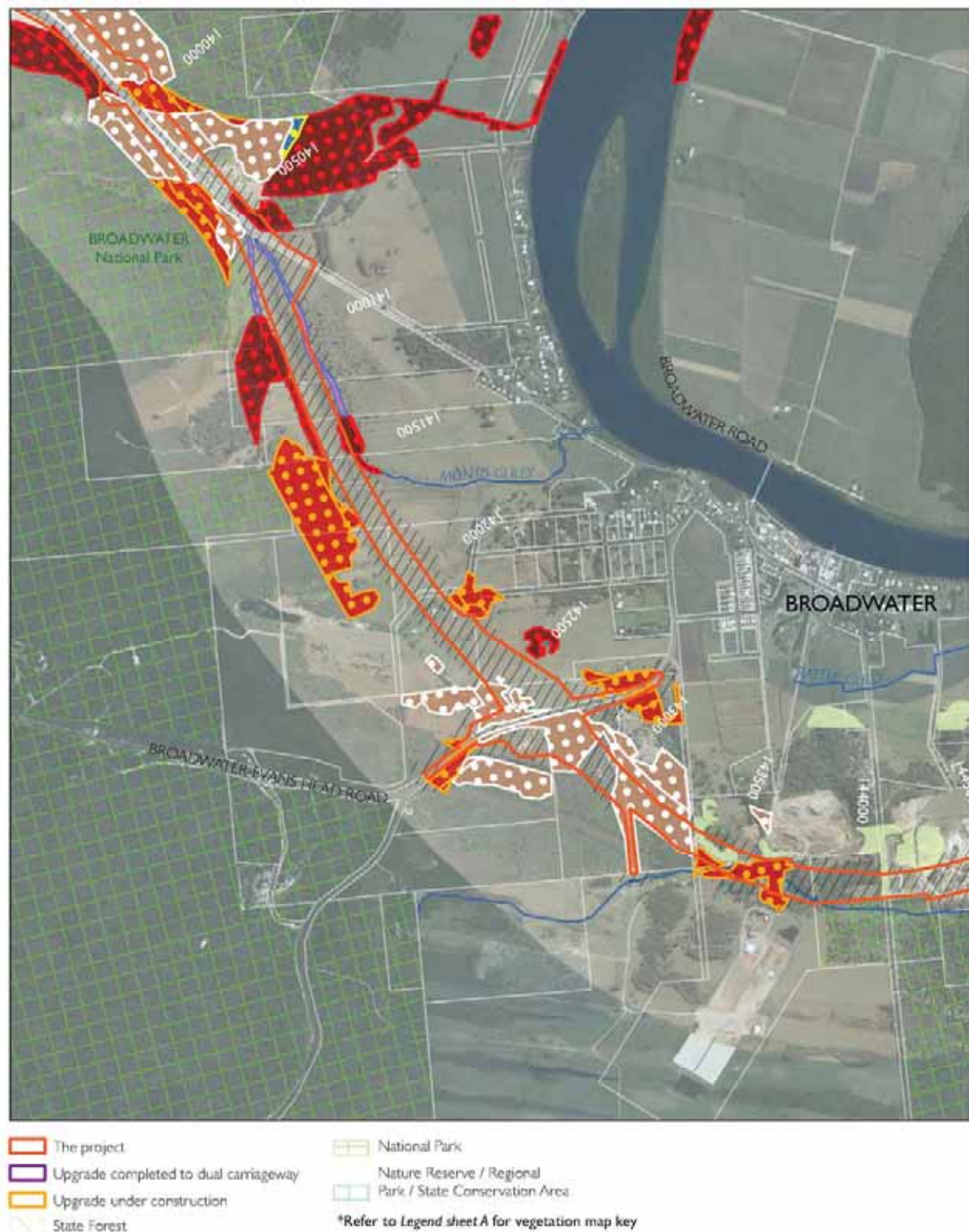
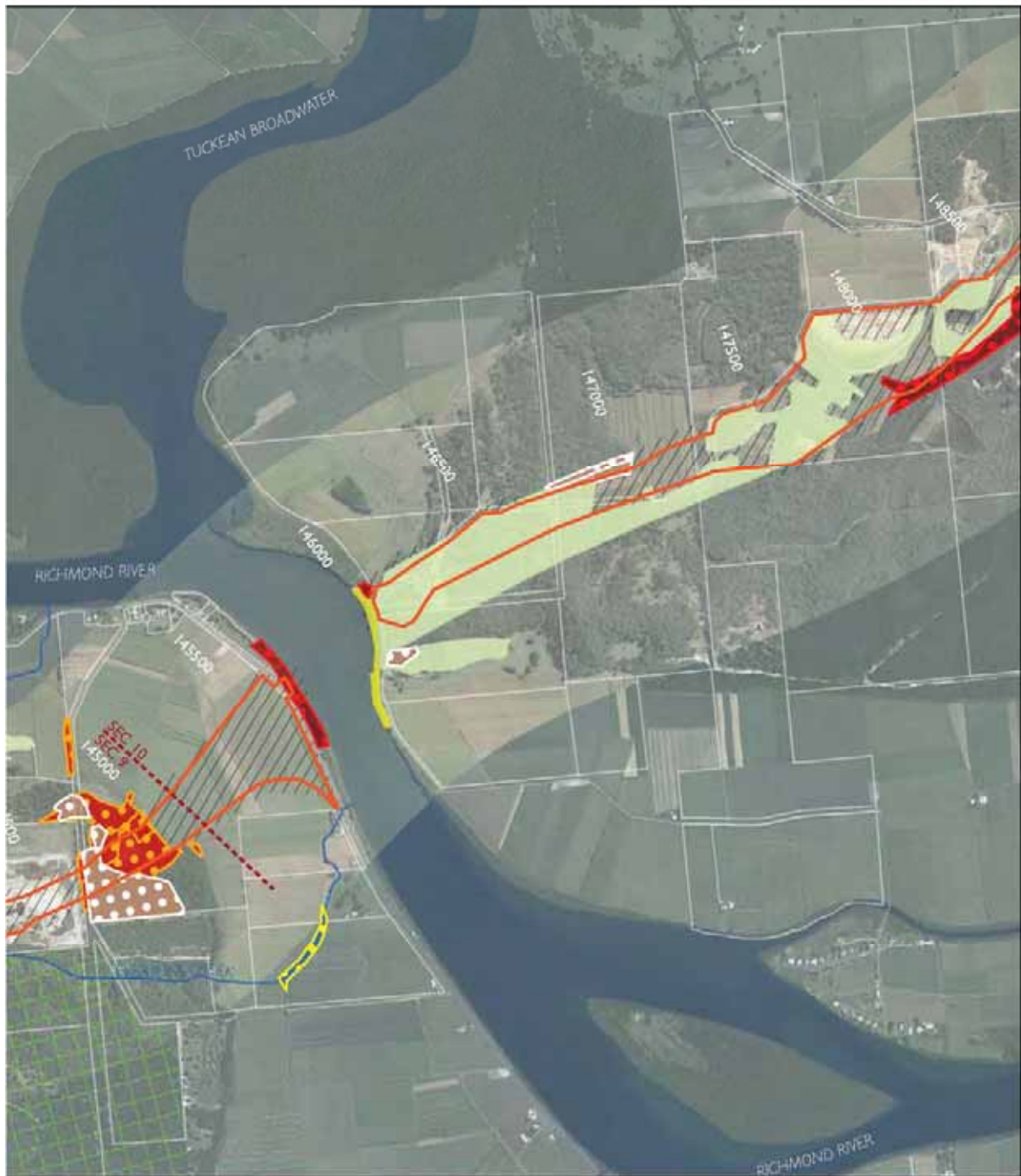


Figure 10-26: Ecological communities and threatened flora species in the study area (Station 140.0 to 148.5)



0 500
Metres



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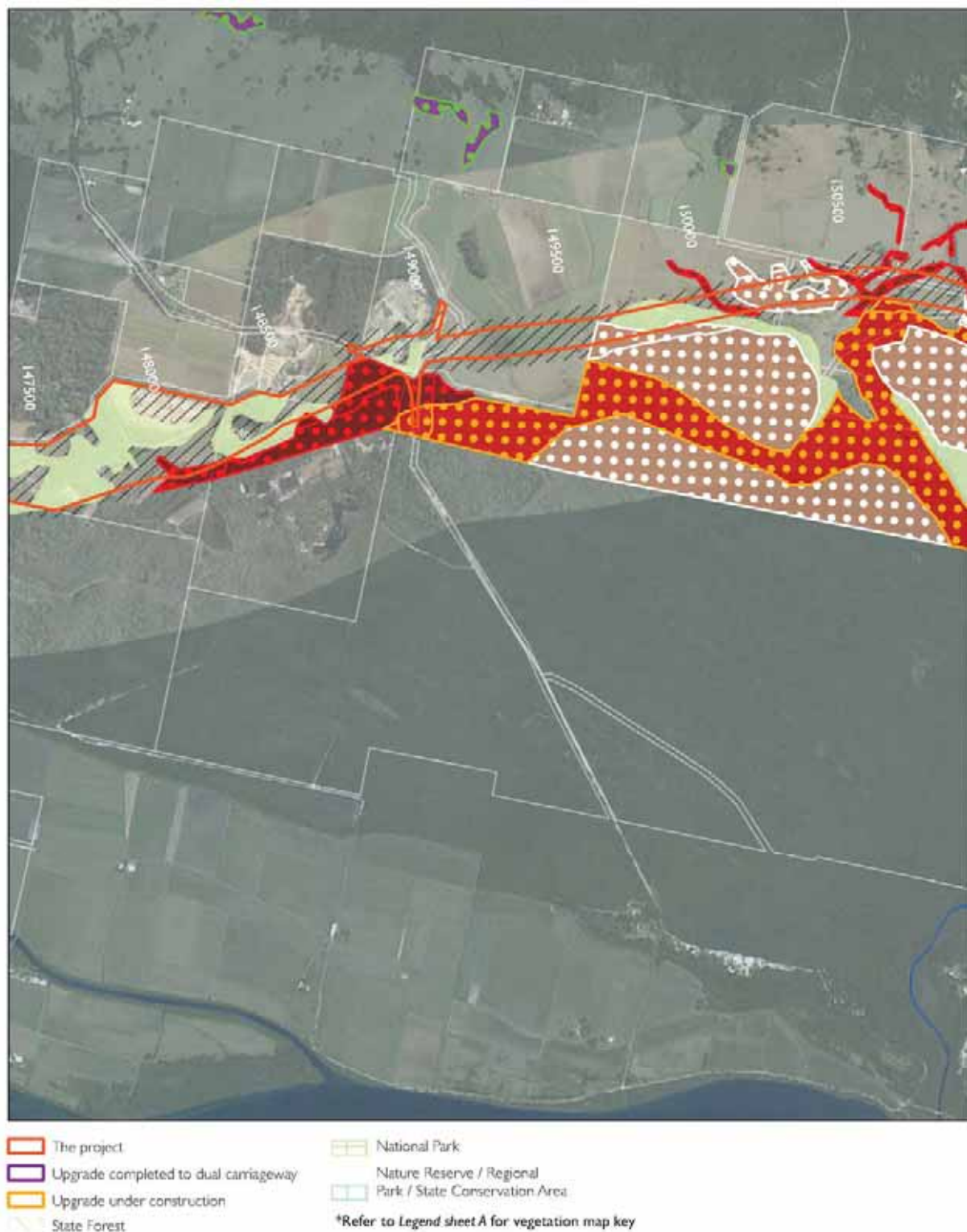
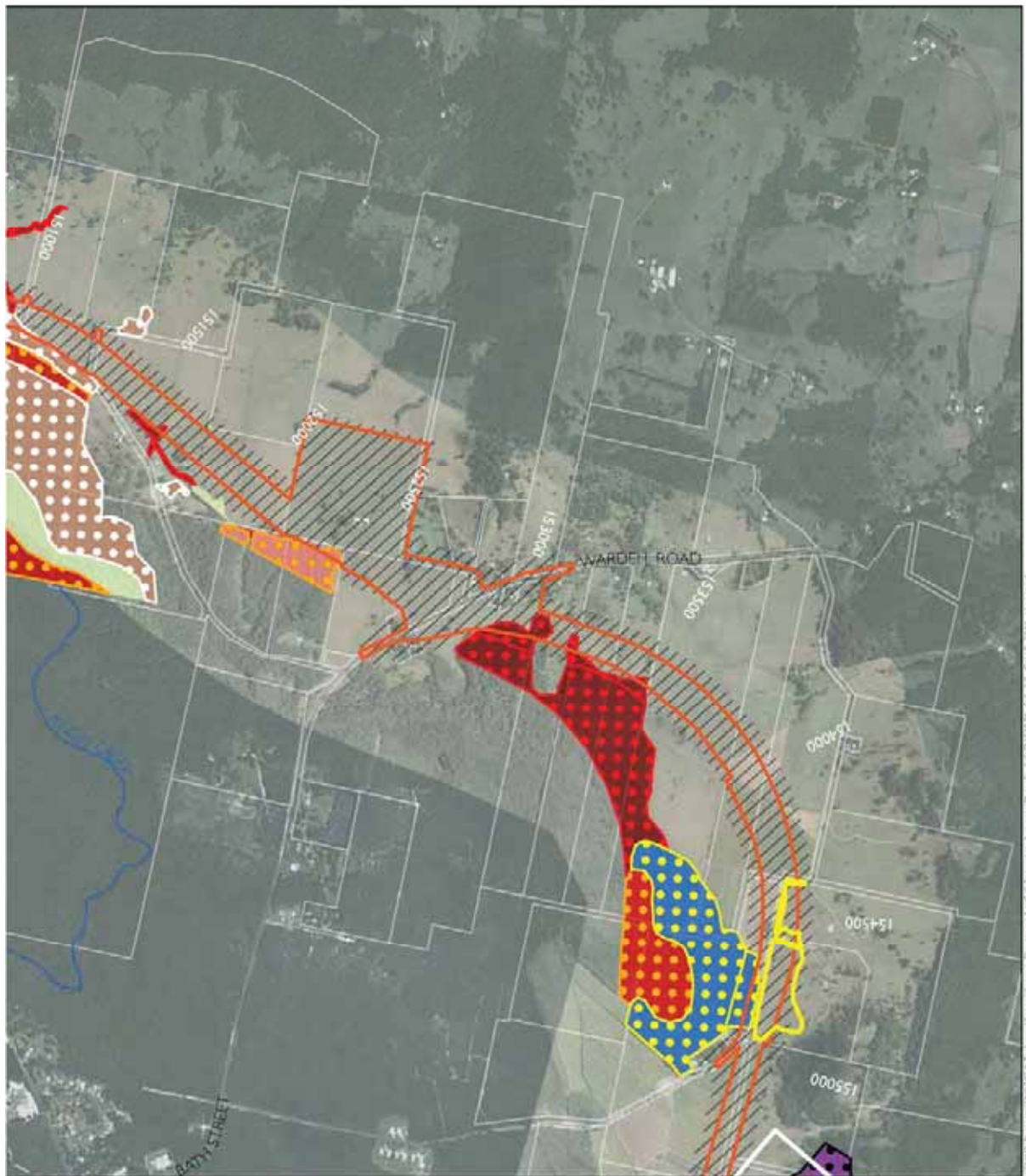


Figure 10-27: Ecological communities and threatened flora species in the study area (Station 147.5 to 155.0)



0 500
Metres



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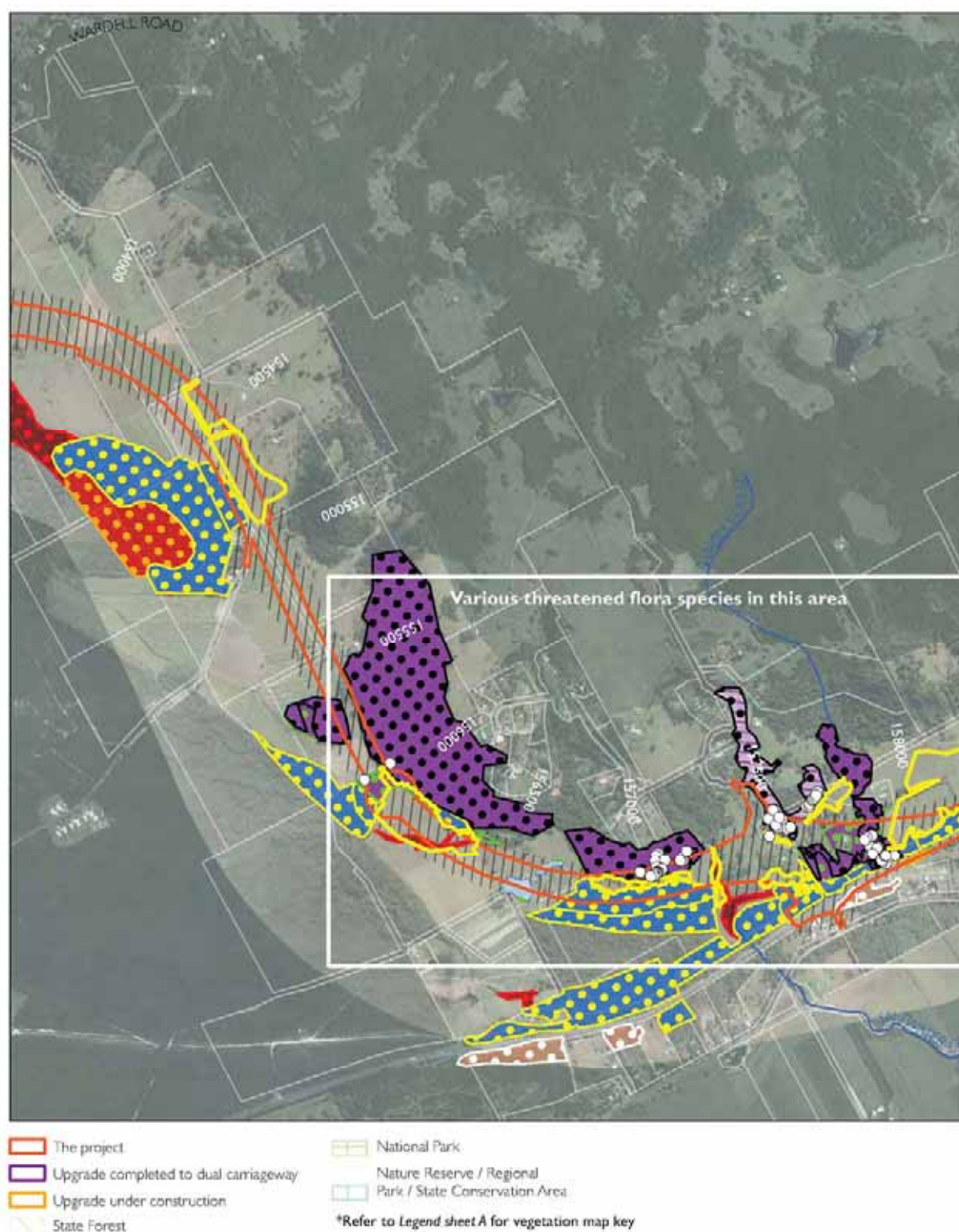
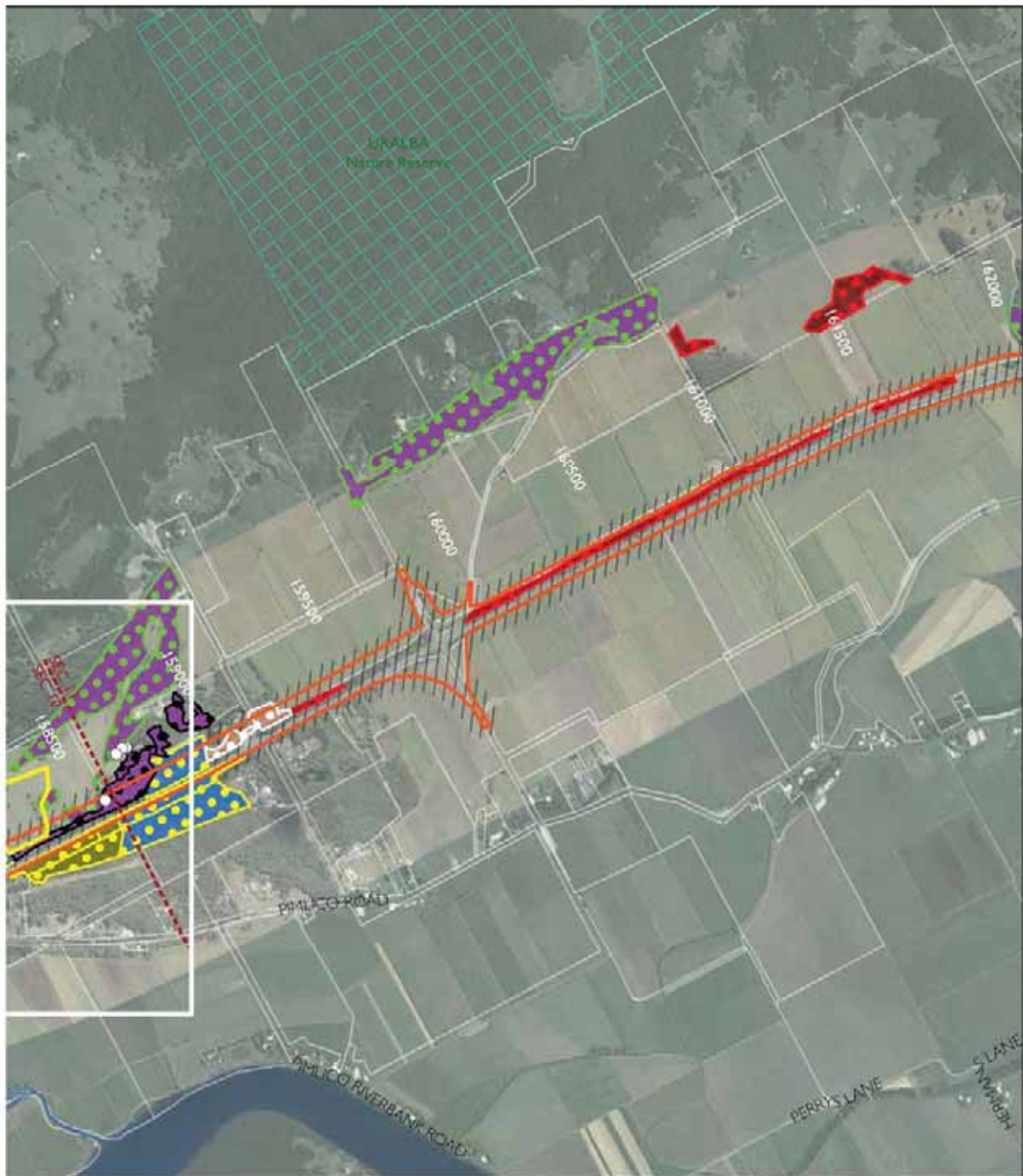


Figure 10-28: Ecological communities and threatened flora species in the study area (Station 154.0 to 162.0)



0 500
Metres

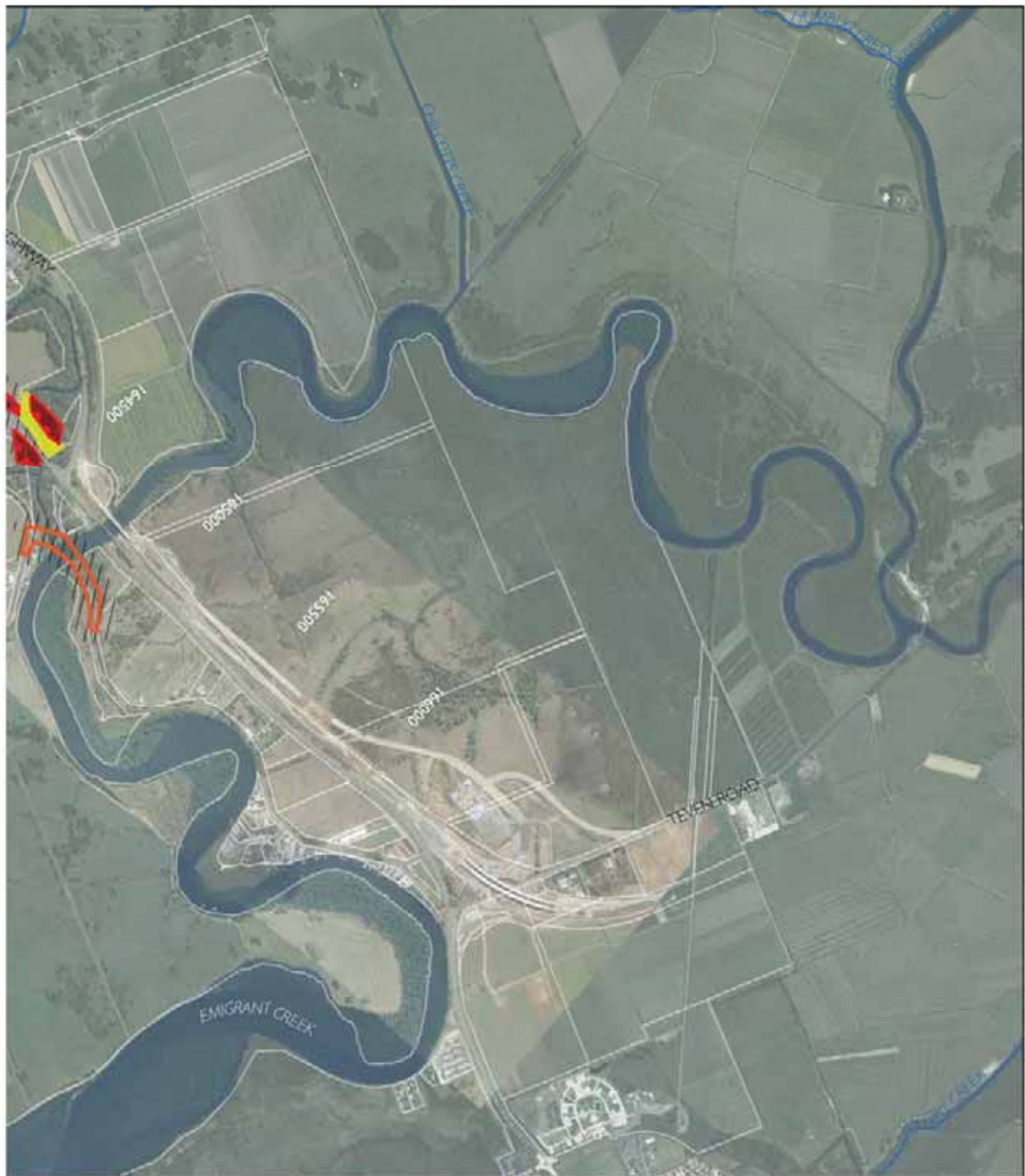


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Figure 10-29: Ecological communities and threatened flora species in the study area (Station 161.0 to 166.0)



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Metres



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Table 10-6: Descriptions of NSW and Commonwealth listed Threatened Ecological Communities in the study area

Threatened Ecological Community	Status	General notes on characteristics and distribution
Freshwater wetlands on coastal floodplains of the NSW North Coast, Sydney Basin & South East Corner bioregions	Endangered (TSC Act)	- Associated with periodic or semi-permanent inundation by freshwater, with some minor saline influence in certain wetlands. Typically occurs on silts, muds or humic loams in depressions, flats, and drainage lines on floodplains, generally below 20 metres elevation - Found in Sections 3, 4, 8 and 9.
Sub-tropical coastal floodplain forest of the NSW North Coast Bioregion	Endangered (TSC Act)	- Includes numerous eucalypt-dominated vegetation associations on periodically inundated alluvial flats, drainage lines and river terraces on floodplain areas. Generally occurs below 50 metres elevation and varies in structure from the open forests and woodlands of the adjoining elevated lands. The composition primarily determined by flooding regimes and the texture, nutrient and moisture content of the soil, in addition to latitude and history of disturbance. The community consists of: - A dominant mixed eucalypt canopy - The presence of rainforest elements as scattered trees or understorey plants - The relatively low abundance or sub-dominance of Swamp Oak <i>Casuarina glauca</i> and Paperbark (<i>Melaleuca spp.</i>) - The relatively low abundance of Swamp Mahogany (<i>Eucalyptus robusta</i>) - The prominent groundcover of soft-leaved forbs and grasses - Patchily distributed throughout the central or marginal parts of the floodplains and sandy flats, habitats where flooding is periodic and soils are rich in silt and sand, sometimes humic, and show little influence of saline groundwater - Found in all project sections.
Swamp sclerophyll forest on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions	Endangered (TSC Act)	- Associated with humic clay loams and sandy loams, on waterlogged or periodically inundated flats and drainage lines of floodplain areas. Generally occurs below 20 metres (though sometimes up to 50 metres) elevation. In some areas the tree stratum is low and dense, so that the community takes on the structure of scrub, fernland and tall reedland or sedgeland, where trees may be sparse or sometimes absent - Characterised by a relatively dense tree canopy dominated by Swamp Mahogany and / or Broad-leaved Paperbark. A relatively infrequent occurrence of other Eucalypts may occur, as well as Swamp Oak or Swamp Turpentine (<i>Lophostemon suaveolens</i>) and the occasional presence of rainforest elements (eg scattered trees or understorey plants) and the prominence of large sedges and ferns in the groundcover. Soils are usually waterlogged, stained black or dark grey with humus, and show little influence of saline ground water - Found in all project sections except Section 11.

Threatened Ecological Community	Status	General notes on characteristics and distribution
Swamp oak floodplain forest of the NSW North Coast, Sydney Basin and South East Corner bioregions	Endangered (TSC Act)	• Generally occurs below 20 metres (rarely above 10 metres) elevation • Associated with grey-black clay-loams and sandy loams, where groundwater is saline or sub-saline, on waterlogged or periodically inundated flats, drainage lines, lake margins and estuarine fringes associated with coastal floodplains • The structure of the community may vary from open forests to low woodlands, scrubs or reedlands with scattered trees • Found in Sections 1, 3-5, and 8-11.
Lowland Rainforest on Floodplain in the New South Wales North Coast Bioregion	Endangered (TSC Act)	• Occurs on fertile soils in lowland river valleys (only occurring as small remnants on the NSW North Coast), with less than 1000 hectares predicted to remain • In an undisturbed state, it exhibits a closed canopy of rainforest tree species with high species richness and structural complexity. In disturbed stands (as are represented in the study area) the canopy continuity may be broken, or the canopy may have introduced tree species, such as Camphor Laurel, or sometimes smothered by exotic vines
Lowland Rainforest of Sub-tropical Australia	Critically Endangered (EPBC Act)	• Common representative rainforest tree species include: Rough-leaved Elm (<i>Aphananthe philippinensis</i>), Bangalow Palm (<i>Archontophoenix cunninghamiana</i>), Cabbage Tree Palm (<i>Livistona australis</i>), Figs (<i>Ficus spp.</i>), Pepperberry (<i>Cryptocarya obovata</i>), Lilly Pilly (<i>Syzygium spp.</i>) and Weeping Lilly Pilly (<i>Waterhousea floribunda</i>) • Found in Sections 3 and 8-11.
Coast Cypress Pine shrubby open forest of the North Coast Bioregion	Endangered (TSC Act)	• Has a closed to open canopy of Coastal Cypress Pine (<i>Callitris columellaris</i>), which may be mixed with eucalypts, wattles, banksias and/or rainforest trees, and an open to sparse understorey of shrubs, sedges and herbs • Found on coastal sand plains, north from the Angourie area. Currently known occurrences of the community are generally within 35 kilometres of the coast and below 100 metres elevation • Found in Sections 8-11.

10.2.4 Fauna habitats

The vegetation in the study area can be divided into seven fauna habitats, with eucalypt-dominated sclerophyll forest the most widespread fauna habitat. There is no critical fauna habitat identified within the study area. The fauna habitat types confirmed in the study area are described below and their distribution shown in Figure 10-31 to Figure 10-56. Figure 10-30 provides the legend for this series of figures.

Dry forest habitats

Dry forest habitats are the most abundant habitat along the project and include a large range of vegetation types. Dry forest habitats contain the highest proportion of hollow bearing trees. They provide important habitat for a range of fauna groups, particularly hollow-dependent species such as:

- Forest owls (eg Masked Owl and Powerful Owl)
- Arboreal mammals (eg Yellow-bellied Glider, Squirrel Glider and Brush-tailed Phascogale)
- Microchiropterean bats (eg Hoary Wattled Bat, Eastern Freetail Bat and Eastern Long-eared Bat)
- Glossy Black-cockatoo
- Brown Treecreeper.

Dry open forest habitats also provide a range of year-round food resources for fauna. Foraging features include peeling bark, fallen logs, leaf litter, shrubby understorey and grassy groundcover and 'spaces' for fauna.

KEY TERM – Arboreal

To live in, or be connected with, trees

Wet and riparian forests and floodplain eucalypt habitat

Wet sclerophyll and semi-mesic forests occur throughout the project, on mid- to lower-slopes of low undulating rises. The community is dominated by flowering trees (Myrtaceae), providing a suite of fauna habitat resources, including hollow bearing trees, fallen wood, leaf litter, shrubby understorey, grassy groundcover, and a year-round supply of nectar and pollen.

The most commonly encountered floodplain forests within the study area are Eastern Red Gum Floodplain Forest, and Forest Red Gum Floodplain Forest, dominated by Forest Red Gum. They are moderately tall to tall woodland and open forests, supporting hollow bearing trees, flowering trees and shrubs, and abundant fallen wood. This habitat type is frequented by woodland and forest birds, arboreal and terrestrial mammals, bats, numerous reptiles and often frogs.

KEY TERM – Riparian

Relating to the banks of a natural waterway.

Riparian habitat zones include areas of moist forest, rainforest and mangrove elements along larger tributaries and, in agricultural areas on cleared floodplain. Riparian habitats include tall moist forest up to heights of 35 metres, dominated by Blackbutt, Flooded Gum, Brushbox and Tallowwood with rainforest and/or swamp elements in the understorey. Threatened species known to roost, nest or forage in riparian habitats in the study area include Black-necked Stork, Black Bittern, Square-tailed Kite, Osprey, Golden-tipped Bat, Southern Myotis and tree roosting microbats. The Giant-barred Frog and Stuttering Frog could also be expected to occur within riparian habitat.

Swamp forest habitat

Swamp Sclerophyll Forest occurs on seasonally waterlogged floodplain or swampy creek lines throughout all sections, mostly on the Clarence and Richmond river floodplains. It provides habitat for a broad range of animals, including many that are dependent on trees for food, nesting or roosting (Law et al., 2000). The blossoms of Swamp Mahogany (*Eucalyptus robusta*) and Broad-leaved Paperbark are an important food source for the Grey-headed Flying Fox and Common Blossom Bat (Law, 1994), Yellow-bellied Glider, Squirrel Glider, Regent Honeyeater, Swift Parrot and Little Lorikeet.

Other species which may use Swamp Sclerophyll Forest includes Osprey, Australasian Bittern, Southern Myotis, Olongburra Frog and Wallum Froglet. Swamp Sclerophyll Forest also provides potential Koala habitat, with Swamp Mahogany one of the preferred feed trees for Koala.

Wetland habitats

A range of freshwater wetland forests occur in floodplain areas throughout the project. These comprise both permanent and ephemeral wetlands. Species dominating the upper strata include Lepironia (*Lepironia articulata*) and Common Reed (*Phragmites australis*). Jointed Baumea (*Baumea articulata*), Common Baumea (*Baumea rubiginosa*) and Tall Knotweed (*Persicaria lapathifolium*) are also common occurrences. Bungwahl Fern (*Blechnum indicum*) and Bristly Knotweed (*Persicaria strigosa*) dominate the lower strata, with Swamp Rice Grass (*Leersia hexandra*), Rough Ground Fern (*Hypolepis muelleri*) and Triglochin (*Triglochin procerum*) commonly occurring.

These freshwater wetland habitats offer foraging, shelter, roosting and breeding habitat for a range of fauna including frogs, fish, turtles, waterbirds and a diversity of micro- and macro-invertebrates. The frog families represented are Myobatrachidae (southern frogs) and Hylidae (tree frogs), including the threatened Green and Golden Bell Frog. Freshwater wetland habitat provides potential breeding sites for local populations of waterbirds as well as habitat for migratory birds. Threatened or migratory waterbirds which use wetland habitat within the study area include Black-necked Stork, Latham's Snipe and Comb-crested Jacana. These areas are also important for threatened frog species such as Wallum Froglet and Olongburra Frog, and the threatened fish species Oxleyan Pygmy Perch.

Wet and dry heath habitat

Heath-Sedgeland is floristically rich and occurs as a heath and shrubland with occasional stunted trees to 10 metres high. Dominant species include Heath Banksia (*Banksia oblongifolia*), Swamp Grasstree (*Xanthorrhoea fulva*) and White Paperbark (*Melaleuca sieberi*), with occasional emergent trees including Scribbly Gum, Broad-leaved Paperbark and Ball Honey-myrtle (*M. nodosa*). The ground layer comprises leaf litter and bare ground.

Heath-sedgeland habitat provides habitat for a range of terrestrial fauna groups, including frogs, reptiles, nectivorous birds and small terrestrial mammals. Threatened species considered likely to occur include Wallum Froglet and Wallum Sedgefrog. Emergent trees, banksias and paperbarks within this habitat may also provide foraging habitat for Squirrel Glider, Grey-headed Flying-fox and the Ground Parrot.

Lowland rainforest

Lowland rainforest is typically highly structurally diverse and productive, providing a range of habitat for fauna. These areas support hollow bearing trees, and year-round flowering and fruiting plants, providing a reliable food source for terrestrial and arboreal animals.

The dominant tree cover consists of Bangalow Palms (*Archontophoenix cunninghamiana*), Turpentine (*Syncarpia glomulifera*), Swamp Turpentine (*Lophostemon suaveolens*) and Paperbarks (*Melaleuca* spp.). The ground layer is sparse with ferns, *Lomandra* spp., *Gahnia* spp. and *Cordyline* most prominent. Vines and epiphytes are common.

Species that prefer moist forest habitats, including rainforest, are fruit-dove species, Sooty Owl, Giant-barred and Stuttering Frogs, Golden-Tipped Bat, Common Blossom Bat and Stephen's Banded Snake. Other threatened species within adjoining vegetation communities also make use of the rainforest remnants on a seasonal basis.

Cleared and modified habitats

Modified communities are former forests which have been modified through land clearing and draining for the development of farm land. Modified communities include cleared pasture with scattered trees, plantation, cropland, market garden, pine forest and cleared open pasture.

Small isolated fragments of the former forest communities often occur with an understorey dominated by introduced pasture or weeds. Cleared cropping land is mostly sugar cane or introduced pasture grasses, with limited remnant vegetation and a generally low native floral diversity. Commonly, scattered remnant trees and small fragmented native vegetation patches are present, as are planted areas for windbreaks and landscaped gardens. The areas are dominated by introduced pasture grasses including *Paspalum* (*Paspalum dilatatum*) and Kikuyu (*Pennisetum clandestinum*).

Although heavily modified, these environments do provide habitat for some fauna including some microchiropteran bats are known to forage and may roost in scattered paddock trees and forest and woodland remnants (Lumsden and Bennett, 2004), while owls and other predatory birds may frequent cane fields for foraging.

Hollow bearing tree density and log lengths

Hollow bearing trees were recorded in all habitat types and project sections, irrespective of vegetation community type. The highest densities of hollow bearing trees, and the most logs on the ground were recorded in the clay and sandy dry forests, and in moist floodplain forest. These features are important for hollow-dependent arboreal mammals and birds, such as gliders and large forest owls, and ground-dwelling mammals such as Rufous Bettong and Brush-tailed Phascogale. An average of between 28 and 76 hollow bearing trees per hectare were found in habitats within the study area.

Forest successional stage

Forest habitat condition was generally high throughout the study area. Canopy cover and canopy height were relatively similar across all broad vegetation communities in the study area. Vegetation surveys found that each broad vegetation community type were regenerating, except for sub-tropical floodplain forest and mature swamp forest, which had more mature forest present. These community types largely exist as remnants along watercourses and in areas too wet for agricultural production. A greater proportion of the clay dry forest and sandy dry forest types were regenerating compared to the other broad vegetation communities assessed as they were mostly managed for timber production.

The successional stage of forests influences habitat condition. It will influence the potential for hollow bearing trees, fallen timber on the forest floor and for flowering trees used as foraging resources. Forest areas which support a combination of mature and regenerating stages offer a range of opportunities for foraging, refuge and nesting for birds, and arboreal and ground-dwelling mammals. Mature forests are more likely to support optimum leaf litter and soil conditions, which contributes to invertebrate biodiversity, which in turn is a foraging resource for small mammals.

Allocasuarina in the study area

Allocasuarina is an important foraging resource for Glossy-black Cockatoo (*Calyptorhynchus lathami*), a listed vulnerable species under the TSC Act. This species forages on Allocasuarina seeds and nests in hollows, so is reliant on mature forest habitats for breeding and foraging.

Allocasuarinas were found in all broad vegetation communities in the study area. Of these, the highest densities of Allocasuarina were encountered in dry forests (sandy and clay soils).



Photo 2: View north towards Wardell Heath