

Proposed Hexham Relief Roads Ecological Assessment

April 2012

**Australian Rail Track Corporation
(UHVA Alliance)**

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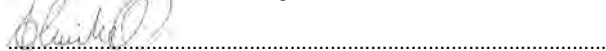
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Glossary

ARTC	Australian Rail Track Corporation
Biodiversity	The biological diversity of life is commonly regarded as being made up of the following three components: <ul style="list-style-type: none"> ▪ genetic diversity — the variety of genes (or units of heredity) in any population ▪ species diversity — the variety of species ▪ ecosystem diversity — the variety of communities or ecosystems.
Bioregion (region)	A bioregion defined in a national system of bioregionalisation. For this study this is the Sydney Basin bioregion as defined in the Interim Biogeographic Regionalisation for Australia (Thackway & Cresswell 1995).
Critical Habitat	The whole or any part or parts of an area or areas of land comprising the habitat of an Endangered species, an Endangered population or an Endangered ecological community that is critical to the survival of the species, population or ecological community (Department of Environment and Conservation 2004). Critical habitat is listed under either the TSC Act or the EPBC Act and both the state (Department of Environment, Climate Change and Water) and Federal (Department of the Environment, Water, Heritage and the Arts) Directors-General maintain a register of this habitat. Capitalisation of the term ‘Critical Habitat’ in this report refers to the habitat listed specifically under the relevant state and Commonwealth legislation.
Department of Environment and Conservation (DEC)	A former name for the Office of Environment and Heritage (OEH).
Department of Environment, Climate Change and Water (DECCW)	The Department of Environment and Climate Change (DECC) is the former title for the Office of Environment and Heritage (see below). The DECC formed on 27 April 2007 incorporating the former NSW Department of Environment and Conservation (DEC) in addition to some functions of the former Department of Natural Resources, Department of Energy, Utilities and Sustainability and The Greenhouse Office.
Department of Sustainability, Environment, Water, Population and Communities (SEWPAC)	The Commonwealth department responsible for the protection and conservation of Australia’s natural environment and cultural heritage (September 2010–). The department develops and implements national policy, programs and legislation including administering the EPBC Act.
Department of the Environment and Heritage (DEH)	A former name (July 2004–January 2007) for the Department of Sustainability, Environment, Water, Population and Communities.
Department of the Environment and Water Resources (DEWR)	A former name (January 2007–December 2007) for the Commonwealth Department of the Environment, Water, Heritage and the Arts.
Department of the Environment, Water, Heritage and the Arts (DEWHA)	A former name (December 2007–September 2010) for the Commonwealth Department of Sustainability, Environment, Water, Population and Communities.
Ecological community	An assemblage of species occupying a particular area.
EIS	Environmental Impact Statement
Environmental weed	Any plant that is not native to a local area that has invaded native vegetation.

EPBC Act	Commonwealth <i>Environment Protection and Biodiversity Conservation Act 1999</i>
FM Act	<i>Fisheries Management Act 1994</i>
GPS	Global Positioning System - a navigational tool that uses radio receivers to pick up signals from four or more special satellites to provide precise determination of location.
Habitat	An area or areas occupied, or periodically or occasionally occupied, by a species, population or ecological community, including any biotic or abiotic components.
Industry and Investment NSW	Formerly the NSW Department of Primary Industries.
Key Threatening Processes	A process that threatens, or could threaten, the survival, abundance or evolutionary development of native species, populations or ecological communities (Department of Environment and Conservation 2004). Key threatening processes are listed under the TSC Act, the FM Act and the EPBC Act. Capitalisation of the term 'Key Threatening Processes' in this report refers to those processes listed specifically under the relevant state and Commonwealth legislation.
Likely	Taken to be a real chance or possibility (Department of Environment and Conservation 2004).
Local population	The population that occurs within the site, unless the existence of contiguous or proximal occupied habitat and the movement of individuals or exchange of genetic material across the boundary can be demonstrated as defined by Department of Environment and Climate Change (2007b).
Locality	The area within a 10 km of the Study Area.
Migratory species	Species listed as Migratory under the EPBC Act relating to international agreements to which Australia is a signatory. These include Japan-Australia Migratory Bird Agreement (JAMBA), China-Australia Migratory Bird Agreement (CAMBA), Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA) and the Bonn Convention on the Conservation of Migratory Species of Wild Animals. Capitalisation of the term 'Migratory' in this report refers to those species listed as Migratory under the EPBC Act.
Noxious weed	An introduced species listed under the <i>Noxious Weeds Act 1993</i> . Under the Act, noxious weeds have specific control measure and reporting requirements.
NSW	New South Wales
Office of Environment and Heritage (OEH)	<p>The Office of Environment and Heritage (OEH) is a division of the NSW Department of Premier and Cabinet. Broadly, the OEH works towards a healthy environment cared for and enjoyed by the whole NSW community: manages the state's natural resources, including biodiversity, soils and natural vegetation: manages natural and cultural heritage across the state's land and waters: acts to minimise the impacts of climate change: promotes sustainable consumption, resource use and waste management: regulates activities to protect the environment: and conducts biodiversity, plant, environmental and cultural heritage research to improve decision making.</p> <p>The OEH formed on 4 April 2011 incorporating the former NSW Department of Environment, Climate Change and Water (DECCW) and the Heritage Office, from the Department of Planning, while moving the Office of Water on to Industry and Investment NSW (formerly the Department of Primary Industries).</p>
Priorities Action Statements (PAS)	Priorities Action Statements outline the broad strategies and detailed priority actions to be undertaken in NSW to promote the recovery of Threatened species, population and ecological communities and manage key threatening processes (Department of Environment and Climate Change 2007a).
Proposed Project	Comprises the construction and operation of five Relief Roads and associated infrastructure. The proposed Project is also referred to as the Project.

Proposed Project Area	The proposed Project Area (42 38.2 ha) is the area in which the proposed Project would operate and be constructed. This includes the extent of direct impacts that will be affected by the proposed rail corridor and ancillary areas defined as the footprint. This includes comprises the footprint of the proposed Project and includes associated infrastructure, access tracks, temporary construction compounds, drainage devices spoil dumps.and stockpile locations.
Protected species	Those species defined as protected under the <i>National Parks and Wildlife Act 1974</i> . Includes all native animals, as well as all native plants listed on Schedule 13 of the <i>National Parks and Wildlife Act 1974</i> .
Recovery plan	A plan prepared under the TSC Act, FM Act or the EPBC Act to assist the recovery of a Threatened species, population or ecological community.
SEPP 14 Wetland	Coastal wetlands gazetted under the NSW State Environmental Planning Policy No. 14 - Coastal Wetlands to be preserved and protected in the environmental and economic interests of the State.
Significant	Important, weighty or more than ordinary as defined by Department of Environment, Climate Change and Water (2007b).
Stag	A dead tree
Study Area	It includes the existing rail corridor and a nominal 75 m buffer on the down track. This buffer includes the Proposed Project Area..
Threatened biodiversity	Threatened species, populations or ecological communities as listed under the TSC Act, FM Act or the EPBC Act.
Threatened species, populations and ecological communities	Species, populations and ecological communities listed as Vulnerable, Endangered or Critically Endangered (collectively referred to as Threatened) under the TSC Act, FM Act or the EPBC Act. Capitalisation of the terms 'Threatened', 'Vulnerable', 'Endangered' or 'Critically Endangered' in this report refers to listing under the relevant state and/or Commonwealth legislation.
TSC Act	NSW <i>Threatened Species Conservation Act 1995</i>
UHVA	Upper Hunter Valley Alliance
Viable local population	A population that has the capacity to live, develop and reproduce under normal conditions, unless the contrary can be conclusively demonstrated through analysis of records and references (Department of Environment and Climate Change 2007b).
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Proposed Project	Comprises the construction and operation of five Relief Roads and associated infrastructure. The proposed Project is also referred to as the Project.
Proposed Project Area	The proposed Project Area (39.05 ha) is the area in which the proposed Project would operate and be constructed. This includes the extent of direct impacts that will be affected by the proposed rail corridor and ancillary areas defined as the footprint. This includes comprises the footprint of the proposed Project and includes associated infrastructure, access tracks, temporary construction compounds, drainage devices spoil dumps.and stockpile locations.
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Viable local population	A population that has the capacity to live, develop and reproduce under normal conditions, unless the contrary can be conclusively demonstrated through analysis of records and references (Department of Environment and Climate Change 2007b).

Executive summary

ARTC proposes to develop five Relief Roads (train lines) and associated infrastructure at Hexham in the NSW Hunter Valley (the proposed Project). The proposed Project is located approximately 15 kilometres north west of Newcastle and 176 kilometres north of Sydney by rail.

Key components of the proposed Project comprise:

- Five Up Relief Roads (train lines) to the west of the existing Up and Down Mains between the existing Up Coal and a new Down Coal including:
 - ▶ The removal of the existing Down Coal (located to the west and right of the Up Coal).
 - ▶ The construction of five new train lines (tracks) for the Relief Roads.
 - ▶ The construction of a new Down Coal to the west and outside of the proposed Relief Roads.
- Each Relief Road to accommodate trains generally comprising two or three locomotives and up to 91 wagons (1,543 m long) requiring a minimum standing room of 1,670 m.
 - ▶ New turnouts, return curves and other track changes.
- Installing new signal infrastructure for the five Relief Roads (including signal location cases, huts and gantries).
- Earth and civil works of approximately 265,000 cubic metres, including cut to fill, track formation, drainage and minor structures.
- Ancillary infrastructure including vehicle access tracks, temporary construction compounds and stockpile sites.
- Vehicular tracks, land acquisition and upgrading of existing rail infrastructure and public utilities.

The estimated cost of the proposed Project is approximately \$90 million and it is expect to take approximately 18 months to construct.

This report outlines the ecological assessment of the proposed Project described above. This report supports the Environmental Impact Statement (EIS) for the proposed Project under Part 5.1 of the *Environmental Planning and Assessment Act 1979* (EP&A Act). It provides a worst case scenario for impacts of the proposed Project on biodiversity as it provides a broad corridor assessment. The area of vegetation and habitats to be cleared would be reduced as a result of ongoing detailed design.

Terrestrial and aquatic field surveys were undertaken on 15 to 22 June, 5-6 September, 4 November and 7-8 November 2011 and included:

- Biobanking quadrat and random meander surveys.
- Vegetation community mapping.
- Microbat surveys using anabat bat detector.
- Spotlighting and call playback.

- Diurnal bird surveys.
- Active herpetofauna searches.
- Targeted Green and Golden Bell Frog surveys.
- Hollow tree survey (where appropriate).
- General habitat assessment.
- Water quality assessments.
- Estuarine habitat assessments.
- Benthic epifauna assessments.
- Fish bait trapping in estuarine and freshwater habitats.

The Study Area has been previously cleared and extensively modified as a result of historic and current grazing and the former location of a coal loader. As a result, the dominant vegetation is exotic grassland/disturbed areas. The open forest areas occur on old fill sites with the soil composed of ballast and building refuse.

There are areas of regrowth native vegetation, particularly Swamp Oak Swamp Forest Fringing Estuaries and Swamp Mahogany Swamp Forest on Coastal Lowlands. *Phragmites australis* and *Typha orientalis* Coastal Freshwater Wetlands occur in the lower lying areas with the northern wetlands being currently grazed and the southern wetlands a result of manmade dams or natural depressions. Coastal Saltmarsh in Estuaries occurs in the southern portion of the Study Area where tidal influences occur from an inlet from the Hunter River. The proposed Study Area contains seven distinct vegetation types:

- Swamp Oak Swamp Forest Fringing Estuaries– covering approximately 6.18 ha.
- Swamp Mahogany Swamp Forest on Coastal Lowlands– covering approximately 1.12 ha.
- *Phragmites australis* and *Typha orientalis* Coastal Freshwater Wetlands – covering approximately 3.46 ha.
- Coastal Saltmarsh in Estuaries – covering approximately 1.62 ha.
- Exotic Grasslands/Disturbed vegetation – covering 35.56 ha.
- Exotic Herbfield – covering 9.29 ha.
- Planted Vegetation – covering 2.72 ha.

Aquatic habitats included two estuarine communities of mangroves and saltmarsh. Water quality within the estuarine environments within the study area was found to be low and fell outside of ANZECC/ARMCANZ guidelines. Two taxa of benthic epifauna were recorded in the saltmarsh habitats within the study area. One species of fish and one species of prawn were recorded in the Hunter River Estuary. Three types of freshwater aquatic communities of drainage channels, wetlands and ponded pastures were recorded in the study area. Water quality within the freshwater aquatic communities also recorded readings below the ANZECC/ARMCANZ guidelines. One species of fish was recorded within the fish traps in the freshwater aquatic environments, the Mosquitofish.

The proposed Project will include the removal of 9.10 ha of native vegetation, including 5.28 ha of Swamp Oak Swamp Forest Fringing Estuaries, 1.12 ha of Swamp Mahogany Swamp Forest on Coastal Lowlands and 2.70 ha of *Phragmites australis* and *Typha orientalis* Coastal Freshwater Wetlands, which are all consistent with endangered ecological communities listed under the TSC Act.

No threat-listed ecological community listed under the EPBC Act was recorded in the Study Area. No Endangered Population listed under the TSC Act and/or the EPBC Act was identified or was considered likely to occur in the Study Area.

No threat-listed species of plant listed under the TSC Act or the EPBC Act was identified in the Study Area. However, significance assessments were completed on three threat-listed plant species, *Maundia triglochinos* (Vulnerable under the TSC Act), *Persicaria elatior* (Vulnerable under the TSC Act and EPBC Act) and *Zannichellia palustris* (Endangered under the TSC Act), based on the presence of potential habitat. These assessments concluded that, even if these threat-listed plant species were present, the proposed Project was unlikely to have a significant impact on these species due to the small area of potential habitat likely to be affected and its disturbed and fragmented nature.

Four threat-listed species of animal listed under the TSC Act and or EPBC Act were either recorded in the Study Area or in vicinity of the Study Area, including Grey-headed Flying Fox, White-fronted Chat, Black-necked Stork and Spotted Harrier. Significance assessments were completed for these four threat-listed animal species, as well as for a further 23 threat-listed species of animal, based on the presence of suitable habitat. Significance assessments completed for these species concluded that the proposed Project was not likely to have a significant impact for one or more of the following reasons:

- The proposed Project Area essentially followed disturbed easements with no preferred habitat recorded therein.
- The Study Area existed as highly fragmented and isolated regrowth/remnant vegetation.
- The proposed Project Area lacked important microhabitat elements such as roosting and breeding habitat (i.e. large tree hollows).
- The species' were highly mobile and while the proposed Project Area potentially occurred as part of a larger home range, the species would use larger tracts of vegetation/habitat in the locality and not the Study Area exclusively.

Commonly occurring or pest species of aquatic fauna were identified during the aquatic surveys and no threat-listed species have potential to occur within the proposed Project Area. The estuarine and wetland communities within the surrounding the proposed project area are unlikely to support any threat-listed species and their removal is not considered likely to cause significant impacts to the broader Hexham Swamp.

Although the impacts to threat-listed biodiversity are not considered to be significant, given that the proposed Project would result in clearing of native vegetation, including an endangered ecological community and habitat for threat-listed species, it would be necessary to develop offset strategies to meet the Director General's and OEH's requirements for the Part 5.1 assessment, particularly the principle of 'maintain and improve'. The offset strategy will also be developed in accordance with *The Principles for the Use of Biodiversity Offsets in NSW* (Department of Environment and Climate Change 2008c).

1. Introduction

This report outlines the ecological assessment of the proposed new Hexham Relief Roads between 173.900 km and 177.000 km on the main northern railway line, hereafter referred to as 'the proposed Project' (Figure 1–1). This report supports the Environmental Impact Statement (EIS) for the project under Part 5.1 of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

1.1 Proposed works

Five Up Relief Roads (train lines) to the west of the existing rail lines are proposed to be located adjacent to the Pacific Highway and Hexham Railway Station approximately 15 km north west of Newcastle. The existing Down Coal would be removed to make way for the Relief Roads and would be replaced by a new Down Coal that would be constructed to the west and outside of the proposed Relief Roads.

Each Relief Road would have capacity to accommodate a train comprising 3 locomotives and 91 wagons (1,543 m long), requiring a minimum stand room of 1,670 m. New turnouts, return curves and changes to the existing track formation would also form part of the proposed Project.

The tracks would be constructed on a foundation of coarse rock about 600 mm deep. It is estimated that 88,500 cubic meters of rock would be required which would be brought onto the site using trucks. As the area around Hexham is very flat with poor drainage, the use of coarse rock would allow water to pass through the gaps between the rocks to minimise the impacts on the existing drainage paths and the environment in a flood event.

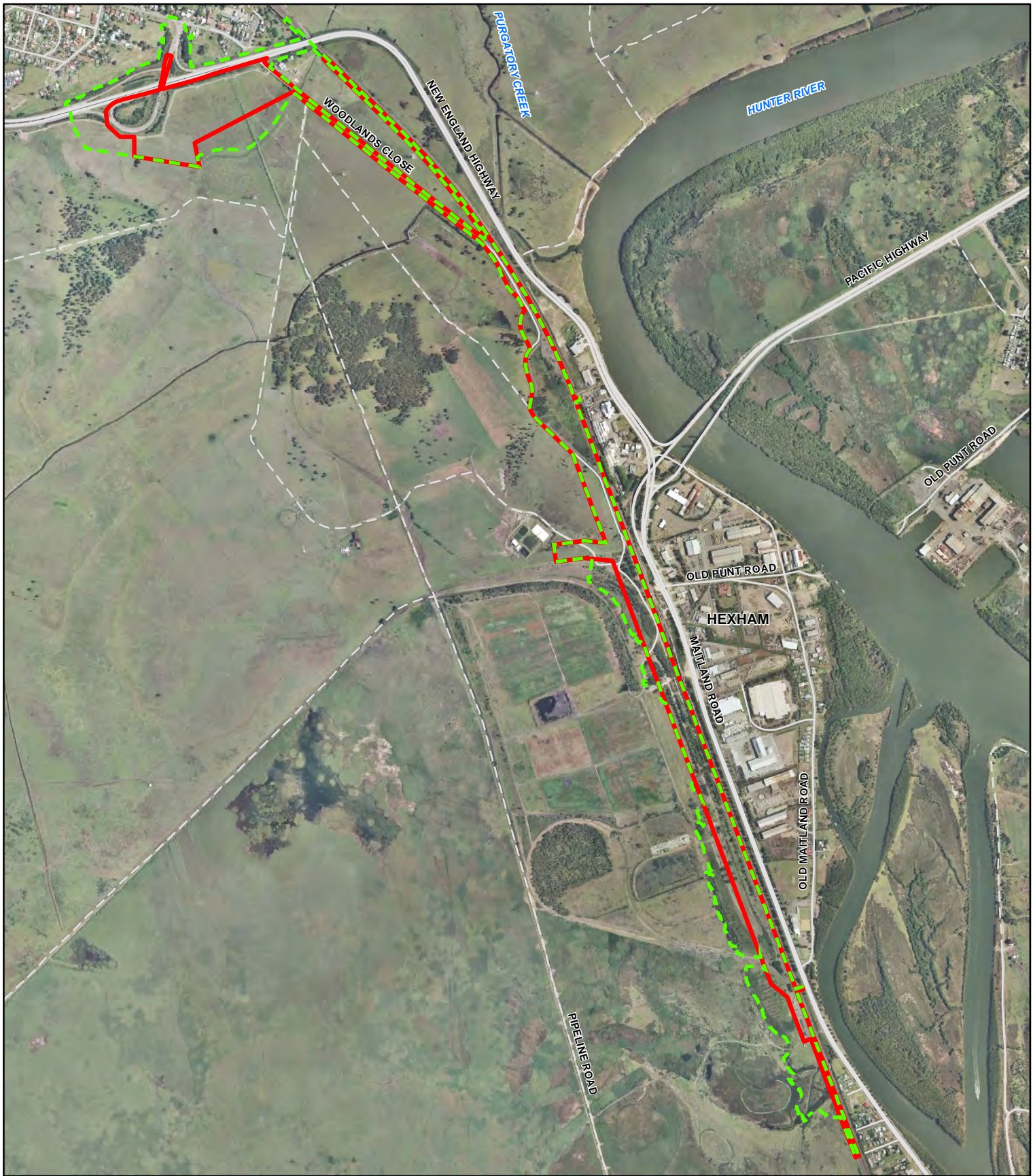
New railway signaling would also be needed for the proposed Project to divert trains off the Up Coal Main, onto the Relief Roads and then back onto the Up Coal Main. This would involve installing electrical cables along the length of the relief roads and building a new overhead gantry for signals to control train movements. Some signaling enclosures would also be required to house the electronic control equipment. These would be built on platforms to be above the 1:100 year flood level.

Ancillary infrastructure would include vehicle access tracks, temporary construction compounds and stockpile sites. Land acquisition and the modification to existing rail infrastructure and public utilities would also be undertaken.

Access to this site for construction and for future operations and maintenance will be off the New England Highway as detailed in the traffic study accompanying the EIS.

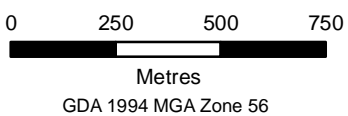
The estimated cost of the proposed Project is approximately \$90 million and it is expected to take approximately 18 months to construct.

This report provides a worst case scenario for impacts to biodiversity as it provides a broad corridor assessment. The area of vegetation and habitats to be cleared would be reduced as a result of ongoing detailed design.



- Major Road
- Local Road
- - - Minor Road
- Study Area
- ▭ Project Area

A4 Original



ARTC
Hexham Relief Roads

Job Number	2110501B
Revision	A2
Date	29.02.2012
Scale	1:18,000

Locality Plan

Figure 1.1

1.2 Director-General’s requirements

A summary of the Director-General’s requirements, guidelines to be followed and requirements provided by Department of Planning and Infrastructure (DP&I) are provided in Table 1–1 including the relevant section of this report where these requirements are addressed.

Table 1-1 Ecological assessment requirements

Assessment requirements	Addressed in report
Director General’s	
Assess and describe <i>‘flora, fauna and habitat (including rare, threatened and endangered species, populations and ecological communities, migratory birds and wetlands)’</i>	Sections 3, 4 and 5
Consideration of <i>‘local, regional, state and corridor impacts (including consideration of the Hunter-Central Rivers Catchment Action Plan’ (Hunter Central Rivers Catchment Management Authority 2007)</i>	Section 3.2
Consideration of <i>‘the Watagan Ranges to Port Stephens Conservation Corridor identified in the Lower Hunter Regional Conservation Plan (Department of Environment Climate Change and Water 2009)’</i>	Section 3.2
<i>‘Flora and fauna surveys including targeted surveys of potentially occurring threatened species’</i>	Section 2
Assessment of <i>‘vegetation clearing (and resultant foraging, roosting habitat loss, fragmentation, connectivity and edge effects) and operational impacts (such as increase in rail movements)’</i>	Section 5
<i>‘Demonstration that the project can be managed to minimise impacts on the Hexham Swamp Rehabilitation Project’ (Hunter Central Rivers Catchment Management Authority 2012)</i>	Section 3.2
Consideration of <i>‘offsets for ecological impacts and native vegetation clearance consistent with the ‘improve and maintain’ principle, taking into account the OEH BioBanking Assessment Methodology’ (Department of Environment and Climate Change 2008c)</i>	Section 8
Consideration of <i>The Draft Guidelines for Threatened species assessment (Department of Environment and Conservation 2005)</i>	Section 2.7, Section 7
<i>‘Taking into account the Threatened biodiversity survey and assessment: Guidelines for developments and activities’ (Department of Environment and Conservation 2004)</i>	Section 2.5
<i>‘Taking into account the Guidelines for Developments Adjoining Land and Water Managed by the Department of Environment, Climate Change and Water (Department of Environment climate Change and Water 2010a)’</i>	Section 3.2
Office of the Environment and Heritage (OEH)	
Provide description of the study area including maps with survey locations, vegetation communities, habitat features, threat-listed species, communities and populations.	Sections 1, 2 and 3
Provide details of the survey methodologies and/or techniques utilised	Section 2, Appendix F
Provide details of all staff undertaking surveys including qualifications	Section 2.2
Document all known and likely threat-listed species, their habitats, population and ecological communities of the site (including any adjacent areas that may be indirectly impacted upon by the proposal)	Section 4, Appendices C and D

Assessment requirements	Addressed in report
Provide a detailed assessment of the impacts on such species, habitats, populations and ecological communities, including impacts to wildlife corridors	Section 5, Appendix E
Detail the actions that will be taken to avoid or mitigate impacts, or compensate or offset for unavoidable impacts of the project on threatened species, populations, ecological communities and their habitats	Section 6
Provision of Statement of Commitments relating to biodiversity	Section 8
The project should be assessed in accordance with the following legislative requirements and guidelines:	
<i>Threatened biodiversity survey and assessment: Guidelines for developments and activities</i> (Department of Environment and Conservation 2004)	Section 2.5
<i>Threatened species survey and assessment guidelines: field survey methods for fauna- Amphibians</i> (Department of Environment and Climate Change 2009)	Section 2.5.2
<i>Threatened species assessment guidelines. The assessment of significance</i> (Department of Environment and Climate Change 2007b)	Section 2.6, Section 7 Appendix E
Principles for the use of biodiversity offsets in NSW (Department of Environment and Climate Change 2008c)	Section 8
The BioBanking assessment methodology (Department of Environment and Climate Change 2008a)	Section 2.5.1.3 and 8
Consideration for assessment of the proposal through the NSW Government's Biodiversity Banking and Offset Scheme (BioBanking)	Section 8

1.3 Aims

The objectives of this ecological assessment, considering the requirements listed in Section 1.2, were to:

- Describe the existing environment, including vegetation communities, and terrestrial, estuarine and aquatic flora and fauna habitats.
- Describe constraints for the proposed Project Area associated with the proposed Project, with particular reference to species, populations and communities, listed under the *Threatened Species Conservation Act 1995* (TSC Act) and/or the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and/or *Fisheries Management Act 1994* (FM Act).
- Prepare significance assessments for the proposed Project's potential impacts, where required, on locally occurring threat-listed species, populations and ecological communities listed under the TSC Act, the EPBC Act and/or the FM Act.
- Develop mitigation measures appropriate for the proposed Project relating to biodiversity.

2. Methods

This ecological assessment included both desk-based assessment of the literature and relevant databases, as well as field survey of the Study Area and surrounding landscape.

2.1 Definitions

For the purpose of this report the following definitions apply:

- **Proposed Project Area** is defined as the extent of direct impacts that will be affected by the proposed rail corridor and ancillary areas defined as the footprint in Figure 1–1. This includes the footprint of the proposed Project and associated infrastructure, access tracks, spoil dumps and any other associated construction areas.
- **Study Area** is defined as the existing rail corridor and a nominal 75 m buffer on the down track. This buffer includes the proposed Project Area and is shown in Figure 1–1.
- **Locality** is defined as 10 km within the vicinity of the Study Area.
- **Region** is a bioregion defined in a national system of bioregionalisation. For this study this is the Sydney Basin bioregion as defined in the Interim Biogeographic Regionalisation for Australia (Thackway & Cresswell 1995).

2.2 Personnel

The contributors to the preparation of this report, their qualifications and roles are listed in Table 2–1.

Table 2-1 Contributors and their roles

Name	Qualification	Role
Alex Cockerill	BSc (Hons)	Lead ecologist – project manager
Allan Richardson	BEnvSc (Hons)	Senior ecologist – fauna assessment
Deborah Landenberger	BSc (Hons)	Ecologist – flora assessment
Nathan Cooper	Grad Cert Ornith, BEnvSc	Ecologist – fauna assessment
Sam Wilkin	Dip GIS	Geospatial Consultant – Mapping
Jemma Sargent	BSc	Principal ecologist – aquatic and marine
Alison Hunt	PhD, BSc (Hons)	Principal ecologist – aquatic and marine

All work was carried out under the appropriate licences, including a scientific licence as required under Clause 22 of the National Parks and Wildlife Regulations 2002 and Section 132C of the *National Parks and Wildlife Act 1974*, Animal Research Authority issued by the Department of Industries and Investment NSW (Agriculture) and Fisheries Collection Permit (P11/0052-1.0).

2.3 Nomenclature

Names of plants used in this document follow Harden (Harden 1992, 1993, 2000, 2002) with updates from PlantNet (Royal Botanic Gardens 2010). Scientific names are used in this report for species of plant followed by the common names in brackets. Scientific and common names of plants are listed in Appendices A and C. Introduced species are identified within the text with an asterisk following the name, for example *Lantana camara**.

Names of vertebrates follow the Census of Australian Vertebrates (CAVS) database maintained by the Department of the Environment, Water, Heritage and the Arts (Department of the Environment Water Heritage and the Arts 2009a). Common names are used in the report for species of animal. Scientific names are included in species lists found in Appendix C.

2.4 Database searches

Records of Threatened species known or predicted to occur within the proposed Project locality were obtained from a range of databases as detailed in Table 2-2.

Table 2-2 Database searches

Database	Search date	Area searched	Reference
Atlas of NSW Wildlife	2 February 2012 (flora and fauna)	10 km buffer around the activity footprint	Office of Environment and Heritage (Office of Environment and Heritage 2012a)
Threatened Species, Populations and Communities Database	2 February 2012 (flora and fauna)	Hunter/Central Rivers Catchment Management Authority area, Hunter subdivision	Department of Environment and Heritage (Office of Environment and Heritage 2012b)
NSW DPI threatened Aquatic Fauna Database	2 February 2012 (flora and fauna)	Hunter/Central Rivers Catchment Management Authority area	NSW Department of Primary Industries (NSW Department of Industry and Investment 2012)
PlantNet	27 January 2012	10 km buffer around the activity footprint	Royal Botanical Gardens, Sydney (Royal Botanic Gardens 2012)
Protected Matters Search Tool	2 February 2012 (flora and fauna)	10 km buffer around the activity footprint	Department of Sustainability, Environment, Water, Population and Communities (Department of Sustainability Environment Water Population and Communities 2012)

Note: Flora and Fauna database searches were completed as a radius (10 km) around the following co-ordinates: GDA94, Zone 56, 376891, 6366854.

2.5 Field survey

Targeted surveys were undertaken from 15 to 22 June, 5-6 September, 4 November and 7-8 November 2011, inclusive. Survey effort is described below and mapped in Figures 2-1A, 2-

1B, 2–1C (terrestrial flora and fauna) and Figures 2–4A, 2-4B, 2–4C (estuarine and aquatic flora and fauna).

2.5.1 Flora

The floristic diversity and possible presence of threat-listed species was assessed using a combination of random meander and plot-based (quadrat) surveys in accordance with the NSW *Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities (Working Draft)* (Department of Environment and Conservation 2004).

Due to the linear nature of the proposed Project, random meander surveys were completed along the entire length of the proposed Project corridor. Random meander surveys are a variation of the transect type survey and were completed in accordance with the technique described by Cropper (1993), whereby the recorder walks in a random manner throughout the site recording all species observed, boundaries between various vegetation communities and condition of vegetation. The time spent in each vegetation community was generally proportional to the size of the community and its species richness.

2.5.1.1 Desktop analysis of vegetation

The Study Area’s vegetation community boundaries were assessed using aerial photo interpretation. Analysis of the aerial photographs identified past land use practices, disturbance and native vegetation regrowth, changes in vegetation structure and floristics throughout the Study Area. This provided an initial split of vegetation communities into simple structural and disturbance classifications.

2.5.1.2 Field verification of existing vegetation mapping

Vegetation within the Study Area and locality has been mapped at the regional scale by Lower Hunter and Central Coast Regional Environmental Management Strategy (2003). Field validation (ground-truthing) of the initial vegetation classification (Lower Hunter and Central Coast Regional Environmental Management Strategy 2003) identified from aerial photograph interpretation and existing vegetation mapping was undertaken to determine the site specific classification of the vegetation structure, dominant canopy species, native diversity and condition.

2.5.1.3 Quadrats

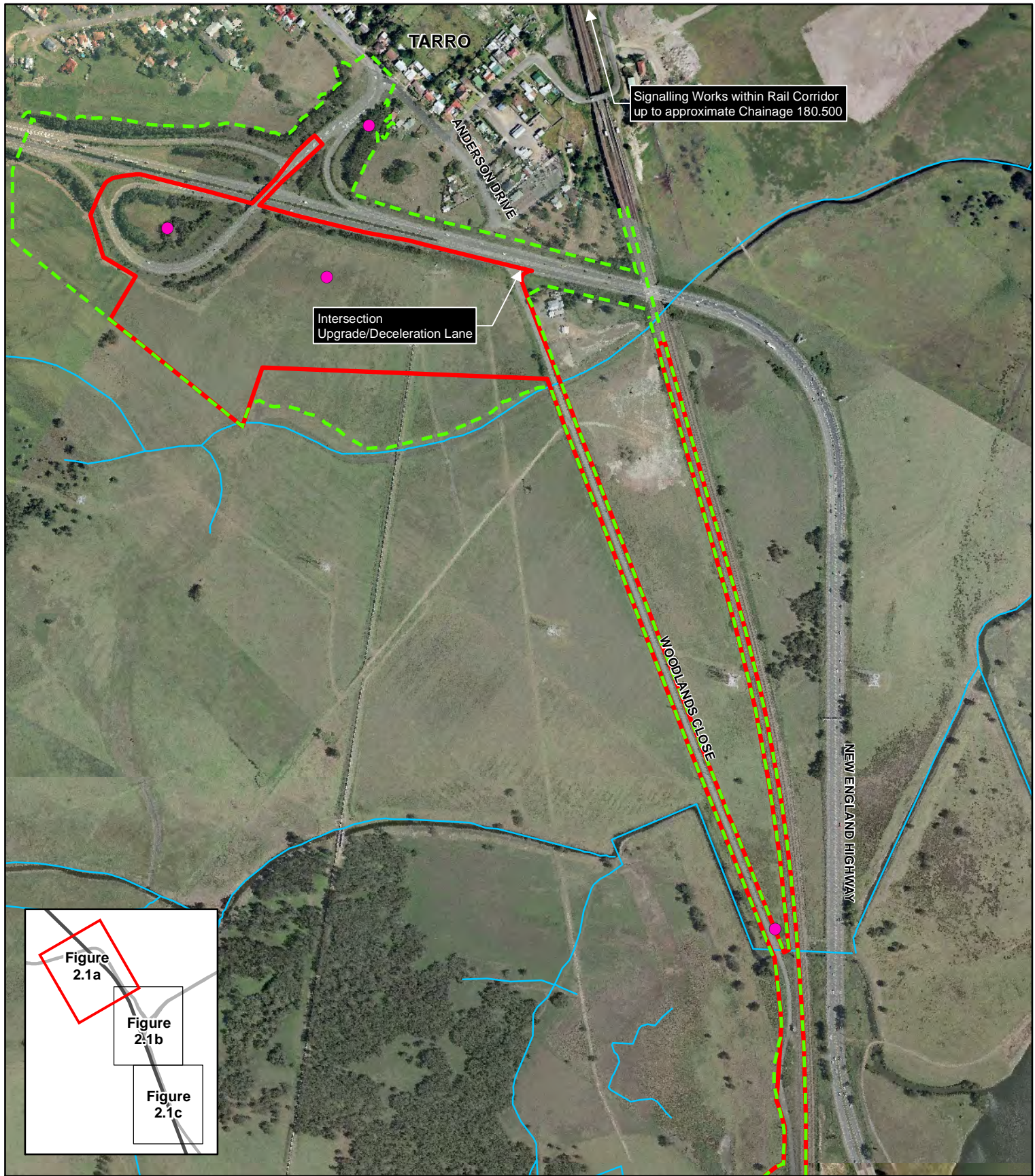
Sixteen quantitative (quadrat/transect) site surveys (Table 2–3 and Figures 2–1A, 2-1B and 2-1C) were undertaken as outlined in the methodology contained within BioBanking Operation Manual (Seidel & Briggs 2008) and described below. Figure 2–2 illustrates the plot layout that was used at each site.

Table 2-3 Location of flora quadrats

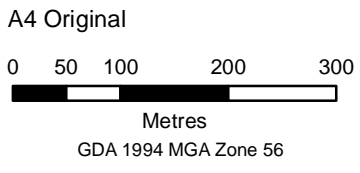
Biobanking Quadrat\Transect ID	Easting	Northing
B1	376409	6367829
B2	376484	6367636
B3	376589	6367508
B4	376760	6367032
B5	376697	6367031

Biobanking Quadrat\Transect ID	Easting	Northing
B6	376799	6366855
B7	376831	6366785
B8	376955	6366470
B9	377049	6366254
B10	377251	6365684
B11	377236	6365769
B12	377381	6365279
B13	375173	6368929
B14	376200	6368256
B15	375226	6368721
B16	375005	6368672

Notes: GDA 94: Zone 56



- Drainage
- Survey Transect
- Study Area
- Project Area
- ▲ White-fronted Chat
- Flora Survey
- Bird Survey
- Call Playback
- Habitat Assessment
- Reptile Survey

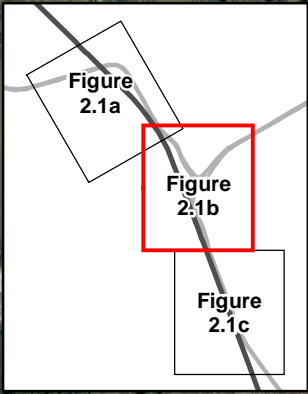
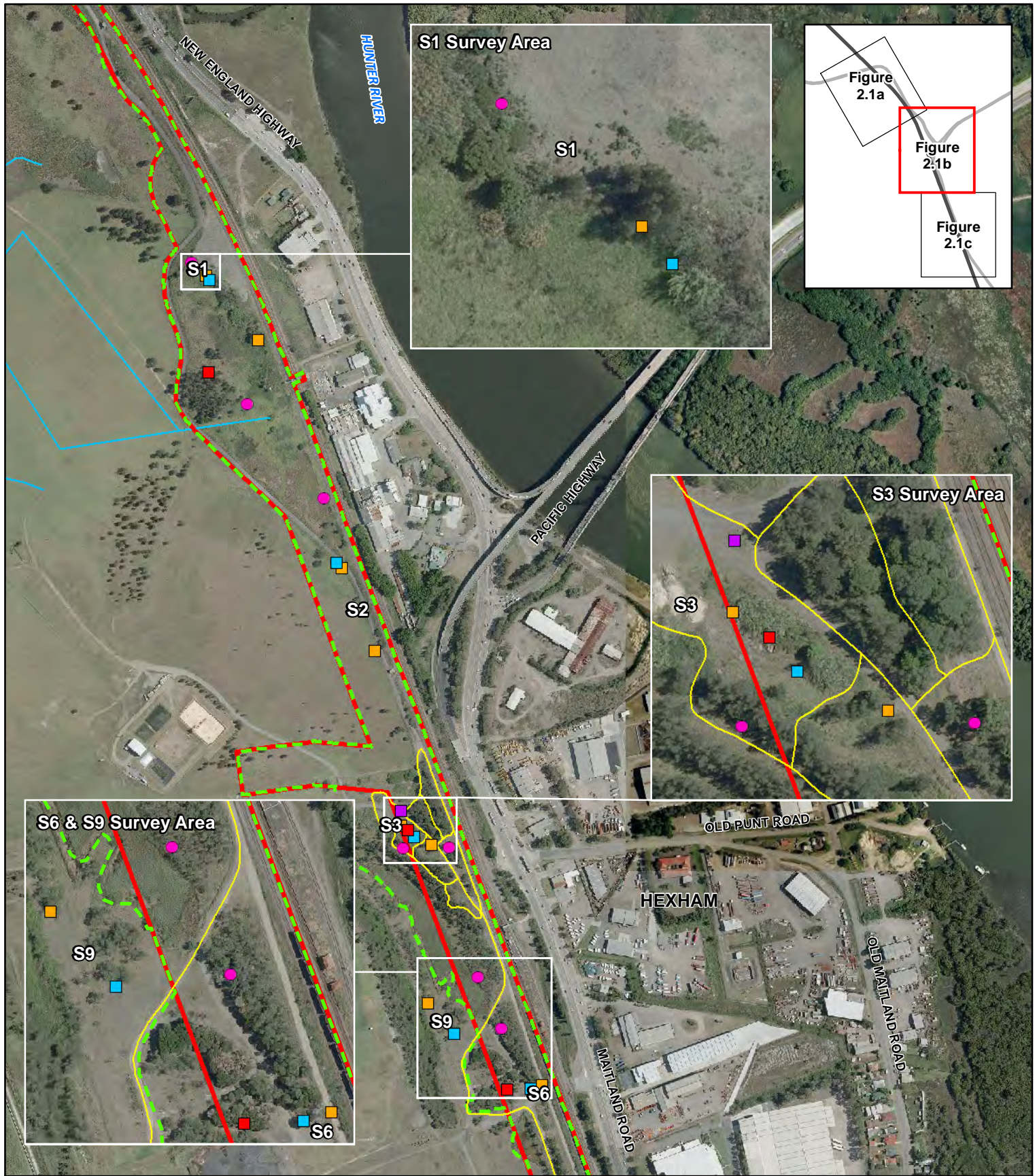


ARTC
Hexham Relief Roads

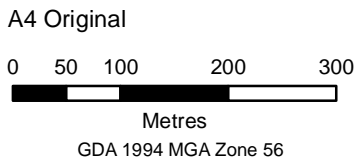
Job Number	2110501A
Revision	A5
Date	29.02.2012
Scale	1:7,000

Survey Effort

Figure 2.1a



- Drainage
- Survey Transect
- Study Area
- Project Area
- ▲ White-fronted Chat
- Flora Survey
- Bird Survey
- Call Playback
- Habitat Assessment
- Reptile Survey

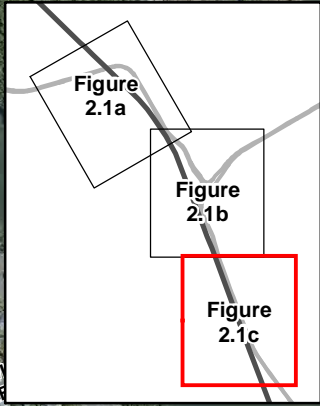
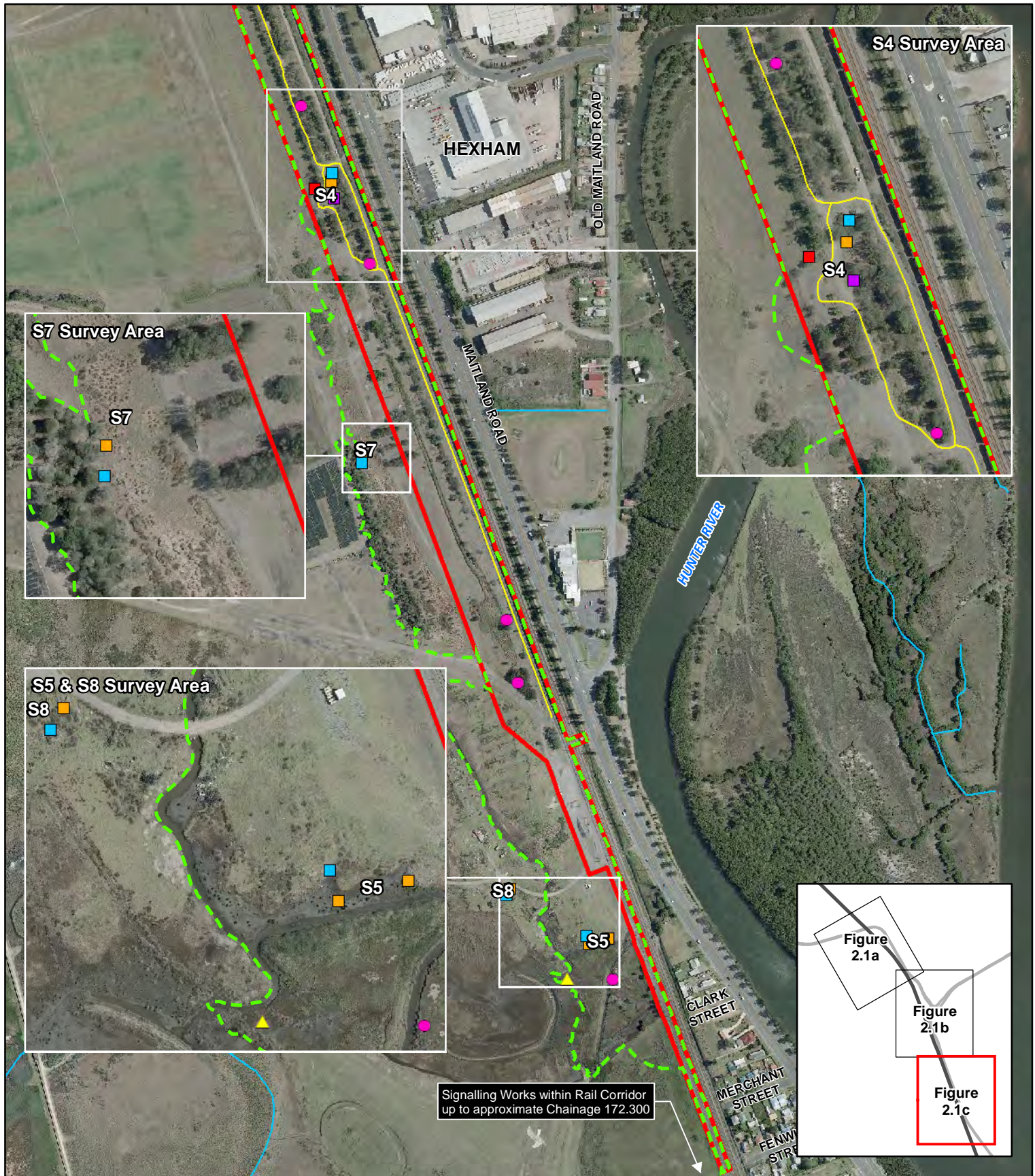


ARTC
Hexham Relief Roads

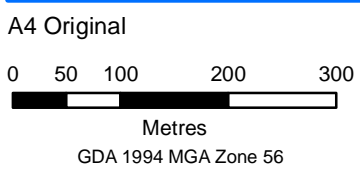
Job Number	2110501A
Revision	A5
Date	29.02.2012
Scale	1:7,000

Survey Effort

Figure 2.1b



- Drainage
- Survey Transect
- Study Area
- Project Area
- ▲ White-fronted Chat
- Flora Survey
- Bird Survey
- Call Playback
- Habitat Assessment
- Reptile Survey



ARTC
Hexham Relief Roads

Survey Effort

Job Number	2110501A
Revision	A5
Date	29.02.2012
Scale	1:7,000

Figure 2.1c

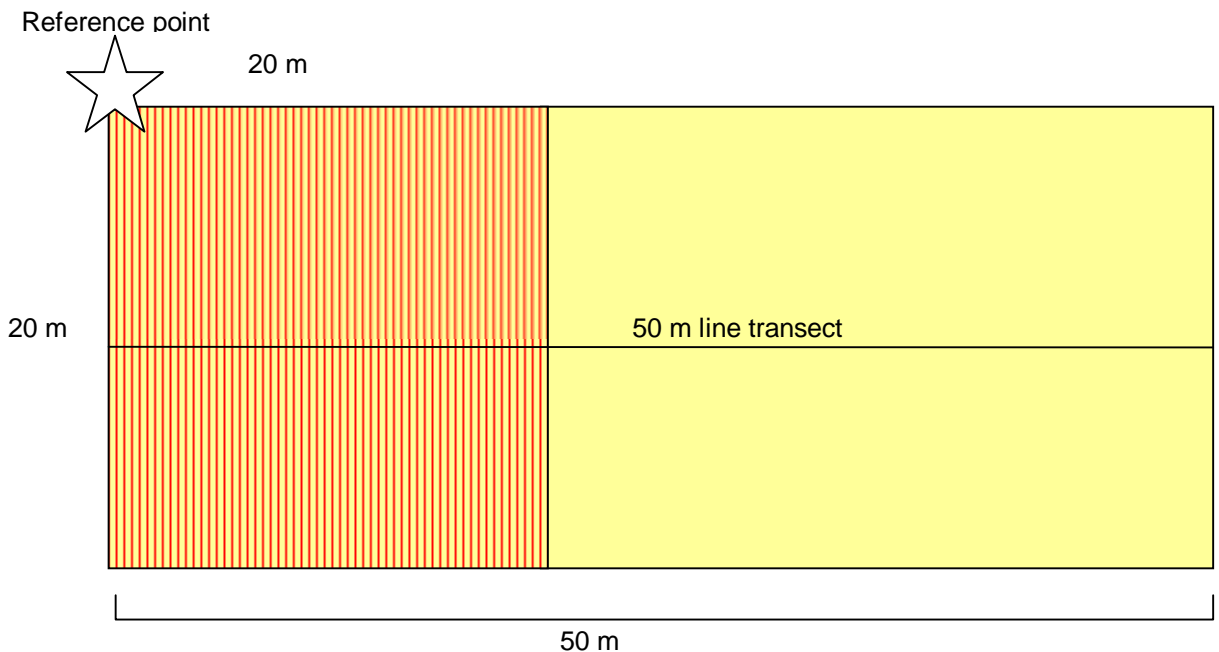


Figure 2-2 Schematic diagram illustrating the layout of the nested 20 x 50 m and 20 x 20 m quadrats used for the assessment of condition attributes at each site

Key:  20 x 20 m quadrat  20 x 50 m quadrat

The following site attributes were recorded at each site:

- **Location** (easting – northing grid type MGA 94, Zone 56).
- **Vegetation structure and dominant species and vegetation condition.**
- **Native and exotic species richness** (within a 400 m² quadrat): This consisted of recording all species by systematically walking through each 20 x 20 m quadrat. The cover abundance of each species was estimated.
- **Number of trees with hollows** (1,000 m² quadrat): This was the frequency of hollows within living and dead trees within each 50 x 20 m quadrat. A hollow was only recorded if (a) the entrance could be seen: (b) the estimated entrance width was at least 5 cm across: (c) the hollow appeared to have depth: (d) the hollow was at least 1 m above the ground and the (e) the centre of the tree was located within the sampled quadrat.
- **Total length of fallen logs** (1,000 m² quadrat): This was the cumulative total of logs within each 50 x 20 m quadrat with a diameter of at least 10 cm and a length of at least 0.5 m.
- **Native overstorey cover:** This consisted of estimating the percentage cover of the tallest woody stratum present (>1 m and including emergents). The woody stratum included species that were native to New South Wales and not necessarily those that were locally endemic.

- **Native mid-storey cover:** This involved estimating the cover of vegetation between the overstorey stratum and a height of 1 m (i.e. tall shrubs, under-storey trees and tree regeneration).
- **Ground cover:** This comprised estimating the cover of plants below 1 m in height. The following categories of plants were recorded:
 - **Native ground cover (grasses):** native grasses (Poaceae family native to NSW).
 - **Native ground cover (shrubs):** all woody vegetation below 1 m in height and native to New South Wales.
 - **Native ground cover (other):** non-woody vegetation (i.e. vascular plants – ferns and herbs) below 1 m in height and native to New South Wales.
 - **Exotic plant cover:** vascular plants not native to Australia.
- **Evaluation of regeneration:** This was estimated as the proportion of overstorey species present at the site that was regenerating (i.e. saplings with a diameter at breast height ≤ 5 cm). The maximum value for this measure was 1.

2.5.1.4 Condition and quality assessment of vegetation communities

The condition of vegetation was assessed through general observation and comparison against this benchmark data as well as using parameters such as intactness, diversity, history of disturbance, weed invasion and health.

Three categories were used to describe the condition of vegetation communities:

- **Good:** Vegetation still retains the species complement and structural characteristics of the pre-European equivalent. Such vegetation has usually changed very little over time and displays resilience to weed invasion due to intact groundcover, shrub and canopy layers.
- **Moderate:** Vegetation generally still retains its structural integrity, but has been disturbed and has lost some component of its original species complement. Weed invasion can be significant in such remnants.
- **Low:** Vegetation that has lost most of its species and is significantly modified structurally. Often such areas have a discontinuous canopy of the original tree cover, with very few shrubs. Exotic species, such as introduced pasture grasses or weeds, replace much of the indigenous ground cover. Environmental weeds are often co-dominant with the original indigenous species.

Following the biometric methodology (NSW Department of Environment and Conservation 2007), woody vegetation, is in low condition vegetation when:

- Overstorey percent foliage cover is $<25\%$ of the lower values of the overstorey per cent foliage cover benchmark for that vegetation type, AND either:
 - Less than 50% of vegetation in the ground layer is indigenous species, OR
 - Greater than 90% is ploughed or fallow.

2.5.2 Fauna

Survey effort considered the methodology detailed in the *NSW Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities (Working Draft)* (Department of Environment and Conservation 2004), the *Threatened Species survey and assessment guidelines: field survey and methods for fauna-Amphibians* (NSW Department of Environment 2009) and the Significant impact guidelines for the vulnerable Green and Golden Bell Frog (*Litoria aurea*) (Australia 2009).

Surveys included fauna habitat assessments as well as targeted surveys including Green and Golden Bell Frog and microchiropteran bat surveys (anabat recordings), spotlighting and call playback, diurnal bird surveys and active herpetofauna searches. The methods used are described below.

All fauna species observed during the fauna surveys were documented and combined into a total species list (Appendix B).

2.5.2.1 Fauna habitats

Fauna habitat assessments were completed to assess the likelihood of threat-listed species of animal occurring in the Study Area. Habitat assessments included the assessment and identification of habitat features and hollow tree surveys through targeted meander surveys.

During habitat assessments and targeted meander surveys, opportunistic recordings of species were made through incidental sightings, aural recognition of calls and observations of indirect evidence of species' presence (i.e. Squirrel Glider chews, Glossy-black Cockatoo chewed cones, nests/dreys, whitewash, burrows and scats). This provided supplementary information on faunal species presence.

Fauna habitats were assessed generally by examining characteristics such as the structure and floristics of the canopy, understorey and ground vegetation, the structure and composition of the litter layer, and other habitat attributes important for feeding, shelter roosting and breeding. The following criteria were used to evaluate habitat values:

- **Good:** A full range of fauna habitat components are usually present (for example, old-growth trees, fallen timber, feeding and roosting resources) and habitat linkages to other remnant ecosystems in the landscape are intact.
- **Moderate:** Some fauna habitat components are missing (for example, old-growth trees and fallen timber), although linkages with other remnant habitats in the landscape are usually intact, but sometimes degraded.
- **Poor:** Many fauna habitat elements in low quality remnants have been lost, including old growth trees (for example, due to past timber harvesting or land clearing) and fallen timber, and tree canopies are often highly fragmented. Habitat linkages with other remnant ecosystems in the landscape have usually been severely compromised by extensive past clearing.

Specific fauna habitat features were assessed at nine locations (Figures 2-1A, 2-1B and 2-1C) in and adjacent to the Study Area. Features measured and assessed at each site are shown in Table 2-4.

Table 2-4 Fauna habitat features assessed

General features	Overstorey features	Other features	Fauna tracks/signs	If water body present
Site number	Dominant vegetation	Artificial habitat features	Fauna scats	Waterbody type
Location (easting, northing)	Dominant overstorey species	Significant flowering events	Squirrel/Sugar Glider chews	Level of permanence
Evidence of disturbance	Senescence in canopy (%)	Midstorey (>2 m) cover	Scratches and worn areas on trees	Fringing composition
Evidence of clearing	Hollows high trunk	Significant species for fauna (e.g. food)	Potential Large Forest Owl roost trees	Riparian vegetation
Erosion	Hollows mid trunk	Understorey (<2 m) cover	Miscellaneous fauna traces	Condition of water body
Evidence of fire	Hollows low trunk	Groundcover vegetation (%)		
Epicormic growth	Fire scar hollows	Groundcover leaf litter (%)		
Other disturbance	Limb hollows	Fallen logs		
	Stags	Size of hollows in fallen logs (if any)		
		Rocks		

2.5.2.2 Microchiropteran bat surveys

Ultrasonic Anabat Bat detection (Anabat SD1 CF Bat Detector – Titley Electronics, Ballina) was used to record and identify the echolocation calls of microchiropterans foraging at one location in the Study Area (Figures 2-1A, 2-1B and 2-1C). One survey location was surveyed using active monitoring methods. Active monitoring of the survey site was completed during a spotlight event, whereby an Anabat detector was used to track the animals and record their calls while actively spotlighting. Bat call analysis was undertaken by Nathan Cooper of Parsons Brinckerhoff (Appendix G), with Bat calls of New South Wales Sydney Basin (Pennay *et al.* 2004) used as a reference collection for bat call identification.

2.5.2.3 Spotlighting

Spotlighting was used to target arboreal, flying and large ground-dwelling mammals, as well as nocturnal birds, reptiles and amphibians. Spotlighting was done after dusk at two locations in the Study Area (Figures 2-1A, 2-1B and 2-1C). At least one person hour of survey effort was undertaken at six survey locations (survey sites S1, S3, S4 and three supplementary sites) on foot using two 100 watt vari-beam spotlights (see Appendix F). The speed of the spotlight surveys was approximately 1 km per hour. Surveys concentrated on areas that contained suitable habitat for nocturnal species, with sighted animals identified to the species level.

One other spotlight survey consisted of a drive transect along the existing downside rail easement from chainage 173.900 km to 176.800 km. The vehicle was driven at approximately 5 km per hour. Two 100 watt vari-beam spotlights were used to survey habitat along the existing rail alignment, with sighted animals identified to the species level.

2.5.2.4 Call playback

Call playback was used to survey for the Grass Owl and Powerful Owl, using standard methods (Debus 1995; Kavanagh & Debus 1994). Call playback was done after dusk at two locations in the Study Area (Figures 2-1A, 2-1B and 2-1C and Appendix F).

For each survey, an initial listening period of 10 to 15 minutes was undertaken, followed by a spotlight search for 10 minutes to detect any animals in the immediate vicinity. The calls of the target species were then played intermittently for five minutes (Grass Owl and Powerful Owl respectively) followed by a 10 minute listening period. After the calls were played, another 10 minutes of spotlighting was done in the vicinity to check for animals attracted by the calls, but not vocalising. Calls from Stewart (Pennay *et al.* 2004; Stewart 1998) were broadcast using an MP3 player and amplified through a megaphone.

2.5.2.5 Diurnal bird surveys

Bird surveys were completed at nine locations in the Study Area (Figures 2-1A, 2-1B and 2-1C and Appendix F). Bird surveys completed at survey sites S1-S9 were completed by actively walking through the nominated sites (transect) over a period of 20 minutes. All birds were identified to the species level, either through direct observation or identification of calls.

2.5.2.6 Herpetofauna active searches

Herpetofauna active searches involved looking for active specimens and eye shine (frogs only): turning over suitable ground shelter, such as fallen timber, sheets of iron and exposed rocks, racking debris, and peeling decorticating bark. Specimens were either identified visually, by aural recognition of call (frogs only) or were collected and identified using nomenclature outlined in Swan *et al.* (2004) (A Field Guide to Reptiles of New South Wales).

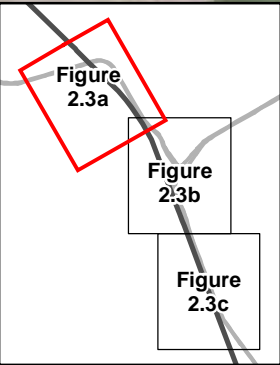
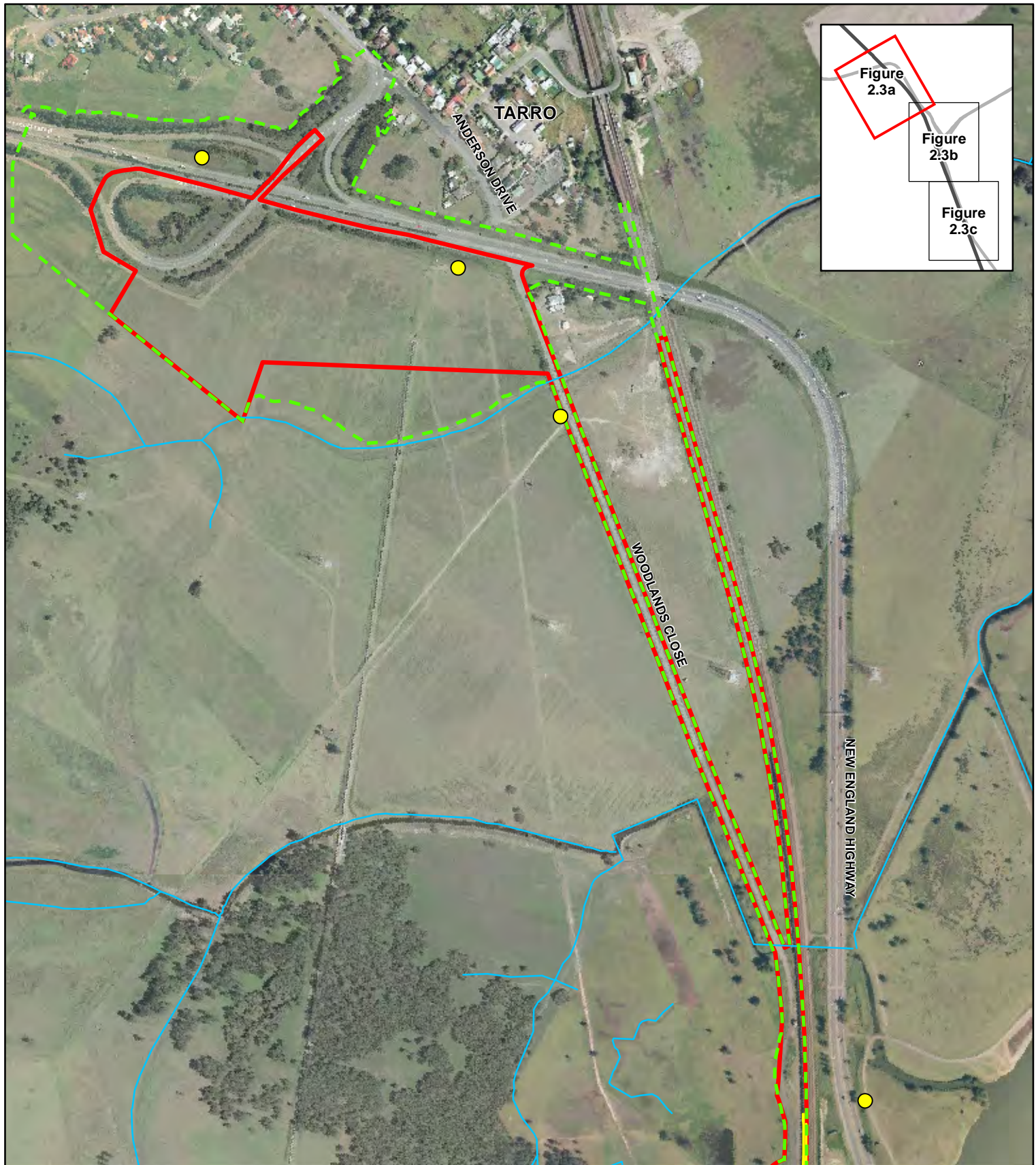
Herpetofauna surveys were completed by two persons over a 20 minute period and all ground shelter was returned to their original positions. Herpetofauna active searches were completed at standard trap sites (S1-S9) (Figures 2-1A, 2-1B and 2-1C and Appendix F). Frogs and reptiles were also surveyed during spotlight events and opportunistically across the Study Area.

Frog surveys were conducted in accordance with frog survey guidelines (Department of the Environment Water Heritage and the Arts 2010a) and the hygiene protocol for the control of disease in frogs (NSW National Parks and Wildlife Service 2001).

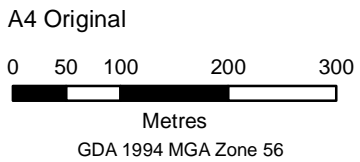
2.5.2.7 Targeted Green and Golden Bell Frog surveys

Targeted searches for Green and Golden Bell Frog followed methodology described in Survey guidelines for Australia's threatened frogs {Department of the Environment Water Heritage and the Arts, 2010 #3436} and Significant impact guidelines for the vulnerable Green and Golden Bell Frog (*Litoria aurea*) (Department of the Environment, Water, Heritage and the Arts 2009c, 2009d). Targeted searches were completed during optimal weather conditions in September and November 2011, and included call detection, call playback and spotlighting (Figure 2-3A-C, Appendix F).

A reference site was surveyed in conjunction with targeted searches so as to ensure species detectability. Personal communication with Professor Michael Mahony (Newcastle University) further ensured adequacy of survey timing and detectability. Green and Golden Bell Frog survey effort is shown in Figure 2-3.



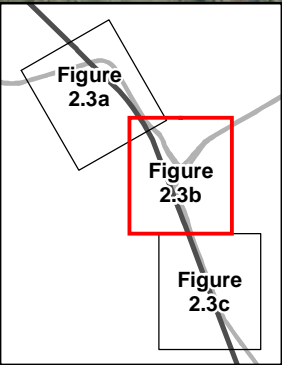
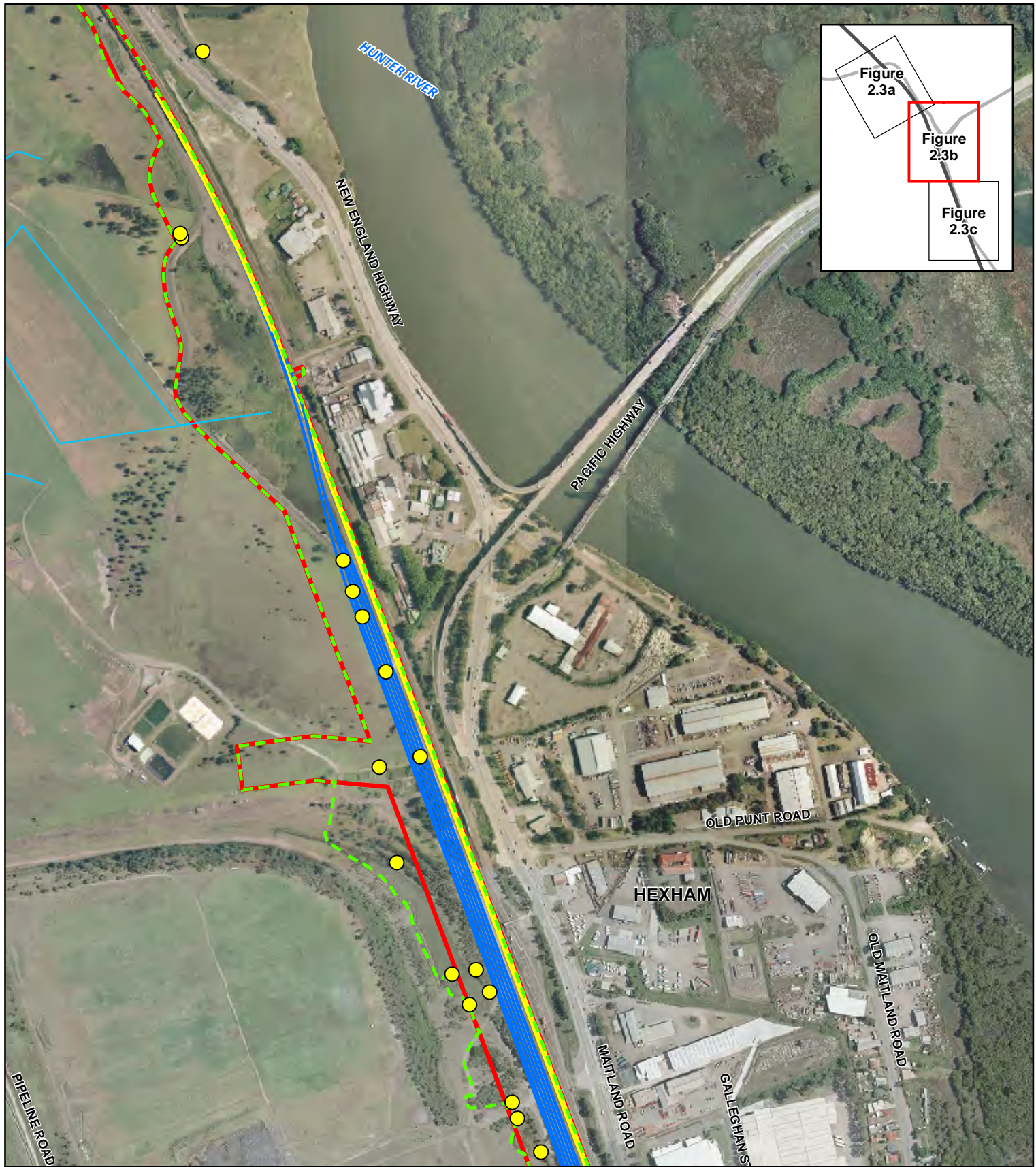
- Drainage
- Proposed Alignment
- Existing Alignment
- Study Area
- Project Area
- Targeted Green and Golden Bell Frog Survey Site



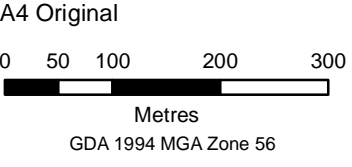
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Figure 2.3a



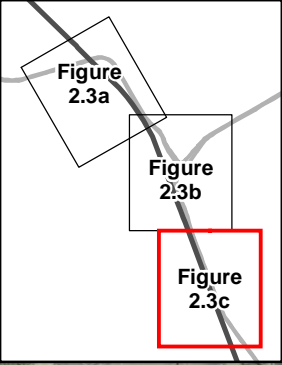
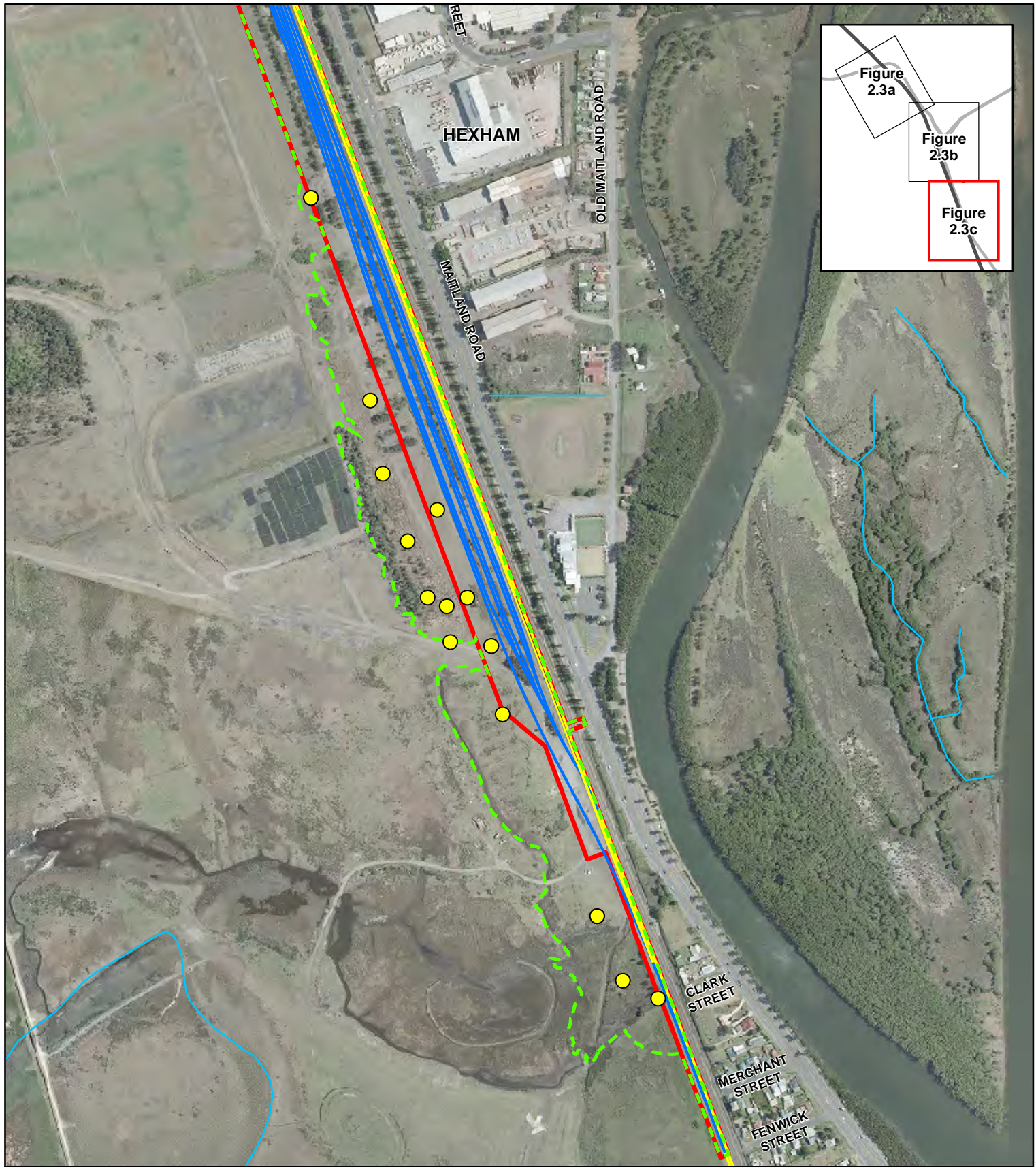
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- Proposed Alignment
- Existing Alignment
- - - Study Area
- - - Project Area
- Targeted Green and Golden Bell Frog Survey Site



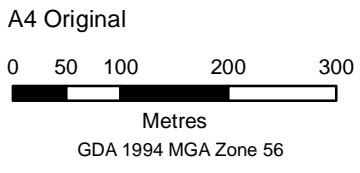
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Figure 2.3b



- Drainage
- Proposed Alignment
- Existing Alignment
- - - Study Area
- Project Area
- Targeted Green and Golden Bell Frog Survey Site



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Figure 2.3c

2.5.3 Estuarine and aquatic

Survey effort considered the methodology detailed in the Guidelines for the Assessment of Aquatic Ecology in EIA (Department of Planning 2003) and *NSW Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities (Working Draft)* (Department of Environment and Conservation 2004).

Surveys involved habitat assessments of estuarine and freshwater habitats including: intertidal mangrove, saltmarsh, wetland and creek systems and targeted flora and fauna surveys. The site surveys included: water quality recordings, quadrat and transect surveys of flora communities, quadrat surveys for epibenthic fauna and trapping for fish species (Figure 2-4). The site survey methods used are described in this section.

All flora and fauna species observed during the aquatic surveys were documented and compiled into a total species list (Appendix H).

2.5.3.1 Water quality

A multi-probe water quality meter was used to record insitu water quality at the sites. The water quality parameters measured included pH, turbidity (NTU), conductivity (s/cm), temperature (°C), dissolved oxygen (% saturation). The water quality sampling was undertaken following procedures outlined in:

- AS/NZS 6557.1:1998 Water Quality-Sampling-Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples.
- AS/NZS 5667.6:1998 Water Quality-Sampling-Guidance on sampling of rivers and streams. Provides detailed guidance on the design of sampling programs, sampling techniques and the handling and preservation of samples from rivers and streams.
- Australian Guidelines for Water Quality Monitoring and Reporting (2000).

The water quality data was analysed against the Australian and New Zealand Marine and Fresh Water Quality Guidelines (ANZECC 2000) (ANZECC/ARCANZ Guidelines).

2.5.3.2 Estuarine communities

The coastal saltmarsh and mangrove communities were quantitatively surveyed for species abundance and richness at two sites within the Study Area, and three sites on the Hunter River associated with the culvert draining from the Study Area. Where the Study Area was considered likely to have direct impacts upon the communities, study sites were surveyed at direct and indirect impact sites. This provides a stratified assessment of the species composition in the communities present at each site. The following survey methods for each estuarine flora and fauna community were undertaken:

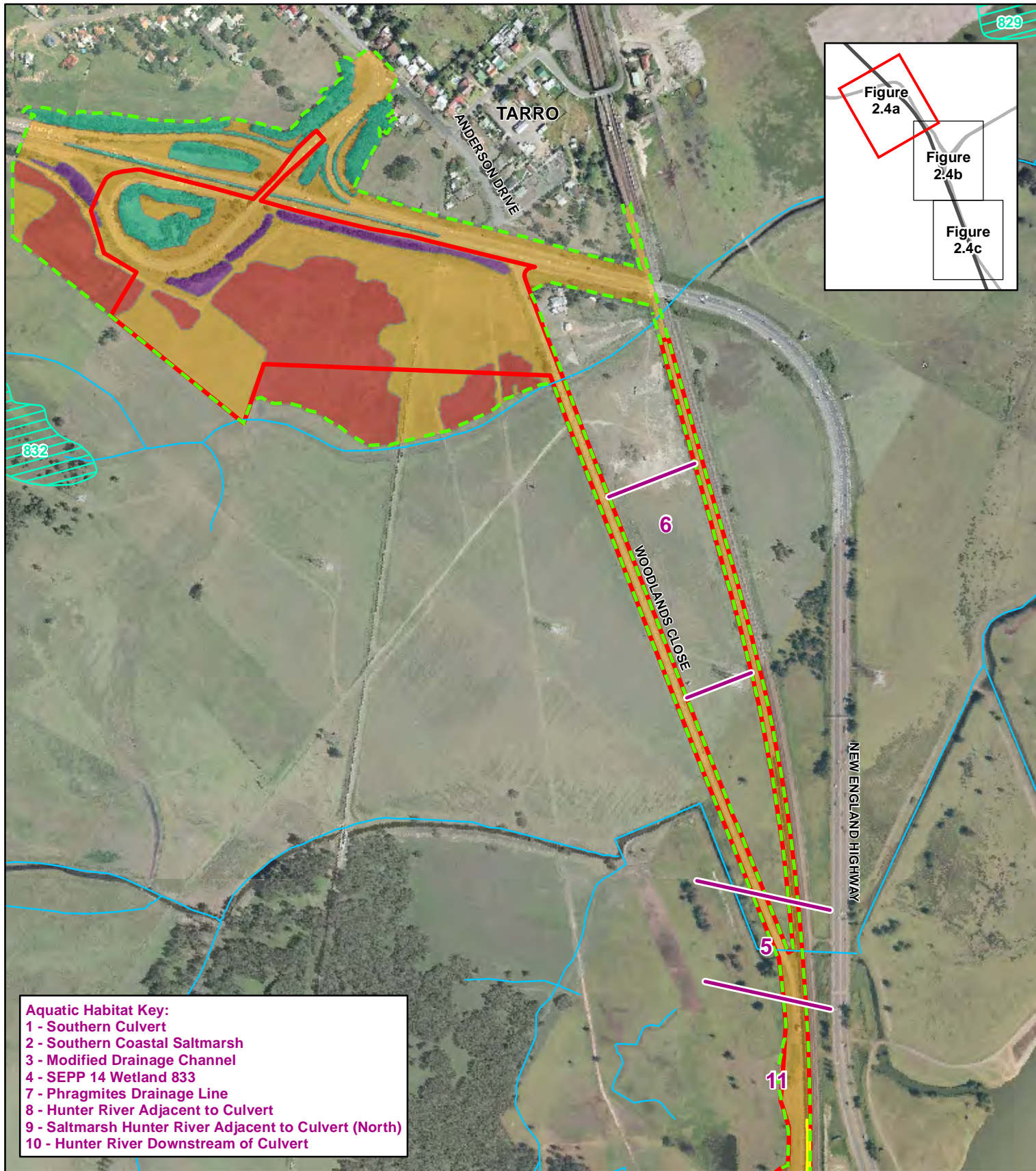
- Habitat assessments: undertaken at each site to provide a character summary of each site. The assessment included important habitat features including: benthic substrate, vegetation density, canopy cover, bank stability, tidal inundation, habitat potential for estuarine fauna, disturbance and connectivity to adjoining habitat.
- Water quality: water quality measurements were recorded at each site. The variables measured were: pH, turbidity (NTU), conductivity (s/cm), temperature (°C), dissolved oxygen (mg/L).

- Saltmarsh: at each site, five quadrats (1 x 1 m) were surveyed with species type and density recorded.
- Mangroves: at each site, transects from bank to bed extent were surveyed. Measurements of species type, height, density and number of pneumatophores within quadrats (1 x 1 m) were recorded.
- Benthic epifauna: at each saltmarsh site, five quadrats (1 x 1 m) were surveyed with species type and density were recorded.
- Fish: Six bait traps were deployed at each site for 13 hours where water depth allowed. These were set by baiting with dry dog food and placed in the wetland/creek/drainage line marked using small floats.

2.5.3.3 Aquatic communities

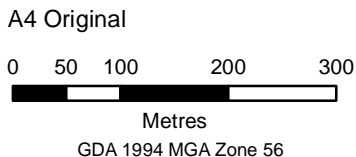
A variety of freshwater habitats were present within the study area corridor including wetlands (including two SEPP14 wetlands), drainage lines and ponded pastures. Depending on habitat availability and species present, various survey techniques were used to provide a stratified assessment of the species composition in the communities present at each site. The following survey methods were undertaken at each site for each aquatic flora and fauna community:

- Habitat assessments: undertaken at each site to provide a character summary of each site. The assessment included important habitat features including: benthic substrate, flow velocity, riparian vegetation density, canopy cover, bank stability, habitat potential for aquatic fauna, disturbance and connectivity to adjoining habitat.
- Water quality: water quality measurements were recorded at each site. The variables measured were: pH, turbidity (NTU), conductivity (s/cm), temperature (°C), dissolved oxygen (mg/L).
- Wetland plants: at each site, five quadrats (1 x 1 m) were surveyed and species type and density were recorded.
- Fish: Six bait traps were deployed at each site for 13 hours where water depth allowed. These were set by baiting with dry dog food and placed in the wetland/creek/drainage line marked using small floats.



Aquatic Habitat Key:
 1 - Southern Culvert
 2 - Southern Coastal Saltmarsh
 3 - Modified Drainage Channel
 4 - SEPP 14 Wetland 833
 7 - Phragmites Drainage Line
 8 - Hunter River Adjacent to Culvert
 9 - Saltmarsh Hunter River Adjacent to Culvert (North)
 10 - Hunter River Downstream of Culvert

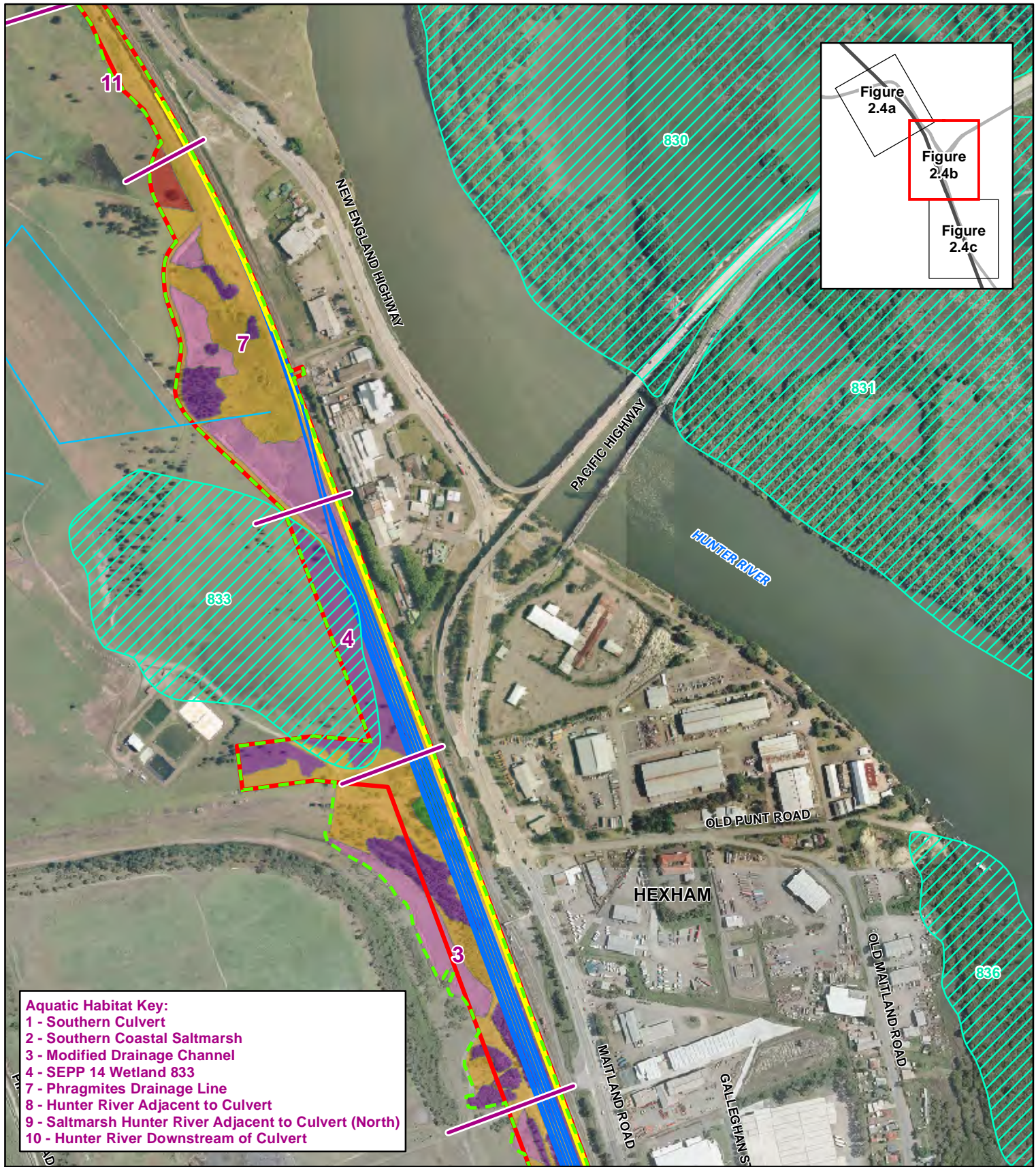
- | | | | |
|------------------------|--------------|--------------------------------|---|
| Drainage | Study Area | Coastal Saltmarsh in Estuaries | <i>Phragmites australis</i> and <i>Typha orientalis</i> Coastal Freshwater Wetlands |
| Proposed Alignment | Project Area | Exotic Grassland / Disturbed | Swamp Mahogany Swamp Forest on Coastal Lowlands |
| Existing Alignment | | Exotic Herbfeld | Swamp Oak Swamp Forest Fringing Estuaries |
| Aquatic Habitat Extent | | Planted Vegetation | |
| SEPP14 Wetland | | Water | |



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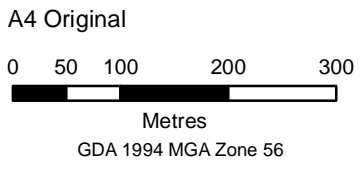
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Figure 2.4a



Aquatic Habitat Key:
 1 - Southern Culvert
 2 - Southern Coastal Saltmarsh
 3 - Modified Drainage Channel
 4 - SEPP 14 Wetland 833
 7 - Phragmites Drainage Line
 8 - Hunter River Adjacent to Culvert
 9 - Saltmarsh Hunter River Adjacent to Culvert (North)
 10 - Hunter River Downstream of Culvert

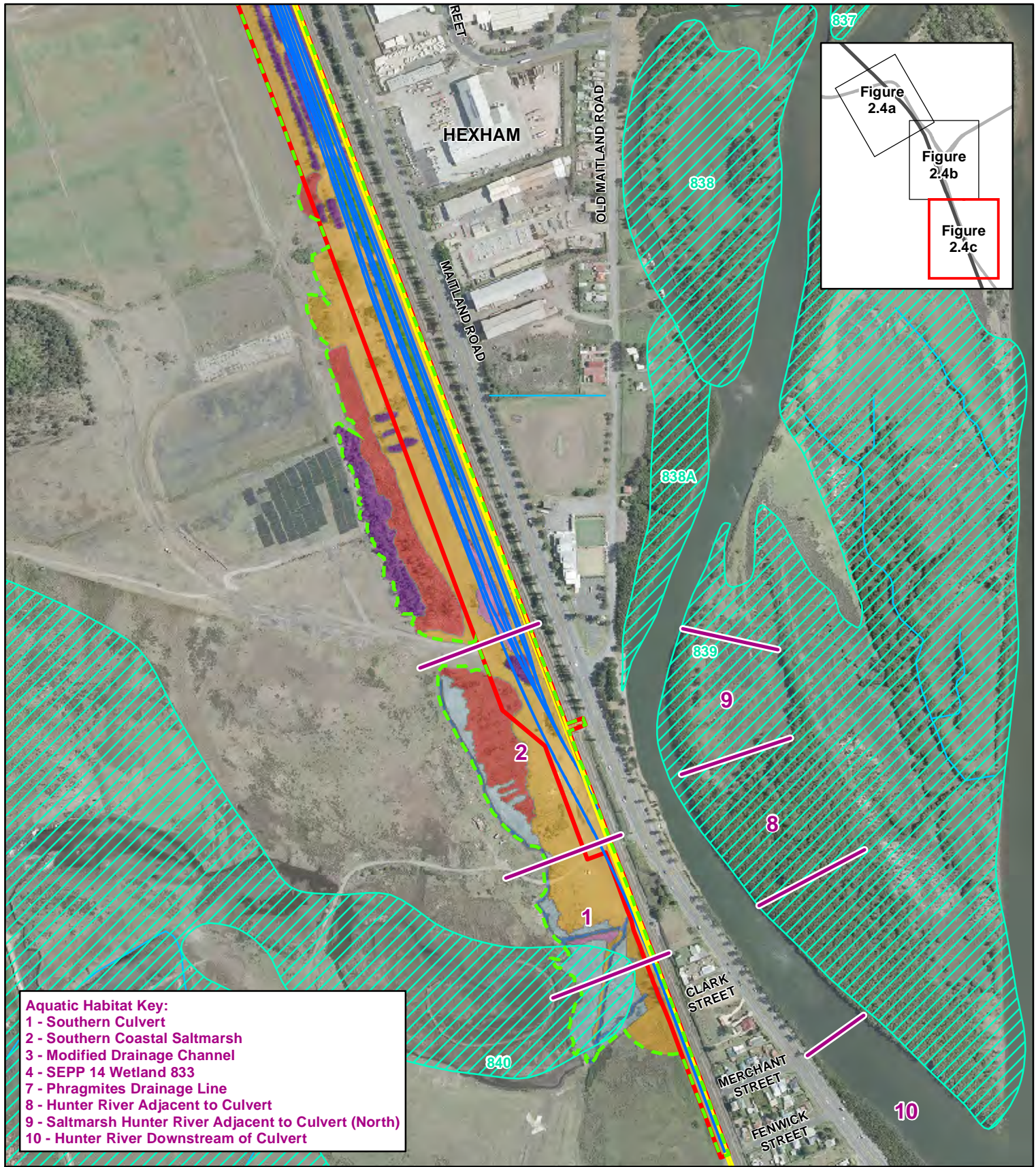
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|------------------------|--------------|--------------------------------|---|
| Drainage | Study Area | Coastal Saltmarsh in Estuaries | <i>Phragmites australis</i> and <i>Typha orientalis</i> Coastal Freshwater Wetlands |
| Proposed Alignment | Project Area | Exotic Grassland / Disturbed | Swamp Mahogany Swamp Forest on Coastal Lowlands |
| Existing Alignment | | Exotic Herbfeld | Swamp Oak Swamp Forest Fringing Estuaries |
| Aquatic Habitat Extent | | Planted Vegetation | |
| SEPP14 Wetland | | Water | |



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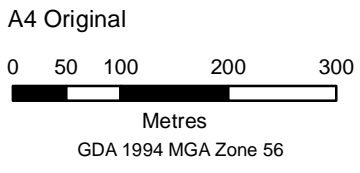
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Scale	1:7,000

Figure 2.4b



Aquatic Habitat Key:
 1 - Southern Culvert
 2 - Southern Coastal Saltmarsh
 3 - Modified Drainage Channel
 4 - SEPP 14 Wetland 833
 7 - Phragmites Drainage Line
 8 - Hunter River Adjacent to Culvert
 9 - Saltmarsh Hunter River Adjacent to Culvert (North)
 10 - Hunter River Downstream of Culvert

- | | | | |
|------------------------|--------------|--------------------------------|---|
| Drainage | Study Area | Coastal Saltmarsh in Estuaries | <i>Phragmites australis</i> and <i>Typha orientalis</i> Coastal Freshwater Wetlands |
| Proposed Alignment | Project Area | Exotic Grassland / Disturbed | Swamp Mahogany Swamp Forest on Coastal Lowlands |
| Existing Alignment | | Exotic Herfield | Swamp Oak Swamp Forest Fringing Estuaries |
| Aquatic Habitat Extent | | Planted Vegetation | |
| SEPP14 Wetland | | Water | |



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Figure 2.4c

2.6 Likelihood of occurrence

For this study, likelihood of occurrence of threat-listed species within the Study Area for species recorded or predicted to occur in the locality is defined in Table 2–5.

Table 2-5 Likelihood of occurrence of threat-listed species

Likelihood	Description
Low	<p>Species considered to have a low likelihood of occurrence include species not recorded during the field surveys that fit one or more of the following criteria:</p> <ul style="list-style-type: none"> ▪ Have not been recorded previously in the Study Area and surrounds and for which the Study Area is beyond the current distribution range. ▪ Rely on specific habitat types or resources that are not present in the Study Area. ▪ Are considered locally extinct. ▪ Are a non-cryptic perennial flora species that were specifically targeted by surveys and not recorded.
Moderate	<p>Species considered to have a moderate likelihood of occurrence include species not recorded during the field surveys that fit one or more of the following criteria:</p> <ul style="list-style-type: none"> ▪ Have infrequently been recorded previously in the Study Area and surrounds. ▪ Use habitat types or resources that are present in the Study Area, although generally in a poor or modified condition. ▪ Are unlikely to maintain sedentary populations, however, may seasonally use resources within the Study Area opportunistically during variable seasons or migration. ▪ Are cryptic flowering flora species that were not seasonally targeted by surveys and that have not been recorded.
High	<p>Species considered to have a high likelihood of occurrence include species not recorded that fit one or more of the following criteria:</p> <ul style="list-style-type: none"> ▪ Have frequently been recorded previously in the Study Area and surrounds. ▪ Use habitat types or resources that are present in the Study Area that are abundant and/or in good condition within the Study Area. ▪ Are known or likely to maintain resident populations surrounding the Study Area. ▪ Are known or likely to visit the site during regular seasonal movements or migration.
Recorded	Any threat-listed species recorded during field surveys.

2.7 Significance assessments

The impact assessments followed the methodologies outlined in Appendix E and Section 7 and were based upon the proposed Project description provided in Section 1.1. Tests for significance were completed for threat-listed species, populations or ecological communities considered to have a moderate or higher likelihood of occurrence.

For threat-listed biodiversity listed under the TSC Act, the proposed Project will be assessed under Part 5.1 of the *Environmental Planning & Assessment Act 1979* (EP&A Act). While Part 5.1 of the EP&A Act does not make specific reference to Section 5A of the EP&A Act (the 7 part test) the DGRs have requested that impacts on threatened species, populations and communities be assessed against Section 5A of the EP&A Act with guidance from the

Threatened Species Assessment Guideline – The Assessment of Significance (Department of Environment and Climate Change 2007b). The outcomes of these assessments are therefore used to determine the level of significance of the impacts, but not to determine the need for a Species Impact Statement, which does not form part of the Part 5.1 approvals.

For threat-listed biodiversity listed under the EPBC Act significance assessments have been completed in accordance with the EPBC Act *Significant Impact Guidelines* (Department of the Environment and Heritage 2006).

For species, populations or communities listed under both Acts, both assessments were completed.

2.8 Limitations

2.8.1 Reliance on externally supplied data

In preparing this study, Parsons Brinckerhoff has relied upon data, surveys, analyses, designs, plans and other information provided by the client and other individuals and organisations. Except as otherwise stated in the study, Parsons Brinckerhoff has not verified the accuracy or completeness of the data. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations in this study (conclusions) are based in whole or part on the data, those conclusions are contingent upon the accuracy and completeness of the data. Parsons Brinckerhoff will not be liable in relation to incorrect conclusions should any data, information or condition be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to Parsons Brinckerhoff.

2.8.2 Study for benefit of client

This ecological assessment has been prepared for the exclusive benefit of the client and no other party. Parsons Brinckerhoff assumes no responsibility and will not be liable to any other person or organisation for or in relation to any matter dealt with in this study, or for any loss or damage suffered by any other person or organisation arising from matters dealt with or conclusions expressed in this study (including without limitation matters arising from any negligent act or omission of Parsons Brinckerhoff or for any loss or damage suffered by any other party relying upon the matters dealt with or conclusions expressed in this study). Other parties should not rely upon the study or the accuracy or completeness of any conclusions and should make their own inquiries and obtain independent advice in relation to such matters.

2.8.3 Field survey limitations

No sampling technique can totally eliminate the possibility that a species is present on a site. For example, some species of plant may be present in the soil seed bank and some fauna species use habitats on a sporadic or seasonal basis and may not be present on site during surveys. The conclusions in this report are based upon data acquired for the site and the environmental field surveys and are, therefore, merely indicative of the environmental condition of the site at the time of preparing the report, including the presence or otherwise of species. It should be recognised that site conditions, including the presence of threat-listed species, can change with time.

Fieldwork for this study was completed during winter with low overnight temperatures recorded. This may have limited the activity (and therefore detectability) of some nocturnal species of frogs, reptiles, and small mammals. However, if suitable habitat was observed, a precautionary approach was taken and it was assumed that the species was present (refer section 2.6 for likelihood of occurrence assessment). Furthermore, targeted searches for the Green and Golden Bell Frog were completed during optimal conditions in September and November 2011.

2.8.4 Other limitations

To the best of Parsons Brinckerhoff's knowledge, the proposed Project presented and the facts and matters described in this study reasonably represent the client's intentions at the time of preparation of the study. However, the passage of time, the manifestation of latent conditions or the impact of future events (including a change in applicable law) may have resulted in a variation of the proposed Project and of its possible environmental impact.

Parsons Brinckerhoff will not be liable to update or revise the ecological assessment to take into account any events or emergent circumstances or facts occurring or becoming apparent after the date of the ecological assessment.

3. Existing environment

3.1 Landscape context

The Study Area occurs on the lower Hunter River floodplain, at Hexham. The Study Area and surrounding lands is the site of a coal loading facility which ceased operations in the late 1970s. The buildings and rail lines that were associated with the former coal loader have been removed, with only cement footings and pavements remaining. As a result, the soils and remaining vegetation within the Study Area are highly modified. The soils are mainly composed of fill and ballast, with the vegetation being mainly regrowth interspersed with planted vegetation from previous gardens. Where the landscape and soil profile haven't been significantly modified the original vegetation is regenerating from a soil stored seed bank.

The Study Area consists of a low-lying floodplain subject to periodic inundation with tidal inundation occurring from the Hunter River in the south of the Study Area. Currently land use is for grazing, with a sewage works located to the north west of the study area. The Study Area has a long history of grazing and the majority of the Study Area is currently being grazed. The wetlands located within the north of the Study Area are currently being grazed and are highly modified with pasture weeds.

The rail corridor within the proposed Project Area is highly modified as a result of the rail construction. It contains ballast piles and access tracks, and the majority of the soil profile is modified and underlain by ballast and building fill.

A summary of the Study Area locality is provided in Table 3-1.

Table 3-1 Site locality

Criteria	Location
Council	Newcastle City Council
Bioregion	Sydney Basin
Catchment Management Area (CMA)	Hunter/Central Rivers CMA Hunter Sub-catchment
Botanical Subdivision	North Coast
Mitchell landscape	Lower Hunter Channels and Floodplains
Noxious weed control area	Newcastle City Council

3.1.1 Bioregion

The Study Area is within the Sydney Basin bioregion. This region covers approximately 3,624,008 hectares (4.53% of NSW). The bioregion is on the coast and extends from just north of Batemans Bay to Nelson Bay on the central coast, and almost as far west as Mudgee. As well as Sydney itself, the Sydney Basin bioregion encompasses the towns of Wollongong, Nowra, Newcastle, Cessnock, Muswellbrook and Blue Mountains towns such as Katoomba and Mt Victoria.

It includes a significant proportion of the catchments of the Hawkesbury-Nepean, Hunter and Shoalhaven river systems, all of the smaller catchments of Lake Macquarie, Lake Illawarra,

Hacking, Georges and Parramatta Rivers, and smaller portions of the headwaters of the Clyde and Macquarie rivers.

The Sydney Basin bioregion has the third highest area of conservation-oriented tenures of the NSW bioregions, with conservation areas occupying about 1,384,418.33 hectares (equivalent to 38.2% of the bioregion). This includes the Greater Blue Mountains, which is one of four World Heritage areas within NSW.

It is a highly variable region with variation in geology, topography and climate resulting in one of the most species diverse areas in Australia.

The Study Area is within the Hunter subregion, characterised by:

- Rolling hills, wide valleys, with a meandering river system on a wide flood plain and river terraces.
- A complex of Permian shales, sandstones, conglomerates, volcanics and coal measures, bounded on the north by the Hunter Thrust fault and on the south by cliffs of Narrabeen Sandstone.
- A variety of harsh texture contrast soils on slopes and deep sandy loam alluvium on the valley floors.
- Dunes on the southern tributaries of the Hunter and deep sands in dunes on the barrier, saline, organic muds in the estuary.
- Soil salinity commonly occurs on some bedrocks in the upper catchment.
- Streams that are brackish or saline at low flow.
- Numerous small swamps in upper catchment, extensive estuarine swamps behind the coastal barrier of beach and dunes.
- A variety of vegetation types including:
 - ▶ Rainforest brush in the lower valley.
 - ▶ Forest and open woodland of white box, forest red gum, narrow-leaved ironbark, grey box, grey gum spotted gum, rough-barked apple and extensive of stands of swamp oak in upper reaches and foothills.
 - ▶ River oak and river red gum along the streams.
 - ▶ Coastal dune vegetation of blackbutt, smooth-barked apple, coast banksias and swamp mahogany.
 - ▶ Mangroves, salt marsh and freshwater reed swamps in the estuary (NSW National Parks and Wildlife Service 2003).

3.1.2 Mitchell landscapes

Landscapes (Mitchell) of NSW (NSW National Parks and Wildlife Service 2002) outlines a system of ecosystem classification mapped at the 1:250,000 scale, based on a combination of soils, topography and vegetation.

The Study Area falls entirely within the Lower Hunter Channels and Floodplains landscape. This landscape consists of channels, floodplains, and estuarine swamps on Quaternary alluvial estuarine sediments of the Hunter River estuary tract. General elevation varies from 0 to 30 m with local relief <10 m. Soils are typically harsh brown texture-contrast soils on the third terrace, gradational sandy loam on the second terrace and loamy sand on the low terrace and floodplain. Acid peaty silty sand, silt and clay are present in swamps with uniform quartz sand with podsol development on marginal coastal dunes and sand sheets. Vegetation varies from open grassland with scattered *Eucalyptus melliodora*, *Eucalyptus tereticornis*, and *Angophora floribunda* on higher fluvial landscapes. Freshwater and brackish swamps with open water contain aquatic plants with fringing woodlands of *Melaleuca quinquenervia*, *Eucalyptus robusta*, *Casuarina cunninghamiana*, *Casuarina glauca*, *Phragmites australis*, *Aegiceras corniculatum*, *Avicennia marina*, and extensive saltmarsh in tidal areas (NSW National Parks and Wildlife Service 2002).

This landscape has been 78% cleared (NSW Department of Environment and Conservation 2005). Under the *Environmental Outcomes Methods of the Native Vegetation Act* (NSW Department of Natural Resources 2005), a landscape that is greater than 70% cleared is considered to be over-cleared and thus a priority for conservation.

3.1.3 Surrounding land uses

The surrounding land has generally been extensively cleared. To the east of the Project Area is the main northern railway line and adjoining the rail corridor is the New England Highway. To the south east of the Project Area are residential houses in the township of Sandgate. To the east in the mid portion of the Project Area is the industrial zoned lands of Hexham. These lands extend from the rail corridor to the Hunter River. The remaining areas to the south and west of the proposed Project Area consist of disturbed rural lands comprising degraded native vegetation, pasture wetlands and exotic grassland. Hexham Swamp Nature Reserve (occurs approximately 1 km to the west of the Study Area and is listed as a nationally important wetland. Kooragang Nature Reserve and Shortland Wetlands occur approximately 4 km to the east and 5 km south of the proposed Project Area respectively, and together, are designated as a RAMSAR wetland (see further details in Section 4.5.2). Hunter Wetlands National Park was created in 2007 and includes Hexham Swamp Nature Reserve, Kooragang Nature Reserve and Shortland Wetlands.

3.2 Regional conservation planning

3.2.1 Lower Hunter Regional Strategy

The Lower Hunter Regional Strategy (LHRS) (Department of Planning 2006) has been implemented to ensure that adequate land is available and appropriately located to sustainably accommodate the projected housing and employment needs of the region's population from 2006-2031. In addition, the strategy identifies a number of 'Green corridor' areas marked for protection between the Watagan Ranges and Stockton Bight. Within the Green Corridor, the LHRS states that Local Environmental Plans (LEP) are to provide for the ongoing role of the biodiversity corridor.

The majority of the Study Area is identified as existing employment land with the adjacent Hexham Swamp identified as a part of the green corridor. Two small areas identified as 7(b) Environmental protection zone under the Newcastle City Council's LEP (2003) are within the potential impact zone of the rail design. The existing vegetation within the proposed Project

Area that will be impacted upon is already fragmented and highly disturbed. Furthermore, as the rail design is a small widening of the existing rail corridor with industrial land use and the New England Highway adjacent, impacts are considered minimal, and will not further fragment any areas of existing remnant vegetation.

3.2.2 Lower Hunter Regional Conservation plan

The Lower Hunter Regional conservation Plan (Department of Environment Climate Change and Water 2009) sets out a 25 year program to direct and drive conservation planning and efforts in the Lower Hunter Valley. The plan sets to establish a framework to guide conservation efforts in the Lower Hunter. It is a partner document to the NSW Government's Lower Hunter Regional Strategy that sets out the full range of the NSW Government planning priorities, and identifies the proposed areas for growth as identified above.

In 2006, approximately 20,000 ha of various high conservation value government lands were set aside which included a new green corridor stretching from the Watagan ranges, through Hexham Swamp to Port Stephens.

The corridor is of relevance to the study area which lies between the Hexham Swamp, the Hunter River and the Kooragang Wetland Rehabilitation Project on Ash Island, which are key components of the green corridor. The proposed Project Area consists of a small widening of the existing highly disturbed rail corridor, which lies adjacent to industrial developments and a major road (Maitland Road). Thus, the proposed Project is not likely to have any significant effect on habitat connectivity, genetic exchange and dispersal capabilities of any threat-listed species, populations or endangered ecological communities.

3.2.3 The Hunter Central Rivers Catchment Action Plan

The Hunter-Central Rivers Catchment Action Plan (CAP) (Hunter Central Rivers Catchment Management Authority 2007) was adopted in January 2007. Under the heading of Rivers and Freshwater Wetlands, the CAP contains a number of objectives including:

- Maintaining or improving aquatic habitat.
- Maintaining and improving riparian vegetation.

The CAP identifies principles for the management of wetland areas including the protection of existing wetlands and restoration of degraded areas. The CAP is not a regulatory document, rather it guides investment of funds towards the management of key natural resources in the catchment. The Hunter Estuary Wetlands which are located adjacent to the study area are identified as high priority wetlands in the CAP.

The proposed Project will require the removal of 9.10 ha of native vegetation, however if the mitigation measures recommended in Section 6 are adhered to then the proposed Project is likely to have a minimal impact upon the remaining aquatic habitat and wetland vegetation within the locality.

3.2.4 Kooragang Wetland Rehabilitation Project

The Kooragang Wetland Rehabilitation Project (KWRP) (Hunter Central Rivers Catchment Management Authority 2012) launched in 1993 is an integrated, adaptive wetland restoration project located within the Hunter River Estuary to the north and north west of Newcastle. It

covers an area of 1500 ha, encompassing three sites, Ash Island (780 ha), Tomago wetlands (800 ha) and Stockton Sandspit (10 ha).

The vision of the KWRP is for an estuary in which healthy, restored fisheries, shorebird, threatened species and other wildlife habitat is in balance with the thriving port, providing opportunities for research, education and recreation.

The nearest rehabilitation projects to the current proposal are the Hexham Swamp rehabilitation project located to the South, and the Kooragang wetland rehabilitation project located on Ash Island to the South east beyond the Pacific Highway and the Hexham industrial area. Given the distance, and nature of the works in the proposed Project, the actions do not propose a significant impact on the aims and restoration objectives of the KWRP.

3.3 Vegetation communities

The majority of the vegetation within the Study Area has been previously cleared and extensively modified as a result of:

- historic and current grazing
- rail construction in the current and former locations
- a coal loader and former associated rail lines which have since been removed.

The majority of the open forest areas are underlain with fill and ballast, from the previous railway workings that were associated with the former coal loader which ceased operations in the late 1970s. The buildings and rail lines that were associated with the former coal loader have been removed, with only cement footings and pavements remaining. There is some regeneration in areas where the soil profile has been disturbed/removed through dispersal of seeds from isolated mature trees and colonising species (such as *Acacia* spp.). Trees that were planted for garden purposes, such as Figs, Palms and Pine trees, are present throughout the regrowth native vegetation. Where the landscape and soil profile haven't been significantly modified the original vegetation is regenerating from a soil stored seed bank.

Lower Hunter Central Coast Regional Environment Management Strategy (Lower Hunter and Central Coast Regional Environmental Management Strategy 2003) has mapped four vegetation communities within the Study Area. These include Swamp Oak Rushland Forest, Swamp Mahogany – Paperbark Forest, Freshwater Wetland Complex and Mangrove-Estuarine Complex. The field survey confirmed the presence of three of these vegetation communities, with an additional three more exotic communities.

The Study Area was a mixture of exotic vegetation, open forest, saltmarsh and wetlands. A large part of the Study Area has been used as a coal loader in the late 1970's and has been previously cleared. The southern portion of the Study Area is subject to tidal influences from an inlet from the Hunter River in which saltmarshes have formed. The native vegetation communities all correspond with locally occurring threat-listed ecological communities listed under the TSC Act (Table 3–2 and Figure 3-1).

Table 3-2 Vegetation communities identified in the Study Area

Vegetation community	Area (ha) within the Study Area	Threat-listed ecological community Listed on the TSC Act
Swamp Oak Swamp Forest Fringing Estuaries	6.18	Swamp Oak Floodplain Forest of the NSW North Coast, Sydney Basin and South East Corner Bioregions (as described in the determination of the Scientific Committee under Division 5 of Part 2)
Swamp Mahogany Swamp Forest on Coastal Lowlands	1.12	Swamp Sclerophyll Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions (as described in the determination of the Scientific Committee under Division 5 of Part 2)
<i>Phragmites australis</i> and <i>Typha orientalis</i> Coastal Freshwater Wetlands	3.46	Freshwater Wetlands on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions
Coastal Saltmarsh in Estuaries	1.62	Coastal Saltmarsh in the NSW North Coast, Sydney Basin and South East Corner Bioregions
Exotic Grassland/Disturbed	35.56	N/A
Exotic Herbfield	9.29	N/A
Planted Vegetation	2.72	N/A

3.3.1 Swamp Oak Swamp Forest Fringing Estuaries

Vegetation mapping of the Study Area identified the presence of Swamp Oak Rushland Forest (MU 40) within the Study Area (Lower Hunter and Central Coast Regional Environmental Management Strategy 2003). This was confirmed during the site surveys (Photograph 3-1). The community covers 6.18 ha equivalent to 10.2% of the Study Area. This community had two variants: one was dominated by *Casuarina glauca* (Photograph 3-1) and the other one was dominated by *Melaleuca ericifolia* (Photograph 3-2). The vegetation characteristics of this community are summarised in Table 3-3.

Table 3-3 Summary of characteristics of Swamp Oak Swamp Forest Fringing Estuaries

Swamp Oak Swamp Forest Fringing Estuaries			
Conservation significance	Listed as an endangered ecological community of Swamp Oak Floodplain Forest on Coastal Floodplains under the TSC Act.		
Condition	The majority of this community has been previously cleared, occurs as fragmented patches and is subject to ongoing disturbance from grazing or edge effects from the existing unformed roads and the railway. Moderate – Canopy is generally regrowth with a dense understorey of exotic species, particularly <i>Lantana camara</i> *. Very few native shrubs present. The only native grass present within this community was <i>Cynodon dactylon</i> .		
Strata	Height range (m)	Foliage cover (%)	Dominant species
Canopy	6-12	20 - 60	<i>Casuarina glauca</i> , with scattered individuals of <i>Eucalyptus robusta</i> and <i>Melaleuca quinquenervia</i> .

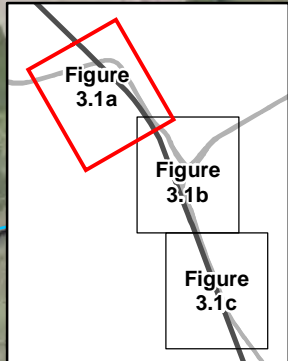
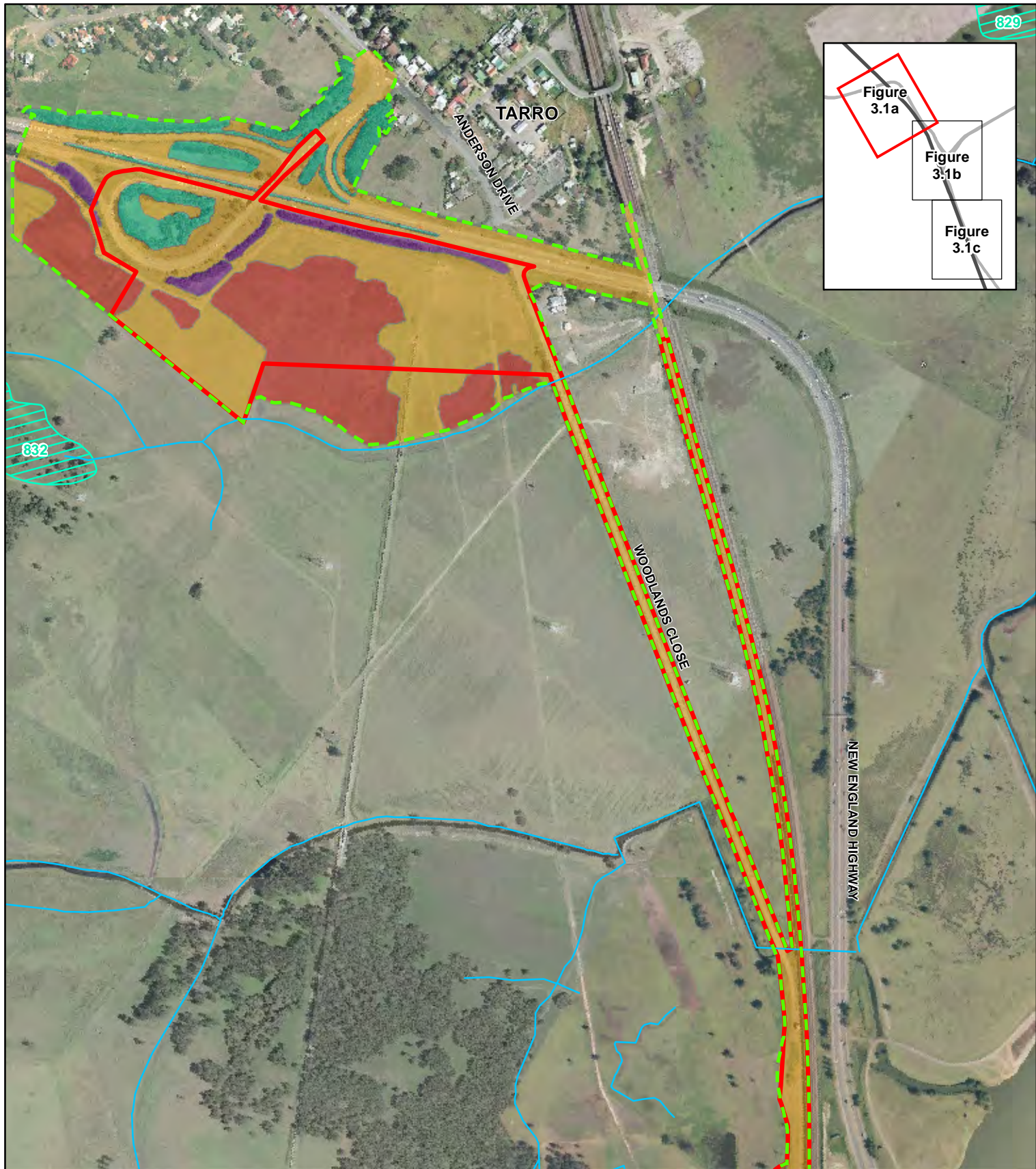
Swamp Oak Swamp Forest Fringing Estuaries			
Shrub stratum	0.5-4	0 - 5	<i>Lantana camara</i> *, <i>Melaleuca ericifolia</i> and <i>Acacia saligna</i>
Ground cover	0-0.5	60-90	<i>Cynodon dactylon</i> , <i>Ehrharta erecta</i> *, <i>Cirsium vulgare</i> *, <i>Ambrosia tenuifolia</i> *, <i>Eleocharis gracilis</i> *, <i>Juncus kraussii</i> and <i>Senecio madagascariensis</i> *



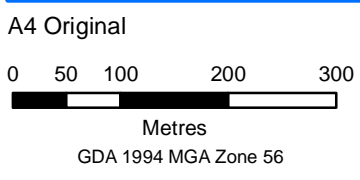
Photograph 3-1 Swamp Oak Swamp Forest dominated by *Casuarina glauca* at B5



Photograph 3-2 Swamp Oak Swamp Forest dominated by *Melaleuca ericifolia*



- Drainage
- Coastal Saltmarsh in Estuaries
- *Phragmites australis* and *Typha orientalis* Coastal Freshwater Wetlands
- Study Area
- Exotic Grassland / Disturbed
- Swamp Mahogany Swamp Forest on Coastal Lowlands
- Project Area
- Exotic Herbfield
- Planted Vegetation
- SEPP14 Wetland
- Water
- Swamp Oak Swamp Forest Fringing Estuaries

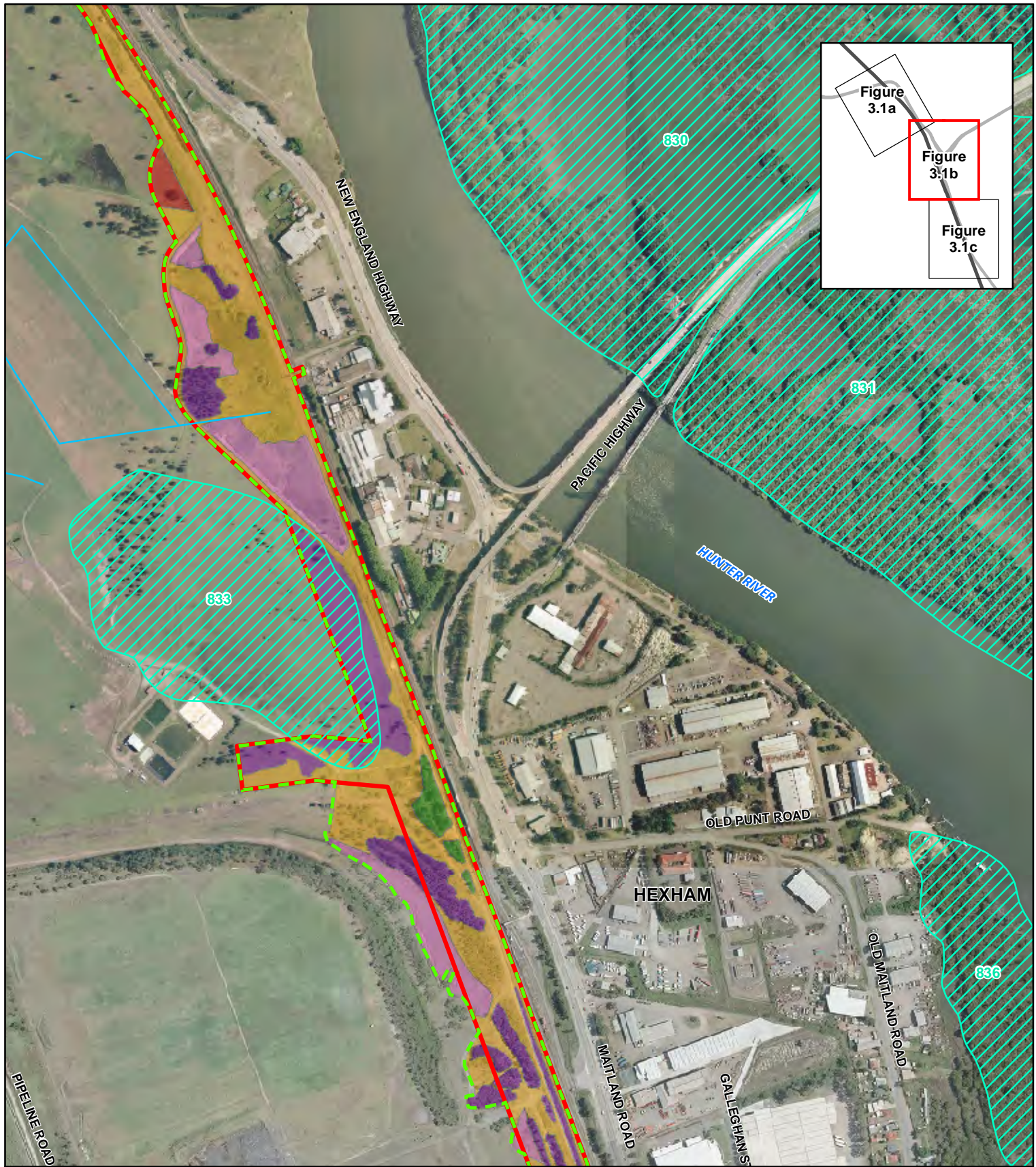


ARTC
Hexham Relief Roads

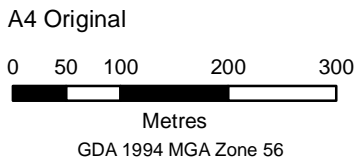
**Vegetation
Communities**

Job Number	2110501A
Revision	A4
Date	29.02.2012
Scale	1:7,000

Figure 3.1a



- | | | |
|----------------|--------------------------------|--|
| Drainage | Coastal Saltmarsh in Estuaries | <i>Phragmites australis</i> and <i>Typha orientalis</i>
Coastal Freshwater Wetlands |
| Study Area | Exotic Grassland / Disturbed | Swamp Mahogany Swamp Forest
on Coastal Lowlands |
| Project Area | Exotic Herbfield | Swamp Oak Swamp Forest
Fringing Estuaries |
| SEPP14 Wetland | Planted Vegetation | |
| | Water | |

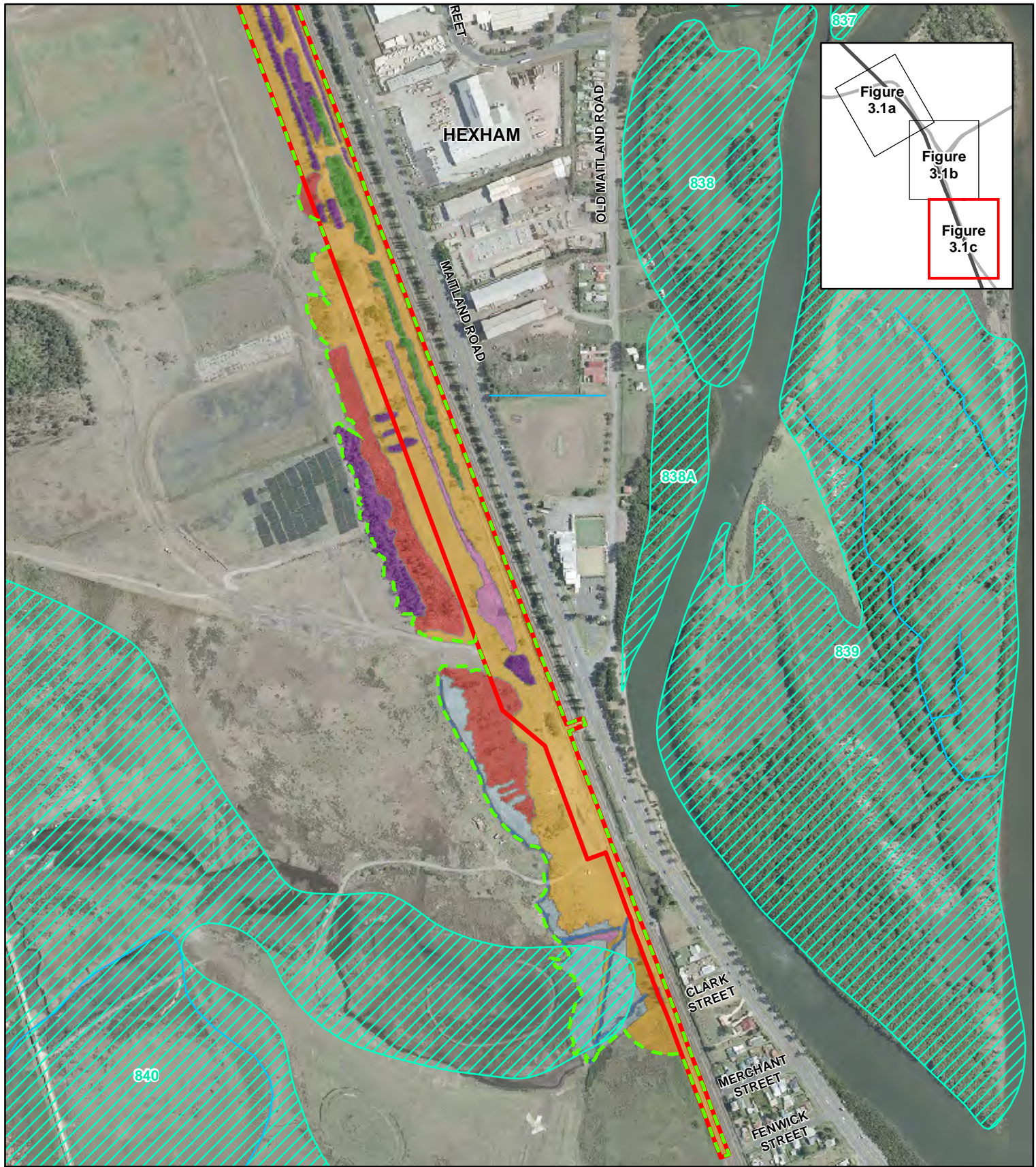


ARTC
Hexham Relief Roads

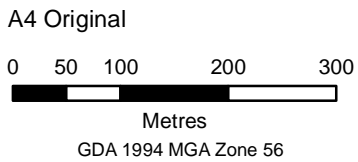
**Vegetation
Communities**

Job Number	2110501A
Revision	A4
Date	29.02.2012
Scale	1:7,000

Figure 3.1b



- | | | |
|----------------|--------------------------------|---|
| Drainage | Coastal Saltmarsh in Estuaries | <i>Phragmites australis</i> and <i>Typha orientalis</i> Coastal Freshwater Wetlands |
| Study Area | Exotic Grassland / Disturbed | Swamp Mahogany Swamp Forest on Coastal Lowlands |
| Project Area | Exotic Herbfield | Swamp Oak Swamp Forest Fringing Estuaries |
| SEPP14 Wetland | Planted Vegetation | |
| | Water | |



ARTC
Hexham Relief Roads

**Vegetation
Communities**

Job Number	2110501A
Revision	A4
Date	29.02.2012
Scale	1:7,000

Figure 3.1c

A comparison of the quadrat data against biometric benchmark data (NSW Department of Environment and Conservation 2007) suggests that within the Study Area, this community was degraded with many of the vegetation characteristics below benchmark condition (Table 3-4). In particular the understorey was dominated by exotic species, which has been shown in the data in Table 3-4.

Table 3-4 Comparison of Swamp Oak Swamp Forest in Fringing Estuaries quadrat data against vegetation benchmark data

Site	Plant species richness	Native overstorey (% cover)	Native mid-storey cover (% cover)	Native groundcover (% cover)			Number of trees with hollows	Length of fallen timber
				grasses	shrubs	other		
Benchmark¹	15	15-65	0-50	0-90	1-15	2-90	0.8	10
B2	7	30	0	16	0	56	0	0
B5	6	43	0	80	0	2	0	2.5
B7	10	26	1	2	0	0	0	11
B8	3*	37	0	8	0	0	0	2
B10	6	31	9	0	0	0	0	0

Notes: 1) benchmark data for equivalent community in Hunter Central Rivers CMA (Vegetation Type: Swamp Oak swamp forest fringing estuaries, Sydney Basin and South East Corner: Keith Formation: Forested wetlands: Keith Class: 'Coastal Floodplain Wetlands): source (Keith 2004): Red font indicates results below benchmark value: * indicates, less than 25% of lower benchmark value.

3.3.2 Swamp Mahogany Swamp Forest on Coastal Lowlands

Vegetation mapping of the Study Area identified the presence of Swamp Mahogany Paperbark Swamp Forest (MU37) within the Study Area (Lower Hunter and Central Coast Regional Environmental Management Strategy 2003). This was confirmed during the site surveys (Photograph 3-3). It covers 1.12 ha equivalent to 1.8% of the Study Area. The vegetation characteristics of this community are summarised in Table 3-5.

Table 3-5 Summary of characteristics of Swamp Mahogany Swamp Forest on Coastal Lowlands

Swamp Mahogany Swamp Forest on Coastal Lowlands			
Conservation significance	Listed as an endangered ecological community of Swamp Sclerophyll Forest on Coastal Floodplains under the TSC Act.		
Condition	The majority of this community has been previously cleared, occurs as fragmented patches and is subject to ongoing disturbance from grazing or edge effects from the existing unformed roads and the railway. Moderate – Canopy is generally regrowth native trees with a dense shrublayer of the exotic species, <i>Lantana camara</i> *. The groundwater is dominated by exotic grasses such as <i>Ehrharta erecta</i> and <i>Panicum maximum</i> .		
Strata	Height range (m)	Foliage cover (%)	Dominant species
Canopy	8-15	5 - 40	<i>Eucalyptus robusta</i> , <i>Melaleuca quinquenervia</i> , <i>Casuarina glauca</i> , with scattered individuals of <i>Eucalyptus grandis</i> and <i>Eucalyptus tereticornis</i>

Swamp Mahogany Swamp Forest on Coastal Lowlands			
Sub-canopy	3 - 6	5 - 50	<i>Melaleuca styphelioides</i> , <i>Acacia saligna</i> * and <i>Melaleuca ericifolia</i> .
Shrub stratum	0.8 - 2	5 - 80	<i>Lantana camara</i> * and <i>Callistemon citrinus</i>
Ground cover	0-0.5	60-80	<i>Ehrharta erecta</i> *, <i>Panicum maximum</i> *, <i>Cirsium vulgare</i> *, <i>Ambrosia tenuifolia</i> *, <i>Cynodon dactylon</i> , <i>Pennisetum clandestinum</i> *, <i>Plantago lanceolata</i> *, <i>Sida rhombifolia</i> * and <i>Senecio madagascariensis</i> *



Photograph 3-3 Swamp Mahogany Swamp Forest on Coastal Lowlands at B4

A comparison of the quadrat data against biometric benchmark data (NSW Department of Environment and Conservation 2007) suggests that within the Study Area, this community was degraded with many of the vegetation characteristics below benchmark condition (Table 3-6).

Table 3-6 Comparison of Swamp Mahogany Swamp Forest on Coastal Lowlands quadrat data against vegetation benchmark data

Site	Plant species richness	Native overstorey (% cover)	Native mid-storey cover (% cover)	Native groundcover (% cover)			Number of trees with hollows	Length of fallen timber
				grasses	shrubs	other		
Benchmark¹	24	15-70	10-60	5-50	5-30	5-40	0.2	5
B4	9	35	0	8	0	0	0	8
B9	8	5	18	4	0	0	0	4

Notes: 1) benchmark data for equivalent community in Hunter Central Rivers CMA (Vegetation Type: Swamp Mahogany swamp forest on coastal lowlands of the North Coast and northern Sydney Basin: Keith Formation: Forested wetlands: Keith Class: Coastal Swamp Forests): source (Keith 2004): Red font indicates results below benchmark value: * indicates, less than 25% of lower benchmark value.

3.3.3 Coastal Saltmarsh in Estuaries

The site survey identified Coastal Saltmarsh in Estuaries (Photograph 3-4) as occurring within the Study Area. This community covers 1.62 ha equivalent to 2.6% of the Study Area. The broad scale vegetation mapping of the Study Area did not identify the presence of Coastal Saltmarsh (MU47a) (Lower Hunter and Central Coast Regional Environmental Management Strategy 2003). This vegetation mapping project was based on mainly aerial interpretation and computer modelling with limited ground-truthing. This community occurred in the south of the Study Area (Figure 3-1) where an inlet is present that is subjected to tidal influences from the South Arm of the Hunter River. Therefore Coastal Saltmarsh is present and some isolated stands of *Avicennia marina* (Mangroves) and *Casuarina glauca*. The vegetation characteristics of this community are summarised in Table 3-7.

Table 3-7 Summary of characteristics of Coastal Saltmarsh in Estuaries

Coastal Saltmarsh in Estuaries			
Conservation significance	Listed as an endangered ecological community of Coastal Saltmarsh under the TSC Act.		
Condition	Good – High diversity of native species present with weeds incursions restricted to the edges of the Saltmarsh areas.		
Strata	Height range (m)	Foliage cover (%)	Dominant species
Canopy	1.5 - 4	<5%	<i>Avicennia marina</i> and <i>Casuarina glauca</i>
Ground cover	0-1.5	50 - 90%	<i>Sarcocornia quinqueflora</i> , <i>Sporobolus virginicus</i> , <i>Juncus kraussii</i> , <i>Cotula coronopifolia</i> * and <i>Cakile edentula</i> *



Photograph 3-4 Coastal Saltmarsh in Estuaries at B12 and mapped as SEPP 14 Wetland No. 840

A comparison of the quadrat data against biometric benchmark data (NSW Department of Environment and Conservation 2007) suggests that within the Study Area, this community is in good condition with the vegetation characteristics either at or above benchmark for Coastal Saltmarsh (Table 3-8).

Table 3-8 Comparison of Coastal Saltmarsh in Estuaries quadrat data against vegetation benchmark data

Site	Plant species richness	Native overstorey (% cover)	Native mid-storey cover (% cover)	Native groundcover (% cover)			Number of trees with hollows	Length of fallen timber
				grasses	shrubs	other		
Benchmark ¹	5	0	0	0-10	0-40	30-70	0	0
B12	6	0	0	44	0	56	0	0

Notes: 1) benchmark data for equivalent community in Hunter Central Rivers CMA (Vegetation Type: Saltmarsh in estuaries of the Sydney Basin and South East Corner: Keith Formation: Saline Wetlands: Keith Class: Saltmarshes): source (Keith 2004).

3.3.4 *Phragmites australis* and *Typha orientalis* Coastal Freshwater Wetlands

Vegetation mapping of the Study Area mapped large areas of Freshwater Wetland Complex (MU46) within the Study Area (Lower Hunter and Central Coast Regional Environmental Management Strategy 2003) that is associated with Hexham Swamp. This community covers 3.46 ha equivalent to 5.7% of the Study Area. These wetlands have been modified and are likely to have formed as a result of clearing of swamp forest. These freshwater

wetlands are likely to contain areas with influxes from the saline waters of the South Arm of the Hunter River and groundwater mixing. Two variants of these freshwater wetlands occur, being the *Phragmites australis* dominated wetlands (Photograph 3-5) and wetlands that have open water (Photograph 3-6). The vegetation characteristics of this community are summarised in Table 3-9.

Table 3-9 Summary of characteristics of *Phragmites australis* and *Typha orientalis* Coastal Freshwater Wetlands

<i>Phragmites australis</i> and <i>Typha orientalis</i> Coastal Freshwater Wetlands			
Conservation significance	Listed as an endangered ecological community of Freshwater Wetlands on Coastal Floodplains under the TSC Act.		
Condition	Moderate - moderate diversity of native species, with some invasion of exotic species.		
Strata	Height range (m)	Foliage cover (%)	Dominant species
Emergent Trees	5 - 8	<5	<i>Casuarina glauca</i> , <i>Melaleuca linearifolia</i> and <i>Melaleuca styphelioides</i> .
Floating aquatics			<i>Azolla pinnata</i> , <i>Marsilea mutica</i> and <i>Vallisneria nana</i> .
Ground cover/Emergent aquatics	0 - 2	20 - 90%	<i>Phragmites australis</i> , <i>Commelina cyanea</i> , <i>Typha orientalis</i> , <i>Juncus usitatus</i> , <i>Eleocharis gracilis</i> * and <i>Pennisetum clandestinum</i> .



Photograph 3-5 *Phragmites australis* and *Typha orientalis* Coastal Freshwater Wetlands dominated by P. australis and T. orientalis at B3



Photograph 3-6 Phragmites australis and Typha orientalis Coastal Freshwater Wetlands with open water at B11

A comparison of the quadrat data against biometric benchmark data (NSW Department of Environment and Conservation 2007) suggests that within the Study Area, this community was of moderate condition as most of the vegetation characteristics are at or below benchmark condition (Table 3-10).

Table 3-10 Comparison of Freshwater Wetlands quadrat data against vegetation benchmark data

Site	Plant species richness	Native overstorey (% cover)	Native mid-storey cover (% cover)	Native groundcover (% cover)			Number of trees with hollows	Length of fallen timber
				grasses	shrubs	other		
Benchmark ¹	7	3-90	0-5	1-5	0	60-95	0	0
B1	12	2	14	0	8	68	0	0
B3	3	0	0	0	0	88	0	0
B6	5	0	0	6	0	94	0	0
B11	5	0	0	0	0	70	0	0

Notes: 1) benchmark data for equivalent community in Hunter Central Rivers CMA (Vegetation Type: *Phragmites australis* and *Typha orientalis* coastal freshwater wetlands of the Sydney Basin: Keith Formation: Freshwater wetlands: Keith Class: Coastal Freshwater Lagoons): source (Keith 2004): Red font indicates results below benchmark value: * indicates, less than 25% of lower benchmark value.

3.3.5 Exotic grassland/disturbed

Exotic grassland/disturbed vegetation is the most common vegetation within the rail corridor, covering 35.56 ha, equivalent to 59% of the Study Area. This vegetation is not consistent with a native vegetation community and is unlikely to regenerate due to modification of soil profile (Photograph 3-7). Areas of the grassland have been invaded with the *Arundo donax**

and *Lantana camara** (Photograph 3-8). The vegetation characteristics of this community are summarised in Table 3-11.

Table 3-11 Summary of characteristics of Exotic Grassland/Disturbed

Exotic Grassland/Disturbed			
Conservation significance	Low. Not consistent with a native vegetation community.		
Condition	Low- had less than 25% of benchmark canopy cover and has less than 50% native ground cover. Unlikely to regenerate due to disturbance of soil profile and native seedbank. Native species recorded were colonising species are likely to have germinated as a result of wind-dispersed seed.		
Strata	Height range (m)	Foliage cover (%)	Dominant species
Canopy	1-5	<1%	<i>Casuarina glauca</i>
Shrub stratum	0.3-2	5-10%	<i>Acacia saligna</i> *, <i>Lantana camara</i> * and <i>Arundo donax</i> *
Ground cover	0-1.5	50 - 90%	<i>Chloris gayana</i> *, <i>Melinis repens</i> *, <i>Capillipedium spicigerum</i> *, <i>Cirsium vulgare</i> *, <i>Foeniculum vulgare</i> *, <i>Ricinus communis</i> *, <i>Pennisetum clandestinum</i> * and <i>Ehrharta erecta</i> *



Photograph 3-7 Exotic grassland/disturbed vegetation adjoining the rail line



Photograph 3-8 Exotic grasslands with *Arundo donax* (Giant Reed) in the foreground

3.3.6 Exotic herbfield

Exotic herbfield vegetation community is a modified wetland that has been dominated by exotic pasture weeds and occurs in the north of Study Area adjoining the New England Highway and in the south of the Study Area. This vegetation community encompasses 9.29 ha, equivalent to 15% of the Study Area. This vegetation is not consistent with a native vegetation community and is unlikely to regenerate due to modification of soil profile and current and previous grazing regimes (Photograph 3-9). Areas of this community were dominated by Alligator Weed which is classified as a noxious weed at a state and federal level. The vegetation characteristics of this community are summarised in Table 3-12.

Table 3-12 Summary of characteristics of Exotic Herbfield

Exotic Herbfield			
Conservation significance	Low. Not consistent with a native vegetation community.		
Condition	Low- had less than 25% of benchmark canopy cover and has less than 50% native ground cover. Unlikely to regenerate due to disturbance of soil profile and previous grazing regimes		
Strata	Height range (m)	Foliage cover (%)	Dominant species
Ground cover	0-1.5	50 - 90%	<i>Alternanthera philoxeroides*</i> , <i>Cyperus congestus*</i> , <i>Juncus acutus*</i> , <i>Juncus cognatus*</i> , <i>Phalaris aquatica*</i> , <i>Rumex crispus*</i> , <i>Eleocharis gracilis</i> , <i>Persicaria decipiens</i> , <i>Persicaria hydropiper</i> and <i>Triglochin sp.</i>



Photograph 3-9 Exotic herbfield at B15, showing infestation of Alligator Weed

3.3.7 Planted vegetation

This vegetation community is the result of rehabilitation works conducted by the RTA for the on and off ramps for Anderson Road. The vegetation community encompasses 2.72 ha, equivalent to 5% of the Study Area. This vegetation is not consistent with a native vegetation community and contains planted areas of *Callistemon sp.*, (Photograph 3-10) *Casuarina glauca* (Photograph 3-11) and sediment detention basins constructed to receive runoff from the road. The *Casuarina glauca* area differs from the endangered ecological community of Swamp Oak Floodplain Forest as it does not occur on a coastal floodplain. It is elevated on embankments built as part of the road works (Photograph 3-10). The vegetation characteristics of this community are summarised in Table 3-13.

Table 3-13 Summary of characteristics of Planted Vegetation

Planted Vegetation			
Conservation significance	Low. Not consistent with a native vegetation community.		
Condition	Low- had less than 25% of benchmark canopy cover and has less than 50% native ground cover. Unlikely to regenerate due to disturbance of soil profile and native seedbank. Native species recorded are a result of previous rehabilitation works undertaken as part of road works.		
Strata	Height range (m)	Foliage cover (%)	Dominant species
Canopy	1-6	30 to 50%	<i>Casuarina glauca</i> and <i>Ficus sp.</i>
Shrub stratum	0.9-2	>5%	<i>Acacia falcata</i> , <i>Callistemon sp.</i> (Hybrid) and <i>Lantana camara</i> *
Ground cover	0.1-1.5	50 - 90%	<i>Panicum maximum</i> *, <i>Sida rhombifolia</i> *, <i>Lolium perennans</i> *, <i>Cirsium vulgare</i> *, <i>Pennisetum clandestinum</i> * and <i>Ehrharta erecta</i> *



Photograph 3-10 Planted Vegetation at B16 on the on ramp to Anderson Drive



Photograph 3-11 Planted *Casuarina glauca* with an exotic understorey

3.4 Species of plant recorded

A total of 158 species of plant were recorded in the Study Area, of which 71 species (45%) were native (Appendix A). The most diverse family recorded was Poaceae (grasses) with 32 species, followed by Asteraceae with 16 species (Appendix A).

Of the 87 exotic species of plant recorded, seven are listed under the *Noxious Weeds Act 1993* for the Newcastle City Council noxious weed control area (see Table 3-14). Other

highly invasive species occurred abundantly within the Study Area and included: *Arundo donax**, *Chloris gayana**, *Melinis repens**, *Foeniculum vulgare** *Acacia saligna** (This species is native to Western Australia and does not naturally occur in NSW) and *Ricinus communis**.

Table 3-14 Noxious weeds within the Study Area

Scientific name	Common name	Noxious Weeds Act 1993 control class ¹	Weeds of National Significance
<i>Alternanthera philoxeroides</i> *	Alligator Weed	3	Yes
<i>Cestrum parqui</i> *	Green Cestrum	3	
<i>Ageratina adenophora</i> *	Crofton Weed	4	
<i>Cortaderia selloana</i> *	Pampas Grass	4	
<i>Echium plantagineum</i> *	Paterson's Curse	4	
<i>Lantana camara</i> *	Lantana	4	Yes
<i>Rubus fruticosus</i> * aggregate species (<i>Rubus ulmifolius</i>)	Blackberry	4	Yes

Notes 1) Control Categories under the *Noxious Weeds Act 1993*: Class 3: The plant must be fully and continuously suppressed and destroyed. Class 4: The growth and spread of the plant must be controlled according to the measures specified in a management plan published by the local control authority.

3.5 Terrestrial fauna habitats

The suitability, size and configuration of the fauna habitats correlated broadly with the vegetation communities, as summarised in Table 3-15. These areas provided habitat for a range of birds, mammals and herpetofauna, and were in moderate to poor condition.

Habitat features recorded in the Study Area generally include those associated with Swamp forest, Saltmarsh, Aquatic habitats and Cleared land. The habitats and species associations are discussed in Sections 3.4.1 to 3.4.4. Specific habitat attributes of each community type are described in further detail in Table 3-16.

Table 3-15 Fauna habitat with corresponding vegetation description

Fauna habitat description	Corresponding vegetation community (Section 3.2) (Figures 3-1A – 3-1C)
Swamp Forest	Swamp Oak Forest, Swamp Mahogany-Paperbark Forest, Planted vegetation
Saltmarsh	Coastal Saltmarsh
Aquatic habitat (including ephemeral soaks)	Freshwater Wetlands
Cleared land	Exotic grassland, Exotic herbfield and disturbed areas

3.5.1 Swamp forest

Swamp forest occurred in riparian areas (drainage lines, floodplains and alluvial flats) within the Study Area. This habitat consisted of *Eucalyptus robusta* and *Melaleuca quinquenervia* with monotypic stands of *Casuarina glauca* (Photograph 3-12). Although only a small number of trees were observed to be flowering during field surveys. Such canopy species would provide flowering resources for nectivorous birds and mammals. Although no tree hollows were observed in this habitat, due to the role of remnant vegetation in providing connectivity amongst the surrounding fragmented landscape, this habitat was considered to have a moderate value to those more mobile species of fauna (i.e. bats and birds).

Swamp forest generally occurred with a shrub layer consisting predominately of Lantana, Blackberry and other exotic species. The ground cover mainly consisted of exotic grasses and leaf litter was observed to be scarce. No fallen timber/woody debris was recorded in this habitat.

This habitat provided potential habitat for a number of threat-listed species, including Swift Parrot, Black Bittern and Australasian Bittern. Furthermore, *Eucalyptus robusta*, is listed as a primary feed tree species for Koala, as listed under the approved Koala Recovery Plan (Department of Environment and Climate Change 2008e).

Species recorded in Swamp Forest habitat in the Study Area included Eastern Spinebill, Red-browed Finch, Fan-tailed Cuckoo, Spotted Grass Frog and Red-bellied Black Snake.



Photograph 3-12 Swamp forest at survey site S3

3.5.2 Saltmarsh

Saltmarsh occurred in the south of the Study Area where an existing culvert subjected the area to tidal influences of the south arm of the Hunter River (Photograph 3-13). This area existed as part of the western edge of Hexham floodplain estuarine habitat. While parts of this habitat have been degraded from waste debris and other disturbances, Saltmarsh was functional for a range of estuarine species and migratory waders, including threat-listed species such as the White-fronted Chat and Black-necked Stork, which were recorded in this habitat inside and outside the Study Area respectively.



Photograph 3-13 Saltmarsh at survey site S5

3.5.3 Aquatic habitat

The Study Area contained aquatic habitat in the form of numerous freshwater wetlands and ephemeral water-bodies (Photograph 3-14 and Photograph 3-15). Collectively, these habitats provided areas of ephemeral soaks to large areas of temporary/permanent water-bodies. Such areas provided habitat for frogs, waterbirds and resident waders, as well as providing a source of water for other vertebrate fauna.

The Study Area contained two SEPP 14 wetlands (wetland 833 and 840) of which, wetland 833 occurred as a large, shallow sedge-meadow (survey site S2, Photograph 3-14). Importantly, Aquatic habitat in the Study Area provided potential habitat for threat-listed species, including Green and Golden Bell Frog, Australasian Bittern and Black-necked Stork, as well as and migratory species, including Latham's Snipe and other freshwater shorebirds.

In total, eight species of frog were observed to use this habitat in the Study Area. Moreover, the Study Area encompasses the historic range of the Green and Golden Bell Frog and potential habitat was observed therein. Species observed in Aquatic habitat included Australian White Ibis, White-faced Heron, Little Grassbird, Verreaux's Tree Frog and Common Eastern Froglet.

A number of water-bodies have been modified as result of existing rail infrastructure, agricultural practices and historical infrastructure related to the former Coal and Allied Rail loop.



Photograph 3-14 Aquatic habitat (SEPP14 wetland 833) at chainage 176.100 (site S2)



Photograph 3-15 Ephemeral wetland at survey site S7

3.5.4 Cleared land

Cleared land areas provided limited habitat for fauna and essentially occurred as maintained easements and stock pile areas associated with existing rail infrastructure and farm land (Photograph 3-16). This habitat was either cleared or had scattered trees with a managed understorey, effectively removing ground cover and understorey habitat which provides both

foraging resources and shelter. Cleared land lacked a range of habitat features such as tree hollows, leaf litter, fallen timber and moderate shrub layer that would support potentially diverse fauna. The condition of this habitat was considered poor due to the removal of microhabitat structures through clearing and maintenance practices.



Photograph 3-16 Cleared land (farm land) at survey site S6

3.6 Fauna microhabitats

Table 3-16 describes fauna microhabitats that were recorded during habitat assessments in each fauna stratification unit.

Table 3-16 Fauna microhabitats

Microhabitat attributes	Fauna habitat stratification			
	Swamp forest	Saltmarsh	Aquatic habitat	Cleared land
Upper canopy	Upper canopy generally regrowth up to 12 m consisting of <i>Eucalyptus robusta</i> , <i>Eucalyptus grandis</i> , <i>Casuarina glauca</i> , <i>Melaleuca quinquenervia</i> . An average crown cover across this habitat was estimated at up to 60 %. Mistletoe was not recorded in the Study Area.	Upper canopy sparse. Some <i>Avicennia marina</i> and <i>Casuarina glauca</i> .	Emergent trees included <i>Casuarina glauca</i> , <i>Melaleuca linearifolia</i> and <i>Melaleuca styphelioides</i> .	Generally absent
Shrub layer	Generally a dense understorey of exotic species dominated by <i>Lantana camara</i> *. Very few native shrubs present, but included <i>Melaleuca ericifolia</i> and <i>Acacia saligna</i> .	Absent	Absent	Generally absent due to clearing and current management practices.
Grasses, herbs, forbs, sedges and rushes	A moderate ground cover of grasses to 80 % cover was observed in this habitat. Generally dominated by exotic grasses including, <i>Ehrharta erecta</i> *, <i>Cirsium vulgare</i> *, <i>Ambrosia tenuifolia</i> *, <i>Eleocharis gracilis</i> *, <i>Juncus kraussii</i> , <i>Senecio madagascariensis</i> *, <i>Panicum maximum</i> *, <i>Pennisetum clandestinum</i> * and <i>Plantago lanceolata</i> *.	<i>Sarcocornia quinqueflora</i> , <i>Sporobolus virginicus</i> , <i>Juncus kraussii</i> , <i>Cotula coronopifolia</i> * and <i>Cakile edentula</i> *	Generally dominated by <i>Phragmites australis</i> , <i>Commelina cyanea</i> , <i>Typha orientalis</i> , <i>Juncus usitatus</i> , <i>Eleocharis gracilis</i> * and <i>Pennisetum clandestinum</i> .	Ground cover composition was generally dominated by exotic species.
Leaf litter	Generally absent	Absent	Absent	Absent
Fallen timber	Generally absent	Absent	Absent	Absent
Tree hollows and stags	Absent	Absent	Absent	Absent
Rocks and rock shelves	Absent	Absent	Absent	Absent
Drainage lines and water bodies	This habitat was typically inundated during field surveys, or is likely to be periodically inundated.	Subjected to tidal influences of the south arm of the Hunter River.	Generally occurred as freshwater wetlands and ephemeral water-bodies/soaks that are periodically inundated.	Generally absent, but due to position on Hexham floodplain, likely to contain areas that are periodically inundated.
Overall condition	Moderate-poor	Moderate	Good-moderate	Poor

3.6.1 Hollow tree resources

Six of the 26 threat-listed fauna species that are considered to have potential habitat in the Study Area use hollow tree resources for breeding and roosting. While many attributes of tree hollows may be selected by hollow using species, such as hollow depth, entrance size and hollow type (Goldingay 2009), hollows are more likely to occur and be used by wildlife in large trees that are many decades or even centuries old (Goldingay 2009). No hollow trees were observed in the Study Area.

3.6.2 Feeding resources

Fauna occurring in the locality are likely to use a range of foraging resources. Flora provided a range of feeding resources for fauna in the Study Area, although at the time of survey, few of the sites showed significant flowering. The species in the Study Area provide foraging resources and include a range of species that together would flower throughout the year, with a peak through autumn to early spring (Table 3-17). Based on flowering times, these flowering resources would potentially support a range of species throughout the year, including threat-listed species such as Swift Parrot. However, the isolation of such habitat in the Study Area to other stands of remnant habitat effectively renders it useful to more mobile species.

Table 3-17 Flowering times of select plants in the Study Area

Species	Flowering time ¹											
	J	F	M	A	M	J	J	A	S	O	N	D
<i>Acacia saligna</i>												
<i>Acacia terminalis</i> ssp. <i>angustifolia</i>												
<i>Callistemon citrinus</i>												
<i>Eucalyptus robusta</i>												
<i>Eucalyptus tereticornis</i>												
<i>Melaleuca quinquenervia</i>												
<i>Melaleuca ericifolia</i>												
<i>Melaleuca styphelioides</i>												

Notes: 1: Flowering times from PlantNet (Royal Botanic Gardens 2006), Euclid (Brooker *et al.* 2002) and flowering time for honey (Somerville 2002).

3.7 Species of animal recorded

Seventy-seven vertebrate fauna species (Table 3-18, Appendix B and Appendix H) were recorded during field surveys. The paucity of fauna recorded during surveys is likely due to the disturbed nature of much of the Study Area, the lack of flowering resources during the time of field surveys and the general timing of field surveys (i.e. winter). Two threat-listed species of animal, the Grey-headed Flying-fox and White-fronted Chat, were recorded in the Study Area during field surveys (Figure 4-1) (Appendix B). A further two threat-listed species, the Black-necked Stork and Spotted Harrier, were also recorded during field surveys, however, they were recorded more distantly from the Study Area.. Eight introduced species were also recorded, including Fox, Brown Hare and Common Myna.

Table 3-18 Species of animal recorded

Group	Introduced	Native	Total
Birds	4	53	57
Mammals	4	3	7
Frogs	-	8	8
Reptiles	-	3	3
Fish	1	1	2
Total	9	68	77

3.8 Green and Golden Bell Frog

The Green and Golden Bell Frog was surveyed during optimal weather conditions in September and November 2011 (Appendix F) and included call detection, call playback and spotlighting.

Advice from Professor Michael Mahony (Newcastle University) was obtained concerning the efficacy of the first survey period (5-6 September 2011) and with temperatures consistently reaching around the 22°C mark (Bureau of Meteorology 2011), surveys could be considered. Professor Mahony further acknowledged that some individual Green and Golden Bell Frogs were calling in early September. However, a reference site on Ash Island, which was surveyed for detectability during this period, failed to observe individuals calling or to elicit a response to call playback.

The second survey period was completed from the 7-8 November 2011 with optimal conditions recorded. The reference site on Ash Island was further surveyed for detectability during this survey period, with two individuals recorded as responding to call playback.

A total survey effort of 27.5 person hours, completed during optimal weather conditions, failed to observe or record the Green and Golden Bell Frog in the Study Area. This was at a time when this species was known to be detectable. However, the Study Area did contain potential habitat for this species and occurs within its historical range.

Important populations of the Green and Golden Bell Frog are considered to be any individual sighted post 1995 (Department of the Environment, Water Heritage and the Arts 2009d). Therefore, two historical records (i.e. observations recorded before 1995) occur approximately 500 m to the west of the Study Area on the Hexham floodplain. Furthermore, two important populations have been recorded approximately 300 m to east of the Study Area on Ash Island. However, such records are separated from the Study Area by the existing rail corridor, industrial developments, the Pacific Highway (Maitland Road) and the South Arm of the Hunter River.

3.9 Estuarine habitats

Within and surrounding the proposed Project Area there were two types of estuarine communities: mangroves and coastal saltmarsh. The communities throughout the Study Area were heavily degraded and affected by grazing, constructed channels, tracks and reclamation works. Site descriptions for survey locations in estuarine habitats are as follows:

3.9.1 Site descriptions

3.9.1.1 Site 1: southern culvert

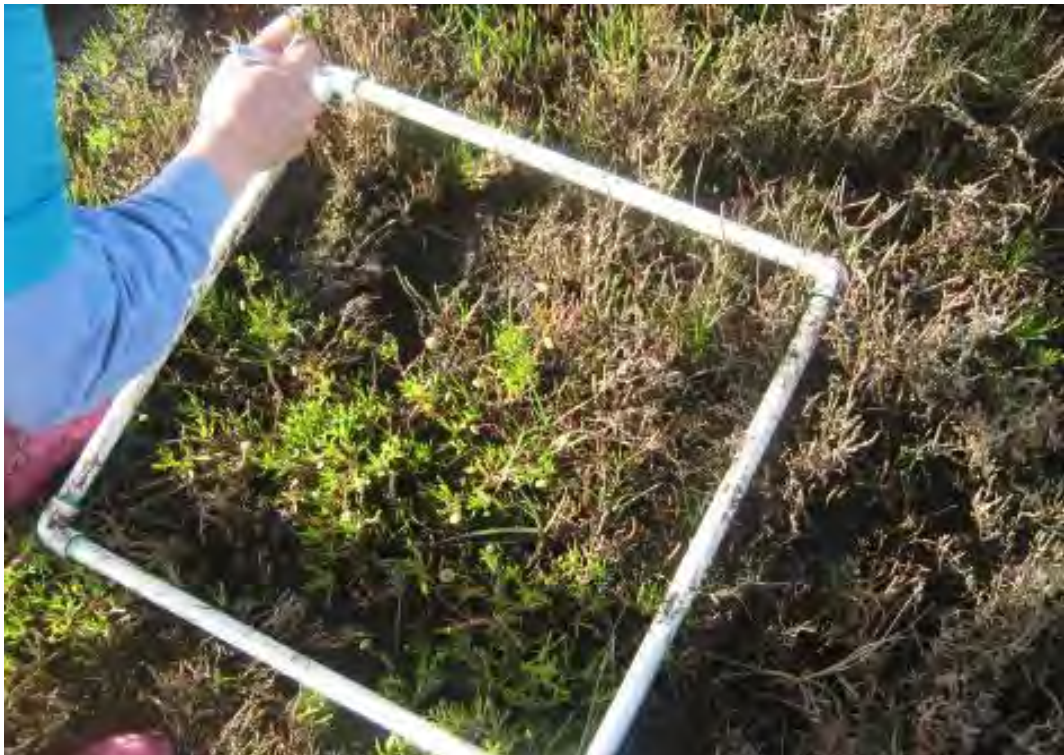
The habitat at the southern end of the corridor is of moderate condition and supports a thin band of highly disturbed small mangroves (Photograph 3-18) and coastal saltmarsh community (Photograph 3-20). The community extended past the Study Area into a wider saltmarsh and introduced grassland to the west, which is part of the SEPP14 Wetland No. 840 and the wider Hexham Swamp Nature Reserve. The area was highly modified by a number of channels that flow into the constructed drainage channel and culvert under the rail corridor into the Hunter River. The western section of the Study Area outside the proposed Project Area was disturbed by a number of smaller constructed drainage lines that have modified the natural surface water flow on the site. The area has been used for extensive cattle grazing and had large numbers of car tyres placed throughout possibly for all weather access. The banks of the drainage channel were well developed and stable. The benthic substrate consists of deep estuarine mud becoming more compact and less tidally influenced to the west.



Photograph 3-17 Site 1: Mangrove community (proposed Project Area)



Photograph 3-18 Site 1: Mangrove community (Study Area)



Photograph 3-19 Site 1: Coastal saltmarsh community (proposed Project Area)



Photograph 3-20 Site 1: Coastal saltmarsh community (Study Area)

3.9.1.2 Site 2: southern coastal saltmarsh

This community was less directly affected by tidal flows and would receive only irregular tidal inundation (Photograph 3-22). The site was characterised by shallow brackish standing water (<15 cm). The coastal saltmarsh community at this site was heavily disturbed by grazing, the construction of channels and a culvert and access track with large numbers of tyres placed throughout the complex.



Photograph 3-21 Site 2: Coastal saltmarsh community (proposed Project Area)



Photograph 3-22 Site 2: Coastal saltmarsh community (Study Area)

3.9.1.3 Site 8: Hunter River adjacent to culvert

Habitat on the Hunter River directly opposite the culvert from the site was composed of a dense well established mangrove forest of Grey Mangroves (Photograph 3-23). The community is dominated by trees greater than 10 m in height with a largely closed canopy. The site has solid mud benthic substrate with exposure to continual strong tidal flow effects. The mangrove band extends up to 130 m from the shore where it graduates into less tidally influenced community of dense River Mangrove.



Photograph 3-23 Site 8: Mangrove community

3.9.1.4 Site 9: saltmarsh Hunter River adjacent to culvert (north)

A coastal saltmarsh community was present to the north of the mangrove site on the Hunter River opposite the site culvert (Photograph 3-24). This saltmarsh community was intact and did not display any effects of anthropogenic disturbance, likely due to the lack of accessibility to the site. The community receives regular tidal inundation and supported a limited number of commonly occurring saltmarsh species.



Photograph 3-24 Site 9: Coastal saltmarsh community

3.9.1.5 Site 10: Hunter River downstream of culvert

Mangroves were present approximately 200 m downstream of the culvert from the site on the Hunter River (Photograph 3-25). This site supports a very narrow fringe of Grey Mangroves between Maitland Road and the Hunter River, which widens into a more established community to the south. The rock wall between the culvert and the site was

being upgraded and construction using a pontoon and punt was being undertaken during the survey.



Photograph 3-25 Site 10: Mangrove community

3.9.2 Mangrove community descriptions

Mangroves are highly productive systems, performing a valuable role in nutrient and carbon cycling, acting as a nursery and breeding habitat for many marine species and supporting populations of a variety of terrestrial organisms (National Marine Science Centre 2010). Mangroves have been shown to be both adaptable and resilient and can be aggressive colonisers but remain under threat from coastal development, modification of river catchments and pollution. The mangrove communities in the Hexham Swamp are dominated by Grey Mangroves (Winning & Saintilan 2009), which tolerate a wide range of conditions.

3.9.2.1 Site 1: Southern culvert

The mangrove community was present as a thin band of immature Grey Mangrove (*Avicennia marina*). The mangroves were all below 1.5 m in height and sparsely spread from the shore to the low tide mark. The community within the proposed Project Area was highly disturbed from channel works and sedimentation and supported a community of less than 50 trees. The mangroves outside the proposed Project Area were similar in structure and density to the impact zone community, being directly tidally influenced and banded along the constructed channel.

Five transects were surveyed within the proposed Project Area (three) and indirect potential impact zone (two) (Table 3-19). The results indicate that the communities closer to the culvert were slightly more established than those further into the swamp area outside the proposed Project Area.

Table 3-19 Site 1: Mangrove transect results

Site 1 Mangroves				
Transect				
Proposed Project Area	Distance from Shore (m)	Height (m)	Count (within 2.5m either side of transect)	Pneumatophore Count (1 x 1m)
Transect 1	8	>1.5	7	11
	8.5	>1.5	3	34
	11	>1.5	1	33
Transect 2	3.5	>1.5	2	9
	8	>1.5	2	9
	9	>1.5	1	12
Transect 3	3.5	>1.5	3	8
	4	>1.5	3	10
Indirect Impact Zone				
Transect 4	3	>1.5	1	12
	4	>1.5	1	14
Transect 5	1	>1.5	1	2
	2.5	>1.5	1	6
	3	>1.5	1	6
	5.5	>1.5	1	8
	9	>1.5	1	21

3.9.2.2 Site 8: Hunter River adjacent to culvert

The mangrove community was present as a wide band of mature Grey Mangroves. The trees were predominantly all above 10 m in height and formed a largely closed canopy. The community is well established, had strong bank stability and thickly spread pneumatophores. The extent of the mangrove forest was strongly tidally influenced and extends in similar species composition and density to the south of the island.

One transect was surveyed within the site (Table 3-20). The results indicate that the community was well established with mature trees.

Table 3-20 Site 8: Mangrove transect results

Site 8 Mangroves				
Transect	Distance from Shore (m)	Height (m)	Count (within 2.5m either side of transect)	Pneumatophore Count (1 x 1m)
Transect 1	0	>10	2	120
	4	>10	3	80
	8	>10	7	95
	12	>10	6	144
	14	>10	2	133
	17	>10	1	121
	21	>10	6	80
	26	>10	3	123
	30	>10	3	109
	71	>10	1	112
	81	>10	2	72
	97	>10	5	71
	101	>10	3	37
	107	>10	3	65
	112	>10	2	55
	124	>10	2	67
127	>10	7	64	

3.9.2.3 Site 10: Hunter River downstream of culvert

The mangrove community was present as a narrow strip of saplings and mature plants of the Grey Mangrove. The established trees varied in size from less than 1.5 m to greater than 10 m in height and formed a sparse patch of remnant community. The community was disturbed by the adjacent rockwall and was established in the thin strip of available habitat between Maitland Road and the river.

One transect was surveyed within the site (Table 3-21). The results indicate that the community was a narrow band of various sized trees.

Table 3-21 Site 10: Mangrove transect results

Site 8 Mangroves				
Direct Impact Zone	Distance from Shore (m)	Height (m)	Count (within 2.5m either side of transect)	Pneumatophore Count (1 x 1m)
Transect 1	1.5	>10	2	63
		<2	2	69
	3	>10	1	

3.9.3 Coastal saltmarsh community descriptions

Coastal saltmarsh ecosystems are fragile areas of saltwater wetland habitat occupied by communities of salt-tolerant vegetation. These plants are usually low (<0.5 m tall) and adapted to harsh growing conditions (high salinity, full light exposure and moisture extremes). They provide extensive ecosystem services, including biofiltration, gas regulation, carbon and nutrient retention, physical protection of coastlines during storms, and habitat for fauna, algae and microbial communities, many of which are unique (National Marine Science Centre 2010).

3.9.3.1 Site 1: southern culvert

The coastal saltmarsh community both within the proposed Project Area and outside the direct impact zone was considered to be very degraded by constructed channel works with large numbers of car tyres scattered throughout the area and evidence of recent cattle grazing. There were constructed drainage lines throughout the area which had changed the structure of the saltmarsh community present. The community was dominated by commonly occurring saltmarsh species including: Samphire, Saltwater Couch and Streaked Arrowgrass with scattered individuals of Common Rushes and Sea Rush banding the saltmarsh community. This saltmarsh area connects to the SEPP14 Wetland No.840 wetland complex and Hexham Swamp Nature Reserve to the west of the site outside of the direct impact zone.

Five quadrats were surveyed within the proposed Project Area (three) and indirect impact zone (two) (Table 3-22). The results indicate that the communities within the proposed Project Area and indirect impact zones are similar in species composition and density.

Table 3-22 Site 1: Coastal saltmarsh quadrat results

Proposed Project Area	Common Name	Cover (%)
Quadrat 1	Samphire	20
	Saltwater Couch	80
Quadrat 2	Samphire	15
	Saltwater Couch	60
	Streaked Arrowgrass	5
	Bare ground	20
Quadrat 3	Saltwater Couch	8
	Streaked Arrowgrass	5
	Bare ground	87
Indirect Impact Zone		
Quadrat 4	Samphire	15
	Saltwater Couch	10
	Streaked Arrowgrass	10
	Bare ground	65
Quadrat 5	Samphire	15
	Saltwater Couch	15
	Bare ground	70

3.9.3.2 Site 2: southern coastal saltmarsh

The coastal saltmarsh community, both within the proposed Project Area and indirect impact zones, was highly modified and primarily supports two commonly occurring saltmarsh species, Samphire and Saltwater Couch with patches of Sea Rush. The saltmarsh community outside of the impact zone was largely influenced by standing freshwater with occasional tidal flows. The area has been heavily affected by constructed channels.

Five quadrats were surveyed within the proposed Project Area (three) and indirect impact zones (two) (Table 3-23). The results indicate that the communities within the proposed Project Area and indirect impact zones are similar in species composition and density.

Table 3-23 Site 2: Coastal saltmarsh quadrat results

Proposed Project Area	Common Name	Cover (%)
Quadrat 1	Samphire	15
	Water Button	25
	Common Reed	>5%
	Bare Ground	45
Quadrat 2	Samphire	80
	Saltwater Couch	5
	Bare Ground	15
Quadrat 3	Samphire	85
	Saltwater Couch	10
	Bare Ground	5
Indirect Impact Zone		
Quadrat 4	Samphire	80
	Saltwater Couch	5
	Bare Ground	15
Quadrat 5	Samphire	75
	Saltwater Couch	10
	Bare Ground	15

3.9.3.3 Site 9: saltmarsh Hunter River adjacent to culvert (north)

The saltmarsh community was fringed on the outer margins by the well-established mangrove forest that lines the island along the Hunter River. The site was part of a larger saltmarsh wetland that extends northwards. The saltmarsh was densely populated by extensive beds of Sea Bite, Streaked Arrowgrass and Samphire that ring central beds of Sea Rush.

Five quadrats were surveyed within the site (Table 3-24). The results indicate that the community supports a limited number of evenly distributed beds of saltmarsh species.

Table 3-24 Site 9: Coastal saltmarsh quadrat results

Proposed Project Area	Common Name	Cover (%)
Quadrat 1	Sea Bite	70
	Streaked Arrowgrass	20
	Bare ground	10
Quadrat 2	Sea Bite	60
	Streaked Arrowgrass	10
	Samphire	30
Quadrat 3	Sea Bite	60
	Samphire	30
	Bare ground	10
Quadrat 4	Sea Bite	60
	Streaked Arrowgrass	25
	Bare ground	15
Quadrat 5	Sea Rush	100

3.9.4 Water quality

The water quality across the proposed Project Area and within the Lower Hunter Estuary was of low value and largely fell outside the ANZECC/ARMCANZ Guideline (ANZECC 2000) values. The proposed Project Area and this area of the Hunter River was located within the Ironbark Creek Catchment that has historically been characterised by water quality with high nutrient levels and undesirable variability in dissolved oxygen (Newcastle City Council 2004). Highly polluted and possibly toxic fine sediments from urban areas flush through the system and are probably deposited within the Hunter Estuary or in Hexham Swamp when overbank flooding occurs. Poor water quality from pollutants including solid matter, sediments, scum, oils, toxins, nutrients and bacterial inputs and possible leachate from garbage dump fill sites in the Hunter River catchment. The water quality of the estuary is particularly vulnerable given the mixture and extent of industry, agriculture and urban development along the river. Water quality was sampled at three sites where standing water was available Sites 1, 8 and 10.

3.9.4.1 Site 1: Southern culvert

The water quality at the site was tidally influenced and the muddy benthic substrate was resuspended within the water column during tidal flows causing the channels to be highly turbid, with results elevated above ANZECC/ARMCANZ Guideline values (ANZECC 2000). Dissolved oxygen levels were extremely depressed and well below Guideline values (Table 3-25).

3.9.4.2 Site 8: Hunter River adjacent to culvert

The water quality off shore of the site was tidally influenced and slightly turbid. The pH levels were within the ANZECC/ARMCANZZ Guideline values (ANZECC 2000), while dissolved oxygen levels were depressed and fell below Guideline values (Table 3-25).

3.9.4.3 Site 10: Hunter River downstream of Culvert

The water quality offshore of the site was tidally influenced and appeared turbid though the turbidity reading was within the ANZECC/ARMCANZ Guideline values (ANZECC 2000). The pH levels were within the Guideline values while dissolved oxygen levels were depressed and fell well below Guideline values (Table 3-25).

Table 3-25 Water quality results (survey sites 1, 8 and 10)

Variable	Site 1	Site 8	Site 10	ANZECC/ARMCANZZ Trigger value ¹
pH	7.04	7.21	7.72	7 – 8.5
Turbidity (NTU)	52	15.3	8.88	0.5 - 10
Conductivity (usm)	261	6.25	29	NA ²
Temperature (°C)	17.1	23.7	22.6	NA ²
Dissolved Oxygen (% saturation)	13.4	55.3	23.5	80-110%

Note: 1: Trigger Values are derived from the ANZECC/ARMCANZ Guidelines for South Eastern Australia: slightly disturbed ecosystems: estuaries. 2: NA denotes trigger values not available under the ANZECC/ARMCANZ Guidelines.

3.9.5 Benthic epifauna

Benthic epifauna was sampled where habitat was available at Sites 1, 2 and 9.

3.9.5.1 Site 1: southern culvert

Two taxa of benthic epifauna were present within the proposed Project Area and indirect impact zone (Table 3-26). Both were commonly occurring air breathing gastropod species that have been studied previously in relation to rehabilitating degraded saltmarsh in NSW (Green *et al.* 2009). The results indicate that the communities within the proposed Project Area and indirect impact zones are similar in species composition and density.

Table 3-26 Site 1: Benthic saltmarsh epifauna

Proposed Project Area	Taxa	Count
Quadrat 1	na	
Quadrat 2	Phallomedusidae	9
	Ellobioidea	6
Quadrat 3	Phallomedusidae	11
	Ellobioidea	3
Indirect Impact Zone		
Quadrat 4	Phallomedusidae	9
	Ellobioidea	6
Quadrat 5	Phallomedusidae	12
	Ellobioidea	13

3.9.5.2 Site 2: southern coastal saltmarsh

Two taxa of benthic epifauna were present within the proposed Project Area and indirect impact zone (Table 3-27). Both were commonly occurring air breathing gastropod species that have previously been studied in relation to rehabilitating degraded saltmarsh in NSW (Green *et al.* 2009). The results indicate that the communities within the proposed Project Area and indirect impact zones are dissimilar in species composition and density with no gastropods present outside the proposed Project Area. This result is likely due to the infrequent inundation by tidal waters further into the swamp complex.

Table 3-27 Site 2: Benthic saltmarsh epifauna

Proposed Project Area	Taxa	Count
Quadrat 1	Ellobioidea	6
Quadrat 2	Ellobioidea	6
	Ellobioidea	6
Quadrat 3	Phallomedusidae	14
Indirect Impact Zone		
Quadrat 4	na	
Quadrat 5	na	

3.9.5.3 Site 9: saltmarsh Hunter River adjacent to culvert (north)

Two taxa of benthic epifauna were present within the site (Table 3-28). Both were commonly occurring air breathing gastropod species that have been studied previously in relation to rehabilitating degraded saltmarsh in NSW (Green *et al.* 2009).

Table 3-28 Site 9: Benthic saltmarsh epifauna

Proposed Project Area	Taxa	Count
Quadrat 1	<i>Phallomedusidae</i>	3
	<i>Ellobioidea</i>	4
Quadrat 2	<i>Phallomedusidae</i>	5
	<i>Ellobioidea</i>	6
Quadrat 3	<i>Phallomedusidae</i>	2
	<i>Ellobioidea</i>	3
Quadrat 4	<i>Phallomedusidae</i>	3
	<i>Ellobioidea</i>	12
Quadrat 5	na	

3.9.6 Fish

The culvert at site one contained enough habitat and standing water to adequately sample fish and aquatic fauna.

Site 1: southern culvert

Six fish traps were deployed at the site over a 13 hour period. One species of fish, the Sea Mullet and one prawn genus *Acetes* were collected (Table 3-29). The Sea Mullet were small juveniles all less than 5 cm in length. Both the fish and the prawn are commonly occurring marine fauna previously recorded throughout the Hunter River Estuary. No estuarine fauna were collected within the indirect impact zone inland from the culvert.

Table 3-29 Site 1: Fish results

Quadrat	Taxa	Count
Direct Impact Zone		
Trap 1	Acetes	>60
Trap 2	Acetes	>60
	Sea mullet	7
Trap 3	Acetes	>30
	Sea Mullet	2
Indirect Impact Zone		
Trap 4	na	
Trap 5	na	

3.9.7 Statistical analysis – coastal saltmarsh communities

Statistical analysis was undertaken on the flora and fauna components of the coastal saltmarsh communities (cluster analysis and multidimensional scaling) to determine whether the communities within the proposed Project Area, the indirect impact zones and the Hunter estuary were similar in composition.

Site 9, Quadrat 5, was removed from the analysis as it was very dissimilar to the other sites. The multivariate analysis identified that the community on the Hunter River was dissimilar to the communities within Hexham Swamp (Figure 3-2 and Figure 3-3). The species assemblages within and surrounding the proposed Project Area were similar to each other and did not change further west from the site.

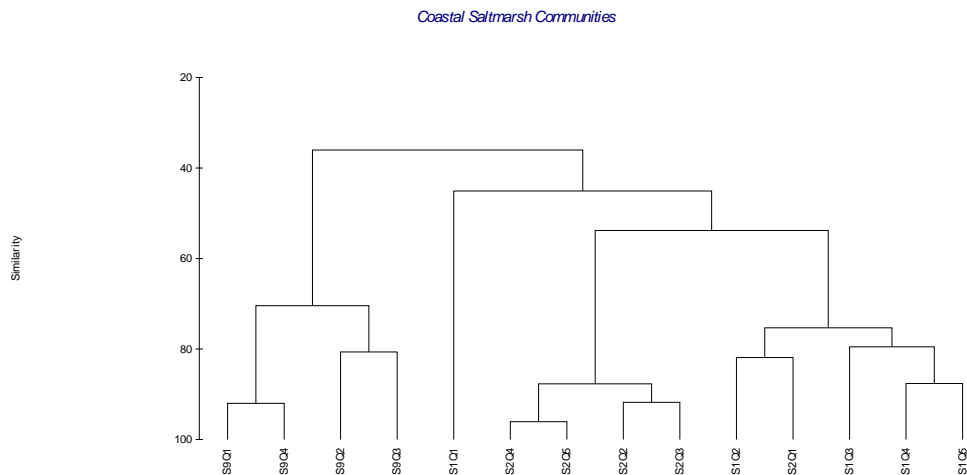


Figure 3-2 Coastal saltmarsh community cluster analysis

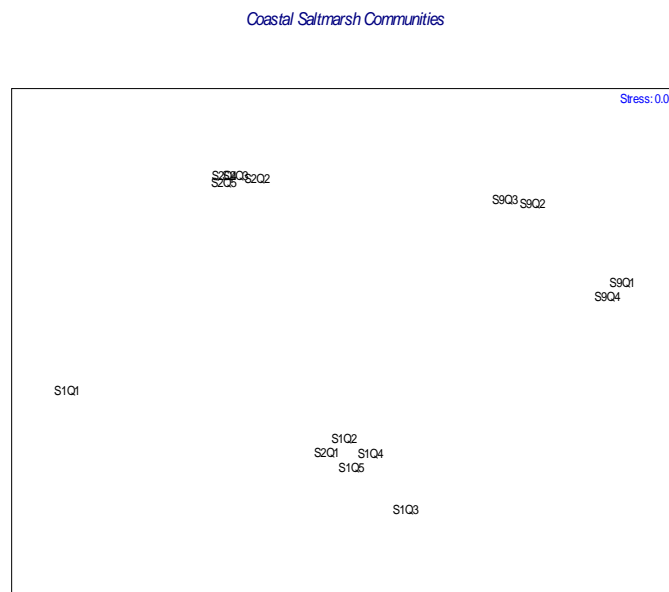


Figure 3-3 Coastal saltmarsh MDS ordination

3.10 Freshwater aquatic habitats

Within and surrounding the proposed Project Area there were three types of freshwater aquatic communities: drainage channels, wetlands and ponded pastures. The communities throughout the proposed Project Area were heavily degraded and affected by grazing,

constructed channels, tracks and reclamation works. Freshwater habitats within the study area were generally considered to be of poor condition.

3.10.1 Site descriptions

3.10.1.1 Site 3: modified drainage lines

This site supported a small freshwater wetland (Photograph 3-26) and a vegetated drainage channel (Photograph 3-27). The wetland was formed as a result of the construction of batters to obstruct flow into the adjoining paddocks further south. The water was approximately 50 cm deep and the water surface was covered by Ferny Azolla and individual Swamp Oak trees with *Carex* spp sedges scattered throughout the channel. The wetland was scattered with Spiny Rush and patches of the Common Rush. The small wetland narrows into a channel north of the batter which is densely populated with Broad-leaved Cumbungi, the Common Reed and *Juncus* spp.



Photograph 3-26 Site 3: Freshwater wetland



Photograph 3-27 Site 3: Vegetated channel community

3.10.1.2 Site 4: SEPP 14 wetland (833)

The SEPP 14 wetland (wetland 833) was situated on a flat plain (Photograph 3-28) that was heavily impacted upon by grazing. The wetland was almost completely treeless with some individual paperbark and Swamp Oak trees scattered throughout the complex. There was a limited amount of large woody debris habitat scattered throughout the wetland with patches of Spiny Rush and Common Rush. The site was largely a monoculture of Common Cotula, Scurvy Weed and pasture grasses. The site was covered by standing water to a depth of approximately 30 cm as a result of recent rainfall.



Photograph 3-28 Site 4: Freshwater wetland

3.10.1.3 Site 5: Drainage line

This constructed drainage line (Photograph 3-29) contained fast flowing water channelled under the highway. The drainage line was approximately 1-1.5 m in depth with established stable banks vegetated by Common Reeds with a thick muddy benthic substrate.



Photograph 3-29 Site 5: Northern drainage channel

3.10.1.4 Site 6: Poned pasture

This ponded pasture held standing water within areas of paddocks that have been filled for grazing (Photograph 3-30). The pasture supported a limited number of wetland flora species and was dominated by pasture grasses. The standing water depth was up to 50 cm across the site. There were dense beds of Common Cotula, Native Carrot and Water Primrose throughout the wetted area.



Photograph 3-30 Site 6: Poned pasture

3.10.1.5 Site 7: Phragmites drainage line

This site was dominated by dense well established stands of Common Reed (Photograph 3-31). The community was associated with shallow drainage lines that would only intermittently hold water. The community was disturbed around the edge margins by a large number of weed species including Lantana and Blackberry.



Photograph 3-31 Site 7: Phragmites drainage line

3.10.2 Freshwater community descriptions

3.10.2.1 Site 3 and 4: Freshwater wetlands and channel community

Five quadrats were surveyed within the site (Table 3-30). The results indicated that the community supported a very limited number of wetland species and pasture grasses.

Table 3-30 Site 4: Wetland quadrat results

	Common Name	Density (%)
Quadrat 1	Common Cotula	55
	Pasture Grasses	45
Quadrat 2	Common Cotula	60
	Pasture Grasses	40
Quadrat 3	Common Cotula	30
	Pasture Grasses	70
Quadrat 4	Common Cotula	60
	Pasture Grasses	40
Quadrat 5	Common Cotula	60
	Pasture Grasses	40

3.10.3 Water quality

The water quality across the proposed Project Area is of low value and largely falls outside the ANZECC/ARMCANZ Guideline values (ANZECC 2000). The proposed Project Area is located within the Ironbark Creek Catchment that has historically been characterised by water quality with high nutrient levels and undesirable variability in dissolved oxygen (Newcastle City Council 2004). The catchment supports acid sulphate soils, low pH levels and high soluble iron levels (Ironbark Creek Total Catchment Management Committee 1996). Highly polluted and possibly toxic fine sediments from urban areas flush through the system and are probably deposited within the Hunter Estuary or in Hexham Swamp when overbank flooding occurs. There is little data on the existing water quality in Hexham Swamp, however it is generally described as poor, and opening floodgates to allow tidal flushing has been recommended to neutralise the acid sulphate soils within the wetland (Department of Primary Industries 2008). Water quality was sampled at two sites where standing water was available (Site 3 and 5).

3.10.3.1 Site 3: Freshwater wetland and channel community

The water quality at the small wetland and drainage channel were considered poor with low levels of dissolved oxygen when compared against the ANZECC/ARMCANZ Guideline values (ANZECC 2000). The sites were not particularly turbid but Azolla coverage of the open water would impact light penetration into the water column. The pH results indicate the site is slightly alkaline and the sites were not brackish or affected by tidal inundation (Table 3-31).

3.10.3.2 Site 5: Drainage line

The water quality sampling was undertaken at two sites at the constructed drainage line. Both results indicate that the drainage line was slightly brackish and turbid with low dissolved oxygen levels below the ANZECC/ARMCANZ Guideline levels (ANZECC 2000) despite the water flow (Table 3-31).

Table 3-31 Water quality results

Variable	Site 3 Wetland	Site 3 Drainage Channel	Site 5 Location 1	Site 5 Location 2	ANZECC/ARMCANZZ Trigger value ¹
pH	7.71	6.91	7.14	6.77	6.5 - 8
Turbidity (NTU)	21	19	117	331	6 - 50
Conductivity (usm)	27.9	26.1	193	204	125 - 2200
Temperature (°C)	20.3	21.7	22	24.8	NA
Dissolved Oxygen (% saturation)	15.3	36.2	36	51	90-110

Note: 1: Trigger Values are derived from the ANZECC/ARMCANZ Guidelines for South Eastern Australia: slightly disturbed ecosystems: lowland river (no current trigger values for wetlands). 2: NA denotes trigger values not available under the ANZECC/ARMCANZ guidelines.

Note: red cells denote values outside the ANZECC/ARMCANZ guidelines.

3.10.4 Fish

Both freshwater sites (3 and 5) contained enough habitats and standing water to adequately sample fish and aquatic fauna.

3.10.4.1 Site 3: Freshwater wetland and channel community

Five fish traps were deployed at the site overnight for 13 hours. Only one species of fish was collected, the pest species Eastern Mosquitofish (*Gambusia holbrooki*). NSW DPI has listed Mosquitofish as noxious (Department of Primary Industries (Fishing and Aquaculture) 2012) and they are listed as a Class 1 noxious species outside the greater Sydney area. Predation by Mosquitofish is listed as a key threatening process under the TSC Act. The species has been associated with the decline of abundance or range of fish species including native species such as gudgeon, hardyheads and some rainbow fish. Mosquitofish are widely spread throughout NSW and thrive in shallow low flowing waterbodies, tolerating a wide range of temperatures and water quality.

Table 3-32 Site 3: Fish results

Trap Number	Species	Number
Trap 1	Mosquitofish	14
Trap 2	Mosquitofish	8
Trap 3	Mosquitofish	12
Trap 4	Mosquitofish	15
Trap 5	Mosquitofish	9

3.10.4.2 Site 5: Drainage line

Six fish traps were deployed at the site overnight for 13 hours. No fish were collected.

4. Threatened biodiversity and migratory species

4.1 Threatened ecological communities

Seventeen threat-listed ecological communities listed under the TSC Act and/or EPBC Act have been identified as having potential to occur within the Hunter/Central Rivers Catchment Management Area Hunter subregion (Table 4-1). No threat-listed ecological communities listed under the FM Act have the potential to occur within the locality.

Four threat-listed ecological communities listed under TSC Act were recorded within the Study Area (Table 4-1): Coastal Saltmarsh, Freshwater Wetlands, Swamp Oak Floodplain Forest and Swamp Sclerophyll Forest.

No threat-listed ecological communities listed under the EPBC Act or FM Act are present within the Study Area.

Table 4-1 Threat-listed ecological communities listed predicted to occur in the locality

Threat-listed ecological community	TSC Act	EPBC Act	Occurs within the Study Area?
Central Hunter Grey Box Ironbark Woodland in the NSW North Coast and Sydney Basin bioregions	E		No. Study Area is outside the range of this community.
Central Hunter Ironbark – Spotted Gum – Grey Box Forest in the NSW North Coast and Sydney Basin bioregions	E		No. Study Area is outside the range of this community.
Coastal Saltmarsh in the NSW North Coast, Sydney Basin and South East Corner Bioregions	E		Yes, mapped as occurring within the Study Area and confirmed during site surveys.
Freshwater Wetlands on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions	E		Yes, mapped as occurring within the Study Area and confirmed during site surveys.
Hunter Lowland Redgum Forest in the Sydney Basin and NSW North Coast Bioregions	E		No. Not identified within the Study Area either in vegetation mapping of the region or during site inspections
Hunter Valley Vine Thicket in the NSW North Coast and Sydney Basin Bioregions (as described in the determination of the Scientific Committee under Division 5 of Part 2)	E		No. Study Area is outside the range of this community.
Hunter Valley Weeping Myall Woodland of the Sydney Basin Bioregion (as described in the determination of the Scientific Committee under Division 5 of Part 2)	E	CE ^{*1}	No. Study Area is outside the range of this community.

Threat-listed ecological community	TSC Act	EPBC Act	Occurs within the Study Area?
Kurri Sand Swamp Woodland in the Sydney Basin Bioregion	E		No. Not identified within the Study Area either in vegetation mapping of the region or during site inspections.
River-flat Eucalypt Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions (as described in the determination of the Scientific Committee under Division 5 of Part 2)	E		No. Not identified within the Study Area either in vegetation mapping of the region or during site inspections.
Littoral rainforest in the NSW North Coast, Sydney Basin and South East Corner Bioregions*	E*	CE ²	No. Not identified within the Study Area either in vegetation mapping of the region or during site inspections.
Lower Hunter Spotted Gum – Ironbark Forest in the Sydney Basin bioregion	E		No. Not identified within the Study Area either in vegetation mapping of the region or during site inspections.
Swamp Oak Floodplain forest of the NSW North Coast, Sydney Basin and South East Corner Bioregions (as described in the determination of the Scientific Committee under Division 5 of Part 2)	E		Yes, mapped as occurring within the Study Area and confirmed during site surveys.
Swamp Sclerophyll Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions (as described in the determination of the Scientific Committee under Division 5 of Part 2)	E		Yes, mapped as occurring within the Study Area and confirmed during site surveys.
Sydney Freshwater Wetlands in the Sydney Basin bioregions	E		No. Not identified within the Study Area either in vegetation mapping of the region or during site inspections.
Warkworth Sands Woodland in the Sydney Basin Bioregion	E		No. Study Area is outside the range of this community.
White Box-Yellow Box-Blakely's Red gum Grassy Woodland and Derived Native Grassland*	E*	CE ³	No. Not identified within the Study Area either in vegetation mapping of the region or during site inspections.
Weeping Myall – Coobah – Scrub Wilga Shrubland of the Hunter Valley		CE	No. Study Area is outside the range of this community.

Notes: *There are significant similarities in these TSC and EPBC Act listed communities, however, not all occurrences will fit both listings. Under the EPBC Act, these communities are listed as:

- 1) Weeping Myall - Coobah - Scrub Wilga Shrubland of the Hunter Valley.
- 2) Littoral Rainforest and Coastal Vine Thickets of Eastern Australia.
- 3) White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland.

4.2 Endangered populations

Five Endangered populations listed under the TSC Act have been identified as occurring in the Hunter/Central Rivers CMA, Hunter sub-catchment (Table 4-2). The preferred habitats of these species are provided in Appendix C (flora) and Appendix D (fauna).

No Endangered populations listed under the FM Act occur within the locality.

No Endangered populations occur within the Study Area (Table 4-2).

Table 4-2 Endangered populations predicted to occur in the Hunter/Central Rivers CMA, Hunter sub-catchment

Endangered population	Occurs within the Study Area?
Emu population in the NSW North Coast Bioregion and Port Stephens LGA	No. Study Area is not within the NSW North Coast Bioregion or Port Stephens LGA
<i>Leionema lamprophyllum</i> ssp. <i>obovatum</i> population in the Hunter Catchment	No. <i>Leionema lamprophyllum</i> ssp. <i>obovatum</i> was not recorded within the Study Area. The known distribution of this species is to the west of Maitland near Pokolbin in the Hunter Valley, approximately 10 km to the north of the Study Area.
<i>Eucalyptus camaldulensis</i> (River Red Gum) population in the Hunter Catchment	No. <i>Eucalyptus camaldulensis</i> was not recorded in the Study Area. The known distribution of this species is to the west of Jerrys Plains near Singleton in the Hunter Valley, approximately 100 km to the north west of the Study Area.
<i>Acacia pendula</i> (Weeping Myall) population in the Hunter Catchment	No. <i>Acacia pendula</i> was not recorded in the Study Area. The known distribution of this species is to the west of Jerrys Plains near Singleton in the Hunter Valley, approximately 100 km to the north west of the Study Area.
<i>Cymbidium canaliculatum</i> population in the Hunter Catchment	No. <i>Cymbidium canaliculatum</i> is not a cryptic species and was not recorded the Study Area.

Source: (Department of Environment Climate Change and Water 2010b).

4.3 Threat-listed species

4.3.1 Flora

A total of 20 threat-listed flora species listed under the TSC Act and/or EPBC Act are known or predicted to occur in the locality (Appendix C). A further four species are listed as endangered populations in the region (see Section 4.2). Although no threat-listed species of plant were recorded in the Study Area, three are considered moderately likely to occur based on the presence of potential habitat. These are:

- *Maundia triglochinosoides* (Small Water Ribbons) is listed as Vulnerable under the TSC Act.
- *Persicaria elatior* (Tall Knotweed) is listed as Vulnerable under the both the TSC Act and the EPBC Act.
- *Zannichellia palustris* is listed as Endangered under the TSC Act.

Other threat-listed species known or predicted to occur in the locality are considered unlikely to occur in the Study Area (Appendix C) for one or more of the following reasons:

- Preferred habitat not present.

- Outside known range of the species and habitat marginal.
- Species is not cryptic and, based on survey effort, would have been recorded if present.

4.3.2 Fauna

A total of 64 threat-listed species of animal under the TSC Act, FM Act and/or the EPBC Act have been recorded, or are predicted to have habitat in the locality (Appendix D). Two threat-listed species of animal, the Grey-headed Flying-fox and White-fronted Chat, were recorded in the Study Area during field surveys (Figure 4-1). A further two threat-listed species, the Black-necked Stork and Spotted Harrier, were also recorded during field surveys, however, they were recorded more distantly from the Study Area.

It is not likely, however, that all 64 species would be affected by the proposed Project. Thirty-seven threat-listed species are considered to have a low likelihood of occurrence based on the availability of habitat. Full details of species requirements and reasons for not considering impacts of the proposed Project further are provided in Appendix D.

Significance assessments required under the TSC Act and/or the EPBC Act, have been completed for the remaining 27 species (Section 7 and Appendix E). Although the proposed Project Area may provide potential foraging or breeding habitat, it is not likely that these species (or any other species) would be significantly affected by the proposed Project.

4.3.2.1 Green and Golden Bell Frog

Targeted searches for the Green and Golden Bell Frog were completed in the Study Area during optimal conditions and included the inspection of a reference site to gauge species detectability. While species detectability was confirmed with call playback eliciting two responses at a reference site on Ash Island, this species was not observed or heard calling during 27.5 hours of spotlighting, call detection and call playback in the Study Area.

The Study Area is separated from two important populations (observations recorded post 1995) of Green and Golden Bell Frog, which occur approximately 300 m to the east of the Study Area on Ash Island, by the existing rail corridor, industrial developments, the Pacific Highway (Maitland Road) and the South Arm of the Hunter River (Figure 4-1).

4.4 Migratory species

Migratory species are protected under the international agreements to which Australia is a signatory, including JAMBA, CAMBA, RoKAMBA and the Bonn Convention on the Conservation of Migratory Species of Wild Animals. Migratory species are considered Matters of National Environmental Significance and are protected under the EPBC Act.

Three species of bird listed as Migratory under the EPBC Act, being, the Eastern Great Egret, Cattle Egret and White-bellied Sea-Eagle, were recorded in the Study Area during field surveys (Appendix B). Habitat within the Study Area is considered marginal for these species in light of the abundance of similar or greater quality habitat elsewhere in the locality and the degraded nature of these habitats within the Study Area.

A further 34 migratory (terrestrial, wetland and marine) species have the potential to occur in the wider locality (10 km radius) based on EPBC Protected Matters search, other database searches and experience and knowledge of the area (Appendix D). Of these 34 species, 22

have a moderate or greater likelihood of occurrence in the Study Area on at least an intermittent basis. This is due, in large part, to the Study Area's location within the Hunter River floodplain and proximity to suitable migratory bird habitat.

For 25 migratory species observed or with potential to occur within or over the site, the Study Area is not considered to be of sufficient quality or extent to support these species.

The Study Area is not considered "important habitat" to migratory birds as it does not contain:

- Habitat used by a Migratory species occasionally or periodically within a region that supports an ecologically significant proportion of the population of the species (Department of the Environment Water Heritage and the Arts 2009b).

Under the EPBC Act, an action is likely to have a significant impact on a migratory species if it **substantially** modifies, destroys or isolates an area of **important habitat** for such species (Department of the Environment, Water, Heritage and the Arts 2009b).

Although there is potential for impacts upon relatively small areas of migratory bird habitat within the Study area, those impacts will be limited to the construction subject site and are considered unlikely to substantially impact upon potential habitat for 25 migratory species for the following reasons:

The relatively small amount (9.10 ha) of habitat to be affected.

- The abundance of similar and greater quality habitat areas occurring adjacent to the subject site and also occurring within the Hexham Swamp Nature Reserve.
- The abundance of similar and greater quality habitat areas occurring in the Ramsar listed Hunter River Estuary reserves.
- Historical disturbance of the proposed Project Area, including agricultural developments, the existing rail corridor, industrial developments, access tracks and the former Coal and Allied rail loop.
- Environmental impact mitigation measures undertaken during the construction phase of the project, which will prevent significant impacts upon surrounding migratory bird habitat.

As such, proposed impacts of the proposed Project on Migratory species are not considered further.

4.5 Other ecological values and Matters of National Significance

4.5.1 World heritage properties

No world heritage properties are within the locality of the proposed Project.

4.5.2 Ramsar wetlands

One Internationally important wetland, Hunter Estuary Wetlands (Ramsar site) is mapped in two areas in close proximity to the proposed Project Area. Kooragang Nature Reserve is mapped approximately 4 km to the east across the South Arm of the Hunter River, and the Shortland Wetlands occur approximately 5 km to the south of the proposed Project Area. This wetland is a 'declared Ramsar wetland' due to its significance to international migratory birds. It also supports important mangrove and saltmarsh communities (NSW Fisheries 1999). The proposed Project is not likely to impact (including indirect impacts) these two areas due to their distance from the proposed Project Area.

Matters related to Ramsar wetlands are considered to be of National Environmental Significance (NES) and a significant impact on a matter of NES requires referral to the Department of Sustainability, Environment, Water, Population and Communities (SEWPAC) and the Minister for SEWPAC for consideration. The impact on Hunter Estuary Wetlands is not likely to be significant: however, given the proposed Project's proximity a referral to SEWPAC has been made.

4.5.3 Wetlands of national importance

One wetland of national importance, Hexham Swamp (NSW138) occurs in the west of the Study Area. Hexham Swamp is considered of national estate importance as it is the largest remaining waterfowl habitat on the lower north coast of NSW, containing approximately 37 % of the remaining non-tidal wetland habitat on the lower Hunter floodplain (Hunter Catchment Management Trust 1998). Hexham Swamp, however, occurs outside the proposed Project Area, and is not likely to be impacted due to the linear nature of the proposed Project and the relatively small areas to be affected.

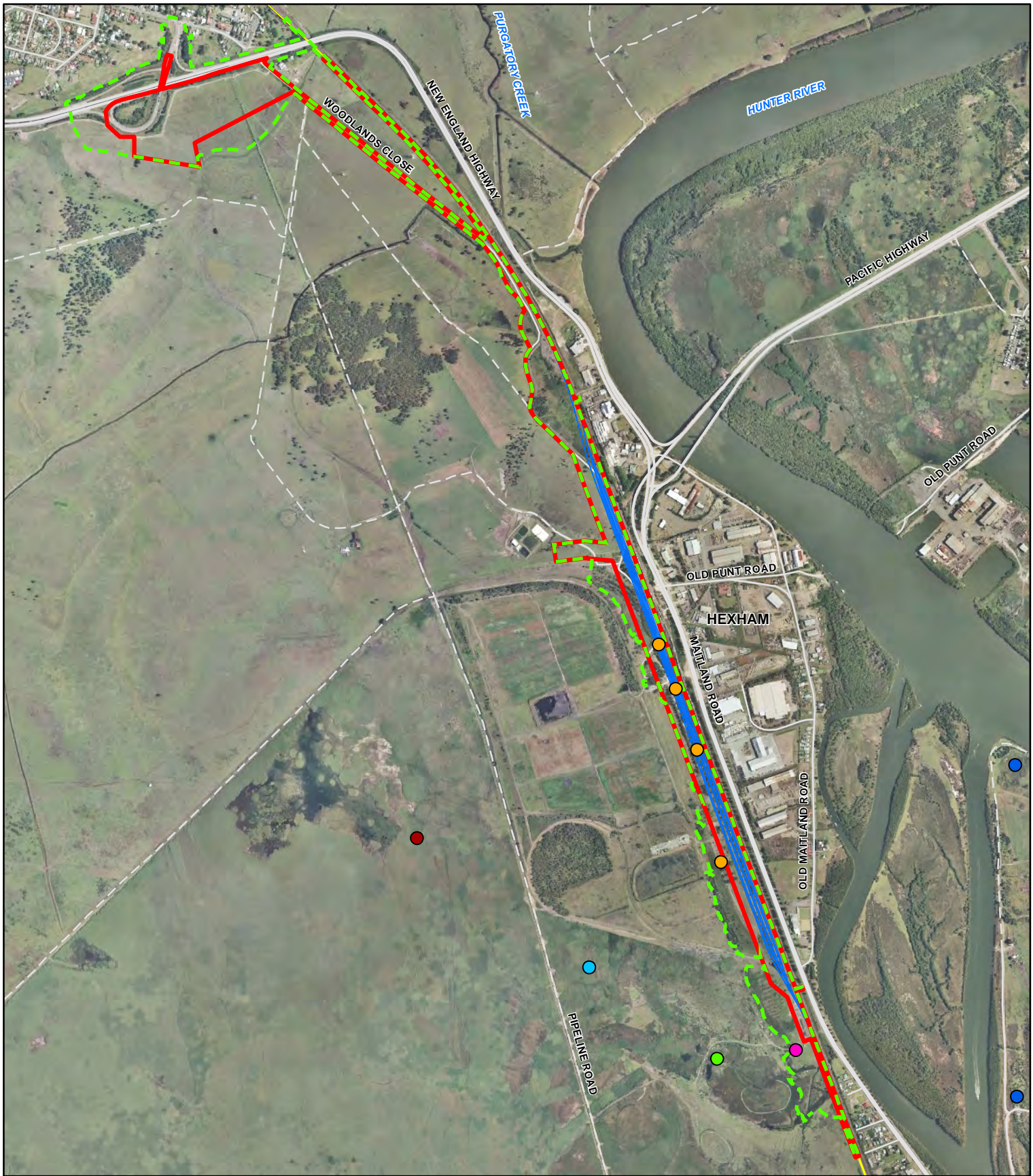
4.5.4 State Environmental Planning Policy No.14–Coastal Wetlands

Two SEPP 14 wetlands have been mapped as occurring in the Study Area:

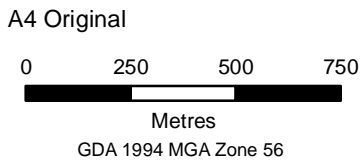
- Wetland 833 – located at approximate chainage 176,100 km in the north of the Study Area (Figure 3-1, Photograph 4-1). This wetland occurs in an adjoining property and is part of the sewage treatment works. Historically, the wetland has been subjected to heavy grazing in the past and is a disturbance that is ongoing. A portion of this wetland will be filled to accommodate the proposed rail lines and an access track.
- Wetland number 840 – located at approximate chainage 173,800 km in the south of the Study Area (Figure 3-1, Photograph 3-4). That portion of the wetland which occurs in the Study Area does not form part of the Hexham Swamp Nature Reserve. However, a large portion of this wetland (outside the Study Area) does form part of the Hexham Swamp Nature Reserve. The proposed Project is not likely to significantly impact this SEPP 14 wetland: however, it is likely to change the surface and overland flows to a limited area of it.



Photograph 4-1 SEPP 14 Wetland 833 in the north of the proposed Project Area



- | | | |
|----------------------|--------------------------|---|
| — Major Road | — Existing Alignment | ● Spotted Harrier |
| — Local Road | - - - Study Area | ● White-fronted Chat |
| - - - Minor Road | ▭ Project Area | ● Green and Golden Bell Frog Observation (1984) |
| — Proposed Alignment | ● Black-necked Stork | ● Green and Golden Bell Frog Observation (1999) |
| | ● Grey-headed Flying-fox | |



ARTC
Hexham Relief Roads
**Location of
Threat-listed
Species of Animal**

Job Number	2110501B
Revision	A3
Date	29.02.2012
Scale	1:18,000

Figure 4.1

5. Impacts from the proposed project

The proposed Project will have both direct and indirect impacts on biodiversity during both the construction and operation phases (Table 5-1). These impacts are described in more detail below.

Table 5-1 Potential impacts of the proposed Project on biodiversity

Impacts of the proposed Project on biodiversity	Construction	Operation
Vegetation/habitat clearing (including estuarine and aquatic habitats)	•	
Migratory species	•	•
Fragmentation and connectivity	•	
Noise impacts on fauna	•	•
Weed invasion	•	•
Increase in edge effects	•	
Hydrological changes	•	•
Fish Passage	•	
Increased presence of Mosquitofish		•
Aquatic disturbance	•	•
Increase in fauna mortality	•	•
Increase in Key Threatening Processes	•	•

5.1 Vegetation and habitat clearing

Clearing of native vegetation is listed as a Key Threatening Process under both the NSW TSC Act and the Commonwealth EPBC Act. Under the TSC Act, native vegetation is made up of plant communities, comprising primarily indigenous species. Clearing is defined as the destruction of a sufficient proportion of one or more strata layers within a stand or stands of native vegetation so as to result in the loss, or long-term modification, of the structure, composition and ecological function of a stand or stands (NSW Scientific Committee 2001).

Construction of the proposed Project will require the clearing of vegetation and habitats as summarised in Table 5-2. This includes a loss of habitat features, although this would only be minor due to a general lack of fauna microhabitats recorded in the proposed Project Area. The estimates of vegetation clearing presented below are based on a broad corridor assessment and represent a worst case scenario for impacts to biodiversity. The impacts would be reduced as a result of detailed design.

The mangrove and saltmarsh community at the southern end of the proposed Project Area forms part of a broader SEPP14 Wetland (wetland 840) that will not be impacted upon by the proposed Project.

No areas of coastal saltmarsh will be impacted upon as part of the proposed Project and there is a wider saltmarsh community across the River from the discharge culvert from the site into the Hunter River. It is not considered likely that any changes to flow and water

quality as a result of any indirect impacts by the proposed Project will impact on the wider saltmarsh community of the Hunter River.

The freshwater wetland community at the northern end of the proposed Project Area forms part of a broader SEPP14 Wetland (wetland 833) that will be directly impacted upon by fill works. This habitat is degraded and removal is unlikely to cause increased edge effects on the value or integrity of the wider wetland complex. In the Study Area, the SEPP14 Wetland (wetland 833) community occurred as a monoculture of commonly occurring flora species.

The remaining aquatic habitats within the proposed Project Area are freshwater communities formed opportunistically along constructed drainage channels. The drainage channel communities support monocultures of commonly occurring flora and fauna species and their removal by fill would not impact upon the wider Hexham Swamp Reserve or habitat values in the locality.

One threat-listed species, Grey-headed Flying-fox, was recorded in the proposed Project Area during surveys, with a further three recorded in the vicinity of the proposed Project Area. The estuarine and wetland communities within and surrounding the proposed Project Area are not likely to support any listed species and their removal is not considered likely to cause significant impacts to the broader Hexham Swamp area.

Table 5-2 Potential loss of vegetation within the proposed Project Area

Vegetation community/Fauna habitat	Extent within Study Area (ha)	Vegetation clearing (ha)
Vegetation		
Swamp Oak Swamp Forest Fringing Estuaries ¹	6.18	5.28
Swamp Mahogany Swamp Forest on Coastal Lowlands ¹	1.12	1.12
<i>Phragmites australis</i> and <i>Typha orientalis</i> Coastal Freshwater Wetlands ¹	3.46	2.70
Coastal Saltmarsh in Estuaries ¹	1.62	0
Exotic Grassland/Disturbed	35.56	25.55
Exotic Herbfield	9.29	3.70
Planted Vegetation	2.72	0.69
Total	59.94	39.05
Total area of EEC	12.37	9.10
Fauna habitats		
Swamp forest	10.01	7.10
Saltmarsh	1.62	0
Aquatic habitat	3.46	2.70
Cleared land	47.57	29.25

Notes: 1 - Endangered Ecological Community as listed under the *Threatened Species Conservation Act 1995*

5.2 Fragmentation and connectivity

Habitat fragmentation through the clearing of vegetation can increase the isolation of remnant vegetation and create barriers to the movements of small and sedentary fauna such as ground dwelling mammals, reptiles and amphibians. Furthermore, habitat fragmentation can create barriers to the movement of pollinator vectors, such as insects, and thereby affect the life cycle of both common and threat-listed flora.

The proposed Project would remove approximately 7.10 ha of forest (including 6.40 ha of Swamp Forest EEC) occurring in the proposed Project Area. Due to the linear nature of the proposed Project, the proposed Project Area would essentially encroach on vegetation at the interface of existing clearing and easements.

Aquatic habitats and Saltmarsh recorded in the Study Area are an extension of and connected to similar habitats occurring in Hexham Swamp Nature Reserve. A small isolated mangrove community occurs in the Study Area and exists at the limit of the tidal extent. This community is part of a larger more established mangrove community on the Hunter River. The small freshwater wetlands and vegetation associated with the channel are small isolated communities and populated by commonly occurring opportunistic species with no connection between sites.

Other vegetation in the Study Area, namely Swamp Forest, occurred as linear strips of regrowth vegetation, subjected to varying degrees of disturbance over recent history. Such vegetation was already isolated from larger areas of contiguous habitat, which occur approximately 3 km to the east and west of the proposed Project. Due to existing infrastructure, including the existing rail corridor, the Pacific Highway and industrial and agricultural developments, the proposed Project would not fragment or sever connectivity of habitats in the locality. However, the proposed Project would add incrementally to isolation of habitat. Over the full extent of the proposed Project Area, the proposed Project is not likely to further fragment or isolate vegetation any more than that currently occurring in the Study Area, given its location adjacent to already disturbed areas.

No threat-listed species of animal recorded in the Study Area is likely to be affected by the incremental addition to habitat isolation. Historically, however, the Green and Golden Bell Frog has been recorded in Hexham Swamp, which occurs adjacent to the Study Area (Department of the Environment, Water, Heritage and the Arts 2009d). Although this species was not recorded in the Study Area during targeted field surveys, potential habitat was recorded therein. If this species was found to be present, it has potential to be affected by incremental isolation of small wetlands in the proposed Project Area.

5.3 Noise and vibration impacts on fauna

It is likely that existing rail and industrial operations would already impact background levels of noise in the Study Area, due to 24 hour operations. However, construction phases of the proposed Project (along with its ancillary activities) may cause temporary disturbance to animals. The impacts from noise emissions are likely to be localised close to the proposed Project (up to 100 m) and are not likely to have a significant long-term impact on wildlife populations. Furthermore, it is considered likely that most animal species will habituate to periodic noise disturbance from regular maintenance activities (Forman *et al.* 2000; Larkin 2005).

Vibration during construction, particularly at the southern culvert, has potential to inhibit fish passage through the channel during tidal events. Fish species with potential to inhabit the site are likely to be commonly occurring species, opportunistically entering the channel on tidal flows. Due to the short-term nature of construction of the culvert, the disturbed nature of the culvert channel and the mobile nature of fish, it is not considered likely to cause long-term disturbance to the fish populations.

5.4 Weeds

The proposed Project has the potential to further disperse weeds into areas of native vegetation within the Study Area, particularly adjacent to cleared areas. The existing rail corridor has a high level of weed invasion, particularly exotic grasses.

The Study Area also includes seven weed species listed under *the Noxious Weeds Act 1993* (see Section 0): *Ageratina adenophora**, *Cortaderia selloana**, *Cestrum parqui**, *Echium plantagineum**, *Alternanthera philoxeroides** *Rubus fruticosus** and *Lantana camara**. The latter three are also recognised as Weeds of National Significance.

The invasion of exotic perennial grasses, such as *Pennisetum clandestinum**, *Chloris gayana** and *Melinis repens** that were recorded abundantly within the existing rail corridor, is recognised as a Key Threatening Process under the TSC Act. The invasion of the exotic aquatic weed *Alternanthera philoxeroides** is recognised as a Key Threatening Process under the EPBC Act.

Other invasive weeds of concern that were recorded in abundance were *Arundo donax**, *Foeniculum vulgare**, and *Acacia saligna**.

The most likely causes of weed dispersal associated with the proposed Project would include earthworks, movement of soil and attachment of seed (and other propagules) to vehicles and machinery.

Existing disturbed vegetation within the Study Area, however, has considerable weed growth already. Therefore, the overall extent of weed invasion is not likely to increase significantly, so long as the mitigation measure outlined in Section 6 of this report are adhered to.

5.5 Edge effects

Edge effects are zones of changed environmental conditions (i.e. altered light levels, wind speed and/or temperature) occurring along the edges of habitat fragments. These new environmental conditions along the edges can promote the growth of different vegetation types and allow invasion by pest animals specialising in edge habitats and/or change the behaviour of resident animals. Edge zones can be subject to higher levels of predation by introduced mammalian predators and native avian predators. Edge effects have mainly been recorded adjacent to roads and at distances greater than 1,000 m from the road surface (Forman *et al.* 2000). However, Bali (2005), in a comparison of edge effects in a variety of different habitat types, estimated that average edge effects generally occur up to 50 m away from the road edge.

Swamp forest vegetation occurring in Study Area has been extensively cleared, with remnant vegetation essentially occurring as thin linear strips adjacent to the existing rail corridor. Such vegetation is already highly fragmented and isolated from other areas of

substantial vegetation by the existing rail corridor, the Pacific Highway, industrial developments, the south arm of the Hunter River, agricultural developments and the extensive Hexham Swamp Nature Reserve.

Estuarine and aquatic wetland communities occurring in the Study Area (including SEPP 14 Wetlands 833 and 840) are relatively well connected to similar habitat occurring in the Hexham Swamp Nature Reserve and floodplain, of which the Study Area forms a part. The Hexham Swamp Nature Reserve has a long history of mangrove and saltmarsh complexity decreasing over time. Between 1971 and 2005 the mangrove communities decreased by 94% to 11 ha and saltmarsh has been reduced by 92% to 58 ha. The dominant vegetation type within the swamp was described as Reedswamp dominated by *Phragmites australis*, which has increased by 530% in the same period (Winning & Saintilan 2009). The two sections of SEPP14 wetlands (wetlands 833 and 840) within the proposed Project Area that will be directly impacted upon by the proposed Project, support mangroves and saltmarsh, and filling will contribute to the overall decrease in community range in the area. However these communities are highly disturbed and impacted upon by constructed channels and grazing. These sections of wetland do not hold intrinsically high environmental values due to disturbance. Thus, removal of these sections of the wetlands is not likely to result in a significant increase in edge effects to the wider wetland complexes.

5.6 Hydrological changes

Modifications to existing drainage lines and waterway crossings, such as culverts, could modify the natural and constructed hydrology of existing wetlands, creeks and drainage lines, which have formed around batters and along linear infrastructure in the Study Area, wider wetland complex and estuarine communities of the Hunter River. Changes to these existing habitats could ultimately affect the aquatic assemblages that use the area (Fairfull & Witheridge 2003). The water quality across the proposed Project Area is of low value and largely falls outside the ANZECC/ARMCANZ Guideline values (ANZECC 2000). The proposed Project will contribute to water quality values discharging from the site, however, it is unlikely to cause significant changes to the existing water quality values of Hexham Swamp or the Hunter River. If foundations for the proposed Project are designed to allow lateral drainage towards Hexham Swamp, particularly for the northern portion of the proposed Project, then appropriate measures should be investigated to ensure water discharging into Hexham Swamp conforms with ANZECC/ARMCANZ Guideline values (ANZECC 2000).

General impacts from changes to surface and drainage flows and waterway crossings may include:

- excessive flow velocities, which could erode creek banks and lead to changes in water quality, as well as acting as a barrier to any fish movements in the creek
- changes to tidal inundation patterns, which would affect species assemblages across the plain area (including saltmarsh in SEPP 14 wetland 840)
- decreased pH in water quality from exposure of acid sulphate soils during construction
- changes to standing water flow patterns across SEPP14 wetlands, which could change community assemblage
- changes to water quality variables such as dissolved oxygen as a result of flow concentrations to the culvert channel

- modified water depths and temperatures of the waterway, which could act as a barrier to fish movement and cause loss of interconnectivity between pools
- changes to water turbulence and suspended solids in the water column, which could lead to the avoidance of the area by various aquatic organisms and smothering of others.

While a number of freshwater wetlands occurred in the Study Area, most of these and their associated drainage lines have been modified as a result of agricultural practices and existing rail infrastructure. However, several of the freshwater wetlands, including SEPP 14 wetland 840, will require infilling to accommodate the proposed rail infrastructure and access tracks. Any such works will require assessment and erosion and sediment control measures to minimise potential impacts to the remaining wetlands and drainage lines in vicinity of works.

5.7 Fish passage

There are a number of fish species recorded previously in the Hunter River and Hexham Swamp Reserve (Appendix I), and many of these have potential to access the proposed Project Area during high tide events via the existing southern culvert or swamp flood events.

A recent study undertaken by NSW Department of Primary Industries (2011) stated that an estimated 70% of fish inhabiting coastal drainages in south eastern Australia may migrate between estuarine and freshwater environments throughout their life. It has been demonstrated throughout the world that the removal of barriers that impede fish passage can lead to some of the largest increases in fish production, when compared to other in-stream habitat works. Culverts impede fish passage more than any other structure (Petthebridge *et al.* 1998) and both common designs of culverts, box and pipe, result in significantly modified bed structure, depth, turbulence and flow velocities. Box culverts such as the existing design at the proposed Project Area are generally preferred over pipe culverts for fish passage, due to the higher velocities and slope of pipe culverts (Bouska & Paukert 2010). The abovementioned NSW Department of Primary Industries (2011) study found that a double box culvert constructed as a replacement of a causeway was able to pass a large range of freshwater and estuarine species and size classes in both the upstream and downstream direction.

The proposed Project may require the strengthening of the existing box culvert. However, this is unlikely to impact upon fish entering the culvert during tidal events. If the existing box culvert design is retained for the proposed Project it is unlikely that the assemblages of fish travelling through the culvert to the Study Area will change dramatically.

General impacts from changes to the existing culvert structure as a result of the proposed Project could include:

- short-term blockage to fish passage to and from the drainage line during construction
- increased volumes of suspended solids being introduced into the water column during construction causing smothering of fish species
- long-term blockage of fish passage if 'fish friendly' design is not incorporated (refer to Table 7-1).

5.8 Increased presence of Mosquitofish

The noxious fish species *Gambusia holbrooki* was present in the freshwater drainage channels. Changes to the nature of drainage in the proposed Project Area have the potential to allow the Mosquitofish to extend its range further into the Hexham Swamp Reserve complex if flows from the proposed Project Area are not directed away from the wetland (refer to Table 7-1). The Swamp supports a number of native gudgeon species (Appendix H) that have potential to be greatly impacted upon if the Mosquitofish were to widen its infiltration into the complex as a result of the proposed Project.

5.9 Aquatic disturbance and impacts on fish passage

The proposed Project would require a linear strip (approximately 0.5 ha) of SEPP 14 wetland 833 in the north of the Study Area to be in-filled to accommodate the proposed rail corridor. Furthermore, a number of Freshwater wetlands (both permanent and ephemeral) would be affected by the proposed Project, approximately 2.70 ha in total, which potentially provide habitat for the threat-listed Green and Golden Bell Frog. However, little ongoing aquatic disturbance in the Study Area is expected once construction of the proposed Project is completed.

The proposed Project might require works to be completed at the location of an existing culvert near chainage 173,920 km. However, little ongoing aquatic disturbance is expected once construction of any waterway crossing is complete. It is unlikely that any potential works to this drainage line would result in a barrier to fish passage to and from the south arm of the Hunter River.

Areas of riparian vegetation likely to be damaged or removed during construction should be replanted or replaced with similar native vegetation on completion of works. In addition, appropriate erosion and sediment control measures should be put in place around any proposed waterway crossing (including Freshwater wetlands) prior to construction, to ensure minimal change in water quality due to run-off.

During construction, run-off from disturbed surfaces could potentially affect water quality in permanent and ephemeral wetlands due to sedimentation. In addition, there is the potential for accidental spillage/leakage of rail construction materials including fuels, lubricants and hydraulic oils from construction equipment.

Best practice erosion and sediment controls should be implemented in accordance with Volume 2D of *Managing Urban Stormwater: soils and construction* (Department of Environment and Climate Change 2008b).

5.10 Potential impacts on groundwater dependent ecosystems

Groundwater dependant ecosystems (GDEs) are communities of plants, animals and other organisms whose extent and life processes are dependent on groundwater (Department of Land and Water Conservation 2002). When considering groundwater dependant ecosystems, groundwater is generally defined as the saturated zone of the regolith (the layer of loose rock resting on bedrock, constituting the surface of most land) and its associated capillary fringe, however it excludes soil water held under tension in soil pore spaces (the unsaturated zone or vadose zone) (Eamus *et al.* 2006).

Groundwater dependant ecosystems include a diverse range of ecosystems as shown in Figure 5-1. These ecosystems range from those entirely dependent on groundwater to those that may use groundwater while not having a dependency on it for survival (i.e. ecosystems or organisms that use groundwater opportunistically or as a supplementary source of water) (Hatton & Evans 1998). Eamus *et al.* (2006) considers the following broad classes of these ecosystems:

- Aquifer and cave ecosystems, where stygofauna (groundwater-inhabiting organisms) may reside within the groundwater resource. The hyporheic zones (see ecosystem 5 in Figure 5-1) of rivers and floodplains are also included in this category because these ecotones often support stygobites (obligate groundwater inhabitants).
- All ecosystems dependent on the surface expression of groundwater. This category includes base-flow rivers and streams, wetlands (see ecosystems 2 and 3 in Figure 5-1), some floodplains and mound springs and estuarine seagrass beds. While it is acknowledged that plant roots are generally below ground, this class of groundwater dependant ecosystems requires a surface expression of groundwater, which may, in many cases, then soak below the soil surface and thereby become available to plant roots.
- All ecosystems dependent on the subsurface presence of groundwater, often accessed via the capillary fringe (non-saturated zone above the saturated zone of the water table) when roots penetrate this zone. This class includes terrestrial ecosystems such as River Red Gum (*Eucalyptus camaldulensis*) forests on the Murray–Darling basin (see ecosystems 1 and 4 in (Figure 5-1). No surface expression of groundwater is required in this class of groundwater dependant ecosystems.

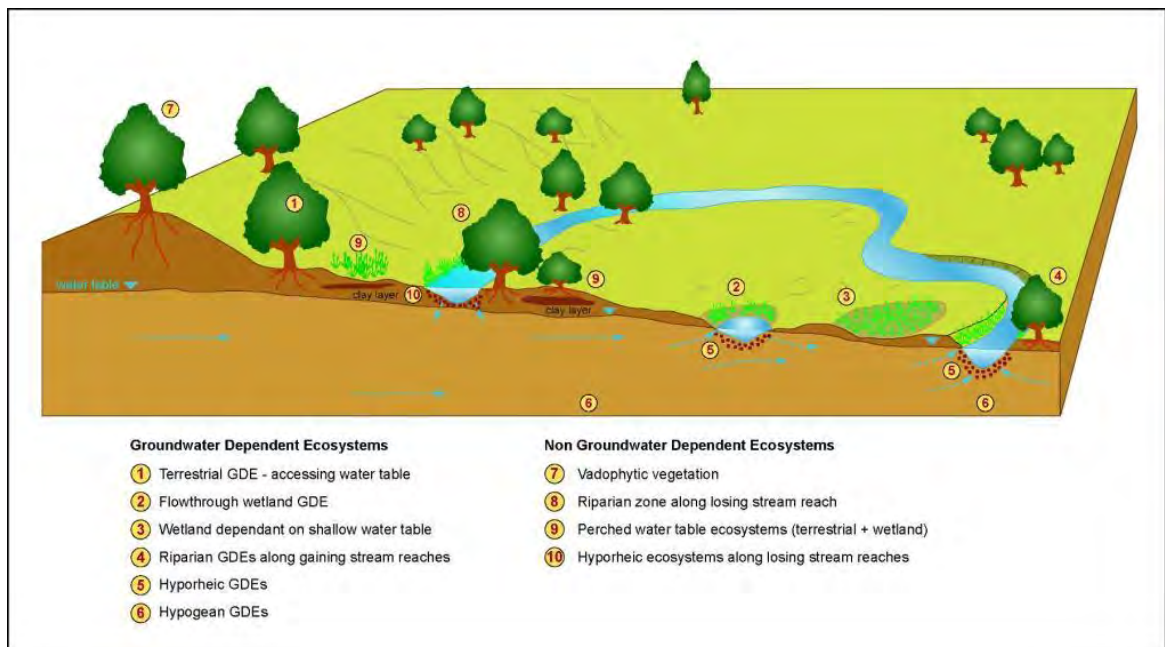


Figure 5-1 Conceptual biophysical model of groundwater dependent ecosystems

Groundwater dependent ecosystems possess a range of values, including being important and sometimes rare ecosystems in themselves, as well as providing important ecosystem services such as water purification (Department of Land and Water Conservation 2002). Groundwater is also an increasingly important resource for human uses in Australia (there was a 90% increase in groundwater extraction between 1985 and 1997 (National Land and Water Resources Audit 2001). Nationally groundwater is extracted for uses including

irrigation (48%), urban and industrial use (33%) and stock watering and rural use (19%) (Department of the Environment and Heritage 2001).

The potential for groundwater extraction to exceed recharge has resulted in awareness of the effects of groundwater availability or regimes that may result in adverse impacts to groundwater dependent ecosystems (2003), and thereby threaten the values they provide.

5.10.1 Legislation

Due to the concern of the impacts upon groundwater dependent ecosystems several levels of legislation have been developed. These include state legislation and state planning polices and these include the following:

- *Water Management Act 2000* in which the Minister for Land and Water Conservation manages and controls the extraction of groundwater. Section 5(2)a of the Act relates to protection of water source: and Section 5(2)c relates to water quality. Both of these sections of the Act would directly relate to GDEs as both water quality and quantity would impact upon these ecosystems.
- The NSW State Groundwater Dependent Ecosystem Policy (2002) has been developed to protect ecosystems which have a reliance on groundwater for survival. This document outlines a rapid assessment process which is used for identifying and valuing GDEs which assists in the management of GDEs at a state level.
- Groundwater Dependent Ecosystems Assessment, Registration and Scheduling of High Priority (Department of Land and Water Conservation 2006). This document was written by Department of Land and Water Conservation and was developed to classify GDEs in order of priority of protection.

The above documents have been used in this report to assist in the identification and assessment of the impacts upon GDEs within the study area.

5.10.2 GDEs in the Study Area

Whether or not ecosystems show some level of groundwater dependence will depend, in part, on their location in the landscape relative to the level of groundwater. Within the Study Area, the groundwater level is likely to be a shallow alluvial groundwater aquifer (water was observed above surface levels during the field surveys) due to the flat topography and close proximity to the Hunter River.

Dependence (or interaction) of the vegetation communities identified in the Study Area on groundwater was determined by aligning them with the groundwater dependant ecosystem types identified by the Groundwater Dependent Ecosystems Assessment, Registration and Scheduling of High Priority (Department of Land and Water Conservation 2006).

All of the vegetation communities were identified as being groundwater dependent (Table 5-3) given their location in the landscape. These swamp forests, wetlands and estuarine vegetation communities were found to occur on the floodplain of the Hunter River which would be linked to shallow alluvial groundwater systems. No groundwater aquifer or cave systems, or other potential groundwater dependant ecosystems were identified within the study area from the field surveys and desktop assessment.

Table 5-3 Vegetation community dependency on groundwater

Ecosystem Type ¹	GDE Class ¹	Description of Class ¹	Vegetation Communities ²	Known Dependence on Groundwater ³
Wetlands (W)	W1	Coastal Floodplain Freshwater Wetlands	<i>Phragmites australis</i> and <i>Typha orientalis</i> Coastal Freshwater Wetlands	Known dependence upon groundwater
	W2	Coastal Floodplain Forested Wetlands	Swamp Oak Swamp Forest fringing estuaries	Known dependence upon groundwater
	W2	Coastal Floodplain Forested Wetlands	Swamp Mahogany Swamp Forest on Coastal Lowlands	Known dependence upon groundwater
Marine/Estuarine Habitats (M)	M3	Intertidal Saltmarshes	Coastal Saltmarsh in Estuaries	Known dependence upon groundwater

Notes: 1 – Ecosystem Types as per DLWC (2006); 2 – Vegetation Communities as per PB Vegetation communities described in Section 3.2 of this report, 3 – Known groundwater dependency as per (Eamus *et al.* 2006).

The proposed Project will not require extraction of groundwater from existing alluvial aquifers: however, the proposed Project will require the infilling of areas of *Phragmites australis* and *Typha australis* Coastal Freshwater Wetlands and removal of the Swamp Oak Swamp Forest Fringing Wetlands and Swamp Mahogany Swamp Forest on Coastal Lowlands which are all groundwater dependent.

The NSW Groundwater Dependancy Policy (Department of Land and Water Conservation 2002) has five management principles to manage groundwater systems to ensure that the ecological process and biodiversity of their ecosystems are maintained or restored for the future. The proposed Project will result in the removal of 9.10 ha of groundwater dependent ecosystems within the study area, which is not in keeping with the five management principles. However, these ecosystems are highly disturbed, with the entire study area having previously been cleared in the early 1970s and a coal loader being operated at the site. The soil profile has been significantly altered due to the addition of fill from building sites and the existing rail corridor. The existing GDEs are highly disturbed and likely to be regrowth from previous clearing. Therefore the removal of a small area of these communities is unlikely to have significant impacts upon the GDEs in the locality or the wider region.

5.11 Direct fauna mortality

Fauna injury or death could occur as a result of the proposed Project's construction phase, when vegetation and habitats are being cleared. Fauna injury or mortality also have the potential to occur during operation of the rail corridor as a result of collision with survey/maintenance vehicles and through increased rail movements.

While some mobile species, such as birds, have the potential to move away from the path of clearing, other species that are less mobile, or those that are nocturnal and restricted to tree hollows, may have difficulty moving over relatively large distances. Threat-listed species that may be affected by vegetation clearing include microchiropteran bats and Green and Golden Bell Frog.

The proposed Project would increase the width of an existing linear rail corridor that effectively traverses a modified landscape. This would increase the distance and area for animals to cross and negotiate, increasing the extent of vehicle strikes. Threat-listed fauna that may be affected by vehicle strikes include Green and Golden Bell Frog.

It is not likely that the proposed Project would significantly add to direct fauna mortality, which would currently occur in the existing rail corridor.

5.12 Key threatening processes

Key Threatening Processes are listed under Schedule 3 of the NSW TSC Act, NSW FM Act and also under the Commonwealth EPBC Act. Key Threatening Processes relevant to the proposed Project are listed in Table 5-4.

Table 5-4 Key Threatening Processes relevant to the proposed Project

Listed Key Threatening Process			Proposed Project would increase threat?
TSC Act	EPBC Act	FM Act	
Pest species			
Competition and grazing by the feral European rabbit	Competition and land degradation by rabbits		No. Proposed Project unlikely to increase this threat any more than that currently occurring in the Study Area
Competition and habitat degradation by feral goats	Competition and land degradation by unmanaged goats		No. Feral Goats were not recorded in the Study Area
Invasion and establishment of the Cane Toad	The biological effects, including lethal toxic ingestion, caused by Cane Toads (<i>Bufo marinus</i>)		No. Proposed Project unlikely to result in invasion or establishment of the Cane Toad
Predation by the European Red Fox	Predation by European red fox		No. Proposed Project unlikely to increase this threat any more than that currently occurring in the Study Area
Importation of red imported fire ants into NSW	The reduction in the biodiversity of Australian native fauna and flora due to the red imported fire ant, <i>Solenopsis invicta</i> (fire ant)		No. Proposed Project unlikely to result in the importation of red fire ants
Predation, habitat degradation, competition and disease transmission by feral pigs (<i>Sus scrofa</i>)	Predation, habitat degradation, competition and disease transmission by feral pigs		No. This species was not recorded in the Study Area and the proposed Project is unlikely to increase this threat
Invasion of the yellow crazy ant (<i>Anoplolepis gracilipes</i>)	Loss of biodiversity and ecosystem integrity following invasion by the Yellow Crazy Ant (<i>Anoplolepis gracilipes</i>) on Christmas Island, Indian Ocean		No. Proposed Project unlikely to result in the invasion of the yellow crazy ant
Introduction of the large earth bumblebee (<i>Bombus terrestris</i>)			Unlikely. Species not recorded in Study Area
Predation and hybridisation by feral Dogs (<i>Canis lupus familiaris</i>)			Unlikely. Species not recorded in Study Area

Listed Key Threatening Process			Proposed Project would increase threat?
TSC Act	EPBC Act	FM Act	
Predation by the Plague Minnow (<i>Gambusia holbrooki</i>)			Yes. This species was recorded in the Study Area and has the potential to increase its presence from modified drainage works in the proposed Project Area.
Predation by the ship rat (<i>Rattus rattus</i>) on Lord Howe Island			No
Predation by feral cats			No. Proposed Project unlikely to increase predation by feral cats
Competition from feral honeybees			No. Proposed Project is unlikely to increase competition
Herbivory and environmental degradation caused by feral deer			No. Species not recorded in Study Area
	Predation by exotic rats on Australian offshore islands of less than 1000 km ² (100,000 ha)		No
Weeds			
Invasion and establishment of exotic vines and scramblers	-		Unlikely. Exotic vines and scramblers not recorded within Study Area
Invasion, establishment and spread of <i>Lantana camara</i>*	-		Yes, <i>Lantana camara</i> recorded as dominant understorey in two of the swamp forest communities within the rail corridor. Potential to spread these to other areas, during construction works.
Invasion of native plant communities by bitou bush and boneseed (<i>Chrysanthemoides monilifera</i> *)	-		Unlikely. Species not recorded within the area
Invasion of native plant communities by exotic perennial grasses	-		Yes, rail corridor is dominated by exotic perennial grasses and proposed Project has potential to spread these to other areas

Listed Key Threatening Process			Proposed Project would increase threat?
TSC Act	EPBC Act	FM Act	
	Invasion of northern Australia by Gamba Grass and other introduced grasses		No. Site is not within northern Australia
	Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants		Yes, The aquatic weed <i>Alternanthera philoxeroides</i> (Alligator Weed) was recorded within the Exotic Herbfield and proposed Project has potential to spread this weed into other areas.
Habitat loss or change			
Clearing of native vegetation¹	Land clearance		Yes. See Section 5.1
Human-caused climate change	Loss of terrestrial climatic habitat caused by anthropogenic emissions of greenhouse gases	Human-caused climate change	Unlikely. The alternative is transport using trucks
Loss of hollow-bearing trees			Unlikely. No hollow-bearing trees were observed in the Study Area
Removal of dead wood and dead trees			No. The majority of the Proposed Project Area occurred as maintained tracks, regrowth vegetation and cleared land
Bush rock removal			No. Bush rock was not recorded in the Study Area
Ecological consequences of high frequency fires	-		No. Proposed Project unlikely to increase frequency of fires
Loss and/or degradation of sites used for hill-topping by butterflies			No
Forest eucalypt dieback associated with over-abundant psyllids and Bell Miners			Unlikely. Proposed Project is unlikely to affect the abundance of psyllids or Bell Miners
Alteration of habitat following subsidence due to longwall mining			No. proposed Project does not include long wall mining

Listed Key Threatening Process			Proposed Project would increase threat?
TSC Act	EPBC Act	FM Act	
Alternation to the natural flow regimes of rivers and streams and their floodplains and wetlands	-		Yes. The proposed Project will affect a small linear strip SEPP 14 wetland and parts of the historic Hexham floodplain
Disease			
Infection by Psittacine circoviral (beak and feather) disease affecting endangered psittacine species	Disease affecting endangered psittacine species		No. Proposed Project unlikely to increase frequency
Infection of frogs by amphibian chytrid fungus causing the disease chytridiomycosis	Infection of amphibians with chytrid fungus resulting in chytridiomycosis		Unlikely. Proposed Project is unlikely to spread chytrid fungus
Infection of native plants by <i>Phytophthora cinnamomi</i> ²	Dieback caused by the root-rot fungus (<i>Phytophthora cinnamomi</i>)		Unlikely. No evidence of <i>Phytophthora</i> within the Study Area
Introduction and Establishment of Exotic Rust Fungi of the order Pucciniales pathogenic on plants of the family Myrtaceae			Unlikely. No evidence of Myrtle Rust within the Study Area.
Threats to marine species and habitats			
	Incidental catch (bycatch) of Sea Turtle during coastal otter-trawling operations within Australian waters north of 28 degrees South		No. Proposed Project will not impact marine species or areas
	Incidental catch (or bycatch) of seabirds during oceanic longline fishing operations		No. Proposed Project will not impact marine species or areas
Death or injury to marine species following capture in shark control programs on ocean beaches		Current shark meshing program in NSW waters	No. Proposed Project will not impact marine species or areas
Entanglement in, or ingestion of anthropogenic debris in marine and estuarine environments	Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris		No. Proposed Project will not impact marine species or areas
		Introduction of non-indigenous fish and marine vegetation to the coastal waters of New South Wales	No. Proposed Project will not impact marine species or areas

Listed Key Threatening Process			Proposed Project would increase threat?
TSC Act	EPBC Act	FM Act	
Impacts to riparian habitats and species			
		The degradation of native riparian vegetation along New South Wales water courses	The proposed Project would impact areas of Freshwater wetlands, including adjoining areas of Swamp forest. However, these effects are not likely to significantly impact downstream water courses (i.e. Hunter River).
		Hook and line fishing in areas important for the survival of threatened fish species	No. Proposed Project will not include fishing
		The introduction of fish to fresh waters within a river catchment outside their natural range	No. Proposed Project will not include introduction of fish
		The removal of large woody debris from NSW rivers and streams	No. The proposed Project will not impact rivers or streams
		Instream structures and other mechanisms that alter natural flow	No. There are no natural streams or rivers that would be impacted by the proposed Project

6. Cumulative Assessment – Queensland Rail (QR) National Train Support Facility (TSF)

Queensland Rail (QR) National is currently preparing plans for a Train Support Facility (TSF) and adjoining industrial development located immediately to the west of the Relief Roads. The layout and key features of both projects are shown in Volume 1, Chapter 4, of this EIS. QR National is liaising with ARTC to co-ordinate the design and approval processes.

Impacts summary

The potential biodiversity impacts of the proposed Project have been considered as a consequence of the construction and operation of the proposed Project within the existing environment. The effects of multiple sources of impact are referred to as cumulative impacts and provide an opportunity to consider the proposed Project within a strategic context. This is necessary so that impacts associated with the proposed Project and other activities within the region are examined collectively.

The Study Area generally consists of a highly modified environment due to industrial development and a long history of grazing in the area. The majority of the Study Area is currently grazed and an existing rail alignment runs through the proposed Project Area. The soil profile and subsequent landscape has also been highly modified as a result of fill dumping, rail infrastructure development and grazing. The surrounding area consists of open grazing lands, freshwater wetlands and remnant swamp forests. Hexham Swamp Nature Reserve occurs approximately 1 km to the west of the proposed Project Area and is listed as a nationally important wetland.

The primary developments within the proposed Project locality are industrial, residential or agricultural. The biodiversity impacts of the proposed Project considered in this report are likely to be more significant as a result of past clearing for agricultural activities and the existing industrial infrastructure. Cumulative impacts exacerbate the biodiversity impacts associated with the proposed Project.

Potential developments in the nearby area that may interact with the proposed Project include:

- future industrial developments in the region
- expansion of transport corridors (rail or road)
- significant residential or commercial developments.

All such developments are likely to contribute to a greater extent of vegetation clearing in the region and a further fragmentation of habitat.

One other known rail expansion project is proposed to occur in the vicinity of the proposed Project which will result in a larger area of cleared vegetation and contribute to habitat fragmentation. As part of this cumulative impact assessment, the QR National 2008 Ecological Assessment Report (ADW Johnson Pty Limited 2008) has been reviewed so that the impacts of the proposed rail expansion project can be assessed with the proposed Project.

The cumulative impact of the two projects is examined in Table 6-1 which compares the extent of clearing and the expected impact to the surrounding environment.

Table 6-1 Cumulative potential loss of vegetation for QR National project and the proposed Project

Vegetation community/Fauna habitat	Hexham Relief Roads (HRR) Project clearing (ha)	QR Train Support Facility (TSF) project impacted area (ha)	Cumulative area cleared (ha)	Area of vegetation within locality-10km radius ² (ha)	Cumulative impact within locality (%)
Vegetation					
Swamp Oak Swamp Forest Fringing Estuaries ¹	5.28	5.52	10.80	582.91	1.9
Swamp Mahogany Swamp Forest on Coastal Lowlands ¹	1.12		1.12	569.61	0.19
<i>Phragmites australis</i> and <i>Typha orientalis</i> Coastal Freshwater Wetlands ¹	2.70	8.1	10.80	2984.48	0.36
Coastal Saltmarsh in Estuaries ¹	0	0.03	0.03	2091.01	>0.00
Exotic Grassland/Disturbed	25.55		25.55		
Exotic Herbfield	3.70		3.70		
Planted Vegetation	0.69		0.69		
Total	39.05	13.65	52.70	6228.01	8.46
Total area of EEC	9.10	13.65	22.75	6228.01	3.65

Notes: 1 - Endangered Ecological Community as listed under the *Threatened Species Conservation Act 1995*
 2- According to the LHCCREMS regional vegetation mapping {Lower Hunter and Central Coast Regional Environmental Management Strategy, 2000 #344}

The cumulative impact of the proposed Project and the proposed QR project is expected to have a negligible impact on the regions biodiversity. Less than 4 % of the localities total EEC area is expected to be removed cumulatively as a result of the two projects assessed. Mitigation and management measures are provided in Table 7-1 to reduce the impact of the proposed Project on residing species and surrounding communities. Such mitigation and management measures for the proposed Project are transferable and equally applicable for the proposed QR project.

7. Mitigation

The general principle to minimise impacts to biodiversity, should in order of consideration, endeavour to:

- avoid impacts on habitat, through the planning process
- minimise impacts on habitat, through the planning process
- mitigate impacts on habitat, though the use of a range of mitigation measures.

The avoidance of impacts can be achieved through the planning process. This process involves a preliminary examination of a number of possible route options and their potential impacts on the environment and other factors (for example, economic and social considerations). Those potential routes that best fit the environmental, social and economic criteria are then short-listed. This was conducted for the proposed Project through the early examination of options prior to selection of the preferred design, and where practical the alignment was moved to avoid sensitive ecological features within the study area.

Minimising impacts involves reducing the loss of habitat or significant species as far as practicable. Through detailed surveys, it is usually possible to fine-tune the final alignment and the width of the footprint to minimise loss of important vegetation communities or habitats and avoid significant plant species or habitat features. The final alignment and footprint are also subject to engineering constraints and safety standards.

The proposed Project has undertaken this process through suitable siting of works compounds and access tracks in disturbed areas, minimising impact to native forest vegetation. The area of impact will also be reviewed throughout the detailed design stage and where possible be further reduced. It has been necessary to survey and assess a larger area of impact in this study to provide flexibility for alterations in the design process although it is unlikely that the entire area will need to be disturbed.

Residual impacts that cannot be avoided or minimised are mitigated wherever possible. Depending on vegetation and project type, mitigation measures generally employed during construction can include the following:

- landscaping and revegetation
- site rehabilitation.

In order to address the potential impacts of the proposed Project on biodiversity, the following mitigation measures are recommended (Table 7-1).

Table 7-1 Proposed mitigation measures

Impact	Mitigation
General	<ul style="list-style-type: none"> ▪ Ensure all workers are provided an environmental induction prior to starting work on site. This would include information on the ecological values of the site, protection measures to be implemented to protect biodiversity, and penalties for breaches. ▪ Prepare a flora and fauna management plan as part of the CEMP.
Vegetation and habitat loss	<ul style="list-style-type: none"> ▪ Limit disturbance of vegetation to the minimum necessary to construct works. ▪ Implement clearing protocols, including: <ul style="list-style-type: none"> ▶ Marking trees to be removed and preparing an inventory of trees and hollows (if observed) to be removed. ▶ Pre-clearance surveys to be completed by an appropriately qualified ecologist, particularly for the Green and Golden Bell Frog. ▶ Check trees for the presence of bird nests and potentially arboreal mammals, prior to felling. ▶ As far as practicable, animals found to be occupying trees would be allowed to leave before clearing. ▪ Where practicable, restrict equipment storage and stockpiling of resources to designated areas in cleared land.
Weeds	<ul style="list-style-type: none"> ▪ Develop weed management actions to manage weeds during the construction phase of the proposed Project. This will include the management of exotic perennial grasses, such as <i>Chloris gayana</i>*, <i>Melinis repens</i> * that were recorded abundantly within the existing rail corridor and adjacent lands, and the seven noxious weeds of <i>Alternanthera philoxeroides</i>*, <i>Ageratina adenophora</i>*, <i>Cestrum parqui</i>*, <i>Cortaderia selloana</i>*, <i>Echium plantagineum</i>*, <i>Rubus fruticosus</i>* and <i>Lantana camara</i>* as per the <i>Noxious Weeds Act 1993</i>.

Impact	Mitigation
Aquatic disturbance	<ul style="list-style-type: none"> ▪ Minimise the clearing of freshwater wetlands, coastal saltmarsh and mangroves to that which is absolutely necessary for the safe construction and operation of the proposed Project. ▪ Incorporate existing drainage channels into design of proposed Project drainage channels where practicable. ▪ Where required, install high visibility signs at freshwater wetland and coastal saltmarsh sites occurring outside the proposed Project Area, to inform workers of no go areas. This is particularly important during spring and summer when migratory shorebirds and waders use such habitats. ▪ Erosion and sediment controls should be implemented in accordance with the Blue Book (Department of Environment and Climate Change 2008b) . ▪ Where practicable undertake channel works affected by tidal flow during low or ebb tides. ▪ Develop an Acid Sulfate Soil Management Plan for construction works. ▪ Design and construct waterway crossings in accordance with the DPI's fish passage requirements (Fairfull & Witheridge 2003). Retain the double box culvert design of the existing culvert. ▪ Control and manage potential contaminants (fuels, oils, lubricants) from construction activities.
Residual impacts	<ul style="list-style-type: none"> ▪ Develop an offset strategy to mitigate the impact of clearing vegetation. This will fulfil the need to improve or maintain as required in the <i>Principles for the use of biodiversity offsets in NSW</i>.

8. Section 5A of EP&A Act 1979 Impact assessment

This chapter summarises the assessment of significance of the potential impacts following the requirements of the Section 5A of the EP&A Act 1979 and the EPBC Act.

For threat-listed biodiversity listed under the TSC Act, the DGRs have requested that impacts on threat-listed species, populations and communities be assessed against Section 5A of the EP&A Act with guidance from the *Threatened Species Assessment Guideline – The Assessment of Significance* (Department of the Environment Water Heritage and the Arts 2009b). The factors for consideration under this assessment address the likelihood and significance of the impacts on the threatened species' life cycle, habitat and recovery. Section 5A of the EP&A Act requires that a 7 part test is undertaken to assess the likelihood of significant impact upon any threat-listed species, populations or ecological communities. The outcome of these assessments are therefore used to determine the level of significance of the impacts, but not to determine the need for a Species Impact Statement, which do not form part of the Part 5.1 approvals under the EP&A Act in which this proposed Project is being assessed.

Threatened biodiversity listed under the EPBC Act require assessment following the *Principal Significant Impact Guidelines* (Department of Environment and Conservation 2005). The factors for consideration under this assessment include considerable overlap with the state significance assessments. This assessment, however, also addresses conservation status, population size and area of occupancy, likelihood of the establishment of invasive species and introduction of disease, in addition to species life cycle, habitat and recovery.

8.1 Impacts to threat-listed biodiversity

Four threat-listed ecological communities and two threat-listed species of animal listed under the TSC Act and/or the EPBC Act were recorded in the Study Area. This included:

- Swamp Oak Floodplain Forest on Coastal Floodplains.
- Swamp Sclerophyll Forest on Coastal Floodplains.
- Freshwater Wetlands on Coastal Floodplains.
- Coastal Saltmarsh (will not be impacted upon).
- Grey-headed Flying-fox.
- White-fronted Chat.

A further two threat-listed species of animal were recorded during field surveys but were observed more distantly from the Study Area and included the Spotted Harrier and Black-necked Stork. Three threat-listed species of plant, *Maundia triglochoides*, *Persicaria elatior* and *Zannichellia palustris* have habitat within the Study Area, but were not recorded.

A further 23 threat-listed species of animal have the potential to use the Study Area as foraging habitat and two threat-listed species of plant have the potential habitat in the Study Area (Table 8-1).

Significance assessments for species recorded or with a moderate or higher likelihood of occurrence were completed (Appendix E). The impacts to threat-listed biodiversity are summarised in Table 8-1. This assessment was based on a broad corridor assessment and as such overestimates the area of vegetation and habitats to be cleared. The proposed Project Area would be reduced as a result of ongoing detailed design. Significance assessments for these threat-listed ecological communities and threat-listed species concluded that the proposed Project is not likely to result in any significant impact due to the relatively small area (9.10 ha) of native vegetation communities likely to be affected and the existing disturbed nature of the proposed Project Area.

Table 8-1 Summary of likely impacts to threat-listed biodiversity

Threat-listed biodiversity		TSC Act ¹	EPBC Act ²	Threat-listed Biodiversity Recorded with the Study Area (Y/N)	Impacts						
Scientific name	Common name				Habitat clearing	Fragmentation	Affect the lifecycle	Weeds/pests/disease	Noise	Change to current disturbance regimes	Likely to be significantly affected
Threat-listed ecological communities											
Freshwater Wetlands		E		Yes	Yes, 2.70ha would be cleared	Unlikely. Study Area already highly fragmented. Proposed Project unlikely to increase fragmentation.	N/A	Potential impact, however, mitigation measures will likelihood of weed spread.	N/A	No	No
Coastal Saltmarsh		E		Yes	No. area will be cleared	No	N/A		N/A	No	No
Swamp Oak Floodplain Forest		E	-	Yes, dominant community within Study Area	Yes. 5.28 ha would be cleared	Unlikely. Study Area already highly fragmented. Proposed Project unlikely to increase fragmentation.	N/A	Potential impact, however, mitigation measures will likelihood of weed spread.	N/A	No	No
Swamp Sclerophyll Forest		E		Yes	Yes, 1.12 ha would be cleared	Unlikely. Study Area already highly fragmented. Proposed Project unlikely to increase fragmentation.	N/A	Potential impact, however, mitigation measures will likelihood of weed spread.	N/A	No	No
Flora											
<i>Maundia triglochoides</i>	Small Water Ribbons	V		No	Yes, 2.70 ha potential habitat would be cleared. No critical habitat would be cleared.	Unlikely. Study Area already highly fragmented. Proposed Project unlikely to increase fragmentation.	No	Potential impact, however, mitigation measures will decrease likelihood of weed spread.	N/A	No	No
<i>Persicaria elatior</i>	Tall Knotweed	V	V	No	Yes, 3.82 ha potential habitat would be cleared. No critical habitat would be cleared.	Unlikely. Study Area already highly fragmented. Proposed Project unlikely to increase fragmentation.	No	Potential impact, however, mitigation measures will likelihood of weed spread.	N/A	No	No
<i>Zannichellia palustris</i>	Horned Pondweed	V	-	No	Yes, 2.70 ha potential habitat would be cleared. No critical habitat would be cleared.	Unlikely. Study Area already highly fragmented. Proposed Project unlikely to increase fragmentation.	No	Potential impact, however, mitigation measures will decrease likelihood of weed spread.	N/A	No	No
Fauna											
Green and Golden Bell Frog		E	E	No	Yes, 2.70 ha of potential habitat would be impacted.	No. The Proposed Project will effectively add incrementally to the width of an existing rail easement and will not fragment any new areas of habitat. The Study Area is already highly fragmented from important populations on Ash Island.	No	No	No	No	No
Threat-listed aquatic birds (Australian Painted Snipe, Australasian Bittern, Black Bittern, Black-necked Stork and Magpie Goose)		E/V	E/V	Yes. Black-necked Stork	Yes, 9.10 ha of known and potential habitat would be impacted.	No. The Proposed Project will effectively add incrementally to the width of an existing rail easement and will not fragment any new areas of habitat.	No	No	Yes. Increased rail traffic likely to increase timing and duration of noise impacts.	No	No
Threat-listed raptors (Little Eagle and		V	-	Yes. Spotted	Yes, 9.10 ha	No. The Proposed Project	No	No	Yes. Increased	No	No

Threat-listed biodiversity		TSC Act ¹	EPBC Act ²	Threat-listed Biodiversity Recorded with the Study Area (Y/N)	Impacts						
Scientific name	Common name				Habitat clearing	Fragmentation	Affect the lifecycle	Weeds/pests/disease	Noise	Change to current disturbance regimes	Likely to be significantly affected
Spotted Harrier)				Harrier	of known and potential habitat would be impacted.	will effectively add incrementally to the width of an existing rail easement and will not fragment any new areas of habitat.					rail traffic likely to increase timing and duration of noise impacts.
Grass Owl		V	-	No	Yes 9.10 ha of potential habitat would be impacted.	No. The Proposed Project will effectively add incrementally to the width of an existing rail easement and will not fragment any new areas of habitat.	No	No		Yes. Increased rail traffic likely to increase timing and duration of noise impacts.	No
Threat-listed opportunistic blossom nomads (Swift Parrot, Little Lorikeet and Grey-headed Flying-fox)		E/V	E/V	Yes. Grey-headed Flying-fox	Yes, 1.12 ha of known and potential habitat would be impacted.	No. The Proposed Project will effectively add incrementally to the width of an existing rail easement and will not fragment any new areas of habitat.	No	No		No	No
Microchiropteran bats (Eastern False Pipistrelle, East-coast Freetail Bat, Yellow-bellied Sheath-tail Bat, Greater Broad-nosed Bat, Little Bent-wing Bat, Eastern Bent-wing Bat, Large-footed Myotis)		V	-	No	Yes, 9.10 ha of potential habitat would be impacted.	No. The Proposed Project will effectively add incrementally to the width of an existing rail easement and will not fragment any new areas of habitat.	No	No		No	No
Varied Sittella		V	-	No	Yes, 6.40 ha of potential habitat would be impacted.	No. The Proposed Project will effectively add incrementally to the width of an existing rail easement and will not fragment any new areas of habitat.	No	No		No	No
White-fronted Chat		V	-	Yes	Yes, 9.10 ha of known habitat would be impacted.	No. The Proposed Project will effectively add incrementally to the width of an existing rail easement and will not fragment any new areas of habitat.	No	No		Yes. Increased rail traffic likely to increase timing and duration of noise impacts.	No
Waders (Great Knot, Greater Sand Plover, Lesser Sand Plover, Broad-billed Sandpiper and Black-tailed Godwit)		V	-	No	Yes, 2.70 ha of potential habitat would be impacted.	No. The Proposed Project will effectively add incrementally to the width of an existing rail easement and will not fragment any new areas of habitat.	No	No		Yes. Increased rail traffic likely to increase timing and duration of noise impacts.	No
Red-backed Button Quail		V	-	No	Yes,	No. The Proposed Project will effectively add incrementally to the width of an existing rail easement and will not fragment any new areas of habitat.	No	No		Yes. Increased rail traffic likely to increase timing and duration of noise impacts.	No

Notes:

- 1) TSC Act - *Threatened Species and Conservation Act 1995*. CE = Critically Endangered, E1 = Endangered V = Vulnerable E2= Endangered Population.
- 2) EPBC Act - *Environmental Protection and Biodiversity Conservation Act 1999*. CE = Critically Endangered, E = Endangered V = Vulnerable.

9. Offsets

9.1 Is an offset required?

The need for biodiversity offsets is founded in the theory of 'avoid, minimise, mitigate' the impacts of projects. The accepted approach to environmental mitigation require that, in the first instance, environmental impacts are avoided or minimised as far as possible and subsequently reduced to acceptable levels through appropriate mitigation techniques. Where measures to avoid and mitigate impacts are not feasible or cost effective, then offset strategies can be used to compensate the residual impacts of the development on biodiversity. Ideally offsets should be undertaken prior to development to provide certainty that the offsets are effective and to ensure that there would be no net loss in biodiversity (Department of Environment and Conservation 2005a).

The Director-General's requirements include consideration of the Principles for the use of biodiversity offsets in NSW (Department of Environment and Climate Change 2008c). These principles outline how to develop biodiversity offsets in situations where a loss of biodiversity is expected.

More requirements on offsets were provided by OEH. The Department require the EIS to '*detail the actions that will be taken to**compensate or offset for unavoidable impacts of the project on threatened species, populations, ecological communities and their habitats***'.

Given that the proposed Project would result in clearing of native vegetation, including three Endangered Ecological Communities and habitat for threat-listed species, it would be necessary to develop offset strategies to fulfill the requirements of 'maintain and improve' requirements of the *Principles for the use of biodiversity offsets in NSW* and the Director General's and OEH's requirements.

9.2 Offsets for the proposed Project

Potential offsets for the proposed Project are being investigated. These would be developed in accordance with the Principles for the use of biodiversity offsets in NSW (Department of Environment and Climate Change 2008d) provided below in .

Table 9-1 Assessment of Biodiversity Offset Strategy against OEH Offsets requirement

OEH principles for offsets	Response
Impacts must be avoided first by using prevention and mitigation measures.	<p>A general principle of environmental management is to, in order of preference:</p> <ul style="list-style-type: none"> ▪ Avoid environmental impacts. ▪ Minimise impacts. ▪ Mitigate the impacts. <p>Where impacts cannot be avoided or minimised, compensate for the residual impacts using other mitigation measures such as offsets.</p> <p>These principles have been followed, where possible, for the proposed Project.</p>
All regulatory requirements must be met.	<p>These have been followed, where possible, for the proposed Project. DECCW have identified the proposed Projects offsets should meet the quantum of offsets determined by the BioBanking credit calculator.</p>
Offsets must never reward ongoing poor performance.	<p>ARTC is not known to have a history of poor performance. The existing operation of the rail infrastructure has been satisfactory to all regulatory authorities.</p>
Offsets will complement other government programs.	<p>The offsets proposed consider the landscape and assessment requirements for determining offsets requirements under the NSW BioBanking Assessment Scheme.</p>
Offsets must be underpinned by sound ecological principles.	<p>The offsets strategy has been developed in accordance with the following broad ecological principles:</p> <ul style="list-style-type: none"> ▪ Distance from proposed Project. ▪ Presence of Threatened biodiversity. ▪ Current condition and potential for improvement. ▪ Connectivity. ▪ Management issues. ▪ 'Like for Like'. ▪ Improve or Maintain.
Offsets should aim to result in a net improvement in biodiversity over time.	<p>The biodiversity offsets strategy will aim to result in a net improvement in biodiversity over time.</p>
Offsets must be enduring and they must offset the impact of the development for the period that the impact occurs.	<p>It is proposed the Offset strategy will be designated for conservation with binding title agreements attached to the properties in-perpetuity.</p>
Offsets should be agreed prior to the impact occurring.	<p>The Offset Strategy is currently being developed and commitment to an appropriate offset suitable for agencies approval is likely to be finalised prior to the approval of the Proposed Project.</p>

OEH principles for offsets	Response
Offsets must be quantifiable (the impacts and benefits must be reliably estimated).	The ecological characteristics, including areas of remnant vegetation and rehabilitation will be calculated using the best available information and incorporate the BioBanking assessment methodology. It is likely that further ground truthing and surveys of the final offsets site will be completed prior to finalisation of the strategy.
Offsets must be targeted.	The offsets will meet the 'like for like' or better criteria of similar condition, size and conservation significance, including the Threatened and/or other suitable vegetation types as identified in the BioBanking assessment).
Offsets must be located appropriately.	All of the proposed offsets will be located within Hunter CMA boundary in accordance with the NSW BioBanking Assessment Scheme.
Offsets must be supplementary.	The Proposed Projects offsets will be supplementary to a range of strategies including ongoing mitigation and management activities, changes in land management, restoration rehabilitation.
Offsets and their actions must be enforceable through development consent conditions, licence conditions, conservation agreements or a contract.	It is proposed the Offset strategy will be designated for conservation with binding title agreements attached to the properties in-perpetuity.

9.3 Offset requirements for state significant developments

Offsets for biodiversity values in NSW are required to be developed and quantified through the application of the NSW Biobanking Scheme and in accordance with the OEH offsetting policy (OEH June 2011) for state significant developments. While state significant developments are to be assessed under the Part 3A (or equivalent approval pathway) are not required to develop biodiversity offsets strictly in accordance with this scheme, the Department of Planning and Infrastructure (DoPI) and the Office of Environment and Heritage (OEH) are applying the BioBanking Assessment Methodology (BBAM) to determine if the quantum of offsets provided are adequate.

The OEH offsetting policy (OEH June 2011) provides state significant developments some flexibility in the provision of what constitutes an adequate offset (refer to Table 9–2 below). In particular, projects unable to meet the Tier 1 - “Improve or Maintain” offset outcome due to impacts on “red flag” ecological constraints like endangered ecological communities may provide offsets under the Tier 2 – “No Net Loss” or Tier 3 – “Mitigated Net Loss” outcomes.

Table 9–2 Possible outcomes for offsets to meet adequacy using the OEH offsetting policy (OEH June 2011)

Outcome achieved	Level of impact	Offsetting requirement
Improve or maintain (Tier 1)	Red flag assets protected and clearing only occurs within the variation rules set by the BBAM	
No net loss (Tier 2)	Some/all red flags not protected and clearing allowed outside the variations rules permitted by the BBAM	Calculated by the credit calculator
Mitigated net loss (Tier 3)	As for 'no net loss'	Calculated by the credit calculator but then amended by the offset variation criteria to a minimum land offset to clearing ratio of 2:1

Given the projects impacts on three endangered ecological communities, the adequacy of the projects offset will have to meet the Tier 2 or Tier 3 outcome. ARTC is committed to developing an offset strategy that aims to deliver a Tier 2 No Net loss outcome, however it is recognised that the required offsets for the three endangered ecological communities may not be currently available and the Tier 3 outcome may be required.

9.4 Quantification of offset requirements

To quantify the biodiversity offset required for the project, the BioBanking credit calculator (BBAM tool version 2.0) has been completed and an estimate of the likely credits determined.

A summary of the extent of each vegetation community to be impacted by the Project and the subsequent ecosystem credits required to offset impacts are provided in Table 9–3. The area of impact is conservatively based on a broad potential area of impact. The final offset area will be redefined and reduced as a result of the progression of detailed design and the construction methodology. The redefined area will form part of the Submission Report following exhibition.

Table 9–3 Summary of vegetation to be impacted and BBAM ecosystem credits required to offset impacts

Vegetation community	Threatened Ecological Community (TSC Act)	Area to be Impacted ¹ (Ha)	Estimated credits required
HU673 - <i>Phragmites australis</i> and <i>Typha orientalis</i> coastal freshwater wetlands of the Sydney Basin	EEC	2.7	75
HU633 - Swamp Mahogany swamp forest on coastal lowlands of the North Coast and northern Sydney Basin	EEC	1.12	24
HU635 - Swamp Oak swamp forest fringing estuaries, Sydney Basin	EEC	5.28	131
Total		9.1	230

Note 1 = The area of impacts is based on a conservative footprint and is likely to be reduced with the development of a final design.

ARTC is committed to developing an offset that adequately meets the quantum of the biodiversity offset requirement calculated using the BBAM, in accordance with the OEH offsetting policy (OEH June 2011).

9.5 Identification and evaluation of possible offset strategies

An offset strategy will be developed with reference to the principles for the use of biodiversity offsets in NSW (Table 9-1). In accordance with these principles, the feasibility of potential offset options has been assessed using the following criteria:

- Duration - measures must offset the impact of the development for the period that the impact occurs.
- Accuracy - the impacts and benefits must be reliably estimated.
- Suitability - measures must offset the impacts on a 'like for like or better' basis.
- Location - measures must offset the impact in the same region.
- Effort - measures must be undertaken beyond existing requirements and not already be funded by another scheme.
- Enforcement - measures must be enforceable through development consent conditions, licence conditions, covenants or a contract.

9.6 Possible offset strategies

Offset strategies may include both on and off site or local area proposals that contribute to the long term conservation of threat-listed species (Department of Environment and Conservation 2005). Possible offset strategies in order of preference include:

- On site offsets - such as improving the condition of existing habitat or providing a buffer to an area of existing habitat within the site.
- Off site offsets - securing and improving the condition of existing habitats at another site.
- Off site offsets through a third party - where the developer buys credits or pays a third party to provide an offset.

Based on the results of the BioBanking and ecological assessment, three project specific offset strategies have been assessed:

- Land management for conservation - combined offsetting.
- Participation in the BioBanking Scheme.
- Land acquisition.

Each strategy is described and evaluated below.

9.7 Evaluation of offset strategies

9.7.1 Land management for conservation - combined offsetting

In accordance with the BioBanking Scheme, impacts to biodiversity may be offset through the protection and management of adjoining and nearby vegetation/ habitat. Standard management measures under the BioBanking Scheme include:

- management of grazing for conservation
- weed control
- management of fire for conservation
- management of human disturbance
- retention of regrowth and remnant native vegetation
- replanting or supplementary planting where natural regeneration will not be sufficient
- retention of dead timber
- erosion control
- retention of rocks.

Combined offsetting involves the use of a combined offset resource to meet the requirements of two separate projects. This strategic consolidation of offsets often leads better conservation outcomes, as it promotes the creation of larger, and often better connected offset reserves.

One option currently being considered in discussions between QR National and ARTC is the potential for biodiversity offsets being secured on the adjoining QR National property. QR National are currently developing their own biodiversity offset strategy that includes developing two onsite conservation areas to offset their biodiversity offset requirements for the Hexham TSF Project.

Combined offsetting is also currently been investigated with ARTC other offset packages being developed for the approved Nundah Bank and Maitland to Minabar Projects.

9.7.2 BioBanking scheme

The BioBanking scheme enables a proponent to offset the biodiversity impacts of a proposed development by buying and retiring biodiversity credits. In general BioBank sites to offset a development need to include the same vegetation type or formation and occur within the same CMA. For the purposes of BioBanking, the characteristics of the study area are summarised in Table 9-4.

Table 9-4 Criteria of the study area relevant to BioBanking

Criteria	Location
Council	Newcastle City Council
Bioregion	Sydney Basin
Catchment Management Area (CMA)	Hunter/Central Rivers CMA Hunter Sub-catchment
Vegetation community and (formation) to be cleared	HU633 - Swamp Mahogany swamp forest on coastal lowlands of the North Coast and northern Sydney Basin (Forested Wetlands)
	HU635 - Swamp Oak swamp forest fringing estuaries, Sydney Basin (Forested Wetlands)
	HU673 - <i>Phragmites australis</i> and <i>Typha orientalis</i> coastal freshwater wetlands of the Sydney Basin (Freshwater Wetlands)

The OEH maintains a list of expressions of interest (EOI) for the development of BioBank sites, on the BioBanking public register. There are currently eight EOIs for BioBank sites listed on the register (as of 09/05/12) within the Hunter/Central Rivers CMA. None of the eight EOIs registered contain the vegetation community types or formations to be removed/modified by the project. ARTC have previously identified BioBanking as a preferred strategy for biodiversity offsets for both the UHVA Nudah Bank and

ARTC are currently in discussions with lands owners for two properties listed under the EOI web site.

9.7.3 Property acquisition

Acquisition of private property containing similar native vegetation communities could be used to offset vegetation to be cleared for the project. Acquired land would need to be actively managed in order to maintain or improve the condition of the vegetation and habitats.

Table 9-5 below indicates that large areas of each vegetation community type proposed for removal are present within the Hunter/ Central Rivers Catchment and Hunter Sub-catchment.

Table 9-5 Regional extent of subject vegetation communities

BioMetric vegetation type	Corresponding LHCCREMS community	Proposed clearing extent (ha) (Hexham Relief Roads Project)	Extent mapped by the LHCCREMS ¹ (ha)	
			Hunter/ Central Rivers CMA	Hunter Sub-catchment
HU633 - Swamp Mahogany Swamp Forest on Coastal Lowlands	Swamp Mahogany Paperbark Swamp Forest (MU37)	1.12	5,165	376
HU635 - Swamp Oak Swamp Forest Fringing Estuaries	Swamp Oak Rushland Forest (MU 40)	5.28	2,241	397
HU673 - <i>Phragmites</i>	Freshwater Wetland	2.7	3,900	3,462

BioMetric vegetation type	Corresponding LHCCREMS community	Proposed clearing extent (ha) (Hexham Relief Roads Project)	Extent mapped by the LHCCREMS ¹ (ha)	
			Hunter/ Central Rivers CMA	Hunter Sub-catchment
<i>australis</i> and <i>Typha orientalis</i> Coastal Freshwater Wetlands	Complex (MU46)			

Note: 1) The LHCCREMS broad-scale vegetation mapping only covers approximately 14% of the Hunter/ Central Rivers Catchment and 31% of the Hunter Sub-catchment.

Whilst large areas of land containing suitable vegetation communities occur throughout the region, the feasibility of acquiring such properties for offsetting purposes is limited by market availability. ARTC have also previously identified a preference not to become land manager of large biodiversity offsets and as such would require any property acquisition to be on sold into the Biobanking scheme or suitable for hand over to OEHL for incorporation into the NSW NPWS reserve estate.

9.8 Securing an offset

ARTC is committed to establishing an offsets strategy that will provide ongoing conservation of land in perpetuity for the benefit of future generations. Offsets must be enduring and must offset the impact of the development for the period that the impact occurs. The security of land tenure and ongoing management of offsets is critical to the long-term viability of offsets and must be carefully considered.

To ensure the conservation of lands in-perpetuity the offset strategy will require the dedication of the identified offsets under a secure conservation arrangement. There are a number of options available to secure land under permanent conservation agreements. ARTC is committed to exploring and identifying the most suitable conservation arrangement for land in consultation with the relevant stakeholders. Potential options may include:

- Conservation Agreements under the NPW Act.
- Trust Agreements under the *Nature Conservation Trust Act 2001* (NCT Act).
- A Property Vegetation Plan registered on title under the *Native Vegetation Act 2003* (NV Act).
- A Planning agreement under s93F of the EPA Act.
- Dedication of lands as offsets under the Biodiversity Banking Scheme.
- Dedication of land to the NSW NPWS branch of OEHL with contributions towards management costs.

10. Conclusion

This report provides a worst case scenario for impacts of the proposed Project on biodiversity as it provides a broad corridor assessment. The area of vegetation and habitats to be cleared would be reduced as a result of ongoing detailed design.

Four endangered ecological communities listed under the TSC Act were recorded in the Study Area. The proposed Project will include the removal of 9.10 ha of native vegetation, including 2.70 ha of *Phragmites australis* and *Typha orientalis* Coastal Freshwater Wetlands, 5.28 ha of Swamp Oak Swamp Forest and 1.12 ha of Swamp Mahogany Swamp Forest which are all listed as endangered ecological communities under the TSC Act. No areas of Coastal Saltmarsh will be removed as part of the proposed Project. Significance assessments were completed for the three endangered ecological communities that will be affected by the proposed Project. These assessments concluded that the proposed Project is unlikely to have a significant impact on these communities due to the small area to be affected, and the disturbed and fragmented condition of these communities.

No threat-listed ecological communities listed under the EPBC Act were recorded in the Study Area.

No Endangered Populations listed under the TSC Act and/or the EPBC Act were identified or were considered likely to occur in the Study Area.

No threat-listed species of plant listed under the TSC Act or the EPBC Act were identified in the Study Area. However, significance assessments were completed on three threat-listed plant species, *Maundia triglochoides* (Vulnerable under the TSC Act), *Persicaria elatior* (Vulnerable under the TSC Act and EPBC Act) and *Zannichellia palustris* (Endangered under the TSC Act), based on the presence of potential habitat. These assessments concluded that the proposed Project was unlikely to have a significant impact on these species due to the small area (3.82 ha for *Persicaria elatior* and 2.70 ha for the remaining two species) of potential habitat likely to be affected, its disturbed and fragmented nature and ongoing disturbance regimes.

Two threat-listed species of animal, the Grey-headed Flying-fox and White-fronted Chat, listed under the TSC Act and/or the EPBC Act were recorded in the Study Area. A further two threat-listed species, Black-necked Stork and Spotted Harrier, were also recorded during surveys, however, they were recorded more distantly from the Study Area. Significance assessments were also completed on a further 23 threat-listed species of animal, based on the presence of suitable habitat. Significance assessments completed for these species (Table 8-1 and Appendix E) concluded that the proposed Project was not likely to have a significant impact for one or more of the following reasons:

- The proposed Project Area essentially followed disturbed easements with no preferred habitat recorded therein.
- The proposed Project Area existed as highly fragmented and isolated regrowth/remnant vegetation.
- The proposed Project Area lacked important microhabitat elements such as roosting and breeding habitat (i.e. large tree hollows).

- The species were highly mobile and while the proposed Project Area potentially occurred as part of a larger home range, the species would use larger tracts of vegetation/habitat in the locality and not the Study Area exclusively.

Therefore, the proposed Project is not likely to have a significant impact on the ecological features of the local area. Although the impacts to threat-listed biodiversity are not considered to be significant, given that the proposed Project would result in clearing of native vegetation, including an Endangered Ecological Community and habitat for threat-listed species, it would be necessary to develop offset strategies to fulfil the requirements of 'maintain and improve' requirements of the Director General's and OEH's requirements.

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Appendix A

Flora recorded

Plant species list

Family Name	Scientific Name	Common Name	Native
Acanthaceae	<i>Thunbergia alata</i>	Black-eyed Susan	N
Adiantaceae	<i>Pellaea falcata</i>	Sickle Fern	Y
Apiaceae	<i>Centella asiatica</i>	Pennywort	Y
Amaranthaceae	<i>Alternanthera philoxeroides</i>	Alligator Weed	N
	<i>Foeniculum vulgare</i>	Fennel	N
	<i>Hydrocotyle bonariensis</i>		N
Apocynaceae	<i>Araujia sericifera</i>	Moth Vine	N
Arecaceae	<i>Howea sp.</i>	Palm	Y
	<i>Livistona australis</i>	Cabbage Tree Palm	Y
		Narrow-leaved Cotton Bush	N
Asclepiadaceae	<i>Gomphocarpus fruticosus</i>		N
Asteraceae	<i>Ageratina adenophora</i>	Crofton Weed	N
	<i>Ambrosia tenuifolia</i>	Lacy Ragweed	N
	<i>Aster subulatus</i>	Wild Aster	N
	<i>Baccharis halimifolia</i>	Groundsel Bush	N
	<i>Bidens pilosa</i>	Cobbler's Pegs	N
	<i>Cirsium vulgare</i>	Spear Thistle	N
	<i>Cotula coronopifolia</i>	Water Buttons	N
	<i>Gamochaeta calviceps</i>	Cudweed	N
	<i>Gamochaeta purpurea</i>	Purple Cudweed	N
	<i>Gamochaeta coarctata</i>	Spiked Cudweed	N
	<i>Hypochaeris radicata</i>	Catsear	N
	<i>Ozothamnus diosmifolius</i>	White Dogwood	Y
	<i>Senecio madagascariensis</i>	Fireweed	N
	<i>Sonchus oleraceus</i>	Common Sowthistle	N
	<i>Tagetes minuta</i>	Stinking Roger	N
	<i>Taraxacum officinale</i>	Dandelion	N
Avicenniaceae	<i>Avicennia marina</i>	Grey Mangrove	Y
Azollaceae	<i>Azolla pinnata</i>		Y
Basellaceae	<i>Anredera cordifolia</i>	Madeira Vine	N
Bignoniaceae	<i>Jacaranda mimosifolia</i>	Jacaranda	N
Boraginaceae	<i>Echium plantagineum</i>	Paterson's curse	N
Brassicaceae	<i>Brassica rapa</i>		N
	<i>Cakile edentula</i>	American Sea Rocket	N
Campanulaceae	<i>Wahlenbergia communis</i>	Native Bluebell	Y
Caryophyllaceae	<i>Cerastium glomeratum</i>	Mouse-ear Chickweed	N
	<i>Stellaria media</i>	Common Chickweed	N
Casuarinaceae	<i>Casuarina glauca</i>	Swamp Oak	Y
Chenopodiaceae	<i>Atriplex prostrata</i>		N
	<i>Einadia hastata</i>		Y
	<i>Sarcocornia quinqueflora</i>	Glasswort	Y
Commelinaceae	<i>Commelina cyanea</i>	Native Wandering Jew	Y
Convolvulaceae	<i>Dichondra repens</i>	Kidney Weed	Y

Family Name	Scientific Name	Common Name	Native
Cupressaceae	<i>Athrotaxis cupressoides</i>	Pencil Pine	Y
Cyperaceae	<i>Baumea juncea</i>		Y
	<i>Carex appressa</i>		Y
	<i>Cyperus difformis</i>	Dirty Dora	Y
	<i>Cyperus congestus</i>		N
	<i>Cyperus eragrostis</i>	Umbrella Sedge	Y
	<i>Cyperus brevifolius</i>		N
	<i>Eleocharis gracilis</i>		Y
	<i>Schoenoplectus mucronatus</i>		Y
Euphorbiaceae	<i>Glochidion ferdinandi</i>	Cheese Tree	Y
	<i>Ricinus communis</i>	Castor Oil Plant	N
	<i>Triadica sebifera</i>	Chinese Tallowood	N
Fabaceae (Caesalpinioideae)	<i>Senna pendula</i>	Senna	N
Fabaceae (Faboideae)	<i>Glycine clandestina</i>	Love Creeper	Y
	<i>Hardenbergia violacea</i>	Native Raspberry	Y
	<i>Lotus sp.</i>		Y
	<i>Medicago polymorpha</i>		N
	<i>Podolobium scandens</i>	Netted Shaggy Pea	Y
	<i>Trifolium arvensis</i>	Hare's Foot Clover	N
	<i>Trifolium repens</i>	White Clover	N
	<i>Vicia sativa</i>		N
Fabaceae (Mimosoideae)	<i>Acacia saligna</i>	Golden Wreath Wattle	N
	<i>Acacia implexa</i>		Y
	<i>Acacia falcata</i>		Y
	<i>Acacia terminalis ssp. angustifolia</i>		Y
Geraniaceae	<i>Geranium solanderi</i>	Native Geranium	Y
Haloragaceae	<i>Myriophyllum papillosum</i>		Y
Juncaceae	<i>Juncus acutus</i>		N
	<i>Juncus australis</i>		Y
	<i>Juncus continuus</i>		Y
	<i>Juncus cognatus</i>		N
	<i>Juncus kraussii</i>		Y
	<i>Juncus usitatus</i>		Y
Juncaginaceae	<i>Triglochin microtuberosum</i>	Water Ribbons	Y
Lamiaceae	<i>Stachys arvensis</i>	Stagger Weed	N
Lauraceae	<i>Cinnamomum camphora</i>	Camphor Laurel	N
Lemnaceae	<i>Spirodela sp.</i>	Duckweed	Y
Lobeliaceae	<i>Pratia purpurascens</i>	Whiteroot	Y
Lomandraceae	<i>Lomandra longifolia</i>	Spiny-headed Mat Grass	Y
Malaceae	<i>Cotoneaster sp.</i>		N
Malvaceae	<i>Modiola caroliniana</i>	Red-flowered Mallow	N
	<i>Sida rhombifolia</i>	Paddy's Lucerne	N
Marsileaceae	<i>Marsilea mutica</i>	Nardoo	Y
Meliaceae	<i>Melia azedarach</i>	White Cedar	Y

Family Name	Scientific Name	Common Name	Native
Moraceae	<i>Ficus rubiginosa</i>	“Port Jackson Fig, Rusty Fig”	Y
Myrtaceae	<i>Callistemon citrinus</i>	Crimson Bottlebrush	Y
	<i>Corymbia maculata</i>	Spotted Gum	Y
	<i>Eucalyptus grandis</i>	Flooded Gum	Y
	<i>Eucalyptus robusta</i>	Swamp Mahogany	Y
	<i>Eucalyptus tereticornis</i>	Forest Red Gum	Y
	<i>Leptospermum polygalifolium</i>	Yellow Tea-tree	Y
	<i>Melaleuca ericifolia</i>	Swamp Paperbark	Y
	<i>Melaleuca hypericifolia</i>	Hillock Bush	Y
	<i>Melaleuca linariifolia</i>	Flax-leaved Paperbark	Y
	<i>Melaleuca nodosa</i>	Ball Honeymyrtle	Y
	<i>Melaleuca quinquenervia</i>	Broad-leaved Paperbark	Y
	<i>Melaleuca styphelioides</i>	Prickly-leaved Tea Tree	Y
Oleaceae	<i>Ligustrum lucidum</i>	Large-leaved Privet	N
	<i>Olea europaea ssp. cuspidata</i>	African Olive	N
Onagraceae	<i>Ludwigia peploides ssp. montevidensis</i>	Water Primrose	Y
Oxalidaceae	<i>Oxalis corniculata</i>	Creeping Oxalis	N
Pinaceae	<i>Pinus radiata</i>	Radiata Pine	N
Pittosporaceae	<i>Pittosporum undulatum</i>	Sweet Pittosporum	Y
Plantaginaceae	<i>Plantago lanceolata</i>	Lamb's Tongues	N
Poaceae	<i>Andropogon virginicus</i>	Whisky Grass	N
	<i>Arundo donax</i>	Giant Reed	N
	<i>Avena fatua</i>	Wild Oats	N
	<i>Axonopus affinis</i>	Narrow-leaved Carpet Grass	N
	<i>Briza minor</i>	Blow-fly Grass	N
	<i>Briza maxima</i>	Shivery Grass	N
	<i>Bromus catharticus</i>	Prairie Grass	N
	<i>Bromus molliformis</i>	Soft Broome	N
	<i>Capillipedium spicigerum</i>	Scented-top Grass	Y
	<i>Chloris gayana</i>	Rhodes Grass	N
	<i>Cortaderia selloana</i>	Pampas Grass	N
	<i>Cynodon dactylon</i>	Common Couch	Y
	<i>Ehrharta erecta</i>	Panic Veldtgrass	N
	<i>Eragrostis curvula</i>	African Lovegrass	N
	<i>Hemarthria uncinata</i>	Matgrass	Y
	<i>Hyparrhenia hirta</i>	Giant Coolatai Grass	N
	<i>Lachnagrostis filiformis</i>		Y
	<i>Melinis repens</i>	Red Natal Grass	N
	<i>Panicum maximum</i>	Guinea Grass	N
	<i>Panicum simile</i>	Two-colour Panic	Y
	<i>Paspalum dilatatum</i>	Paspalum	N
	<i>Paspalum distichum</i>	Water Couch	Y

Family Name	Scientific Name	Common Name	Native
	<i>Paspalum urvillei</i>	Vasey Grass	N
	<i>Pennisetum clandestinum</i>	Kikuyu Grass	N
	<i>Phalaris aquatica</i>		N
	<i>Phragmites australis</i>	Common Reed	Y
	<i>Poa annua</i>		N
	<i>Setaria gracilis</i>	Slender Pigeon Grass	N
	<i>Setaria verticillata</i>	Giant Pigeon Grass	N
	<i>Sporobolus africanus</i>	Parramatta Grass	N
	<i>Sporobolus creber</i>	Slender Rat's Tail Grass	Y
	<i>Sporobolus virginicus</i>		Y
Polygonaceae	<i>Acetosella vulgaris</i>	"Sorrel, Sheep Sorrel"	N
	<i>Persicaria decipiens</i>	Spotted Knotweed	Y
	<i>Persicaria hydropiper</i>	Water Pepper	Y
	<i>Rumex crispus</i>	Curled Dock	N
Primulaceae	<i>Anagallis arvensis</i>	Scarlet/Blue Pimpernel	N
	<i>Samolus repens</i>	Creeping Brookweed	Y
Proteaceae	<i>Banksia integrifolia</i>	Coast Banksia	Y
	<i>Grevillea sp.</i>		Y
Rosaceae	<i>Rubus ulmifolius</i>	Blackberry	N
Ranunculaceae	<i>Ranunculus inundatus</i>		Y
	<i>Ranunculus repens</i>		N
Rubiaceae	<i>Galium aparine</i>	Goosegrass	N
Salicaceae	<i>Salix babylonica</i>	Weeping Willow	N
Solanaceae	<i>Cestrum parqui</i>	Green Cestrum	N
	<i>Solanum mauritianum</i>	Tobacco Bush	N
	<i>Solanum nigrum</i>	Black-berry Nightshade	N
Typhaceae	<i>Typha orientalis</i>	Broad-leaved Cumbungi	Y
Verbenaceae	<i>Lantana camara</i>	Lantana	N
	<i>Verbena bonariensis</i>	Purpletop	N
	<i>Verbena rigida</i>	Veined Verbena	N

Appendix B

Fauna recorded

Family Name	Common Name	Scientific Name	Study Area ¹	TSC Act ²	EPBC Act ³
Amphibians					
Hylidae	Bleating Tree Frog	<i>Litoria dentata</i>	OW		
Hylidae	Eastern Dwarf Tree Frog	<i>Litoria fallax</i>	OW		
Hylidae	Peron's Tree Frog	<i>Litoria peronii</i>	OW		
Hylidae	Tyler's Tree Frog	<i>Litoria tyleri</i>	OW		
Hylidae	Verreaux's Tree Frog	<i>Litoria verreauxii</i>	W		
Myobatrachidae	Common Eastern Froglet	<i>Crinia signifera</i>	O		
Myobatrachidae	Spotted Grass Frog	<i>Limnodynastes tasmaniensis</i>	O		
Myobatrachidae	Brown-striped Frog	<i>Limnodynastes peronii</i>	O		
Reptiles					
Elapidae	Red-bellied Black Snake	<i>Pseudechis porphyriacus</i>	O		
Scincidae	Eastern Water Skink	<i>Eulamprus quoyii</i>	O		
Scincidae	Striped Skink	<i>Ctenotus robustus</i>	O		
Native Birds					
Accipitridae	Brown Goshawk	<i>Accipiter fasciatus</i>	O		
Accipitridae	Pacific Baza	<i>Aviceda subcristata</i>	O		
Accipitridae	Spotted Harrier	<i>Circus assimilis</i>	O	V	
Accipitridae	Swamp Harrier	<i>Circus approximans</i>	O		
Accipitridae	Whistling Kite	<i>Haliastur sphenurus</i>	O		
Accipitridae	White-bellied Sea-Eagle	<i>Haliaeetus leucogaster</i>	O		M
Anatidae	Black Swan	<i>Cygnus atratus</i>	O		
Anatidae	Pacific Black Duck	<i>Anas superciliosa</i>	O		
Ardeidae	Cattle Egret	<i>Ardea ibis</i>	O		M
Ardeidae	Eastern Great Egret	<i>Ardea modesta</i>	O		M
Ardeidae	Little Egret	<i>Egretta garzetta</i>	O		
Ardeidae	White-faced Heron	<i>Egretta novaehollandiae</i>	O		
Artamidae	Australian Magpie	<i>Gymnorhina tibicen</i>	O		
Artamidae	Pied Butcherbird	<i>Cracticus nigrogularis</i>	O		
Cacatuidae	Little Corella	<i>Cacatua sanguinea</i>	O		
Charadriidae	Masked Lapwing	<i>Vanellus miles</i>	O		
Ciconiidae	Black-necked Stork	<i>Ephippiorhynchus asiaticus</i>	O	E1	
Columbidae	Crested Pigeon	<i>Ocyphaps lophotes</i>	O		
Corvidae	Australian Raven	<i>Corvus coronoides</i>	O		
Cuculidae	Fan-tailed Cuckoo	<i>Cacomantis flabelliformis</i>	O		
Cuculidae	Eastern Koel	<i>Eudynamys orientalis</i>	W		
Dicruridae	Grey Fantail	<i>Rhipidura fuliginosa</i>	O		
Dicruridae	Magpie-lark	<i>Grallina cyanoleuca</i>	O		
Dicruridae	Willie Wagtail	<i>Rhipidura leucophrys</i>	O		
Falconidae	Australian Hobby	<i>Falco longipennis</i>	O		
Falconidae	Nankeen Kestrel	<i>Falco cenchroides</i>	O		

Family Name	Common Name	Scientific Name	Study Area ¹	TSC Act ²	EPBC Act ³
Hirundinidae	Welcome Swallow	<i>Hirundo neoxena</i>	O		
Laridae	Silver Gull	<i>Larus novaehollandiae</i>	O		
Maluridae	Superb Fairy-wren	<i>Malurus cyaneus</i>	O		
Maluridae	Variiegated Fairy-wren	<i>Malurus lamberti</i>	O		
Meliphagidae	Brown Honeyeater	<i>Lichmera indistincta</i>	O		
Meliphagidae	Eastern Spinebill	<i>Acanthorhynchus tenuirostris</i>	O		
Meliphagidae	Red Wattlebird	<i>Anthochaera carunculata</i>	O		
Meliphagidae	Scarlet Honeyeater	<i>Myzomela sanguinolenta</i>	O		
Meliphagidae	White-fronted Chat	<i>Epthianura albifrons</i>	O	V	
Meliphagidae	Yellow-faced Honeyeater	<i>Lichenostomus chrysops</i>	O		
Motacillidae	Australasian Pipit	<i>Anthus novaeseelandiae</i>	O		
Muscicapidae	Golden-headed Cisticola	<i>Cisticola exilis</i>	O		
Muscicapidae	Little Grassbird	<i>Megalurus gramineus</i>	O		
Oriolidae	Figbird	<i>Sphecotheres viridis</i>	O		
Pachycephalidae	Rufous Whistler	<i>Pachycephala rufiventris</i>	O		
Pardalotidae	White-browed Scrubwren	<i>Sericornis frontalis</i>	O		
Pardalotidae	Yellow Thornbill	<i>Acanthiza nana</i>	O		
Pardalotidae	Yellow-rumped Thornbill	<i>Acanthiza chrysorrhoa</i>	O		
Passeridae	Red-browed Finch	<i>Neochmia temporalis</i>	O		
Pelecanidae	Australian Pelican	<i>Pelecanus conspicillatus</i>	O		
Phalacrocoracidae	Little Black Cormorant	<i>Phalacrocorax sulcirostris</i>	O		
Phalacrocoracidae	Little Pied Cormorant	<i>Phalacrocorax melanoleucos</i>	O		
Psittacidae	Eastern Rosella	<i>Platycercus eximius</i>	O		
Threskiornithidae	Australian White Ibis	<i>Threskiornis molucca</i>	O		
Threskiornithidae	Royal Spoonbill	<i>Platalea regia</i>	O		
Threskiornithidae	Straw-necked Ibis	<i>Threskiornis spinicollis</i>	O		
Zosteropidae	Silvereve	<i>Zosterops lateralis</i>	O		
Introduced Birds					
Columbidae	Rock Dove	<i>Columba livia</i>	O	U	
Passeridae	House Sparrow	<i>Passer domesticus</i>	O	U	
Sturnidae	Common Myna	<i>Acridotheres tristis</i>	O	U	
Sturnidae	Common Starling	<i>Sturnus vulgaris</i>	O	U	
Native Mammals					
Pteropodidae	Grey-headed Flying-fox	<i>Pteropus poliocephalus</i>	OW	V	V
Vespertilionidae	Chocolate Wattled Bat	<i>Chalinolobus morio</i>	W		
Vespertilionidae	Eastern Freetail Bat	<i>Mormopterus ridei</i>	W		
Introduced Mammals					
Canidae	Fox	<i>Vulpes vulpes</i>	O	U	
Leporidae	Brown Hare	<i>Lepus capensis</i>	O	U	
Leporidae	Rabbit	<i>Oryctolagus cuniculus</i>	O	U	

Family Name	Common Name	Scientific Name	Study Area ¹	TSC Act ²	EPBC Act ³
Muridae	Black Rat	<i>Rattus rattus</i>	O	U	

Note:

1 O = observed, W = heard

2 E1 = endangered, V = vulnerable, U = unprotected (introduced species) (NSW *Threatened Species Conservation Act 1995*)

3 V = vulnerable, M = migratory species (Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*).

Appendix C

Threatened species and populations
of plant

Family	Scientific name	Common Name	TSC Act	EPBC Act	ROTAP	Preferred Habitat	Survey timing appropriate for detection	Likelihood of occurrence within the site
Casuarinaceae	<i>Allocasuarina defungens</i>	Dwarf Heath Casuarina	E1	E	2E	Only occurs in NSW, from the Nahiab area (north-west of Forster) to Byron Bay on the NSW north coast. It grows mainly in tall heath on sand, but can also occur on clay soils and sandstone. It also extends onto exposed nearby-coastal hills or headlands adjacent to sandplains (Department of Environment and Conservation 2005).	Yes	Low. Not recorded, and preferred habitat not present
Juncaginaceae	<i>Maundia triglochoides</i>	Small Water-ribbons	V			Occurs north from Sydney. Grows in swamps, creeks or shallow freshwater 30 to 60 cm deep on heavy clay, low nutrients. Associated with wetland species such as <i>Triglochin procerum</i> (Harden 1993).	Yes	Moderate. Not recorded however, habitat is present in the Freshwater wetlands within the subject site.
Fabaceae (Mimosoideae)	<i>Acacia bynoeana</i>	Bynoe's Wattle	E1	V	3V	Occurs south of Dora Creek-Morisset area to Berrima and the Illawarra region and west to the Blue Mountains. Local populations are also associated with Kurri Sand Swamp Woodland in the Cessnock LGA. It grows mainly in heath and dry sclerophyll forest on sandy soils (Harden 2002). Seems to prefer open, sometimes disturbed sites such as trail margins, easements and recently burnt areas. Typically occurs in association with <i>Corymbia gummifera</i> , <i>Eucalyptus haemastoma</i> , <i>E. parramattensis</i> , <i>E. sclerophylla</i> , <i>Banksia serrata</i> and <i>Angophora bakeri</i> (NSW National Parks and Wildlife Service 1999a).	Yes	Low. Not recorded, and preferred habitat not present
Fabaceae (Mimosoideae)	<i>Acacia pendula</i>	Weeping Myall	E2			Within the Hunter catchment the species typically occurs on heavy soils, sometimes on the margins of small floodplains, but also in more undulating locations. This population is known to occur naturally as far east as Warkworth, and extends northwest to Muswellbrook and to the west of Muswellbrook at Wybong. It has only been recorded at six locations: Jerrys Plains, Edderton, Wybong, Appletree Creek, Warkworth and Appletree Flat. The stand at Jerrys Plains is part of the Weeping Myall - Coobah - Scrub Wilga Shrubland of the Hunter Valley, listed under EPBC Act as a Critically Endangered Ecological Community (Department of Environment Climate Change and Water 2010).	Yes	Low. Not recorded, and preferred habitat not present

Family	Scientific name	Common Name	TSC Act	EPBC Act	ROTAP	Preferred Habitat	Survey timing appropriate for detection	Likelihood of occurrence within the site
Myrtaceae	<i>Callistemon linearifolius</i>	Netted Bottle Brush	V		2Ri	Occurs chiefly from Georges to the Hawkesbury River where it grows in dry sclerophyll forest, open forest, scrubland or woodland on sandstone. Found in damp places, usually in gullies (Fairley & Moore 2002; Harden 2002; Robinson 1994). Within the Sydney region, recent records are limited to the Hornsby Plateau area near the Hawkesbury River (NSW Scientific Committee 1999a).	Yes	Low. Not recorded, and preferred habitat not present
Myrtaceae	<i>Eucalyptus camfieldii</i>	Heart-leaved Stringybark	V	V	2Vi	Restricted distribution in a narrow band with the most northerly records in the Raymond Terrace Area south to Waterfall. Localised and scattered distribution includes sites at Norah Head (Tuggerah Lakes), Peats Ridge, Mt Colah, Elvina Bay Trail (West Head), Terrey Hills, Killara, North Head, Menai, Wattamolla and a few other sites in Royal National Park (Department of Environment and Climate Change). Occurs within poor coastal country in shallow sandy soils overlying Hawkesbury sandstone. Coastal heath mostly on exposed sandy ridges. Occurs mostly in small scattered stands near the boundary of tall coastal heaths and low open woodland of the slightly more fertile inland areas. Associated species frequently include stunted species of <i>E. oblonga</i> (Narrow-leaved Stringybark), <i>E. capitellata</i> (Brown Stringybark) and <i>E. haemastoma</i> (Scribbly Gum) (Department of Environment and Climate Change).	Yes	Low. Not recorded, and preferred habitat not present
Myrtaceae	<i>Eucalyptus camaldulensis</i>	River Red Gum	E2			Occurs in the western slopes, western plains, far western plains and in the North Coast (Hunter Catchment). It is typically dominant, occurring within grassy woodland or forest on deep rich alluvial soils adjacent to large permanent water bodies (Harden 2002). In the Hunter it may occur with <i>Eucalyptus tereticornis</i> , <i>Eucalyptus melliodora</i> , <i>Casuarina cunninghamiana</i> subsp. <i>cunninghamiana</i> and <i>Angophora floribunda</i> (NSW Scientific Committee 2005).	Yes	Low. Not recorded, and preferred habitat not present
Myrtaceae	<i>Eucalyptus fracta</i>		V			Known only from State Forests on parts of the northern escarpment of the Broken Back Range, near Cessnock, where it is locally frequent. It is restricted to shallow soils along the upper escarpment of a steep sandstone range (Harden 2002; NSW Scientific Committee 1999b).	Yes	Low. Not recorded, and preferred habitat not present
Myrtaceae	<i>Eucalyptus parramattensis</i> ssp. <i>decadens</i>	Parramatta Red Gum	V	V	2V	Locally frequent, grows in dry sclerophyll woodland on sandy soils in low, often wet sites (Harden 2002).	Yes	Low. Not recorded, and preferred habitat not present

Family	Scientific name	Common Name	TSC Act	EPBC Act	ROTAP	Preferred Habitat	Survey timing appropriate for detection	Likelihood of occurrence within the site
Myrtaceae	<i>Melaleuca biconvexa</i>	Biconvex Paperbark	V	V		Occurs as disjunct populations in coastal New South Wales from Jervis Bay to Port Macquarie, with the main concentration of records is in the Gosford/Wyong area (NSW Scientific Committee 1998b). Grows in damp places, often near streams, or low-lying areas on alluvial soils of low slopes or sheltered aspects (Department of Environment and Climate Change 2008; Harden 2002).	Yes	Low. Not recorded, and preferred habitat not present
Orchidaceae	<i>Cymbidium canaliculatum</i>	Tiger Orchid	E2			In the Hunter Catchment, the endangered population of this species grows singularly or in clumps in tree hollows, commonly between two to six metres above the ground. Found in woodlands and dry sclerophyll forests dominated by <i>Eucalyptus albens</i> , and less commonly found on <i>E. dawsonii</i> , <i>E. crebra</i> , <i>E. moluccana</i> , <i>Angophora floribunda</i> and <i>Acacia salicina</i> . Scattered, non-endangered populations of this species exist across northern Australia, from NSW to Western Australia (NSW Scientific Committee 2006).	Yes	Low. Not recorded, and preferred habitat not present
Orchidaceae	<i>Cryptostylis hunteriana</i>	Leafless Tongue Orchid	V	V	3V	Occurs south from the Gibraltar Range, chiefly in coastal districts but also extends on to tablelands. Grows in swamp-heath and drier forest on sandy soils on granite & sandstone. Occurs in small, localised colonies most often on the flat plains close to the coast but also known from some mountainous areas growing in moist depressions and swampy habitats (Harden 1993; NSW National Parks and Wildlife Service 1999b).	Yes	Low. Not recorded, and preferred habitat not present
Orchidaceae	<i>Pterostylis gibbosa</i>		E1	E	2E	Occurs in the southern part of the Central Coast region with a disjunct population in the Hunter Valley. Grows among grass in sclerophyll forest (Harden 2002). In the Illawarra it grows in Coastal Grassy Red Gum Forest and in Lowland Woollybutt-Melaleuca forest (NSW National Parks and Wildlife Service 2003).	Yes	Low. Not recorded, and preferred habitat not present
Polygonaceae	<i>Persicaria elatior</i>	Tall Knotweed	V	V	3V	Occurs infrequently in coastal regions where it grows in damp places especially beside streams and lakes. Also occasionally occurs in swamp forest or associated with disturbance. This species flowers in Summer and Autumn. (Department of Environment and Conservation 2005; Harden 2000).	Yes	Moderate Habitat within the Swamp Forests and Freshwater wetlands within the subject site.

Family	Scientific name	Common Name	TSC Act	EPBC Act	ROTAP	Preferred Habitat	Survey timing appropriate for detection	Likelihood of occurrence within the site
Proteaceae	<i>Grevillea parviflora</i> <i>ssp. parviflora</i>	Small-flower Grevillea	V	V		Mainly known from the Prospect area (but now extinct there) and lower Georges River to Camden, Appin and Cordeaux Dam areas, with a disjunct populations near Putty, Cessnock and Cooranbong. Grows in heath or shrubby woodland in sandy or light clay soils usually over thin shales (Harden 2002; NSW Scientific Committee 1998a).	Yes	Low. Not recorded, and preferred habitat not present
Rhamnaceae	<i>Pomaderris bodalla</i>		V			<i>Pomaderris bodalla</i> is endemic to NSW and is currently known to occur on the south coast between Bodalla and Merimbula, and in the upper Hunter valley near Muswellbrook (Royal Botanic Gardens 2012). On the south coast, it occurs in moist open forest along sheltered gullies or along stream banks. In the upper Hunter valley, it occurs in open forest or woodland on open slopes. There are ten populations of <i>Pomaderris bodalla</i> currently known, and a further two imprecisely described locations from which the species was collected approximately 40 years ago. The majority of populations are small with seven of the populations having estimates of less than a hundred plants each. All populations have locally restricted distributions. The largest known population is in Wollemi National Park and is unlikely to include more than one thousand plants (Department of Environment and Conservation 2005).	Yes	Low. Not recorded, and preferred habitat not present
Rubiaceae	<i>Asperula asthenes</i>	Trailing Woodruff	V	V	3V	This small herb occurs only in NSW in scattered locations from Bulahdelah north to near Kempsey, with several records from the Port Stephens/Wallis Lakes area. It grows in damp sites, often along river banks (Department of Environment and Conservation 2005; Harden 1992).	Yes	Low. Not recorded and closest record is at Port Stephens to the north of the study area.
Rubiaceae	<i>Galium australe</i>	Tangled Bedstraw	E1			Previously presumed extinct in NSW, this species is now known from a number of sites in coastal regions. In NSW, this species has been recorded in moist gullies of tall forest, <i>Eucalyptus tereticornis</i> forest, coastal Banksia shrubland, and <i>Allocasuarina nana</i> heathland. In other States the species is found in a range of near-coastal habitats, including sand dunes, sand spits, shrubland and woodland (Department of Environment and Conservation 2005; Royal Botanic Gardens 2005).	Yes	Low. Not recorded, and preferred habitat not present
Rutaceae	<i>Leonema lamprophyllum</i> <i>ssp. obovatum</i>		E2			Grows south from Tidbinbilla, in heath on exposed ridges at higher altitudes (Royal Botanic Gardens 2008). Also recorded near Pokolbin, where it is listed as an Endangered population in Pokolbin State Forest, part of the Singleton Local Government Area in the Hunter Catchment (NSW Scientific Committee 2007).	Yes	Low. Not recorded, and preferred habitat not present

Family	Scientific name	Common Name	TSC Act	EPBC Act	ROTAP	Preferred Habitat	Survey timing appropriate for detection	Likelihood of occurrence within the site
Scrophulariaceae	<i>Euphrasia arguta</i>		E4	X	3X	Grows in grassy areas near rivers, recorded from Bathurst to Walcha area (possibly extinct) (NC, NT, CT, NWS, CWS botanical subdivisions) (Royal Botanic Gardens 2005)	Yes	Low. Not recorded, and preferred habitat not present
Scrophulariaceae	<i>Lindernia alsinoides</i>	Noah's False Chickweed	E1			Grows in swampy sites in sclerophyll forest and coastal heath, north from Bulahdelah.	Yes	Low. Not recorded, and preferred habitat not present
Sterculiaceae	<i>Rulingia prostrata</i>	Dwarf Kerrawang	E1	E	2Ei	Occurs south of Picton lakes where it mainly grows in gullies along the escarpment, south from Picton Lakes (Harden 2000), on the Southern Tablelands (one plant at Penrose State Forest, one plant at Rowes Lagoon and one plant at Tallong) and on the North Coast (less than 100 plants at the Tomago sandbeds north of Newcastle). It occurs on sandy, sometimes peaty soils in a wide variety of habitats: <i>Eucalyptus pauciflora</i> (Snow Gum) Woodland at Rose Lagoon; <i>E. agglomerata</i> (Blue leaved Stringybark) Open Forest at Tallong; and in <i>E. mannifera</i> (Brittle Gum) Low Open Woodland at Penrose; (<i>E. haemastoma</i> Scribbly Gum)/ <i>E. robusta</i> (Swamp Mahogany) Ecotonal Forest at Tomago. Associated native species may include <i>Imperata cylindrica</i> , <i>Empodisma minus</i> and <i>Leptospermum continentale</i> (Department of Environment and Climate Change 2007).	Yes	Low. Not recorded, and preferred habitat not present
Tremandraceae	<i>Tetradlea juncea</i>	Black-eyed Susan	V	V	3Vi	Occurs in coastal districts from Bulahdelah to Port Macquarie where it grows in dry sclerophyll forest and occasionally swampy heath in sandy, (Harden 1992) low nutrient soils with a dense understorey of grasses. Specifically it is known to occur within Coastal Plains Smooth-barked Apple Woodland and Coastal Plains Scribbly Gum Woodland (Payne <i>et al.</i> 2002).	Yes	Low. Not recorded, and preferred habitat not present
Zannichelliaceae	<i>Zannichellia palustris</i>	Homed Pondweed	E1	-	3R	Grows in fresh or slightly saline stationary or slowly flowing water (Royal Botanic Gardens 2005). Populations are known to occur in wetlands on the Hunter River flood plain.	Yes	Moderate although not recorded, this species is cryptic and therefore an impact assessment has been undertaken in Appendix E.

Notes:

1. V= Vulnerable, E1 = Endangered, E2 = Endangered Population E4 = Extinct (*Threatened Species Conservation Act 1995*).
2. X = Extinct, V = Vulnerable, E = Endangered, M = Migratory, C = Conservation Dependent (*Environment Protection and Biodiversity Conservation Act 1999*).
3. ROTAP (Rare or Threatened Australian Plants (Briggs & Leigh 1996)) is a conservation rating for Australian plants. Codes are:
 - 1 Species only known from one collection.
 - 2 Species with a geographic range of less than 100 km in Australia.
 - 3 Species with a geographic range of more than 100 km in Australia.
 - X Species presumed extinct; no new collections for at least 50 years.
 - E Endangered species at risk of disappearing from the wild state if present land use and other casual factors continue to operate.
 - V Vulnerable species at risk of long-term disappearance through continued depletion.
 - R Rare, but not currently considered to be endangered.
 - K Poorly known species that are suspected to be threatened.
 - C Known to be represented within a conserved area.
 - a At least 1,000 plants are known to occur within a conservation reserve(s).
 - l Less than 1,000 plants are known to occur within a conservation reserve(s).
4. Based on database searches and field surveys.
5. Likelihood of occurrence (refer Section 2.6 in main report).

APPENDIX C REFERENCES

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Appendix D

Threatened species of animal

Scientific name	Common name	TSC Act ¹	EPBC Act ²	Preferred habitat	Survey timing appropriate for detection ³	Likelihood of occurrence within the site ⁴
Amphibians						
<i>Crinia tinnula</i>	Wallum Froglet	V		Occurs along coast from south-eastern Queensland to Sydney. Mostly associated with swamps, dams and flooded roadside ditches, usually in heathland, where it is confined to acid, paperbark swamps and sedge swamps of the 'wallum' country. Males call anytime of year. Breed in late winter (Anstis 2002; NSW National Parks and Wildlife Service 2002).	Yes	Low. Preferred habitat not present
<i>Litoria aurea</i>	Green and Golden Bell Frog	E1	V	Has a fragmented distribution of mainly near coastal locations from Lakes Entrance (Victoria) to south of the NSW-Queensland border; as far west as Bathurst in the more elevated southern tablelands and central slopes of NSW. Various types of utilised habitat have been documented. For breeding utilises a wide range of waterbodies, including both natural and man-made structures, such as marshes, dams and stream sides, and ephemeral locations that are more often dry than wet. Is found in various small pockets of habitat in otherwise developed areas and has the tendency of often turning up in highly disturbed sites. Lotic situations such as fast flowing streams appear to be one of the few water bodies not utilised, at least for breeding purposes. Habitat attributes associated with the various waterbodies occupied by the GGBF, and that appear to make such habitat more likely to be occupied, include that the water body is shallow, still or slow flowing, ephemeral and/or widely fluctuating, unpolluted and without heavy shading. Permanent waterbodies are also known to be used and there is historical evidence of occupation of large, often deep and permanent bodies of water. There is a clear preference shown by GGBF for sites with a complexity of vegetation structure and associated terrestrial habitat attributes that appear to favour the species include extensive grassy areas and an abundance of shelter sites such as rocks, logs, tussock forming vegetation and other cover, considered to be used for foraging and shelter. Over-wintering sites may be adjacent to or some distance away from breeding sites; such sites include the bases of dense vegetation tussocks, beneath rocks, timber, within logs or beneath ground debris, including human refuse such as sheet iron, but the full range of possible habitat used for this purpose is not yet well understood (Department of Environment and Conservation 2004, 2005b).	Yes	Moderate - High. Occurs elsewhere in the Hunter River flood plain and potential habitat recorded in the Study Area.
<i>Litoria littlejohni</i>	Heath Frog	V	V	Distributed along the eastern slopes of the Great Dividing Range from Watagan State Forest near Wyong, south to Buchan in north-eastern Victoria. It appears to be restricted to sandstone woodland and heath communities at mid to high altitude. It forages both in the tree canopy and on the ground, and it has been observed sheltering under rocks on high exposed ridges during summer. It is not known from coastal habitats (NSW Scientific Committee 2000).	Yes	Low. Preferred habitat not present
<i>Mixophyes iteratus</i>	Giant Barred Frog	E1	E	Terrestrial species which occurs in rainforests, Antarctic Beech or wet sclerophyll forests. Feeds on insects and smaller frogs (Cogger 2000). The species is associated with permanent flowing drainages, from shallow rocky rainforest streams to slow-moving rivers in lowland open forest. It is not known to utilise still water areas (NSW Scientific Committee 1999). More prevalent at lower altitudes and in larger streams than its congeners, although has been recorded up to 1000 metres asl. (NSW National Parks and Wildlife Service 1999f).	Yes	Low. Preferred habitat not present

Scientific name	Common name	TSC Act ¹	EPBC Act ²	Preferred habitat	Survey timing appropriate for detection ³	Likelihood of occurrence within the site ⁴
Birds						
<i>Actitis hypoleucos</i>	Common Sandpiper		M	A medium sized migratory shorebird of both estuarine and freshwater wetlands, including mangrove habitats. Usually solitary or in pairs, or rarely small groups, it forages along both rocky and muddy shorelines and often roosts in an elevated location (Higgins & Davies 1996).	No	Low – Moderate . May occur intermittently in onsite wetlands
<i>Anseranas semipalmata</i>	Magpie Goose	V		Occurs in shallow wetlands such as large swamps and dams, especially with dense growth of rushes or sedges, and with permanent lagoons and grassland nearby. Feeds on seeds, tubers and green grass. Form large nesting colonies during the wet season. During the dry season this species sometimes migrates hundreds of kilometres to perennial swamps (Garnett & Crowley 2000; NSW National Parks and Wildlife Service 2002).	Yes	Moderate – High . May occur intermittently in onsite wetlands
<i>Apus pacificus</i>	Fork-tailed Swift		M	Breeds from central Siberia eastwards through Asia, and is migratory, wintering south to Australia. Individuals never settle voluntarily on the ground and spend most of their lives in the air, living on the insects they catch in their beaks (Higgins 1999).	No	Moderate – High . May occur over site on a seasonal basis
<i>Ardea modesta</i>	Eastern Great Egret		M	Eastern Great Egrets occur throughout Australia and East Asia. They are common throughout Australia, with the exception of the most arid areas. Great Egrets prefer shallow water, particularly when flowing, but may be seen on any wetland or estuarine habitat, including damp grasslands. Eastern Great Egrets can be seen alone or in small flocks at food sources, often with other egret species, and roost at night in groups. In Australia, the breeding season of this species is normally October to December in the south and March to May in the north. This species breeds in colonies, and often in association with cormorants, ibises and other egrets. (Australian Museum 2003).	Yes	Recorded .
<i>Ardea ibis</i>	Cattle Egret		M	Subspecies <i>A. i. coromanda</i> is found across the Indian subcontinent and Asia as far north as Korea and Japan, and in South-east Asia, Papua New Guinea and Australia (McKilligan 2005). Cattle Egrets are relatively common in Eastern Australia where they are often associated with cattle herds in pastureland (Pizzey & Knight 2007).	Yes	Recorded .
<i>Arenaria interpres</i>	Ruddy Turnstone		M	Occurs at beaches and coasts with exposed rock, stony or shell beaches, mudflats, exposed reefs and wave platforms (Morcombe 2003).	No	Low. Preferred habitat not present
<i>Anthochaera phrygia</i>	Regent Honeyeater	E1	EM	Occurs mostly in box-ironbark forests and woodland and prefers the wet, fertile sites such as along creek flats, broad river valleys and foothills. Riparian forests with <i>Casuarina cunningghamiana</i> and <i>Amyema cambagei</i> are sometimes important for feeding and breeding. Important food trees include <i>Eucalyptus sideroxylon</i> (Mugga Ironbark), <i>E. albens</i> (White Box), <i>E. melliodora</i> (Yellow Box) and <i>E. leucoxylo</i> (Yellow Gum) (Garnett & Crowley 2000).	Yes	Low. Small linear strips of potential habitat in Study Area, but distantly isolated.
<i>Botaurus poiciloptilus</i>	Australasian Bittern	V	V	Occurs in shallow, vegetated freshwater or brackish swamps. Requires permanent wetlands with tall dense vegetation, particularly bulrushes and spikerushes for breeding and shelter. When breeding, pairs are found in areas with a mixture of tall and short sedges but will also feed in more open territory. (Garnett & Crowley 2000; NSW National Parks and Wildlife Service 2002).	Yes	Moderate . May occur intermittently in onsite wetlands

Scientific name	Common name	TSC Act ¹	EPBC Act ²	Preferred habitat	Survey timing appropriate for detection ³	Likelihood of occurrence within the site ⁴
<i>Burhinus grallarius</i>	Bush Stone-curlew	E1		Require sparsely grassed, lightly timbered, open forest of woodland. In southern Australia they often occur where there is a well-structured litter layer and fallen timber debris. Feed on a range of invertebrates and small vertebrates, as well as seeds and shoots (NSW National Parks and Wildlife Service 1999b, 2003b).	Yes	Low. Preferred habitat not present
<i>Calidris alba</i>	Sanderling	V	M	A coastal species found on low and open sand beaches exposed to open sea-swells. A migratory species, it has been recorded in NSW from September to May (Pizzey & Knight 2007).	No	Low. Preferred habitat not present
<i>Calidris acuminata</i>	Sharp-tailed Sandpiper		M	Occurs in a variety of habitats: tidal mudflat, mangrove swamps, saltmarshes, shallow fresh, brackish, saline inland swamps and lakes; flooded and irrigated paddocks, sewage farms and commercial saltfields (Pizzey & Knight 2007).	No	Moderate – High Likely to occur within the site on a seasonal basis.
<i>Calidris canutus</i>	Red Knot		M	Generally a coastal species found on tidal mudflats, sandspits and sandy ocean shores. A migratory species visiting Australian waters between September and March (Pizzey & Knight 2007). Often associated with other waders, including Great Knot (<i>Calidris tenuirostris</i>).	No	Low - Moderate No suitable habitat within the site although may occur on adjacent salt marsh.
<i>Calidris ferruginea</i>	Curlew Sandpiper		M	Occurs in inter-tidal mudflats and sandspits of estuaries, lagoons, mangrove channels and also around lakes, dams, floodwaters and flooded saltbush surrounding inland lakes (Morcombe 2003).	No	Moderate Potential to occur within the site on a seasonal basis.
<i>Calidris ruficollis</i>	Red-necked Stint		M	Occurs across a range of inter-tidal habitat contexts, including, mudflats, sandspits, saltmarsh, sandy/shelly beaches and rock platforms. Also frequents coastal and inland freshwater wetland habitats, including sewerage ponds and saltfields (Pizzey & Knight 2007).	No	Moderate Potential to occur within the site on a seasonal basis.
<i>Calidris tenuirostris</i>	Great Knot	V	M	Generally a coastal species found on tidal mudflats, sandspits and sandy ocean shores. A migratory species visiting Australian waters between September and March (Pizzey & Knight 2007). Often associated with other waders, including Red Knot (<i>Calidris canutus</i>).	No	Low - Moderate No suitable habitat within the site although may occur on adjacent salt marsh.
<i>Callocephalon fimbriatum</i>	Gang-gang Cockatoo	V		Occurs in wetter forests and woodland from sea level to an altitude over 2000 metres, timbered foothills and valleys, coastal scrubs, farmlands and suburban gardens (Pizzey & Knight 1997).	Yes	Low. Preferred habitat not present
<i>Calyptorhynchus lathami</i>	Glossy Black-Cockatoo	V		Occurs in eucalypt woodland and forest with Casuarina/Allocasuarina spp. Characteristically inhabits forests on sites with low soil nutrient status, reflecting the distribution of key Allocasuarina species. Drier forest types with intact and less rugged landscapes are preferred by this species. Nests in tree hollows (Garrett & Crowley 2000; NSW National Parks and Wildlife Service 1999c).	Yes	Low. Preferred habitat not present
<i>Charadrius bicinctus</i>	Double-banded Plover		M	The only east-west migratory shorebird, breeding in New Zealand and visiting eastern Australia during the austral winter. It frequents muddy, gravelly or sandy shores, but often roosts on rock platforms. Extends sometimes well inland onto freshwater and saline shorelines (Marchant & Higgins 1993).	No	Moderate Potential to occur within the site on a seasonal basis.

Scientific name	Common name	TSC Act ¹	EPBC Act ²	Preferred habitat	Survey timing appropriate for detection ³	Likelihood of occurrence within the site ⁴
<i>Charadrius leschenaultii</i>	Greater Sand Plover	V	M	Entirely coastal in NSW foraging on intertidal sand and mudflats in estuaries, and roosting during high tide on sand beaches or rocky shores. A migratory species it is found in New South Wales generally during the summer months (Pizzey & Knight 2007).	No	Low - Moderate Recent regional records associated with estuarine sandflats.
<i>Charadrius mongolus</i>	Lesser Sand Plover	V	M	Migratory bird that migrates from the northern hemisphere to coastal areas of northern and east coast of Australia (Garnett & Crowley 2000).	No	Low - Moderate Recent regional records associated with estuarine sandflats/mudflats.
<i>Circus assimilis</i>	Spotted Harrier	V		The Spotted Harrier occurs throughout the Australian mainland in grassy open woodland including acacia and mallee remnants, inland riparian woodland, grassland and shrub steppe (e.g. chenopods) (Marchant & Higgins 1993). It is found most commonly in native grassland, but also occurs in agricultural land, foraging over open habitats including edges of inland wetlands. The diet of the Spotted Harrier includes terrestrial mammals, birds and reptiles, occasionally large insects and rarely carrion ((Department of Environment Climate Change and Water 2010b).	Yes	High . Recorded in Hexham Swamp during field surveys, approx. 300m west of Study Area.
<i>Climacteris picumnus victoriae</i>	Brown Treecreeper (eastern subs.)	V		Found in eucalypt woodlands and dry open forest of the inland slopes and plains inland of the Great Dividing Range; mainly inhabits woodlands dominated by stringybarks or other rough-barked eucalypts. Nesting occurs in tree hollows (Department of Environment and Conservation 2005a).	Yes	Low. Preferred habitat not present
<i>Daphoenositta chrysoptera</i>	Varied Sittella	V		The Varied Sittella inhabits most of mainland Australia except the treeless deserts and open grasslands. It inhabits eucalypt forests and woodlands, especially rough-barked species and mature smooth-barked gums with dead branches, mallee and Acacia woodland. The Varied Sittella feeds on arthropods gleaned from crevices in rough or decorticating bark, dead branches, standing dead trees, and from small branches and twigs in the tree canopy. It builds a cup-shaped nest of plant fibres and cobwebs in an upright tree fork high in the living tree canopy, and often re-uses the same fork or tree in successive years (Department of Environment Climate Change and Water 2010c).	Yes	Moderate . May occur intermittently in forest remnants in the Study Area.
<i>Ephippiorhynchus asiaticus</i>	Black-necked Stork	E1		Feed in shallow water up to 0.5 m deep on fish, reptiles and frogs. Build nests in trees close to feeding sites (Garnett & Crowley 2000).	Yes	High . Recorded in Hexham Swamp during field surveys, approx. 250m west of Study Area.
<i>Epthianura albifrons</i>	White-fronted Chat	V		The White-fronted Chat occupies foothills and lowlands below 1000 m above sea level (Higgins <i>et al.</i> 2001; Royal Australian Ornithologists Union 2003). In New South Wales the White-fronted Chat occurs mostly in the southern half of the state, occurring in damp open habitats along the coast, and near waterways in the western part of the state (Higgins <i>et al.</i> 2001). Along the coastline, White-fronted Chats are found predominantly in saltmarsh vegetation although they are also observed in open grasslands and sometimes in low shrubs bordering wetland areas(Higgins <i>et al.</i> 2001; Royal Australian Ornithologists Union 2003).	Yes	High . Recorded in close proximity to Study Area (Figure 4-1).

Scientific name	Common name	TSC Act ¹	EPBC Act ²	Preferred habitat	Survey timing appropriate for detection ³	Likelihood of occurrence within the site ⁴
<i>Gallinago hardwickii</i>	Latham's Snipe		M	Occurs in freshwater or brackish wetlands generally near protective vegetation cover. This species feeds on small invertebrates, seeds and vegetation. It migrates to the northern hemisphere to breed (Gamett & Crowley 2000).	Yes	Moderate Potential to occur within the site on seasonal basis.
<i>Glossopsitta pusilla</i>	Little Lorikeet	V		The distribution of the Little Lorikeet extends from just north of Cairns, around the east coast of Australia, to Adelaide. In New South Wales, Little Lorikeets are distributed in forests and woodlands from the coast to the western slopes of the Great Dividing Range, extending westwards to the vicinity of Albury, Parkes, Dubbo and Narrabri (Royal Australian Ornithologists Union 2003). Little Lorikeets are generally considered to be nomadic (Higgins 1999) and forage mainly on flowers, nectar and fruit. The breeding biology of Little Lorikeets is little known however studies indicate that nest hollows are located at heights of between 2 m and 15 m, mostly in living, smooth-barked eucalypts, and hollow openings are approximately 3 cm in diameter (Courtney & Debus 2006).	Yes	Moderate. May occur intermittently in forest remnants in the Study Area.
<i>Haematopus fuliginosus</i>	Sooty Oystercatcher	V		Found on rocky shorelines where it forages on intertidal flats (Gamett & Crowley 2000).	Yes	Low. Preferred habitat not present
<i>Haematopus longirostris</i>	Pied Oystercatcher	E1		Occurs in undisturbed beaches, sandspits, sandbars, tidal mudflats, estuaries and coastal islands. Occasionally found on rocky reefs, shores, rock stacks, brackish or saline wetlands and also in grassy paddocks, golf courses or parks near coast. Eggs are laid in shallow scrape in sand on open beach or among low growth behind beach (Pizzey & Knight 2007).	Yes	Low. Preferred habitat not present
<i>Haliaeetus leucogaster</i>	White-bellied Sea-Eagle		M	Occurs in coastal areas including islands, estuaries, inlets, large rivers, inland lakes and reservoirs. Builds a huge nest of sticks in tall trees near water, on the ground on islands or on remote coastal cliffs (Pizzey & Knight 2007).	Yes	Recorded.
<i>Hamirostra melanosternon</i>	Black-breasted Buzzard	V		Distributed throughout most of inland Australia and prefers arid scrubland, and open woodlands. Feeds on small mammals and birds (Gamett & Crowley 2000).	Yes	Low. Preferred habitat not present
<i>Heteroscelus brevipes</i>	Grey-tailed Tattler		M	A medium sized migratory shorebird visiting Australian shores during the Boreal winter. Frequents a range of intertidal shorelines, including sedimentary flats, but usually encountered on rock platforms, where it forages for intertidal crustaceans and molluscs (Higgins & Davies 1996).	No	Low. Preferred habitat not present
<i>Hieraaetus morphnoides</i>	Little Eagle	V		The Little Eagle is distributed throughout the Australian mainland occupying habitats rich in prey within open eucalypt forest, woodland or open woodland. Sheoak or acacia woodlands and riparian woodlands of interior NSW are also used. For nest sites it requires a tall living tree within a remnant patch, where pairs build a large stick nest in winter and lay in early spring. Prey includes birds, reptiles and mammals, with the occasional large insect and carrion. Most of its former native mammalian prey species in inland NSW are extinct and rabbits now form a major part of the diet (Marchant & Higgins 1993).	Yes	Moderate. May occur intermittently in forest remnants in the Study Area.
<i>Hirundapus caudacutus</i>	White-throated Needle-tail		M	Occurs in airspace over forests, woodlands, farmlands, plains, lakes, coasts and towns. Breeds in the northern hemisphere and migrates to Australia in October-April (Pizzey & Knight 2007).	No	Moderate – High. May occur over site on a seasonal basis

Scientific name	Common name	TSC Act ¹	EPBC Act ²	Preferred habitat	Survey timing appropriate for detection ³	Likelihood of occurrence within the site ⁴
<i>Ixobrychus flavicollis</i>	Black Bittern	V		Usually found in dense vegetation in and fringing streams, swamps, tidal creeks and mudflats, particularly amongst swamp she-oaks and mangroves. Feeds on aquatic fauna along streams, in estuaries and beside billabongs and pools. Breeding occurs in summer in secluded places in densely vegetated wetlands. It nests in trees that overhang the water (Garnett & Crowley 2000; NSW National Parks and Wildlife Service 2002).	Yes	Moderate. May occur in onsite wetlands.
<i>Lathamus discolor</i>	Swift Parrot	E1	E	Breeding occurs in Tasmania, majority migrates to mainland Australia in autumn, over-wintering, particularly in Victoria and central and eastern NSW, but also south-eastern Queensland as far north as Duaringa. Until recently it was believed that in New South Wales, Swift Parrots forage mostly in the western slopes region along the inland slopes of the Great Dividing Range but were only patchily distributed along the north and south coast, including the Sydney region, but new evidence indicates that the forests on the coastal plains from southern to northern NSW are also extremely important. In mainland Australia is semi-nomadic, foraging in flowering eucalypts in eucalypt associations, particularly box-ironbark forests and woodlands. Preference for sites with highly fertile soils where large trees have high nectar production, including along drainage lines and isolated rural or urban remnants, and for sites with flowering <i>Acacia pycnantha</i> , is indicated. Sites used vary from year to year. (Garnett & Crowley 2000),(Swift Parrot Recovery Team 2001).	Yes	Moderate. May occur intermittently in forest remnants in the Study Area.
<i>Limicola falcinellus</i>	Broad-billed Sandpiper	V	M	A migratory species that breeds in the northern hemisphere between June and August. Individuals feed both on exposed mudflats and while wading in water (NSW National Parks and Wildlife Service 1999a).	Yes	Moderate Potential to occur within the site on a seasonal basis.
<i>Limosa lapponica</i>	Bar-tailed Godwit		M	Occurs in coastal mudflats, sandbars, shores of estuaries, salt marsh and sewage ponds (Morcombe 2003).	No	Low. Preferred habitat not present
<i>Limosa limosa</i>	Black-tailed Godwit	V	M	A coastal species found on tidal mudflats, swamps, shallow river margins and sewage farms. Also found inland on larger shallow fresh or brackish waters. A migratory species visiting Australia between September and May (Pizzey & Knight 1997).	Yes	Moderate Potential to occur within the site on a seasonal basis.
<i>Lophoictinia isura</i>	Square-tailed Kite	V		This species hunts primarily over open forest, woodland and mallee communities as well as over adjacent heaths and other low scrubby habitats in wooded towns. It feeds on small birds, their eggs and nestlings as well as insects. Seems to prefer structurally diverse landscapes (Garnett & Crowley 2000).	Yes	Low. Preferred habitat not present
<i>Melithreptus gularis gularis</i>	Black-chinned Honeyeater	V		Found in dry eucalypt woodland particularly those containing ironbark and box. Occurs within areas of annual rainfall between 400-700 mm. Feed on insects, nectar and lerps (Garnett & Crowley 2000).	Yes	Low. Preferred habitat not present
<i>Merops ornatus</i>	Rainbow Bee-eater		M	Usually occur in open or lightly timbered areas, often near water. Breed in open areas with friable, often sandy soil, good visibility, convenient perches and often near wetlands. Nests in embankments including creeks, rivers and sand dunes. Insectivorous, most foraging is aerial, in clearings (Higgins 1999).	No	Moderate Potential to occur over the site on a seasonal basis, although breeding territory opportunities are unlikely.
<i>Monarcha melanopsis</i>	Black-faced Monarch		M	Occurs in rainforests, eucalypt woodlands, coastal scrubs, damp gullies in rainforest, eucalypt forest and in more open woodland when migrating (Pizzey & Knight 1997).	Yes	Low. Preferred habitat not present

Scientific name	Common name	TSC Act ¹	EPBC Act ²	Preferred habitat	Survey timing appropriate for detection ³	Likelihood of occurrence within the site ⁴
<i>Myiagra cyanoleuca</i>	Satin Flycatcher		M	Occurs in heavily vegetated gullies, in forests and taller woodlands. During migration it is found in coastal forests, woodlands, mangroves, trees in open country and gardens (Pizzey & Knight 1997).	Yes	Low. Preferred habitat not present
<i>Neophema pulchella</i>	Turquoise Parrot	V		Occurs in the foothills of the great dividing range in eucalypt woodlands and forests with a grassy or sparsely shrubby understorey. Nests in hollows in trees, stumps or even fence posts. It feeds on seeds of both native and introduced grass and herb species (Garnett & Crowley 2000).	Yes	Low. Preferred habitat not present
<i>Ninox connivens</i>	Barking Owl	V		Occurs in dry sclerophyll woodland. In the south west it is often associated with riparian vegetation while in the south-east it generally occurs on forest edges. It nests in large hollows in live eucalypts, often near open country. It feeds on insects in the non-breeding season and on birds and mammals in the breeding season (Garnett & Crowley 2000).	Yes	Low. Preferred habitat not present
<i>Ninox strenua</i>	Powerful Owl	V		A sedentary species with a home range of approximately 1000 hectares it occurs within open eucalypt, casuarina or callitris pine forest and woodland. It often roosts in denser vegetation including rainforest or exotic pine plantations. Generally feeds on medium-sized mammals such as possums and gliders but will also eat birds, flying-foxes, rats and insects. Prey are generally hollow dwelling and require a shrub layer and owls are more often found in areas with more old trees and hollows than average stands (Garnett & Crowley 2000).	Yes	Low. Preferred habitat not present
<i>Numenius madagascariensis</i>	Eastern Curlew		M	Inhabits coastal estuaries, mangroves, mud flats and sand pits. It is a migratory shorebird which generally inhabits sea and lake shore mud flats, deltas and similar areas, where it forages for crabs and other crustaceans, clam worms and other annelids, molluscs, insects and whatever else it can dig out of the mud with its long, downward-turned bill. Its migration route ranges from its wintering grounds in Australia to its breeding grounds in northern China, Korea and Russia (Pizzey & Knight 1997).	No	Moderate Potential to occur within the site on a seasonal basis.
<i>Numenius minutus</i>	Little Curlew		M	Often observed in large numbers in the north of Australia, but mostly as vagrant individuals further south (Pizzey & Knight 2007). Visits Australian habitats during the northern winter. In contrast to many shorebird species it is often encountered on open grassy plains, both natural and artificial (football ovals airfields etc.) (Higgins & Davies 1997). Prefers shortly grassed or bare habitats, including bare mud around lakes, dams, salt flats and more rarely beaches. Usually associated with open areas with some water, but generally avoids excessively dry or flooded habitats (Higgins & Davies 1997).	No	Moderate Potential to occur within the site on a seasonal basis.
<i>Numenius phaeopus</i>	Whimbrel		M	Migrates to Taiwan, Philippines, PNG, and a race breeding in NE Siberia is found on the north and south-eastern coastlines of Australia. Juveniles arrive to Australia from spring to early summer. Usually only juveniles remain in Australia but very occasionally adults in breeding plumage may be seen in Australian winters (Pizzey & Knight 1997).	No	Moderate Potential to occur within the site on a seasonal basis.
<i>Oxyura australis</i>	Blue-billed Duck	V		Relatively sparse throughout species range. Regularly found breeding in south-east Queensland, north-east South Australia and throughout New South Wales. Found on temperate, fresh to saline, terrestrial wetlands, and occupies artificial wetlands. Prefers deep permanent open water, within or near dense vegetation. Nest in rushes, sedge, Lignum <i>Muehlenbeckia cunninghamii</i> and paperbark Melaleuca (Garnett & Crowley 2000).	Yes	Low. Preferred habitat not present

Scientific name	Common name	TSC Act ¹	EPBC Act ²	Preferred habitat	Survey timing appropriate for detection ³	Likelihood of occurrence within the site ⁴
<i>Pandion cristatus</i>	Eastern Osprey	V	M	<p>Eastern Ospreys occur in littoral and coastal habitats and terrestrial wetlands of tropical and temperate Australia and offshore islands. They are mostly found in coastal areas but occasionally travel inland along major rivers, particularly in northern Australia (Johnstone & Storr 1998; Marchant & Higgins 1993; Olsen 1995). They require extensive areas of open fresh, brackish or saline water for foraging (Marchant & Higgins 1993). They frequent a variety of wetland habitats including inshore waters, reefs, bays, coastal cliffs, beaches, estuaries, mangrove swamps, broad rivers, reservoirs and large lakes and waterholes (Czechura 1985; Domm 1977; Fleming 1987; Gosper 1983; Gosper & Holmes 2002; Johnstone & Storr 1998; Olsen 1995; Roberts & Ingram 1976). They exhibit a preference for coastal cliffs and elevated islands in some parts of their range (Boekel 1976; Domm 1977), but may also occur on low sandy, muddy or rocky shores and over coral cays (Marchant & Higgins 1993). They may occur over atypical habitats such as heath, woodland or forest when travelling to and from foraging sites (Czechura 1985; Hembrow 1988; Pruett-Jones & O'Donnell 2004; Roberts & Ingram 1976).</p> <p>Eastern Ospreys occur sympatrically and sometimes interact with White-bellied Sea-Eagles (Barrett et al. 2003; Clancy 2006; Dennis & Baxter 2006; Kennard & Kennard 2006), which is also listed as Marine and Migratory under the EPBC Act (Department of Sustainability Environment Water Population and Communities 2011a)</p>	Yes	Low. Preferred habitat not present
<i>Petroica boodang</i>	Scarlet Robin	V		<p>In NSW, the Scarlet Robin occupies open forests and woodlands from the coast to the inland slopes. Some dispersing birds may appear in autumn or winter on the eastern fringe of the inland plains. It prefers an open understorey of shrubs and grasses and sometimes in open areas. Abundant logs and coarse woody debris are important structural components of its habitat. In autumn and winter it migrates to more open habitats such as grassy open woodland or paddocks with scattered trees. It forages from low perches, feeding on invertebrates taken from the ground, tree trunks, logs and other coarse woody debris (Department of Environment Climate Change and Water 2010a; Higgins & Peter 2002).</p>	Yes	Low. Preferred habitat not present
<i>Pluvialis fulva</i>	Pacific Golden Plover		M	<p>Prefers sandy, muddy or rocky shores, estuaries and lagoons, reefs, saltmarsh, and or short grass in paddocks and crops. The species is usually coastal, including offshore islands; rarely far inland. Often observed on beaches and mudflats, sandflats and occasionally rock shelves, or where these substrates intermingle; harbours, estuaries and lagoons (Marchant & Higgins 1993).</p>	Yes	Moderate Potential to occur within the site on seasonal basis.
<i>Pluvialis squatarola</i>	Grey Plover		M	<p>An estuarine frequenting migratory shorebird, rarely venturing inland. Preferred habitats are a variety of intertidal shores, often on large sandy or muddy flats, but also occurring on rock platforms (Marchant & Higgins 1993).</p>	No	Low. Preferred habitat not present
<i>Pomatostomus temporalis</i>	Grey-crowned Babbler	V		<p>Found throughout western slopes and plains, southern and central tablelands and occurring in Northern Rivers area, mid-north coast and the Hunter Valley of NSW. Lives in open forest and woodland, acacia shrubland and adjoining farmland. Large stick dome nest with spout-like entrance (Pizzey & Knight 1997).</p>	Yes	Low. Preferred habitat not present
<i>Pterodroma leucoptera</i>	Gould's Petrel	V	EM	<p>A marine species, it nests on islands among rocks and debris of Cabbage Tree Palms. It feeds on fish, cephalopods and other marine animals (Garnett & Crowley 2000).</p>	Yes	Low. Preferred habitat not present
<i>Ptilinopus regina</i>	Rose-crowned Fruit-Dove	V		<p>Occurs in subtropical and dry rainforests and occasionally in moist eucalypt forests and swamp forests where fruit is plentiful. They are thought to move locally as they follow the ripening fruit (NSW National Parks and Wildlife Service 2002).</p>	Yes	Low. Preferred habitat not present

Scientific name	Common name	TSC Act ¹	EPBC Act ²	Preferred habitat	Survey timing appropriate for detection ³	Likelihood of occurrence within the site ⁴
<i>Pyrholaemus sagittatus</i>	Speckled Warbler	V		Occurs in a wide range of eucalypt dominated vegetation with a grassy understorey and is often found on rocky ridges or in gullies. It feeds on seeds and insects and builds domed nests on the ground (Garnett & Crowley 2000).	Yes	Low. Preferred habitat not present
<i>Rhipidura rufifrons</i>	Rufous Fantail		M		No	Moderate Potential to occur within the site on seasonal basis.
<i>Rostratula australis</i>	Australian Painted Snipe	E1	VM	Inhabits shallow, vegetated, temporary or infrequently filled wetlands, including where there are trees such as <i>Eucalyptus camaldulensis</i> (River Red Gum), <i>E. populnea</i> (Poplar Box) or shrubs such as <i>Muehlenbeckia florulenta</i> (Lignum) or <i>Sarcocornia quinqueflora</i> (Samphire). Feeds at the water's edge and on mudflats on seeds and invertebrates, including insects, worms, molluscs and crustaceans. Males incubate eggs in a shallow scrape nest (Garnett & Crowley 2000).	Yes	Moderate. May occur intermittently in onsite wetlands
<i>Sterna albifrons</i>	Little Tern	E1	M	A coastal species found along the coast of New South Wales. They nest between the high tide mark and shore vegetation on undisturbed and unvegetated sites near estuaries and adjacent freshwater lakes. They feed on fish taken from inshore waters (Garnett & Crowley 2000).	Yes	Low. Preferred habitat not present
<i>Stictonetta naevosa</i>	Freckled Duck	V		In most years this species appear to be nomadic between ephemeral inland wetlands. In dry years they congregate on permanent wetlands while in wet years they breed prolifically and disperse widely, generally towards the coast. In inland eastern Australia, they generally occur in brackish to hypo-saline wetlands that are densely vegetated with Lignum (<i>Muehlenbeckia cunninghamii</i>) within which they build their nests (Garnett & Crowley 2000).	Yes	Low. Preferred habitat not present
<i>Tumix maculosa</i>	Red-backed Button-quail	V		The Red-backed Button-quail is a cryptic species and its specific ecology is poorly documented. The species is nocturnal and crepuscular and feeds on insects and seeds. They normally hide and freeze rather than flushing, although individuals will fly for short distances before dropping back to cover. Red-backed Button-quail may be encountered individually, in pairs or in small family groups. Red-backed Button-quail inhabit grasslands, woodlands and cropped lands of warm temperate areas that annually receive 400 mm or more of summer rain. Observations of populations in other parts of its range suggest the species prefers sites near water, including grasslands and sedgeland near creeks, swamps and springs, and wetlands. Red-backed Button-quail usually breed in dense grass near water, and nests are made in a shallow depression sparsely lined with grass and ground litter (Marchant & Higgins 1993).	Yes	Moderate. Potential habitat recorded in the Study Area.
<i>Tringa stagnatilis</i>	Marsh Sandpiper		M	Occurs in coastal and inland wetlands (salt or fresh water), estuarine and mangrove mudflats, beaches, shallow or swamps, lakes, billabongs, temporary floodwaters, sewage farms and saltworks ponds (Morcombe 2003).	No	Moderate Potential to occur within the site on seasonal basis.
<i>Tyto longimembris</i>	Grass Owl	V		Occurs in floodplain grasslands, including swampy areas and tussock grasslands. Known to inhabit treeless plains and those traversed by treed water courses (Higgins 1999). Mostly occurring coastally in NSW, although inland records and coastal population fluctuations suggest coastal populations may disperse inland in response to inland rodent plagues (Higgins 1999)	Yes	Moderate. Potential habitat recorded in the Study Area.

Scientific name	Common name	TSC Act ¹	EPBC Act ²	Preferred habitat	Survey timing appropriate for detection ³	Likelihood of occurrence within the site ⁴
<i>Tyto novaehollandiae</i>	Masked Owl	V		Occurs within a diverse range of wooded habitats including forests, remnants and almost treeless inland plains. This species requires large-hollow bearing trees for roosting and nesting and nearby open areas for foraging. They typically prey on terrestrial mammals including rodents and marsupials but will also take other species opportunistically. Also known to occasionally roost and nest in caves (Garnett & Crowley 2000).	Yes	Low. Preferred habitat not present.
<i>Xenus cinereus</i>	Terek Sandpiper	V	M	Found on tidal mudflats and estuaries and on shores and reefs of offshore islands (Pizzey & Knight 2007).	Yes	Low. Preferred habitat not present
Mammals						
<i>Chalinolobus dwyeri</i>	Large-eared Pied Bat	V	V	Occurs in moderately wooded habitats and roosts in caves, mine tunnels and the abandoned, bottle-shaped mud nests of Fairy Martins. Thought to forage below the forest canopy for small flying insects (Churchill 2008).	Yes	Low. Preferred habitat not present.
<i>Dasyurus maculatus maculatus</i>	Spotted-tailed Quoll (SE mainland population)	V	E	<p>The Spotted-tailed Quoll has a preference for mature wet forest habitat (Belcher 2000b; Green & Scarborough 1990; Watt 1993), especially in areas with rainfall 600 mm/year (Edgar & Belcher 2008; Mansergh 1984). Unlogged forest or forest that has been less disturbed by timber harvesting is also preferable (Catling et al. 1998, 2000). This subspecies has been recorded from a wide range of habitats, including: temperate and subtropical rainforests in mountain areas, wet sclerophyll forest, lowland forests, open and closed eucalypt woodlands, inland riparian and River Red Gum (<i>Eucalyptus camaldulensis</i>) forests, dry 'rain-shadow' woodland, sub-alpine woodlands, coastal heathlands. Occasional sightings from open country, grazing lands, rocky outcrops and other treeless areas (Edgar & Belcher 2008; Green & Scarborough 1990; Jones & Mansergh 1995a; Maxwell et al. 1996; NSW NPWS 1999; Reside 1997 cited in Dawson 2005; Rose 1996 cited in Dawson 2005).</p> <p>Belcher (2000b) observed that Spotted-tailed Quolls at Suggan Buggan used escarpment and gully habitats. Possum, rat and antechinus scats were observed on the cliffs, rock ledges and outcrops along the escarpment suggesting that it was a prey-rich habitat. The gullies utilised by Spot-tailed Quolls featured an abundance of Rabbits (<i>Oryctolagus cuniculus</i>) and possums (Belcher 2000b) (Department of the Environment Water Heritage and the Arts 2010).</p>	Yes	Low. Preferred habitat not present.
<i>Falsistrellus tasmaniensis</i>	Eastern False Pipistrelle	V		Usually roosts in tree hollows in higher rainfall forests. Sometimes found in caves (Jenolan area) and abandoned buildings. Forages within the canopy of dry sclerophyll forest. It prefers wet habitats where trees are more than 20 metres high (Churchill 2008).	Yes	Moderate. Potential habitat present.
<i>Miniopterus australis</i>	Little Bent-wing Bat	V		Feeds on small insects beneath the canopy of well-timbered habitats including rainforest, Melaleuca swamps and dry sclerophyll forests. Roosts in caves and tunnels and has specific requirements for nursery sites. Distribution tends more coastal towards the southern limit of its range in NSW. Nesting sites are in areas where limestone mining is preferred (Strahan 1995).	Yes	Moderate. Potential habitat present.

Scientific name	Common name	TSC Act ¹	EPBC Act ²	Preferred habitat	Survey timing appropriate for detection ³	Likelihood of occurrence within the site ⁴
<i>Miniopterus schreibersii oceanensis</i>	Eastern Bentwing-bat	V		Caves are the primary roosting habitat, but also use derelict mines, storm-water tunnels, buildings and other man-made structures. These bats form discrete populations centred on a maternity cave that is used annually in spring and summer for the birth and rearing of young. The maternity caves have very specific temperature and humidity regimes. At other times of the year, populations disperse within about 300 km range of maternity caves. Cold caves are used for hibernation in southern Australia. Breeding or roosting colonies can number from 100 to 150,000 individuals. Hunt in forested areas, catching moths and other flying insects above the tree tops (Department of Environment and Conservation 2005c).	Yes	Moderate. Potential habitat recorded in the Study Area.
<i>Mormopterus norfolkensis</i>	East-coast Freetail Bat	V		The East-coast Freetail Bat is found along the east coast from south Queensland to southern NSW. Occur in dry sclerophyll forest and woodland east of the Great Dividing Range. Roost mainly in tree hollows but will also roost under bark or in man-made structures (Churchill 2008).	Yes	Moderate. Potential habitat recorded in the Study Area.
<i>Myotis macropus</i>	Southern Myotis	V		Generally roost in groups of 10 - 15 close to water in caves, mine shafts, hollow-bearing trees, storm-water channels, buildings, under bridges and in dense foliage. Forage over streams and pools catching insects and small fish by raking their feet across the water surface. In NSW females have one young each year usually in November or December (Department of Environment and Conservation (NSW) 2005).	Yes	Moderate. Potential habitat recorded in the Study Area.
<i>Petaurus norfolkensis</i>	Squirrel Glider	V		Found in dry sclerophyll forest and woodland but not found in dense coastal ranges. Nests in hollows and feeds on gum of acacias, eucalypt sap and invertebrates (NSW National Parks and Wildlife Service 1999e).	Yes	Low. Small linear strips of potential habitat in Study Area, but distantly isolated from other potential habitat.
<i>Petrogale penicillata</i>	Brush-tailed Rock-wallaby	E1	V	Occurs in inland and sub-coastal south eastern Australia where it inhabits rock slopes. It has a preference for rocks which receive sunlight for a considerable part of the day. Windblown caves, rock cracks or tumbled boulders are used for shelter. Occur in small groups or "colonies" each usually separated by hundreds of metres (NSW National Parks and Wildlife Service 2003a).	Yes	Low. Preferred habitat not present.
<i>Phascogale tapoatafa</i>	Brush-tailed Phascogale	V		Largely arboreal it occurs in a range of habitats which have reliable rainfall (500-2000mm), but has preference for open dry sclerophyll forest on ridges (up to 600 m alt) with little/sparse ground cover. It nests in tree hollows and feeds at dusk on arthropods and small vertebrates (Strahan 1995).	Yes	Low. Preferred habitat not present.

Scientific name	Common name	TSC Act ¹	EPBC Act ²	Preferred habitat	Survey timing appropriate for detection ³	Likelihood of occurrence within the site ⁴
<i>Phascolarctos cinereus</i>	Koala	V		Found in sclerophyll forest. Throughout New South Wales, Koalas have been observed to feed on the leaves of approximately 70 species of eucalypt and 30 non-eucalypt species. However, in any one area, Koalas will feed almost exclusively on a small number of preferred species. The preferred tree species vary widely on a regional and local basis. Some preferred species in NSW include <i>Eucalyptus tereticornis</i> (Forest Red Gum), <i>E. punctata</i> (Grey Gum), <i>E. cypellocarpa</i> (Monkey Gum) and <i>E. viminalis</i> (Ribbon Gum). In coastal areas, <i>E. microcorys</i> (Tallowwood) and <i>E. robusta</i> (Swamp Mahogany) are important food species, while in inland areas <i>E. albens</i> (White Box), <i>E. populnea</i> (Bimble Box) and <i>E. camaldulensis</i> (River Red Gum) are favoured (NSW National Parks and Wildlife Service 1999d, 2003c).	Yes	Low. Potential habitat in Study Area, but isolated from main population to the north-east by Hunter River, Pacific Highway and rail corridor. Isolated from potential population to the west by Hexham floodplain.
<i>Potorous tridactylus tridactylus</i>	Long-nosed Potoroo (SE Mainland)	V	V	The Long-nosed Potoroo (SE Mainland) is sparsely distributed along the coast and Great Dividing Range of south-east Queensland through NSW (Van Dyck & Strahan 2008). There is limited information about the species habitat in Queensland and NSW. There is no consistent pattern to the habitat of the Long-nosed Potoroo (SE Mainland); it can be found in wet eucalypt forests (Seebeck 1995b) to coastal heaths and scrubs (Mason 1997). The main factors would appear to be access to some form of dense vegetation for shelter (Bennett 1987) and the presence of an abundant supply of fungi for food (Claridge et al. 1992) (Department of Sustainability Environment Water Population and Communities 2011b).	Yes	Low. Preferred habitat not present
<i>Pseudomys gracilicaudatus</i>	Eastern Chestnut Mouse	V		The species is mostly found, in low numbers, in heathland and is most common in dense, wet heath and swamps. In the tropics it is more an animal of grassy woodlands. Optimal habitat appears to be in vigorously regenerating heathland burnt from 18 months to four years previously. By the time the heath is mature, the larger Swamp Rat becomes dominant, and Eastern Chestnut Mouse numbers drop again (Strahan 1995).	Yes	Low. Preferred habitat not present
<i>Pseudomys novaehollandiae</i>	New Holland Mouse	V		The New Holland Mouse is a small, burrowing native rodent. The species is similar in size and appearance to the introduced house mouse (<i>Mus musculus</i>), although it can be distinguished by its slightly larger ears and eyes, the absence of a notch on the upper incisors and the absence of a distinctive 'mousy' odour. Known to inhabit open heathlands, open woodlands with a heathland understorey, and vegetated sand dunes (Threatened Species Scientific Committee 2010).	Yes	Low. Preferred habitat not present
<i>Pteropus poliocephalus</i>	Grey-headed Flying-fox	V	V	Occurs in subtropical and temperate rainforests, tall sclerophyll forests and woodlands, heaths and swamps. Urban gardens and cultivated fruit crops also provide habitat for this species. Feeds on the flowers and nectar of eucalypts and native fruits including lilly pillies. It roosts in the branches of large trees in forests or mangroves (Churchill 2008; NSW National Parks and Wildlife Service 2001)	Yes	Recorded.
<i>Saccolaimus flaviventris</i>	Yellow-bellied Sheathtail Bat	V		Occurs in eucalypt forest where it feeds above the canopy and in mallee or open country where it feeds closer to the ground. Generally a solitary species but sometimes found in colonies of up to 10. It roosts in tree hollows. Thought to be a migratory species (Churchill 2008).	Yes	Moderate. Potential habitat recorded in the Study Area.

Scientific name	Common name	TSC Act ¹	EPBC Act ²	Preferred habitat	Survey timing appropriate for detection ³	Likelihood of occurrence within the site ⁴
<i>Scoteanax rueppellii</i>	Greater Broad-nosed Bat	V		The preferred hunting areas of this species include tree-lined creeks and the ecotone of woodlands and cleared paddocks but it may also forage in rainforest. Typically it forages at a height of 3-6 metres but may fly as low as one metre above the surface of a creek. It feeds on beetles, other large, slow-flying insects and small vertebrates. It generally roosts in tree hollows but has also been found in the roof spaces of old buildings (Churchill 2008)	Yes	Moderate. Potential habitat recorded in the Study Area.

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Appendix E

Significance assessments

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1. Significance assessments introduction

Three Endangered Ecological Communities, two threat-listed plants and 26 threat-listed animals listed under state or Commonwealth legislation were either recorded in the Project Area or identified as having moderate to high likelihood of occurrence. Consequently, assessments of the significance of impacts for these species and communities have been completed.

The proposed Project will be assessed under Part 5.1 of the *Environmental Planning & Assessment Act 1979* (EP&A Act). While Part 5.1 of the EP&A Act does not make specific reference to Section 5A of the EP&A Act (the 7 part test) the DGRs have requested that impacts on threatened species, populations and communities be assessed against Section 5A of the EP&A Act with guidance from the Threatened Species Assessment Guideline – The Assessment of Significance (Department of Environment and Climate Change 2007). The outcome of these assessments are therefore used to determine the level of significance of the impacts, but not to determine the need for a Species Impact Statement, which do not form part of the Part 5.1 approvals.

For Threatened biodiversity listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) significance assessments have been completed in accordance with the Matters of National Environmental Significance, Significant Impact Guidelines 1.1 (Department of the Environment Water Heritage and the Arts 2009a).

Species listed under both the TSC Act and the EPBC Act have been assessed using both assessment guidelines separately.

Name	Conservation status ¹		Outcome of assessment	
	State	National	State	National
Ecological communities				
Freshwater Wetlands on Coastal Floodplains	E	-	Not significant	-
Swamp Oak Floodplain Forest on Coastal Floodplains	E	-	Not significant	-
Swamp Sclerophyll Forest on Coastal Floodplains	E	-	Not significant	-
Threat-listed plants				
<i>Maundia triglochinosoides</i>	V	-	Not significant	-
<i>Persicaria elatior</i>	V	V	Not significant	Not significant
<i>Zannichellia palustris</i>	V	-	Not significant	-
Threat-listed animals				
Green and Bell Frog	E	V	Not significant	Not significant
Eastern Grass Owl	V	-	Not significant	-
Varied Sittella	V	-	Not significant	-
White-fronted Chat	V	-	Not significant	-
Threat-listed aquatic birds				
Black-necked Stork	E	-	Not significant	-
Magpie Goose	V	-	Not significant	-
Australasian Bittern	E	E	Not significant	Not significant

Name	Conservation status ¹		Outcome of assessment	
	State	National	State	National
Black Bittern	V	-	Not significant	-
Australian Painted Snipe	E	VM	Not significant	Not significant
Threat-listed waders				
Great Knot	V	-	Not significant	-
Greater Sand Plover	V	-	Not significant	-
Broad-billed Sandpiper	V	-	Not significant	-
Black-tailed Godwit	V	-	Not significant	-
Lesser Sand Plover	V	-	Not significant	-
Threat-listed raptors				
Spotted Harrier	V	-	Not significant	-
Little Eagle	V	-	Not significant	-
Threat-listed Opportunistic Blossom Nomads				
Swift Parrot	E	E	Not significant	Not significant
Little Lorikeet	V	-	Not significant	-
Grey-headed Flying-fox	V	V	Not significant	Not significant
Hollow-dwelling Microchiropteran Bats				
Eastern False Pipistrelle	V	-	Not significant	-
Eastern Free-tail bat	V	-	Not significant	-
Yellow-bellied Sheath-tail Bat	V	-	Not significant	-
Greater Broad-nosed Bat	V	-	Not significant	-
Cave-dwelling Microchiropteran Bats				
Little Bent-wing Bat	V	-	Not significant	-
Eastern Bent-wing Bat	V	-	Not significant	-
Large-footed Myotis	V	-	Not significant	-

1. State conservation status. E = Endangered, V = Vulnerable, National E = Endangered, V = Vulnerable for plants, animals and ecological communities (EPBC Act), M = Migratory.

2. Freshwater Wetlands on coastal floodplains

Status

Freshwater Wetlands on coastal floodplains of the NSW north coast, Sydney Basin and South East Corner Bioregions is listed as an Endangered Ecological Community under the TSC Act.

Description

The structure and floristic composition of freshwater wetlands varies depending upon the water regime. The water regimes can vary in frequency, duration, depth of waterlogging and may be influenced by level of nutrients and salinity of the water in the substrate. The floristic structure of the community varies from sedgeland and reedland to herbfields, and woody species of plant are generally scarce (NSW Scientific Committee 2004a).

Ephemeral wetlands are usually dominated by grassland or sedgeland vegetation often less than 0.5 m in height. These ephemeral wetlands are usually dominated by *Paspalum distichum*, *Leersia hexandra*, *Pseudoraphis spinescens* and *Carex appressa*. Wetlands that are subject to regular inundation and drying the vegetation includes emergent species to over 1 m tall and include *Baumea articulata*, *Eleocharis equisetina* and *Lepironia articulata*. Floating and emergent herbs such as *Hydrocharis dubia*, *Philydrum lanuginosum*, *Ludwigia peploides* subsp. *montevidensis*, *Marsilea mutica* and *Myriophyllum* spp. also occur in this type of wetland. In wetlands that contain deeper or more permanent water emergent species become less dominant with floating and submerged aquatic herbs being more common. These species include: *Azolla filiculoides* var. *rubra*, *Ceratophyllum demersum*, *Hydrilla verticillata*, *Lemna* spp., *Nymphaea gigantea*, *Nymphoides indica*, *Ottelia ovalifolia* and *Potamogeton* spp. (Department of Environment and Conservation 2005).

Habitat

Freshwater wetlands occur in depressions, flats, drainage lines, back swamps, lagoons and lakes associated with low lying parts of coastal floodplains. This community can also occur in backbarrier landforms where floodplains adjoin coastal sandplains. This community generally occurs below 20 m in elevation and typically forms mosaics with other floodplain communities, and often include ephemeral or semi-permanent standing water. Freshwater wetlands can occur in either saline or fresh water depending upon the position in the landscape (NSW Department of Environment and Conservation 2005; NSW Scientific Committee 2004a).

Distribution

Freshwater wetland occurs on the majority of the New South Wales coast. Distribution occurs generally from Bega in the south to the Tweed in the north. It is estimated that there is less than 60-90% of its original extent now remains (NSW Scientific Committee 2004a).

Ecology

Associated with silts, mud or humic loams in depressions, flats, drainage lines, back swamps, lagoons and lakes associated with coastal floodplains. These floodplains are level landform patterns on which there may be active erosion and aggradation by channelled and

overbank stream flow with an average recurrence interval of 100 years or less (NSW Scientific Committee 2004a).

Threats

Recognised threats (Department of Environment and Conservation 2005) to this community include:

- land clearing
- continuing fragmentation and degradation
- flood mitigation and drainage works
- filling associated with urban and industrial development
- pollution and eutrophication from urban and agricultural runoff
- grazing and trampling by stock and feral animals (particularly pigs)
- weed invasion
- over grazing, trampling by livestock
- soil disturbance by pigs
- activation of acid sulfate soils
- dumping of landfill, rubbish and garden refuse
- native fauna is threatened by predation, particularly by mosquito fish and cane toads
- anthropogenic climate change.

Recovery actions

The following recovery actions have been recommended (Department of Environment and Conservation 2005) to help recover and conserve this endangered ecological community:

- instigate enforcement and education campaigns to reduce dumping
- instigate pig control programs
- install stormwater control mechanisms to prevent off-site impacts from adjacent development
- control access of cattle to wetlands by installing fencing
- undertake weed control as required using removal methods that will not damage the community
- protect and actively manage wetlands through conservation mechanisms such as convenanting and the preparation/implementation of site specific vegetation management plans

- restore natural drainage conditions.

Specific impacts

The *Phragmites australis* and *Typha orientalis* Coastal Freshwater Wetland vegetation community described within the study area is commensurate with the endangered ecological community of Freshwater Wetlands on coastal floodplains. This community occurs in several fragmented patches throughout the study area. The proposed Project may impact upon 1.89 ha of this community from direct removal and indirect effects such as weed invasion and sedimentation from runoff, into the remaining areas of this community.

2.1 TSC Act significance assessment

In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable

In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable

In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

- (i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or**

The proposed Project will remove approximately 1.89 ha of this vegetation community. This community is highly disturbed from modifications to the soil profile as a result of the study area being the site of a coal loader in the late 1970's. In addition, some areas of this vegetation community have been modified from current and past grazing activities. Freshwater wetlands occur to the east at the Kooragang Island, as part of the Hunter Estuary Wetlands (which is listed as a RAMSAR Wetland). The removal of a small area of degraded and modified area of this community is unlikely to significantly impact upon this community within the region or the locality. Therefore the proposed Project is unlikely to affect a significant proportion of the community such that its local occurrence is likely to be placed at risk of extinction.

- (ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction**

The Freshwater Wetlands are currently adjoining existing pasture areas and disturbed areas within the rail corridor and are subject to high weed invasions from pastures weeds, exotic grasses and Giant Reed. In addition, the Freshwater Wetlands to be impacted upon are currently fragmented and highly disturbed from soil profile modification and weed incursions. The Proposed Project has the potential to introduce edge effects into new areas, due to the new rail alignment. However the impacts are unlikely to significantly increase edge effects or

weed invasion due to its current condition and implementation of mitigation measures, such as weed control and sediment control measures are implemented to minimise further spread of weeds. The Proposed Project is therefore, unlikely to substantially modify the community's composition or put its local occurrence at risk of extinction.

In relation to the habitat of a threatened species, population or ecological community:

(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The project will remove approximately 1.89 ha of this community. Over 3,500 ha of this community occur along the floodplains of the Hunter River, including the Ramsar Wetland of Hunter Estuary Wetlands (encompassing over 2,900 ha) to the east of the project and Hexham Swamp Nature Reserve located to the west of the proposed Project (covering over 900 ha). The removal of approximately 1.89 ha of Freshwater Wetland would not significantly affect the habitat and ecosystem function of this community occurring along the Hunter River and its' floodplain in the locality. Furthermore 3,900 ha of freshwater wetlands habitat occur within the Lower Hunter Region (Lower Hunter and Central Coast Regional Environmental Management Strategy 2003) and the area that is proposed to be removed represents a small percentage (0.05%) of this available habitat.

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The Proposed Project would involve the removal of approximately 1.89 ha of this community. This will occur as a linear strip along the rail corridor and while the construction of the Proposed Project is likely widen the gap between already fragmented patches of this community it will not further fragment any existing areas of this community.

The Proposed Project would not further inhibit movement of ground dwelling fauna than is already occurring from the existing rail corridor. Mobile species including birds, microbats and insects would also easily traverse the easement. Pollination and seed dispersal agents including birds, insects and wind would also continue to operate across the rail corridor.

Therefore, it is unlikely that this community will become further isolated or fragmented from other areas of this community as a result of the proposed Project.

The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality

The area of this community that will be impacted upon is small (<0.06% in the locality and <0.05% in the wider region), and is highly disturbed from previous rail construction works and weed invasions. The removal of this community will occur as a linear strip and will not further isolate or fragment existing areas of this community. The proposed Project will not further inhibit movement of ground dwelling fauna than is already occurring from the existing rail corridor. Mobile species including birds, microbats and insects would also easily traverse the easement. Pollination and seed dispersal agents including birds, insects and wind would also continue to operate across the easement.

Therefore the small area of this community that will be impacted upon is unlikely to be important for the long term survival of community in the locality or the wider region.

Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations and ecological communities. Under the *Threatened Species Conservation Act 1995*, the Director-General maintains a register of critical habitat. To date, no critical habitat has been declared for this community. There is no critical habitat listed for this community and the areas of impact are not considered to be critical to the survival of this community.

Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

A Recovery plan has not been prepared for this community the under the TSC Act. The Office of the Environment and Heritage has identified 13 priority actions to direct recovery for this community (Refer Table 2-1). None of these recovery actions will be affected by the proposed Project.

Table 2-1 Recovery strategies for Freshwater Wetlands

Recovery strategy	Priority actions	Likely to be affected by the proposal
Recovery strategy 1: Captive Husbandry or ex-situ collection/propagation	Collect seed for NSW Seedbank. Develop collection program in collaboration with BGT - all known provenances (conservation collection).	No
	Investigate seed viability, germination, dormancy and longevity (in natural environment and in storage).	No
Recovery strategy 2: Community and land-holder liaison/ awareness and/or education	Liaise with community to improve recognition of values and encourage landholder participation in site management including weed control.	No
	Liaise with landholders and undertake and promote programs that ameliorate threats such as grazing and human disturbance.	No
Recovery strategy 3: Habitat management: feral control	Undertake control of feral pigs and horses at identified key sites.	No
Recovery strategy 4: Habitat management: Ongoing EIA - Advice to consent and planning authorities	Prepare identification and impact assessment guidelines and distribute to consent and determining authorities.	No
Recovery strategy 5: Habitat management: site protection (fencing/signage)	Identify and prioritise other specific threats and undertake appropriate on-ground site management strategies where required.	No
Recovery strategy 6: Habitat management: Weed Control	Undertake weed control for Bitou Bush and Boneseed at priority sites in accordance with the approved Threat Abatement Plan and associated PAS actions.	No
Recovery strategy 7: Habitat Protection (inc vca/ jma/ critical habitat nomination etc)	Use mechanisms such as Voluntary Conservation Agreements to promote the protection of this EEC on private land.	No
	Investigate acquisition of property that contains this EEC to complement and expand on existing areas reserved.	No
Recovery strategy 8: Monitoring	Collate existing information on vegetation mapping and associated data for this EEC and identify gaps in knowledge. Conduct targeted field surveys and ground truthing to fill data gaps and clarify condition of remnants.	No

Recovery strategy	Priority actions	Likely to be affected by the proposal
Recovery strategy 9: Research	Determine location, species composition and threats to remaining remnants to assist with prioritising restoration works.	No
	Undertake research into environmental flows with a view to the restoration of natural flow regimes.	No

Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

Threatening process means a process that threatens, or may have the capability to threaten, the survival or evolutionary development of species, populations or ecological communities. Key threatening processes are listed under the Threatened Species Conservation Act 1995. At present there are 36 listed key threatening processes under the *Threatened Species Conservation Act 1995*.

The Proposed Project has the potential to contribute to six Key Threatening Processes listed under the TSC Act (see section 5.12). With respect to Freshwater Wetlands, the proposed Project is consistent with three Key Threatening Processes:

- clearing of native vegetation
- alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands clearing of native vegetation
- invasion of native plant communities by exotic perennial grasses.

This community is currently affected by weed invasions from *Pennisetum clandestinum* (exotic perennial grass). The Proposed Project may alter the wetlands from indirect effects such as sedimentation and erosion. If the mitigation measures outlined in Section 6 of the main report are adhered to it is not expected that the proposed Project is likely to exacerbate of the aforementioned Key Threatening Processes such that they are likely to significantly affect freshwater wetlands. No other Key Threatening Processes are likely to be significantly increased by the Proposed Project.

Conclusion

Approximately 3.46 ha of Freshwater Wetlands have been mapped within the Study Area and the Proposed Project will result in the removal of 1.89 ha of this community. However, given that approximately 2,900 ha within 10km of the study area 3,900 ha have been mapped within the wider region, the area that may be impacted upon is small (0.06% in the locality and 0.05% in the wider region) and disturbed and provided that the mitigation measures are followed, the Proposed Project is unlikely to have a significant impact on this community.

3. Swamp Oak Floodplain Forest

Status

Swamp Oak Floodplain Forest of the NSW North Coast, Sydney Basin and South East Corner bioregions is listed as an Endangered Ecological Community under the TSC Act.

Description

Swamp Oak Floodplain Forest is an ecological community dominated by *Casuarina glauca* that occurs on coastal floodplains along the entire NSW coast (North Coast, Sydney Basin and South East Corner bioregions) where the groundwater is saline or sub-saline and the soils are waterlogged or periodically inundated such as along drainage lines, lake margins and estuarine fringes (NSW Scientific Committee 2004b).

Other trees including *Acmena smithii*, *Glochidion* spp. and *Melaleuca* spp. may be present as subordinate species, and are found most frequently in stands of the community northwards from Gosford. Tree diversity decreases with latitude, and *Melaleuca ericifolia* is the only abundant tree in this community south of Bermagui.

The understorey is characterised by frequent occurrences of vines, *Parsonsia straminea*, *Geitonoplesium cymosum* and *Stephania japonica* var. *discolor*, a sparse cover of shrubs, and a continuous groundcover of forbs, sedges, grasses and leaf litter.

The composition of the ground stratum varies depending on levels of salinity in the groundwater. Under less saline conditions prominent ground layer plants include forbs such *Centella asiatica*, *Commelina cyanea*, *Persicaria decipiens* and *Viola banksii*; graminoids such as *Carex appressa*, *Gahnia clarkei*, *Lomandra longifolia*, *Oplismenus imbecillis*; and the fern *Hypolepis muelleri*.

On the fringes of coastal estuaries, where soils are more saline, the ground layer may include the threatened grass species, *Alexfloydia repens*, as well as *Baumea juncea*, *Juncus kraussii*, *Phragmites australis*, *Selliera radicans* and other saltmarsh species (Department of Environment and Conservation 2005).

Habitat

Swamp Oak Floodplain Forest occurs on waterlogged or periodically inundated flats, drainage lines, lake margins and estuarine fringes associated with coastal floodplains. This community generally occurs below 20 m (rarely above 10 m) elevation species (Department of Environment and Conservation 2005; NSW Scientific Committee 2004b).

Distribution

The extent of the Swamp Oak Floodplain Forest prior to European settlement has not been mapped across its entire range. However, the remaining area of Swamp Oak Floodplain Forest is likely to represent much less than 30% of its original range. Major occurrences include: less than 350 ha on the Tweed lowlands; less than 650 ha on the lower Clarence floodplain; less than 400 ha on the lower Macleay floodplain; less than 3,200 ha in the lower Hunter - central Hunter region; less than 5,200 ha in the Sydney - South Coast region; and less than 1,000 ha in the Eden region.

Small areas of Swamp Oak Floodplain Forest are contained within existing conservation reserves, including Stotts Island, Ukerebagh, Tuckean, Pambalong, Wamberal, Towra Point and Cullendulla Creek Nature Reserves and Bongil Bongil, Myall Lakes and Conjola National Parks. These occurrences are unevenly distributed throughout the range and unlikely to represent the full diversity of the community (Department of Environment and Conservation 2005; NSW Scientific Committee 2004b).

Ecology

Swamp Oak Floodplain Forest is associated with grey-black clay-loams and sandy loams, where the groundwater is saline or sub-saline, on waterlogged or periodically inundated flats, drainage lines, lake margins and estuarine fringes associated with coastal floodplains (Department of Environment and Conservation 2005; NSW Scientific Committee 2004b).

Threats

Recognised threats (Department of Environment and Conservation 2005) to this community include:

- clearing for urban and rural development, and the subsequent impacts from fragmentation
- flood mitigation and drainage works
- grazing and trampling by stock and feral animals (e.g. pigs)
- activation of acid sulfate soils
- landfilling and earthworks associated with urban and industrial development
- pollution from urban and agricultural runoff
- rubbish dumping
- climate change
- localised areas, particularly those within urbanised regions, may also be exposed to frequent burning which reduces the diversity of woody plant species

Recovery actions

The following recovery actions have been recommended (Department of Environment and Conservation 2005) to help recover and conserve this endangered ecological community:

- promote public involvement in restoration activities
- instigate pig control programs
- ensure that the fire sensitivity of the community is considered when planning hazard reduction and asset management burning
- protect habitat by minimising further clearing of the community
- promote regeneration by avoiding prolonged or heavy grazing

- weed control
- undertake restoration including bush regeneration and revegetation.

Specific impacts

One vegetation community Swamp Oak Swamp Forest Fringing Estuaries is commensurate with endangered ecological community of Swamp Oak Floodplain Forest on Coastal Floodplains, which occurred in the south and the north west of the study area. The proposed Project would include the clearing of 4.55 ha of this community within the study area.

3.1 TSC Act significance assessment

In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable

In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable

In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

- (i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction**

The proposed Project will remove approximately 4.55 ha of this vegetation community. This community is highly disturbed from modifications to the soil profile as a result of the study area being the site of a coal loader in the late 1970's. As a result this community is likely to be regrowth from previous clearing events and is highly modified from severe *Lantana camara** invasions. In addition, some areas of this vegetation community have been modified from current and past grazing activities. There are large areas of this community being mapped in the locality (582 ha) and wider region (2607 ha) (Lower Hunter and Central Coast Regional Environmental Management Strategy 2003). The removal of a small area of degraded and modified area of this community is unlikely to significantly impact upon this community within the region or the locality. Therefore the proposed Project is unlikely to affect a significant proportion of the community such that its local occurrence is likely to be placed at risk of extinction.

- (ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction**

The vegetation to be cleared is disturbed and subject to high levels of weed invasion from both *Lantana camara** and exotic pasture weeds. Its removal is unlikely to significantly increase edge effects or weed invasion due to its current condition and implementation of

mitigation measures, outlined in section 6 of the main report, to minimise further spread of weeds.

The removal of this small area of vegetation (4.55 ha) is unlikely to substantially modify the community's composition or put its local occurrence at risk of extinction.

In relation to the habitat of a threatened species, population or ecological community:

(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed

The project will remove approximately 4.55 ha of this community. Over 582 ha of this community has been mapped within a 10 km radius of the study area and the area proposed to be removed represents 0.8% within the locality. The removal of approximately 4.55 ha of Swamp Oak Floodplain Forest would not significantly affect the habitat and ecosystem function of this community occurring along the Hunter River and its' floodplain in the locality. Furthermore 2607 ha of Swamp Oak Floodplain Forest habitat occur within the Lower Hunter Region (Lower Hunter and Central Coast Regional Environmental Management Strategy 2003) and the area that is proposed to be removed represents a small percentage (0.8% in the locality and 0.2% in the wider region) of this available habitat.

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The Proposed Project would involve the removal of approximately 4.55 ha of this community. This will occur as a linear strip along the rail corridor and while the construction of the Proposed Project is likely widen the gap between already fragmented patches of this community it will not further fragment any existing areas of this community.

The Proposed Project would not further inhibit movement of ground dwelling fauna than is already occurring from the existing rail corridor. Mobile species including birds, microbats and insects would also easily traverse the easement. Pollination and seed dispersal agents including birds, insects and wind would also continue to operate across the rail corridor.

Therefore, it is unlikely that this community will become further isolated or fragmented from other areas of this community as a result of the proposed Project.

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

The area of this community that will be impacted upon is small (<0.2% wider region and 0.8% within the locality), and is highly disturbed from previous rail construction works and weed invasions, particularly from *Lantana camara** and exotic pasture weeds. The removal of this community will occur as a linear strip and will not further isolate or fragment existing areas of this community. The proposed Project will not further inhibit movement of ground dwelling fauna than is already occurring from the existing rail corridor. Mobile species including birds, microbats and insects would also easily traverse the easement. Pollination and seed dispersal agents including birds, insects and wind would also continue to operate across the easement.

Therefore the small area of this community that will be impacted upon is unlikely to be important for the long term survival of community in the locality or the wider region.

Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations and ecological communities. Under the *Threatened Species Conservation Act 1995*, the Director-General maintains a register of critical habitat. To date, no critical habitat has been declared for this community. There is no critical habitat listed for this community and the areas of impact are not considered to be critical to the survival of this community.

Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

A recovery plan has not been prepared for Swamp Oak Floodplain Forest.

The Office of Environment and Heritage has however identified 11 priority actions to help recover of Swamp Oak Floodplain Forest (Table 3-1). The proposed Project will not affect any of these actions.

Table 3-1 Recovery actions for Swamp Oak Floodplain Forest

Recovery Strategy	Priority Action	Likely to be affected by the proposal
Recovery strategy 1: Captive Husbandry or ex-situ collection/propagation	Collect seed for NSW Seedbank. Develop collection program in collaboration with BGT - all known provenances (conservation collection).	No
	Investigate seed viability, germination, dormancy and longevity (in natural environment and in storage).	No
Recovery strategy 2: Community and land-holder liaison/ awareness and/or education	Enhance the capacity of persons involved in the assessment of impacts on this EEC to ensure the best informed decisions are made.	No
	Liaise with landholders and undertake and promote programs that ameliorate threats such as grazing and human disturbance.	No
Recovery strategy 3: Habitat management: Fire	Implement appropriate fire management practices.	No
Recovery strategy 4: Habitat management: Ongoing EIA - Advice to consent and planning authorities	Prepare identification and impact assessment guidelines and distribute to consent and determining authorities.	No
Recovery strategy 5: Habitat management: Site Protection (e.g. Fencing/Signage)	Identify and prioritise other specific threats and undertake appropriate on-ground site management strategies where required.	No
Recovery strategy 6: Habitat management: Weed Control	Undertake weed control for Bitou Bush and Boneseed at priority sites in accordance with the approved Threat Abatement Plan and associated PAS actions.	No
Recovery strategy 7: Habitat Protection (inc vca/ jma/ critical habitat nomination etc)	Use mechanisms such as Voluntary Conservation Agreements to promote the protection of this EEC on private land.	No
Recovery strategy 8: Research	Undertake research to determine minimum fire frequency.	No

Recovery strategy 9: Survey/Mapping and Habitat assessment	Collate existing information on vegetation mapping and associated data for this EEC and identify gaps in knowledge. Conduct targeted field surveys and ground truthing to fill data gaps and clarify condition of remnants.	No
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Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

Threatening process means a process that threatens, or may have the capability to threaten, the survival or evolutionary development of species, populations or ecological communities. Key threatening processes are listed under the TSC Act. At present there are 36 listed key threatening processes under the TSC Act.

The proposed Project has the potential to contribute to six Key Threatening Processes (see section 5.12). With respect to Swamp Oak Floodplain Forest, the proposed Project is consistent with three Key Threatening Processes:

- clearing of native vegetation
- invasion, establishment and spread of *Lantana camara**
- invasion of native plant communities by exotic perennial grasses.

This community is currently affected by weed invasions from *Lantana camara**, and *Pennisetum clandestinum** (exotic perennial grass). If the mitigation measures outlined in Section 6 of the main report are adhered to it is not expected that the proposed Project is likely to exacerbate of the aforementioned Key Threatening Processes such that they are likely to significantly affect Swamp Oak Floodplain Forest. No other Key Threatening Processes are likely to be significantly increased by the proposed Project.

Conclusion

Approximately 6.18 ha of Swamp Oak Floodplain Forest have been mapped within the Study Area and the proposed Project will result in the removal of 4.55 ha of this community. However, given that approximately 582 ha have been mapped within the locality and 2607 ha have been mapped within the wider region, the area that may be impacted upon is small (0.8% in the locality and 0.2% in the wider region) and disturbed and provided that the mitigation measures are followed, the proposed Project is unlikely to have a significant impact on this community.

4. Swamp Sclerophyll Forest on Coastal Floodplains

Status

Swamp Sclerophyll Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions is listed as an Endangered Ecological Community under the *TSC Act*.

Description

Swamp Sclerophyll Forest is characterised by a canopy layer of eucalypts and/or paperbarks of varying density. Some remnant patches persist as open canopy layers with partly managed understorey strata. Height and density of the upper stratum varies in response to substrate conditions or recovery from destructive events such as fire or clearing. In those forms where *Melaleuca* spp. dominates, the canopy height may not exceed 8 m. In areas subjected to disturbance, regrowing eucalypts may also occur in stunted stands due to regrowth competition. Understorey strata may be dominated by areas of fernland, tall reedland or sedgeland, with trees sometimes absent or very sparse (Department of Environment and Conservation 2005; NSW Scientific Committee 2004b).

A number of dominant trees are widespread and abundant within the community, including, *Eucalyptus robusta* (Swamp Mahogany), *Melaleuca quinquenervia* and, south from Sydney, *E. botryoides* and *Eucalyptus longifolia*. However, other tree species may occur in low abundances or in locally common stands at a few sites, including *Callistemon salignus*, *Casuarina glauca* and *Eucalyptus resinifera* subsp. *hemilampra*, *Livistona australis* and *Lophostemon suaveolens*. A layer of small trees is sometimes present, including *Acacia irrorata*, *Acmena smithii*, *Elaeocarpus reticulatus*, *Glochidion ferdinandi*, *Melaleuca sieberi*, *Melaleuca linariifolia* and *Melaleuca styphelioides*. Shrubs which are sometimes present include *Acacia longifolia*, *Dodonaea triquetra*, *Ficus coronata*, *Leptospermum polygalifolium* subsp. *polygalifolium* and *Melaleuca* spp.. A number of vines species including *Parsonsia straminea*, *Morinda jasminoides* and *Stephania japonica* var. *discolor* are occasionally present. The groundcover is generally made up of an abundant layer of sedges, ferns, forbs, and grasses including, but not limited to, *Gahnia clarkei*, *Pteridium esculentum*, *Hypolepis muelleri*, *Calochlaena dubia*, *Dianella caerulea*, *Viola hederacea*, *Lomandra longifolia*, *Entolasia marginata* and *Imperata cylindrica* var. *major* (Department of Environment and Conservation 2005; NSW Scientific Committee 2004b).

Where sites are situated down-slope of lithic substrates or with soils of clay-loam texture, species such as *Allocasuarina littoralis*, *Banksia oblongifolia*, *B. spinulosa*, *Ptilothrix deusta* and *Themeda australis* may also be present in the understorey (Department of Environment and Conservation 2005; NSW Scientific Committee 2004b).

Habitat and ecology

Swamp Sclerophyll Forest occurs in a number of wet topographic contexts, generally on substrates of humic clays or sandy loams upon coastal floodplains within intermittently inundated alluvial flats or perched depressions along drainage lines. Its location in a floodplain salinity gradient is usually on the fresher side of more salinity tolerant communities, such as Swamp Oak Floodplain Forest and it often forms a buffer between these communities or Freshwater Wetlands and more terrestrial communities upslope.

Most occurrences are at elevations below 20 m, although it is known to occur at elevations up to 50m within its range.

Primary natural variables, including, water regime return and moisture retention rates, salinity, nutrient inputs, latitude and substrate influences are the drivers of community composition, but the community composition is also significantly affected by disturbance regimes associated with fire and human management activities. Such disturbances can open the community to edge effects and leave opportunity for exotic weeds to take hold. (Department of Environment and Conservation 2005; NSW Scientific Committee 2004b).

Distribution

Swamp Sclerophyll Forest is known from parts of the Local Government Areas of Tweed, Byron, Lismore, Ballina, Richmond Valley, Clarence Valley, Coffs Harbour, Bellingen, Nambucca, Kempsey, Hastings, Greater Taree, Great Lakes and Port Stephens, Lake Macquarie, Wyong, Gosford, Hornsby, Pittwater, Warringah, Manly, Liverpool, Rockdale, Botany Bay, Randwick, Sutherland, Wollongong, Shellharbour, Kiama and Shoalhaven but may occur elsewhere in these respective bioregions. Major examples once occurred on the floodplains of the Tweed, Richmond, Clarence, Macleay, Hastings and Manning Rivers, although smaller floodplains would have also supported considerable areas of this community.

The exact amount of its original extent is unknown but it is much less than 30%. There are less than 350 ha of native vegetation attributable to this community on the Tweed lowlands, less than 2,500 ha on the Clarence floodplain, less than 700 ha on the Macleay floodplain, up to 7,000 ha in the lower Hunter – central coast district, and less than 1,000 ha in the Sydney – South Coast region.

Small areas of Swamp Sclerophyll Forest on Coastal Floodplains are contained within existing conservation reserves, including Bungawalbin, Tuckean and Moonee Beach Nature Reserves, and Hat Head, Crowdy Bay, Wallingat, Myall Lakes and Garigal National Parks. The occurrences within conservation reserves are not evenly distributed throughout the community's range and unlikely to represent its full diversity. Furthermore, wetlands within protected areas are exposed to hydrological changes that were, and continue to be initiated outside their boundaries. Some areas of Swamp Oak Floodplain Forest are protected by State Environmental Planning Policy 14, although this has not always prevented impacts on wetlands from the development of major infrastructure (Department of Environment and Conservation 2005; NSW Scientific Committee 2004b).

Threats

Recognised threats (Department of Environment and Conservation 2005) to this community include:

- Further clearing for urban and rural development, and the subsequent impacts from fragmentation.
- Flood mitigation and drainage works.
- Management of water and tidal flows.
- Landfilling and earthworks associated with urban and industrial development.

- Grazing and trampling by stock and feral animals (particularly pigs).
- Changes in water quality, particularly increased nutrients and sedimentation.
- Weed invasion.
- Climate change.
- Activation of acid sulfate soils.
- Removal of dead wood.
- Rubbish dumping.
- Frequent burning which reduces the diversity of woody plant species.

Specific impacts

One vegetation community Swamp Mahogany Swamp Forest on Coastal Lowlands is commensurate with endangered ecological community of Swamp Sclerophyll Forest on coastal floodplains, which occurs in several patches in the south of the study area.

The proposed Project would include the clearing of 1.11 ha of this community. This impact assessment has calculated removal of vegetation as a worst case scenario and the vegetation removal is likely to be less than indicated.

Recovery actions

The following recovery actions have been recommended (Department of Environment and Conservation 2005) to help recover and conserve this endangered ecological community:

- Instigate pig, deer and goat control programs.
- Ensure that the fire sensitivity of the community is considered when planning hazard reduction and asset management burning.
- Protect habitat by minimising further clearing of the community. This requires recognition of the values of all remnants in the land use planning process.
- Promote regeneration by avoiding prolonged or heavy grazing.
- Undertake restoration including bush regeneration, revegetation and weed control, and promote public involvement in this restoration.

4.1 TSC Act significance assessment

In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable

In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered

population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable

In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

- (i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction,**

The proposed Project will remove approximately 1.11 ha of this vegetation community. This community is highly disturbed from modifications to the soil profile as a result of the study area being the site of a coal loader in the late 1970's. As a result this community is likely to be regrowth from previous clearing events and is highly modified from severe *Lantana camara** invasions. There are large areas of this community have been mapped as occurring within the locality (569 ha) and wider region (5,200 ha) (Lower Hunter and Central Coast Regional Environmental Management Strategy 2003). The removal of a small area of degraded and modified area of this community is unlikely to significantly impact upon this community within the region or the locality. Therefore the proposed Project is unlikely to affect a significant proportion of the community such that its local occurrence is likely to be placed at risk of extinction.

- (ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction**

The vegetation to be cleared is disturbed and subject to high levels of weed invasion and modification of the soil profile. The Proposed Project has the potential to introduce edge effects into new areas, due to the new rail alignment. However the impacts are unlikely to significantly increase edge effects or weed invasion due to its current condition and implementation of mitigation measures, such as weed control and sediment control measures are implemented to minimise further spread of weeds. The Proposed Project is therefore, unlikely to substantially modify the community's composition or put its local occurrence at risk of extinction.

In relation to the habitat of a threatened species, population or ecological community:

- (i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and**

The project will remove approximately 1.11 ha of this community. Over 569 ha of this community has been mapped within a 10 km radius of the study area and the area proposed to be removed represents 0.2% within the locality. The removal of approximately 1.11 ha of Swamp Sclerophyll Forest would not significantly affect the habitat and ecosystem function of this community occurring along the Hunter River and its' floodplain in the locality. Furthermore 5,200 ha of Swamp Sclerophyll Forest habitat occur within the Lower Hunter Region (Lower Hunter and Central Coast Regional Environmental Management Strategy 2003) and the area that is proposed to be removed represents a small percentage (0.2% in the locality and 0.02% in the wider region) of this available habitat.

- (ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and**

The Proposed Project would involve the removal of approximately 1.11 ha of this community. This will occur as a linear strip along the rail corridor and while the construction of the Proposed Project is likely to widen the gap between already fragmented patches of this community it will not further fragment any existing areas of this community.

The Proposed Project would not further inhibit movement of ground dwelling fauna than is already occurring from the existing rail corridor. Mobile species including birds, microbats and insects would also easily traverse the easement. Pollination and seed dispersal agents including birds, insects and wind would also continue to operate across the rail corridor.

Therefore, it is unlikely that this community will become further isolated or fragmented from other areas of this community as a result of the proposed Project.

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

The area of this community that will be impacted upon is small (<0.02% wider region and 0.2% within the locality), and is highly disturbed from previous rail construction works and weed invasions, particularly from *Lantana camara** and exotic pasture weeds. The removal of this community will occur as a linear strip and will not further isolate or fragment existing areas of this community. The proposed Project will not further inhibit movement of ground dwelling fauna than is already occurring from the existing rail corridor. Mobile species including birds, microbats and insects would also easily traverse the easement. Pollination and seed dispersal agents including birds, insects and wind would also continue to operate across the easement.

Therefore the small area of this community that will be impacted upon is unlikely to be important for the long term survival of community in the locality or the wider region.

Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations and ecological communities. Under the *Threatened Species Conservation Act 1995*, the Director-General maintains a register of critical habitat. To date, no critical habitat has been declared for this community. There is no critical habitat listed for this community and the areas of impact are not considered to be critical to the survival of this community.

Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

A recovery plan has not been prepared for Swamp Sclerophyll Forest on Coastal Floodplain.

The Office of the Environment and Heritage has however identified 12 priority actions to help recover of Swamp Sclerophyll Forest (Table 4-1). The proposed Project will not affect any of these actions.

Table 4-1 Recovery actions for Swamp Sclerophyll Forest on Coastal Floodplain

Recovery Strategy	Priority Action	Likely to be affected by the proposal
Recovery strategy 1: Captive Husbandry or ex-situ collection/propagation	Collect seed for NSW Seedbank. Develop collection program in collaboration with BGT - all known provenances (conservation collection).	No
	Investigate seed viability, germination, dormancy and longevity (in natural environment and in storage).	No
Recovery strategy 2: Community and land-holder liaison/ awareness and/or education	Enhance the capacity of persons involved in the assessment of impacts on this Endangered Ecological Community to ensure the best informed decisions are made.	No
	Liaise with landholders and undertake and promote programs that ameliorate threats such as grazing and human disturbance.	No
Recovery strategy 3: Habitat management: Ongoing EIA - Advice to consent and planning authorities	Prepare identification and impact assessment guidelines and distribute to consent and determining authorities.	No
Recovery strategy 4: Habitat management: Site Protection (e.g. Fencing/Signage)	Identify and prioritise other specific threats and undertake appropriate on-ground site management strategies where required.	No
Recovery strategy 5: Habitat management: Weed Control	Undertake weed control for Bitou Bush and Boneseed at priority sites in accordance with the approved Threat Abatement Plan and associated PAS actions.	No
Recovery strategy 6: Habitat Protection (inc vca/ jma/ critical habitat nomination etc.)	Use mechanisms such as Voluntary Conservation Agreements to promote the protection of this Endangered Ecological Community on private land.	No
Recovery strategy 7: Research	Determine location, species composition and threats to remaining remnants to assist with prioritising restoration works.	No
	Investigate the ecology of Swamp sclerophyll forest species with particular emphasis on the importance of drying and wetting cycles in maintaining ecosystem health.	No
	Undertake research to determine minimum fire frequency.	No
Recovery strategy 8: Survey/Mapping and Habitat assessment	Collate existing information on vegetation mapping and associated data for this Endangered Ecological Community and identify gaps in knowledge. Conduct targeted field surveys and ground truthing to fill data gaps and clarify condition of remnants.	No

Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

Threatening process means a process that threatens, or may have the capability to threaten, the survival or evolutionary development of species, populations or ecological communities. Key threatening processes are listed under the TSC Act. At present there are 36 listed key threatening processes under the TSC Act.

The proposed Project has the potential to contribute to six Key Threatening Processes (see Section 5.12). With respect to Swamp Sclerophyll Forest, the proposed Project is consistent with three Key Threatening Processes:

- clearing of native vegetation
- invasion, establishment and spread of *Lantana camara**
- invasion of native plant communities by exotic perennial grasses.

This community is currently affected by weed invasions from *Lantana camara**, and *Pennisetum clandestinum** (exotic perennial grass). If the mitigation measures outlined in Section 6 of the main report are adhered to it is not expected that the proposed Project is likely to exacerbate of the aforementioned Key Threatening Processes such that they are likely to significantly affect Swamp Sclerophyll Forest. No other Key Threatening Processes are likely to be significantly increased by the proposed Project.

Conclusion

Approximately 1.11 ha of Swamp Sclerophyll Forest have been mapped within the Study Area and the proposed Project will result in the removal of 1.11 ha of this community. However, given that approximately 569 ha have been mapped in the locality and 5,200 ha have been mapped within the wider region, the area that may be impacted upon is small (0.2% in the locality and 0.02% within the wider region) and disturbed and provided that the mitigation measures are followed, the proposed Project is unlikely to have a significant impact on this community.

5. *Maundia triglochinoxides*

Status

Maundia triglochinoxides is listed as Vulnerable under the TSC Act.

Description and habitat

Maundia triglochinoxides, from the Juncaginaceae family, is an erect rhizomatous perennial emergent aquatic herb. It grows to approximately 1 m in height in coastal wetlands (Sainty & Jacobs 2003). It is a perennial with rhizomes c.5mm thick and emergent tufts of leaves arising along their length. Leaves triangular in cross section, to 80cm long, 5-10mm wide (Harden 1993). The inflorescence are cylindrical and are approximately 10cm long and 2.5cm wide, with the carpels being 6-8mm long, sessile, each with a spreading beak (Harden 1993). This species generally flowers during warmer months of Summer. This species is known to occur within coastal freshwater swamps and streams on heavy clay (Sainty & Jacobs 2003).

Ecology

This species flowers from November to January with pollination likely to be wind dispersed. Seeds are produced from December to January with dispersal mechanism likely to be via water (Benson & McDougall 2002).

Distribution

Maundia triglochinoxides is a monotypic genus. *Maundia triglochinoxides* is almost restricted in its distribution to coastal New South Wales, extending into southern Queensland (Sainty & Jacobs 2003). There are historic records of *Maundia triglochinoxides* in the Sydney region, but the current southern limit is near Wyong. Former sites in Sydney are either no longer wetlands or have been greatly disturbed (NSW Scientific Committee 2001).

Threats

The recognised threat (Department of Environment and Conservation 2005) to this species includes:

- Further loss and fragmentation of habitat
- Changes in hydrology and water quality
- Weed invasion.

Recovery actions

The following recovery action has been recommended (Department of Environment and Conservation 2005) to help recover and conserve this species:

- Implement habitat management programs to address threats at sites.
- Protect habitat from further clearing.

Specific impacts

Maundia triglochinoxoides was not recorded during the current surveys, however this species is difficult to detect and therefore as potential habitat *Phragmites australis* and *Typha orientalis* Coastal Freshwater Wetlands is present in the study area a precautionary approach has been undertaken and an impact assessment has been completed. The proposed Project would result in clearing of 2.70 ha of potential habitat.

5.1 TSC Act significance assessment

In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

No *Maundia triglochinoxoides* individuals were recorded during the field surveys. The proposed Project Area and study area contains suitable habitat for this species within the *Phragmites australis* and *Typha orientalis* Coastal Freshwater Wetlands. The proposed Project would result in clearing of 2.70 ha of potential habitat.

The Lower Hunter Central Coast Management Strategy (Lower Hunter and Central Coast Regional Environmental Management Strategy 2003) has mapped over 3,900 ha of Freshwater Wetlands within the Lower Hunter Region. Furthermore within the locality (10 km) the Lower Hunter Central Coast Management Strategy (Lower Hunter and Central Coast Regional Environmental Management Strategy 2003) has mapped approximately 2984 ha of Freshwater Wetlands habitat for this species. The proposed Project will remove 2.70 ha of potential habitat for *Maundia triglochinoxoides*, this represents 0.09% of the available habitat within the locality and 0.07% of the available habitat within the wider Lower Hunter Region. Therefore the habitat area to be removed is small (2.70 ha) in comparison to the habitat in the locality and the region.

Maundia triglochinoxoides is known to reproduce from sexual reproduction with water being the pollinator vector (Benson & McDougall 2002). Whilst the proposed Project will remove 2.70 ha of habitat for *Maundia triglochinoxoides* this removal will not inhibit the pollination processes in the potential population within the local area. It is unlikely that the proposed Project would create a barrier to the movement pollen nor seed dispersal within freshwater wetland environments between populations as the Freshwater wetland habitats within the study area are already isolated and fragmented from each other.

The proposed Project is therefore unlikely to have an adverse effect on the life cycle of the species such that a viable local population will be placed at risk of extinction.

In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable

In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

- (i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

- (ii) **is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction**

Not applicable

In relation to the habitat of a threatened species, population or ecological community:

- (i) **the extent to which habitat is likely to be removed or modified as a result of the action proposed, and**

The proposed Project would remove approximately 2.70 ha of potential habitat for *Maundia triglochinoxoides*. The area to be removed is relatively small in terms of the extent of similar habitat available within the study area and surrounding landscape.

The proposed Project would remove approximately 2.70 ha of potential habitat for *Maundia triglochinoxoides*. This represents 0.09% of the available habitat within the locality and 0.07% of the available habitat within the wider Lower Hunter Region. Therefore the habitat area to be removed is small (2.70 ha) in comparison to the habitat in the locality and the region.

- (ii) **whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and**

The proposed Project will not result in any areas of *Maundia triglochinoxoides* habitat becoming fragmented or isolated from other areas of habitat. The Proposed Project would involve the removal of approximately 2.70 ha of this habitat for this species. This will occur as a linear strip along the rail corridor and while the construction of the proposed Project is likely to widen the gap between already fragmented patches of habitat it will not further fragment or isolate any remaining areas of habitat.

Therefore, it is unlikely that habitat for *Maundia triglochinoxoides* will become further isolated or fragmented from other areas of habitat as a result of the proposed Project.

- (iii) **the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.**

The proposed Project Area is unlikely to be of critical importance to the long-term survival of the *Maundia triglochinoxoides*. Approximately 3,900 ha of potential habitat is estimated to occur within lower Hunter Valley and central coast area (Lower Hunter and Central Coast Regional Environmental Management Strategy 2003), and approximately 2984 ha within the locality. The proposed Project would include the disturbance of approximately 2.70 ha of habitat and this is not a significant area of habitat for this species. The proposed Project Area also represents a small proportion of the suitable habitat for the species in the locality (0.09%) and <0.07% in the wider Lower Hunter and Central Coast Region.

Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations and ecological communities. Under the *Threatened Species Conservation Act 1995*, the Director-General maintains a register of critical habitat. To date, no critical habitat has been declared for *Maundia triglochinoxoides*. There is no critical habitat listed for this species and the areas of impact are not considered to be critical to the survival of this species.

Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

No recovery plan or priorities action statements or Threat Abatement Plan have been prepared for *Maundia triglochinos* under the TSC Act.

The following recovery action has been recommended (Department of Environment and Conservation 2005) to help recover and conserve this species:

- Implement habitat management programs to address threats at sites.
- Protect habitat from further clearing.

Whilst the proposed Project does remove habitat for this species, as it is a small area it is unlikely to significantly impact upon this species.

Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

Threatening process means a process that threatens, or may have the capability to threaten, the survival or evolutionary development of species, populations or ecological communities. Key threatening processes are listed under the TSC Act. At present there are 36 listed key threatening processes under the TSC Act.

The proposed Project has the potential to contribute to six Key Threatening Processes. With respect to *Maundia triglochinos*, the proposed Project is consistent with three Key Threatening Processes:

- Clearing of native vegetation.
- Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands clearing of native vegetation.
- Invasion of native plant communities by exotic perennial grasses.

This community is currently affected by weed invasions from *Pennisetum clandestinum* (exotic perennial grass). The Proposed Project may alter the wetlands from indirect effects such as sedimentation and erosion. If the mitigation measures outlined in Section 6 of the main report are adhered to it is not expected that the proposed Project is likely to exacerbate of the aforementioned Key Threatening Processes such that they are likely to significantly affect freshwater wetlands. No other Key Threatening Processes are likely to be significantly increased by the Proposed Project.

Conclusion

The proposed Project will remove approximately 2.70 ha of potential habitat for this species. The reduction in the size and extent of the potential habitat of *Maundia triglochinos* is not likely to be significant by comparison to the size of suitable habitat remaining within the locality (0.09%) and the wider region (0.07%). Therefore the proposed Project is not considered to have a significant impact on *Maundia triglochinos*.

6. *Persicaria elatior*

Status

Persicaria elatior is listed as Vulnerable under the TSC Act and the EPBC Act.

Description and habitat

Persicaria elatior is an erect herb to 90 cm tall, with stalked, glandular hairs on most plant parts. Its leaves are up to 11 cm long and 30 mm wide. A sheath encircles the stem at the base of each leaf, which is characteristic of the plant family Polygonaceae of which this species is a member. Its tiny flowers are in long, narrow spikes to 5 cm long. The pink flower-segments are less than 4 mm long (Department of Environment and Conservation 2005). This species occurs in damp places usually in creeklines and lakes. This species has been recorded in swamp forests and freshwater wetlands and associated with disturbance.

Ecology

The ecology of the *Persicaria elatior* is generally unknown, however similar species in the same genus are known to reproduce by self-pollinating and from sexual reproduction with insects being the pollinator vector (Benson & McDougall 1999) The flowering period is in summer and this species is difficult to identify when not in flower due to similarities to other commonly occurring species in this genus (eg. *Persicaria lapathifolia*). Seed dispersal is most likely to be water dispersed and by birds mainly waterfowl such as ducks and grebes.

Distribution

Persicaria elatior has been recorded in south-eastern NSW at Mt Dromedary, Moruya State Forest near Turlinjah, the Upper Avon River catchment north of Robertson, Bermagui, and Picton Lakes. In northern NSW it is known from Raymond Terrace and the Grafton area (Cherry Tree and Gibberagee State Forests). The species is also known to occur in Queensland (Department of Environment and Conservation 2005).

Threats

Recognised threats (Department of Environment and Conservation 2005) to this species include:

- Inadvertent clearing from moist disturbed habitat.
- Damage to road and track populations through maintenance activities.
- Clearing of or hydrological changes to wetland vegetation.

Recovery actions

The following recovery actions have been recommended (Department of Environment and Conservation 2005) to help recover and conserve this species:

- Provide information to landholders in areas likely to contain this species to enable them to identify it.
- Ensure that adequate survey is done for this species in development and clearing projects in suitable habitat within its range.

- Alert road and track maintenance staff (in Sydney Water and State Forests) to its occurrence to ensure that populations are not inadvertently damaged.
- Protect wetland habitat containing (or likely to contain) this species.

Specific impacts

Persicaria elatior was not recorded during the current surveys, however the field surveys were undertaken outside the flowering period for this species. It is unknown whether this species is present within the study area, however potential habitat in the form of the *Phragmites australis* and *Typha orientalis* Coastal Freshwater Wetlands and the Swamp Mahogany Swamp Forest on Coastal Lowlands was recorded within the study area. The proposed Project would result in clearing of 3.82 ha of potential habitat.

6.1 TSC Act significance assessment

In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

No *Persicaria elatior* individuals were recorded during the field surveys, however, these surveys were undertaken outside of the December to February flowering period. This species is difficult to identify when not in flower due to similarities to other commonly occurring species in this genus (eg. *Persicaria lapathifolia*) and therefore the presence or absence of this species cannot be determined.

The proposed Project Area and study area contains suitable habitat for this species within the *Phragmites australis* and *Typha orientalis* Coastal Freshwater Wetlands and the Swamp Mahogany Swamp Forest on Coastal Lowlands. The proposed Project would result in clearing of 3.82 ha of potential habitat.

The Lower Hunter Central Coast Management Strategy (Lower Hunter and Central Coast Regional Environmental Management Strategy 2003) has mapped over 3900 ha of Freshwater Wetlands and 5200 ha of Swamp Mahogany Swamp Forest on Coastal Lowlands within the Lower Hunter Region. Furthermore within the locality (10 km) The Lower Hunter Central Coast Management Strategy (Lower Hunter and Central Coast Regional Environmental Management Strategy 2003) has mapped approximately 3553 ha of Freshwater Wetlands and Swamp Mahogany Swamp Forest on Coastal Lowlands habitat for this species. The proposed Project will remove 3.82 ha of potential habitat for *Persicaria elatior*, this represents 0.08% of the available habitat within the locality and 0.03% of the available habitat within the wider Lower Hunter Region. Therefore the habitat area to be removed is small (3.82 ha) in comparison to the habitat in the locality and the region.

The pollination mechanisms for *Persicaria elatior* is generally unknown, however similar species in the same genus are known to reproduce by self-pollinating and from sexual reproduction with insects being the pollinator vector (Benson & McDougall 1999). Whilst the proposed Project will remove 3.82 ha of habitat for *Persicaria elatior* this removal will not inhibit the pollination processes in the potential population within the local area. It is unlikely that the proposed Project would create a barrier to the movement of insect pollinators. Similarly it would also not create a barrier to the seed dispersal due to the mobility of waterfowl in the locality.

The proposed Project is therefore unlikely to have an adverse effect on the life cycle of the species such that a viable local population will be placed at risk of extinction.

In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable

In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

- (i) **is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or**
- (ii) **is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction**

Not applicable

In relation to the habitat of a threatened species, population or ecological community:

- (i) **the extent to which habitat is likely to be removed or modified as a result of the action proposed, and**

The proposed Project would remove approximately 3.82 ha of potential habitat for *Persicaria elatior*. The area to be removed is relatively small in terms of the extent of similar habitat available within the study area and surrounding landscape.

The proposed Project would remove approximately 3.82 ha of potential habitat for *Persicaria elatior*. This represents 0.10% of the available habitat within the locality and 0.04% of the available habitat within the wider Lower Hunter Region. Therefore the habitat area to be removed is small (3.82 ha) in comparison to the habitat in the locality and the region.

- (ii) **whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and**

The proposed Project will not result in any areas of *Persicaria elatior* habitat becoming fragmented or isolated from other areas of habitat. The Proposed Project would involve the removal of approximately 3.82 ha of this habitat for this species. This will occur as a linear strip along the rail corridor and while the construction of the proposed Project is likely widen the gap between already fragmented patches of habitat it will not further fragment or isolate any remaining areas of habitat.

Therefore, it is unlikely that habitat for *Persicaria elatior* will become further isolated or fragmented from other areas of habitat as a result of the proposed Project.

- (iii) **the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.**

The proposed Project Area is unlikely to be of critical importance to the long-term survival of the *Persicaria elatior*. Approximately 9,100 ha of potential habitat is estimated to occur within

lower Hunter Valley and central coast area (Lower Hunter and Central Coast Regional Environmental Management Strategy 2003) and approximately 3553 ha within the locality.. The proposed Project would include the disturbance of approximately 3.82 ha of habitat and this is not a significant area of habitat for this species. The proposed Project Area also represents a small proportion of the suitable habitat for the species in the locality (0.10%) and <0.04% in the wider Lower Hunter and Central Coast Region.

Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations and ecological communities. Under the *Threatened Species Conservation Act 1995*, the Director-General maintains a register of critical habitat. To date, no critical habitat has been declared for *Persicaria elatior*. There is no critical habitat listed for this species and the areas of impact are not considered to be critical to the survival of this species.

Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

No recovery plan or priorities action statements or Threat Abatement Plan have been prepared for *Persicaria elatior* under the TSC Act.

However the following recovery actions have been recommended (Department of Environment and Conservation 2005) to help recover and conserve this species:

- Provide information to landholders in areas likely to contain this species to enable them to identify it.
- Ensure that adequate survey is done for this species in development and clearing projects in suitable habitat within its range.
- Alert road and track maintenance staff (in Sydney Water and State Forests) to its occurrence to ensure that populations are not inadvertently damaged.
- Protect wetland habitat containing (or likely to contain) this species.

The proposed Project is unlikely to affect any of the above recovery actions.

Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

Threatening process means a process that threatens, or may have the capability to threaten, the survival or evolutionary development of species, populations or ecological communities. Key threatening processes are listed under the TSC Act. At present there are 36 listed key threatening processes under the TSC Act.

The proposed Project has the potential to contribute to six Key Threatening Processes. With respect to *Persicaria elatior*, the proposed Project is consistent with three Key Threatening Processes:

- Clearing of native vegetation.
- Invasion and, establishment and spread of *Lantana camara**.

- Invasion of native plant communities by exotic perennial grasses.

The habitat for this species is currently affected by weed invasions from *Lantana camara**, and *Pennisetum clandestinum**(exotic perennial grass). If the mitigation measures outlined in Section 6 of the main report are adhered to it is not expected that the proposed Project is likely to exacerbate of the aforementioned Key Threatening Processes such that they are likely to significantly affect *Persicaria elatior*. No other Key Threatening Processes are likely to be significantly increased by the proposed Project.

Conclusion

The proposed Project will remove approximately 3.82 ha of potential habitat for this species. The reduction in the size and extent of the potential habitat of *Persicaria elatior* is not likely to be significant by comparison to the size of suitable habitat remaining within the locality (0.10%) and the wider region (0.03%). Therefore the proposed Project is not considered to have a significant impact on *Persicaria elatior*.

6.2 EPBC Act significance assessment

Persicaria elatior is listed as Vulnerable under the EPBC Act. The following assessment has been undertaken following the Matters of National Environmental Significance, Significant Impact Guidelines 1.1 (Department of the Environment Water Heritage and the Arts 2009a). Under the EPBC Act, important populations are:

- likely to be key source populations either for breeding or dispersal
- likely to be necessary for maintaining genetic diversity, and/or
- at or near the limit of the species range.

6.2.1 Is this an important population?

Persicaria elatior species is most likely to reproduce from both self pollination and by outcrossing. It is unknown how large or what proportion of the population that may be impacted upon by the project the study area. Seed dispersal is most likely to be bird dispersed. It is unlikely that the project would create a barrier to the movement insects or birds. The proposed Project Area is therefore unlikely to be a key source population for either for breeding or dispersal.

The size of the local population (i.e. Raymond Terrace locality) for *Persicaria elatior* is not known. Approximately 9,100 ha of potential habitat (Swamp Mahogany Swamp Forest on Coastal Lowlands and Freshwater Wetland habitat) is estimated to occur within lower Hunter Valley and central coast area (Lower Hunter and Central Coast Regional Environmental Management Strategy 2003). The proposed Project Area provides 3.82 ha of potential habitat, representing a small proportion of the suitable habitat for the species in the locality (0.10%) and <0.04% in the wider region. The proposed Project Area is therefore unlikely to be a key source population or be necessary for maintaining genetic diversity.

Persicaria elatior occurs between Moruya and QLD and the study area is therefore not at or near the limit of the species range.

It is therefore considered that if there are individuals of *Persicaria elatior* present they would not be considered an important population.

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will result in one or more of the following.

Lead to a long-term decrease in the size of an important population of a species

Not applicable. If present, *Persicaria elatior* would not be part of important population (refer to Section 2.2.1 above).

Reduce the area of occupancy of an important population

Not applicable. If present, *Persicaria elatior* would not be part of important population (refer to Section 2.2.1 above).

Fragment an existing important population into two or more populations

Not applicable. If present, *Persicaria elatior* would not be part of important population (refer to Section 2.2.1 above).

Adversely affect habitat critical to the survival of a species

Habitat critical to the survival of a species may, however, also include areas that are not listed on the Register of Critical Habitat if they are necessary:

- for activities such as foraging, breeding, roosting, or dispersal
- for the long-term maintenance of the species or ecological community (including the maintenance of species essential to the survival of the species or ecological community, such as pollinators)
- to maintain genetic diversity and long term evolutionary development, or
- for the reintroduction of populations or recovery of the species or ecological community (Department of the Environment Water Heritage and the Arts 2009a).

Due to the large areas of habitat for this species within the Lower Hunter and Central Coast region (over 9,000 ha) and the locality (over 3553 ha) the removal of a small area of 3.82 ha which is less than 0.10% within the locality and 0.04% within the wider region, the extent of the habitat that would be cleared as a result of the proposed Project does not represent habitat critical to the survival of the *Persicaria elatior*.

No critical habitat has been listed for this species, nor is the proposed Project Area critical for the survival of the *Persicaria elatior*.

Disrupt the breeding cycle of an important population

Not applicable. If present, *Persicaria elatior* would not be part of important population (refer to Section 2.2.1 above).

Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

No *Persicaria elatior* individuals were identified within the proposed Project Area during current surveys despite the presence of sub-optimal habitat, however as the surveys were undertaken outside the flowering period for this species the presence or absence of this species cannot be determined.

The proposed Project will not result in any areas of *Persicaria elatior* becoming fragmented or isolated from other areas of habitat. The areas of habitat within the study area are already fragmented and disturbed from the existing rail corridor and past agriculture practices. It is unlikely that the proposed Project would create a barrier to the movement of insect pollinators or birds for seed dispersal.

The project will modify and destroy a small area of approximately 3.82 ha of habitat for *Persicaria elatior*, however due to the occurrence of large areas of suitable habitat within the locality and the wider region, it is considered that the project is unlikely to result in the decline of *Persicaria elatior*.

Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat

The 3.82 ha of vegetation which is to be removed/ modified and which provides sub-optimal habitat for *Persicaria elatior* has already been disturbed from the construction of the existing rail corridor, and edge effects from existing road alignments. Edge effects include weed invasions from exotic grasses such as *Hyparrhenia hirta**, *Lantana camara** and herbaceous weeds associated with past clearing activities. Mitigation measures have been provided to minimise the spread of weeds during construction and the proposed Project will not result in establishment or spread of invasive species that are harmful to *Persicaria elatior*.

Introduce disease that may cause the species to decline

No, there are no known diseases associated with *Persicaria elatior*, however, if the mitigation measures outlined in Section 6 of the main report are adhered to it is not expected that the proposed Project will facilitate the spread of any potential diseases that are likely to significantly affect *Persicaria elatior*.

Interfere substantially with the recovery of the species.

Persicaria elatior was not identified within the proposed Project Area during the field survey, however as the surveys were undertaken outside the flowering period for this species the presence or absence of this species cannot be determined. Whilst the proposed Project Area contains sub-optimal habitat for this species the closest record is 10 km to the north east of the study area. This species has previously been recorded on sandy substrates and is unlikely to occur within the study area.

No recovery plans have been prepared for *Persicaria elatior* and the proposed Project Area has not been identified as important habitat for the recovery of the species. Due to the small area of potential habitat to be removed (3.82 ha) it is considered that project is unlikely to interfere with the recovery of *Persicaria elatior*.

Conclusion

The potential population of *Persicaria elatior* in the proposed Project Area is not considered an important population. Based on the above assessment and that the proposed Project would affect less than 3.82 ha of potential habitat. The reduction in the habitat for *Persicaria elatior* is not likely to be significant by comparison to the size of available habitat within the Lower Hunter and Central Coast Region (over 9,000 ha) and within the locality (over 3500 ha).

The project is unlikely to significantly impact *Persicaria elatior* or interfere with its recovery.

7. *Zannichellia palustris*

Status

Zannichellia palustris is listed as Endangered under the TSC Act.

Description and habitat

Zannichellia palustris, from the Zannichelliaceae family, is a rhizomatous, submerged aquatic plant; that grows in fresh or slightly saline stationary or slow flowing water. Its leaves are up to 2-7 cm long and less than 1 mm wide. Leaves are opposite and the ligule is longer than the sheath. *Zannichellia palustris* is a monoecious annual or perennial plant that produces unisexual flowers; the female flower with a cup-like perianth and the male with no perianth. The fruit is dorsally curved and mostly with tubercles on dorsal surface, 2-4 mm long (Jacobs 1992). Positive identification of this species is difficult without flowering material and therefore survey effort should be concentrated in Spring and Summer to coincide with the flowering period (Murray & Hoyer 1997). This species is known only to occur in the lower Hunter of NSW predicted to occur within the vegetation of freshwater wetlands, coastal freshwater lagoons, saline wetlands and saltmarshes.

Ecology

The ecology of the *Zannichellia palustris* is generally unknown. The species is however known to behave as an annual flowering during the warmer months before dying back completely after every summer. The plant has been found to be self and cross pollinated (Guo *et al.* 1990).

Distribution

Zannichellia palustris has been recorded in in the lower Hunter region of NSW within the Hunter/Central Rivers Catchment Management Region. It is also known or predicted to occur in the Hunter, Karuah Manning and Wyong CMA sub-regions (Department of Environment and Conservation 2005).

Threats

The recognised threat (Department of Environment and Conservation 2005) to this species includes:

- Changes to catchments resulting to changes in hydrological conditions and water quality.

Recovery actions

The following recovery action has been recommended (Department of Environment and Conservation 2005) to help recover and conserve this species:

- Consider action of the conservation requirements when acting to manage or develop areas upstream from known populations.

Specific impacts

Zannichellia palustris was not recorded during the current surveys, however the field surveys were undertaken outside the Summer flowering period for this species. It is unknown

whether this species is present within the study area, however potential habitat in the form of the *Phragmites australis* and *Typha orientalis* Coastal Freshwater Wetlands was recorded within the study area. The proposed Project would result in clearing of 2.70 ha of potential habitat.

7.1 TSC Act significance assessment

In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

No *Zannichellia palustris* individuals were recorded during the field surveys, however, these surveys were undertaken in winter outside of the Spring to Summer flowering period. This species is difficult to identify when not in flower due to similarities to other commonly occurring species (e.g. *Lepilaena*) (Sainty & Jacobs 2003) and therefore the presence or absence of this species cannot be determined.

The proposed Project Area and study area contains suitable habitat for this species within the *Phragmites australis* and *Typha orientalis* Coastal Freshwater Wetlands. The proposed Project would result in clearing of 2.70 ha of potential habitat.

The Lower Hunter Central Coast Management Strategy (Lower Hunter and Central Coast Regional Environmental Management Strategy 2003) has mapped over 3,900 ha of Freshwater Wetlands within the Lower Hunter Region. Furthermore within the locality (10 km) the Lower Hunter Central Coast Management Strategy (Lower Hunter and Central Coast Regional Environmental Management Strategy 2003) has mapped approximately 2984 ha of Freshwater Wetlands habitat for this species. The proposed Project will remove 2.70 ha of potential habitat for *Zannichellia palustris*, this represents 0.09% of the available habitat within the locality and 0.07% of the available habitat within the wider Lower Hunter Region. Therefore the habitat area to be removed is small (2.70 ha) in comparison to the habitat in the locality and the region.

Zannichellia palustris is known to reproduce by self-pollinating and from sexual reproduction with water being the pollinator vector (Guo *et al.* 1990). Whilst the proposed Project will remove 2.70 ha of habitat for *Zannichellia palustris* this removal will not inhibit the pollination processes in the potential population within the local area. It is unlikely that the proposed Project would create a barrier to the movement pollen nor seed dispersal within freshwater wetland environments between populations as the Freshwater wetland habitats within the study area are already isolated and fragmented from each other.

The proposed Project is therefore unlikely to have an adverse effect on the life cycle of the species such that a viable local population will be placed at risk of extinction.

In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable

In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

- (i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or
- (ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

Not applicable

In relation to the habitat of a threatened species, population or ecological community:

- (i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The proposed Project would remove approximately 2.70 ha of potential habitat for *Zannichellia palustris*. The area to be removed is relatively small in terms of the extent of similar habitat available within the study area and surrounding landscape.

The proposed Project would remove approximately 2.70 ha of potential habitat for *Zannichellia palustris*. This represents 0.09% of the available habitat within the locality and 0.07% of the available habitat within the wider Lower Hunter Region. Therefore the habitat area to be removed is small (2.70 ha) in comparison to the habitat in the locality and the region.

- (ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The proposed Project will not result in any areas of *Zannichellia palustris* habitat becoming fragmented or isolated from other areas of habitat. The Proposed Project would involve the removal of approximately 2.70 ha of this habitat for this species. This will occur as a linear strip along the rail corridor and while the construction of the proposed Project is likely widen the gap between already fragmented patches of habitat it will not further fragment or isolate any remaining areas of habitat.

Therefore, it is unlikely that habitat for *Zannichellia palustris* will become further isolated or fragmented from other areas of habitat as a result of the proposed Project.

- (iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

The proposed Project Area is unlikely to be of critical importance to the long-term survival of the *Zannichellia palustris*. Approximately 3,900 ha of potential habitat is estimated to occur within lower Hunter Valley and central coast area (Lower Hunter and Central Coast Regional Environmental Management Strategy 2003), and approximately 2984 ha within the locality. The proposed Project would include the disturbance of approximately 2.70 ha of habitat and this is not a significant area of habitat for this species. The proposed Project Area also represents a small proportion of the suitable habitat for the species in the locality (0.09%) and <0.07% in the wider Lower Hunter and Central Coast Region.

Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

Critical habitats are areas of land that are crucial to the survival of particular threatened species, populations and ecological communities. Under the *Threatened Species*

Conservation Act 1995, the Director-General maintains a register of critical habitat. To date, no critical habitat has been declared for *Zannichellia palustris*. There is no critical habitat listed for this species and the areas of impact are not considered to be critical to the survival of this species.

Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

No recovery plan or priorities action statements or Threat Abatement Plan have been prepared for *Zannichellia palustris* under the TSC Act.

The following recovery action has been recommended (Department of Environment and Conservation 2005) to help recover and conserve this species:

- Consider action of the conservation requirements when acting to manage or develop areas upstream from known populations.

The proposed Project is unlikely to affect any of the above recovery actions.

Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

Threatening process means a process that threatens, or may have the capability to threaten, the survival or evolutionary development of species, populations or ecological communities. Key threatening processes are listed under the TSC Act. At present there are 36 listed key threatening processes under the TSC Act.

The proposed Project has the potential to contribute to six Key Threatening Processes. With respect to *Zannichellia palustris*, the proposed Project is consistent with three Key Threatening Processes:

- Clearing of native vegetation.
- Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands clearing of native vegetation.
- Invasion of native plant communities by exotic perennial grasses.

This community is currently affected by weed invasions from *Pennisetum clandestinum* (exotic perennial grass). The Proposed Project may alter the wetlands from indirect effects such as sedimentation and erosion. If the mitigation measures outlined in Section 6 of the main report are adhered to it is not expected that the proposed Project is likely to exacerbate of the aforementioned Key Threatening Processes such that they are likely to significantly affect freshwater wetlands. No other Key Threatening Processes are likely to be significantly increased by the Proposed Project.

Conclusion

The proposed Project will remove approximately 2.70 ha of potential habitat for this species. The reduction in the size and extent of the potential habitat of *Zannichellia palustris* is not likely to be significant by comparison to the size of suitable habitat remaining within the locality (0.09%) and the wider region (0.07%). Therefore the proposed Project is not considered to have a significant impact on *Zannichellia palustris*.

8. Green and Golden Bell Frog (*Litoria aurea*)

Status

The Green and Golden Bell Frog is listed as Vulnerable under the EPBC Act and Endangered under the TSC Act.

Description and habitat

A relatively large, stout frog, ranging in size from approximately 45 mm to approximately 100 mm snout to vent length. Diagnostic features are a gold or creamish white stripe running along the side, extending from the upper eyelids almost to the groin, with a narrow dark brown stripe beneath it, from nostril to eye. It also has blue or bluish-green colour on the inside of the thighs. The colour of the body varies. Usually a vivid pea-green, splotched with an almost metallic brassy brown or gold. The backs of some individuals may be almost entirely green; in others golden-brown markings may dominate (Office of Environment and Heritage 2011).

The Green and Golden Bell Frog inhabits marshes, dams and stream sides, particularly those containing bullrushes *Typha* spp. or spikerushes *Eleocharis* spp. Optimum habitat includes water bodies which are unshaded, free of predatory fish *Gambusia holbrooki*, have a grassy area nearby and diurnal sheltering sites available such as vegetation and/or rocks (NSW National Parks and Wildlife Service 1999).

Ecology

The Green and Golden Bell Frog is known to breed during late winter to early autumn, but generally during September–February with a peak around January–February after heavy rain or storms. Estimations suggest the average clutch size is approximately 3,700 eggs. Spawn is laid among aquatic vegetation and has been observed in December, January and February. Eggs hatch within 2–5 days after ovipositing/fertilisation, and metamorphosis can take 2–11 months however, six weeks appears to be an average duration in the field (Department of Sustainability Environment Water Population and Communities 2012).

Distribution

The Green and Golden Bell Frog is found in eastern and south-eastern NSW and far-east Victoria. The frog was formerly distributed from the NSW north coast near Brunswick Heads southwards along the NSW coast to Victoria where it extends into East Gippsland, west to Bathurst and the ACT (Cogger 2000).

Despite being widespread in the 1960s declines were noticed in the late 1970s and became severe in the 1980s such that the species now exists as a series of isolated populations within its former known range. Current distribution consists of isolated pockets from various scattered locations, with most populations being coastal or near coastal with inland, upland and northern populations being most affected (Burns et al. 2004).

Threats

Specific threats to the species include:

- destruction of wetlands

- alteration of drainage patterns and stormwater runoff
- a fungal pathogen known as Frog Chytrid Fungus
- predation by feral animals such as foxes
- herbicides and other weed-control measures
- road mortality, where populations are already small due to other threats
- predation by exotic fish such as Plague Minnow
- loss of suitable breeding habitat through alteration by infilling and destruction of wetlands(DECCW 2010).

Recovery actions

A draft recovery plan for Green and Golden Bell Frog was developed by the NSW Department of Environment and Conservation (DEC) in 2005, which includes the following objectives:

- increase the security of key populations by way of preventing the further loss of habitat at key populations across the species range and where possible secure opportunities for increasing protection of habitat areas
- ensure extant populations are managed to eliminate or attenuate the operation of factors that are known or discovered to be detrimentally affecting the species
- implement habitat management initiatives that are informed by data obtained through investigations into the general biology and ecology of the species through a systematic and coordinated monitoring program
- establish, within more than one institution, self-sustaining and representative captive populations (particularly ‘at risk’ populations) of the Green and Golden Bell Frog for the primary purpose of maintaining ‘insurance’ colonies for re-establishment and supplementation of populations of the species
- increase the level of regional and local awareness of the conservation status of the Green and Golden Bell Frog and provide greater opportunity for community involvement in the implementation of this recovery plan.

Specific impacts

The proposed Project has the potential to modify and or remove approximately 2.70 ha of *Phragmites australis* and *Typha orientalis* Coastal Freshwater Wetlands, which provide potential habitat for this species. However, this species was not detected during targeted searches during optimal weather conditions. Furthermore, a nearby reference site was surveyed to gauge Green and Golden Bell Frog detectability from which two individuals responded to call playback.

8.1 EP&A Act assessment

In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

The proposed Project would affect approximately 2.70 ha of suitable habitat along an existing linear corridor. While the Study Area occurs as part of the historic range of the local population of the Green and Golden Bell Frog, no individuals were detected during targeted field surveys coinciding with optimal weather conditions. The proposed Project is unlikely to have an adverse effect upon the lifecycle of the species such that viable local populations in the Lower Hunter Region are likely to be placed at risk of extinction.

In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable

In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

- i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction**

Not applicable

- i) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction**

Not applicable

In relation to the habitat of a threatened species, population or ecological community:

- i) the extent to which habitat is likely to be removed or modified as a result of the action proposed**

The proposed Project has the potential to modify and or remove approximately 2.70 ha of *Phragmites australis* and *Typha orientalis* Coastal Freshwater Wetlands, which provide potential habitat for this species.

- ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and**

The proposed Project is linear in nature, effectively increasing the width by approximately 50 m at the widest point of an existing rail corridor that is situated on the eastern boundary of Hexham Swamp Nature Reserve, and bordered immediately to the east by industrial developments (along part of the alignment) and the Pacific Highway (Maitland Road). The proposed Project Area is further fragmented from the known population occurring on Ash Island, by the Hunter River, effectively removing any terrestrial dispersion of this species. However, culverts under the Pacific Highway and existing rail corridor, link Ash Island and

the Hunter River to Hexham Swamp Nature Reserve, providing aquatic dispersion. Furthermore, potential connectivity would still remain to those individuals that are known to occur south (approximately 8 km) of the study area, near Shortland Wetland Centre.

- iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

Green and Golden Bell Frog has not been recorded within the study area, however the proposed Project would add incrementally to principal threats that affect this species, including, habitat removal and degradation, thus reducing areas of potential habitat, should this species expand its range.

Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

Critical habitat refers to those areas of land listed in the Register of Critical Habitat kept by the Director General of OEH. No critical habitat has been listed for this species, nor is the study area critical for its survival.

Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

The proposed Project is not inconsistent with any specific measures identified in the draft recovery plan.

Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

With respect to the Green and Golden Bell Frog, the proposed Project is consistent with two key threatening processes under the TSC Act:

- clearing of native vegetation
- alteration to the natural flow regimes of rivers, streams, floodplains and wetlands.

The extent of native vegetation clearing and habitat removal associated with the proposed Project is considered relatively minor in terms of available habitat for these species in the Study Area and surrounding landscape.

Conclusion

The proposed Project has the potential to modify and or remove approximately 2.70 ha of *Phragmites australis* and *Typha orientalis* Coastal Freshwater Wetlands, which provide potential habitat for this species. Surveys conducted over the Study Area during optimal weather conditions when Green and Golden Bell Frogs were observed calling at a reference site, were not successful in detecting this species. Although this species historically occurred widely across the Hunter River floodplain, more recent records (post 1995) for this species occur approximately 500 m to the east of the proposed Project Area and separated by industrial developments, the Pacific Highway (Maitland Road) and the South Arm of the Hunter River.

Based on the findings of this assessment, the proposed Project is not likely to have a significant adverse effect on the Green and Golden Bell Frog, or interfere with its recovery.

8.2 EPBC Act significance assessment

Is this an important population?

All current populations of Green and Golden Bell Frog are regarded as an 'important population', due to the continued decline of the species and the restricted nature of all known populations in New South Wales (Department of the Environment Water Heritage and the Arts 2009b). A current population is defined as a site where one or more Green and Golden Bell Frogs have been detected on at least one occasion since 1995 (Department of the Environment Water Heritage and the Arts 2009b).

The proposed Project Area occurs in the historic range of this species on the eastern periphery of Hexham Swamp Nature Reserve, with suitable habitat recorded therein.

While no individual was recorded during targeted searches (during optimal survey conditions) for this species, the proposed Project Area occurs within 10 km of a known important population, and less than 500 m from observations recorded post 1995. However, these records were to the east of the proposed Project Area and are separated by industrial developments, the Pacific Highway (Maitland Road) and the South Arm of the Hunter River. There are two other records within 500 m to the west of the study area occurring in the Hexham floodplain wetlands, but these are historical records made prior to 1995 (Office of Environment and Heritage 2011).

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will result in one or more of the following.

Lead to a long-term decrease in the size of an important population of a species

While the study area occurs as part of the historic range of the known local population of the Green and Golden Bell Frog, it will not decrease the size of an important population, as no individuals were detected during targeted searches coinciding with optimal weather conditions. However, the proposed Project would add incrementally to principal threats that affect this species, including habitat removal and degradation; thus, reducing areas of potential habitat should this species expand its range.

Reduce the area of occupancy of an important population

While the study area occurs as part of the historic range of the local population of the Green and Golden Bell Frog, it will not decrease the area of occupancy of an important population, as no individuals were detected during targeted field surveys coinciding with optimal weather conditions. However, the proposed Project would add incrementally to principal threats that affect this species, including, habitat removal and degradation, thus reducing areas of potential habitat, should this species expand its range.

Fragment an existing important population into two or more populations

The proposed Project is linear in nature, effectively increasing the width by approximately 50 m at the widest point of an existing rail corridor that is situated on the eastern boundary of Hexham Swamp Nature Reserve, and bordered immediately to the east by industrial developments (along part of the alignment) and the Pacific Highway (Maitland Road). The proposed Project Area is further fragmented from the known population occurring on Ash Island, by the Hunter River, effectively removing any terrestrial dispersion of this species. However, culverts under the Pacific Highway and existing rail corridor, link Ash Island and the Hunter River to Hexham Swamp Nature Reserve, providing aquatic dispersion.

Furthermore, potential connectivity would still remain to those individuals that are known to occur south (approximately 8 km) of the study area, near Shortland Wetland Centre.

Adversely affect habitat critical to the survival of a species

No critical habitat is listed for the Green and Golden Bell Frog under the EPBC Act.

Habitat critical to the survival of a species may also include areas that are not listed on the Register of Critical Habitat if they are necessary:

- for activities such as foraging, breeding, roosting, or dispersal
- for the long-term maintenance of the species or ecological community (including the maintenance of species essential to the survival of the species or ecological community, such as pollinators)
- to maintain genetic diversity and long-term evolutionary development
- for the reintroduction of populations or recovery of the species or ecological community.

Habitat recorded in the study area was considered suitable for this species according to Significant Impact Guidelines for the Vulnerable Green and Golden Bell Frog (EPBC policy statement 3.19). Thus a significant impact threshold of 1 was ascertained for the study area. However, the proposed Project effectively increases the existing barrier width by approximately 50 m at the widest point of an existing rail corridor, which is bordered immediately to the east by industrial developments (along part of the alignment) and the Pacific Highway (Maitland Road). The proposed Project Area is further fragmented from the known population occurring on Ash Island, by the Hunter River, effectively removing any terrestrial dispersion of this species.

However, culverts under the Pacific Highway and existing rail corridor, link Ash Island and the Hunter River to Hexham Swamp Nature Reserve, providing aquatic dispersion. Furthermore, potential connectivity would remain for individuals previously recorded south (approximately 3 km) of the study area, near Shortland Wetland Centre.

While the study area occurs as part of the historic range of the local population of the Green and Golden Bell Frog, no individuals were detected during targeted field surveys coinciding with optimal weather conditions. The proposed Project would, however, add incrementally to principal threats that affect this species, including, habitat removal and degradation, thus reducing areas of potential habitat, should this species expand its range.

Disrupt the breeding cycle of an important population

The proposed Project would not disrupt the breeding cycle as no individuals were detected during targeted searches that coincided with optimal weather conditions.

Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

The proposed Project would affect approximately 2.70 ha of suitable habitat along an existing linear corridor. While the study area occurs as part of the historic range of the local population of the Green and Golden Bell Frog, no individuals were detected during targeted field surveys coinciding with optimal weather conditions. The proposed Project would, however, add incrementally to principal threats that affect this species, including, habitat

removal and degradation, thus reducing areas of suitable habitat, should this species expand its range. Furthermore, the known local population essentially occurs to the south and east of the proposed Project near Shortland Wetland Centre and Ash Island (Kooragang Island) respectively.

Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat

No. Introduced mosquito fish (*Gambusia* spp.), which are known to prey on the tadpoles of the Green and Golden Bell Frog (Australia 2009), were recorded in most water bodies in the study area during targeted searches.

Introduce disease that may cause the species to decline

No. It is not likely that amphibian chytrid fungus would be introduced by the proposed Project. Chytrid fungus is already widespread in NSW; however, some populations of Green and Golden Bell Frog are free from or resistant to it (Australia 2009). It has been suggested that such populations are located in areas inhospitable to the growth of the disease, such as fluctuating levels of salinity (Australia 2009).

As a precautionary measure, recommendations could include vehicle wash down points (particularly for tyres) for all heavy machinery and light vehicles entering the proposed Project Area.

Interfere substantially with the recovery of the species.

The proposed Project would not fragment potentially suitable habitat for the known population of Green and Golden Bell Frog any more than that currently occurring in proximity to the proposed Project Area. However, the proposed Project would add incrementally to principal threats that affect this species, including, habitat removal and degradation, thus reducing areas of suitable habitat, should this species expand its range.

Conclusion

Surveys conducted over the proposed Project Area during optimal weather conditions when Green and Golden Bell Frogs were observed calling at known occupation sites, were not successful in detecting this species. Although this species historically occurred widely across the Hunter River floodplain, more recent records (post 1995) for this species occur some distance from the proposed Project Area. The proposed Project is unlikely to threaten current Lower Hunter Region populations.

9. Eastern Grass Owl (*Tyto longimembris*)

Status

The Eastern Grass Owl is listed as Vulnerable under the TSC Act.

Description and habitat

The Eastern Grass Owl is a medium-sized, ground-dwelling bird (35 cm) with a facial disc typical of the Tyto owls. The upperparts are dark brown, buff and yellow-orange, with fine silvery spots. Underparts are white in the male, and buffy in the larger female, with sparse dark spots. The long legs are mostly bare and in flight protrude well beyond the tail, distinguishing the species from the similar Barn Owl.

Eastern Grass Owls are found in areas of tall grass, including grass tussocks, in swampy areas, grassy plains, swampy heath, and in cane grass or sedges on flood plains (Office of Environment and Heritage 2011).

Ecology

Eastern Grass Owls always breed on the ground. Nests are found in trodden grass, and are often accessed by tunnels through vegetation (Office of Environment and Heritage 2011). Breeds any time of the year when prey is abundant but mainly after wet March - June (Morcombe 2003).

Distribution

Eastern Grass Owls have been recorded occasionally in all mainland states of Australia but are most common in northern and north-eastern Australia. In NSW they are more likely to be resident in the north-east. Eastern Grass Owl numbers can fluctuate greatly, increasing especially during rodent plagues (Office of Environment and Heritage 2011).

Threats

The following threats to Eastern Grass Owl are recognised (Office of Environment and Heritage 2011):

- loss of suitable habitat due to grazing, agriculture and development
- habitat disturbance and degradation by stock
- use of pesticides in agriculture to control rodent populations thereby limiting seasonal food sources for owls, reducing reproductive potential, and potentially poisoning owls
- frequent burning, which reduces ground cover needed for safe roosting and nesting, and can reduce prey abundance.

Recovery actions

A recovery plan for Eastern Grass Owl has not been prepared. However, the following recovery actions have been identified (Office of Environment and Heritage 2011):

- protect Eastern Grass Owl habitat from fire

- reduce the use of pesticides where Eastern Grass Owls are known to be present
- identify, retain and protect areas of suitable habitat
- fence off areas of suitable habitat and known nesting sites to prevent degradation by stock.

Specific impacts

Field surveys undertaken for this assessment did not record the Eastern Grass Owl. The proposed Project will remove approximately 25.55 ha of exotic grassland / disturbed vegetation, which provides potential habitat for this species.

9.1 EP&A Act assessment

In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

Eastern Grass Owl has not been recorded within the study area, however the species is considered to have a moderate likelihood of occurrence, as suitable habitat is present within the study area. The area of potential habitat to be removed is in poor condition and represents a very small proportion of similar or greater quality habitat within the study area and locality.

As such the proposed Project is unlikely to have an adverse effect upon the lifecycle of the species' such that a viable local population is likely to be placed at risk of extinction.

In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable

In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

- i) **is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction**

Not applicable

- i) **is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction**

Not applicable

In relation to the habitat of a threatened species, population or ecological community:

- i) **the extent to which habitat is likely to be removed or modified as a result of the action proposed**

The Proposed Project will remove approximately 25.55 ha of exotic grassland / disturbed vegetation, which provides potential habitat for this species.

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The proposed Project is linear in nature, effectively increasing the width by approximately 50 m at the widest point of an existing rail corridor that is situated on the eastern boundary of Hexham Swamp Nature Reserve, and bordered immediately to the east by industrial developments (along part of the alignment) and the Pacific Highway (Maitland Road).

Given this species is highly mobile and that similar and potentially more significant habitat occurs widely in the locality, it is considered not likely that habitat would become further isolated or fragmented significantly beyond that currently existing within the study area.

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

Exotic grassland / disturbed vegetation within the study area does not represent significant or preferred habitat for Eastern Grass Owl. Any local population would not be restricted to habitat resources within the study area and are likely to use similar and more significant habitat resources within the locality. Owing to the condition of habitat to be removed and the mobility of the species', the Proposed Project is unlikely to affect the long-term survival of this species.

Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

Critical habitat refers to those areas of land listed in the Register of Critical Habitat kept by the Director General of OEH. No critical habitat has been listed for this species, nor is the study area critical for its survival.

Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

A recovery plan has not been prepared for Eastern Grass Owl. As this species was not recorded within the study area during detailed field surveys and the condition and extent of potential habitat to be removed is relatively low, it is unlikely that the proposed Project will interfere with the recovery of this species.

Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

With respect to the Eastern Grass Owl, the Proposed Project is consistent with one key threatening process under the TSC Act:

- clearing of native vegetation.

The extent of native vegetation clearing and habitat removal associated with the Proposed Project is considered relatively minor in terms of available habitat for these species within the study area and surrounding landscape.

Conclusion

Whilst the Eastern Grass Owl was not recorded during field surveys undertaken for this assessment, the species is considered to occur within the study area with a moderate likelihood, as potential habitat is present. The proposed Project will remove approximately 25.55 ha potential habitat for this species. Vegetation removal associated with the Proposed Project will be linear in nature, predominately clearing areas of vegetation adjacent to the existing rail reserve. Potential habitat within the study area is in poor condition and does not represent significant or preferred habitat for this species. Furthermore, the area of potential habitat to be removed is relatively small in terms of the extent of similar or greater quality habitat available in the study area and surrounding landscape.

As such, the Proposed Project is not considered to have a significant impact on these species.

10. Varied Sittella (*Daphoenositta chrysoptera*)

Status

The Varied Sittella is listed as Vulnerable under the TSC Act.

Description and habitat

The Varied Sittella is a small (10 cm) songbird with a sharp, slightly upturned bill, short tail, barred undertail, and yellow eyes and feet. In flight the orange wing-bar and white rump are prominent. In NSW most individuals have a grey head and are streaked with dark brown, but in the extreme north-east they have a white head, and in the extreme south-west a black cap (Office of Environment and Heritage 2011).

Occur in eucalypt forest and woodland, mallee, farm trees, shelter belts, roadside trees and parks and gardens. While showing preference for rough-barked trees, these birds occur in most treed habitats except rainforest (Morcombe 2003).

Ecology

Builds a cup-shaped nest of plant fibres and cobwebs in an upright tree fork high in the living tree canopy, and often re-uses the same fork or tree in successive years (Office of Environment and Heritage 2011). Breeds during August October and February - March. Average clutch size is 2-3, with young fledge aged 18 - 20 days (Morcombe 2003).

Distribution

The Varied Sittella is sedentary and inhabits most of mainland Australia except the treeless deserts and open grasslands. Distribution in NSW is nearly continuous from the coast to the far west. The Varied Sittella's population size in NSW is uncertain but is believed to have undergone a moderate reduction over the past several decades (Office of Environment and Heritage 2011).

Threats

The following threats to Varied Sittella are recognised (Office of Environment and Heritage 2011):

- Population viability is sensitive to habitat isolation and simplification, including reductions in tree species diversity, tree canopy cover, shrub cover, ground cover, logs, fallen branches and litter.
- Apparent decline has been attributed to declining habitat. The sedentary nature of the Varied Sittella makes cleared land a potential barrier to movement.
- The Varied Sittella is also adversely affected by the dominance of Noisy Miners in woodland patches.
- Threats include habitat degradation through small-scale clearing for fencelines and road verges, rural tree decline, loss of paddock trees and connectivity, 'tidying up' on farms, and firewood collection.

Recovery actions

A recovery plan for Varied Sittella has not been prepared. However, the following recovery actions have been identified (Office of Environment and Heritage 2011):

- retain existing vegetation and remnant stands along roadsides and in paddocks
- increase the size of existing remnants by planting trees and establishing buffer zones
- where remnants have lost connective links, re-establish links by revegetating corridors or stepping stones
- limit firewood collection and retain dead timber in open forest and woodland areas
- encourage regeneration of habitat by fencing remnant stands and managing the intensity and duration of grazing
- control weeds in areas of known habitat.

Specific impacts

Field surveys undertaken for this assessment did not record the Varied Sittella. The Proposed Project will remove approximately 6.40 ha of vegetation within the Swamp Mahogany Swamp Forest on Coastal Lowlands and Swamp Oak Swamp Forest Fringing Estuaries communities, which provide potential habitat for this species.

10.1 EP&A Act assessment

In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

Varied Sittella was not recorded during field surveys undertaken for this assessment, however the species is considered to have a moderate likelihood of occurrence, as suitable habitat is present within the study area. The area of potential habitat proposed to be removed is relatively small in terms of the extent of similar habitat available within the study area and surrounding landscape. As such the Proposed Project is unlikely to have an adverse effect upon the lifecycle of the species' such that a viable local population is likely to be placed at risk of extinction.

In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable

In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

- i) **is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction**

Not applicable

- ii) **is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction**

Not applicable

In relation to the habitat of a threatened species, population or ecological community:

- i) **the extent to which habitat is likely to be removed or modified as a result of the action proposed**

The Proposed Project will remove approximately 6.40 ha of vegetation within the Swamp Mahogany Swamp Forest on Coastal Lowlands and Swamp Oak Swamp Forest Fringing Estuaries communities, which provide potential habitat for this species.

- ii) **whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and**

The proposed Project is linear in nature, effectively increasing the width by approximately 50 m at the widest point of an existing rail corridor that is situated on the eastern boundary of Hexham Swamp Nature Reserve, and bordered immediately to the east by industrial developments (along part of the alignment) and the Pacific Highway (Maitland Road).

Given this species is highly mobile and that similar and potentially more significant habitat occurs widely in the locality, it is considered not likely that habitat would become further isolated or fragmented significantly beyond that currently existing within the study area.

- iii) **the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.**

Areas of potential habitat to be removed are predominately located adjacent to the existing rail reserve, and as such are subject to edge effects. Whilst Varied Sittella may occur intermittently in forest remnants in the study area, the areas of potential habitat are not considered significant habitat for this species.

Owing to the small extent of potential habitat to be removed and the mobility of the species, the Proposed Project is unlikely to affect its long-term survival.

Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

Critical habitat refers to those areas of land listed in the Register of Critical Habitat kept by the Director General of OEH. No critical habitat has been listed for this species, nor is the study area critical for its survival.

Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

A recovery plan has not been prepared for Varied Sittella. As this species was not recorded within the study area during detailed field surveys and the condition and extent of potential habitat to be removed is relatively low, it is unlikely that the proposed Project will interfere with the recovery of this species.

Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

With respect to the Varied Sittella, the Proposed Project is consistent with one key threatening process under the TSC Act:

- clearing of native vegetation.

The extent of native vegetation clearing and habitat removal associated with the Proposed Project is considered relatively minor in terms of available habitat for these species within the study area and surrounding landscape.

Conclusion

Whilst the Varied Sittella was not recorded during field surveys undertaken for this assessment, the species is considered to occur within the study area with a moderate likelihood, as potential habitat is present. The proposed Project will remove approximately 6.40 ha potential habitat for this species. Vegetation removal associated with the Proposed Project will be linear in nature, predominately clearing areas of vegetation adjacent to the existing rail reserve. Potential habitat within the study area is in moderate condition but does not represent significant habitat for this species. Furthermore, the area of potential habitat to be removed is relatively small in terms of the extent of similar or greater quality habitat available in the study area and surrounding landscape.

As such, the Proposed Project is not considered to have a significant impact on these species.

11. White-fronted Chat (*Epthianura albifrons*)

Status

The White-fronted Chat is listed as Vulnerable under the TSC Act.

Description and habitat

The White-fronted Chat is an endemic Australian passerine bird, 12 cm in length and weighing approximately 13 g. It has a short slender bill, long spindly legs, a short square-tipped tail and rounded wings. Classified as a honeyeater it is most similar in form to its close relatives, the Orange Chat, Yellow Chat and Crimson Chat from which it is easily distinguished by its black and white colouration. The male's plumage is more striking than the females; juvenile plumage is most similar to the female. A distinctive 'tang, tang' is used as a contact call (Office of Environment and Heritage 2011).

Occurs in open country, often within the vicinity of inland salt lakes, coastal estuaries, saltmarshes with low and often sparse samphire; also swamp margins, coastal and inland open low heaths, remnant low vegetation on farmlands (Morcombe 2003).

Ecology

White-fronted Chats have been observed breeding from late July through to early March, with 'open-cup' nests built in low vegetation. Nests in the Sydney region have also been seen in low isolated mangroves. Nests are usually built about 23 cm above the ground (but have been found up to 2.5 m above the ground). Two to three eggs are laid in each clutch, and the complete nesting cycle from nest-building to independent young is approximately 50 days. Birds can breed at one year of age and are estimated to live for five years (Office of Environment and Heritage 2011).

Distribution

In NSW, it occurs mostly in the southern half of the state, in damp open habitats along the coast, and near waterways in the western part of the state. Along the coastline, it is found predominantly in saltmarsh vegetation but also in open grasslands and sometimes in low shrubs bordering wetland areas (Office of Environment and Heritage 2011).

Threats

The following threats to White-fronted Chat are recognised (Office of Environment and Heritage 2011):

- reduction in habitat size and quality
- human disturbance
- elevated next predation levels
- alteration of natural flow regimes.

Recovery actions

A recovery plan for White-fronted Chat has not been prepared. However, the following recovery actions have been identified (Office of Environment and Heritage 2011):

- appropriate flow regimes
- survey to identify the key populations around the state.

Specific impacts

Recent field surveys recorded White-fronted Chat in close proximity to the study area, foraging within the Coastal Saltmarsh in Estuaries vegetation community. Whilst this community will not be impacted, the Proposed Project will modify or remove approximately 2.70 ha of *Phragmites australis* and *Typha orientalis* Coastal Freshwater Wetlands, which provide potential habitat for this species.

11.1 EP&A Act assessment

In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

White-fronted Chat was recorded foraging in coastal saltmarsh nearby the study area during recent field surveys, however this habitat type will not be affected by the Proposed Project. *Phragmites australis* and *Typha orientalis* Coastal Freshwater Wetlands provide additional habitat for this species within the study area, of which approximately 2.70 ha will be removed by the Proposed Project.

The local population of White-fronted Chat would not be restricted to habitat resources within the study area and are likely to use similar and more significant habitat resources within the locality. As such the Proposed Project is unlikely to have an adverse effect upon the lifecycle of the species' such that a viable local population is likely to be placed at risk of extinction.

In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable

In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

- i) **is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction**

Not applicable

- i) **is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction**

Not applicable

In relation to the habitat of a threatened species, population or ecological community:

ii) the extent to which habitat is likely to be removed or modified as a result of the action proposed

The Proposed Project will modify or remove approximately 2.70 ha of *Phragmites australis* and *Typha orientalis* Coastal Freshwater Wetlands, which provide potential habitat for this species.

iii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The proposed Project is linear in nature, effectively increasing the width by approximately 50 m at the widest point of an existing rail corridor that is situated on the eastern boundary of Hexham Swamp Nature Reserve, and bordered immediately to the east by industrial developments (along part of the alignment) and the Pacific Highway (Maitland Road).

Given this species is highly mobile and that similar and potentially more significant habitat occurs widely in the locality, it is considered not likely that habitat would become further isolated or fragmented significantly beyond that currently existing within the study area. The ability to access adjacent habitat occurring outside the study area would remain. Therefore, it is unlikely that local populations of these species would become fragmented or isolated from other areas of habitat

iv) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

White-fronted Chat was recorded within the study area was foraging within the Coastal Saltmarsh vegetation community, which will not be affected by the Proposed Project. Area of potential habitat to be removed is not considered significant for this species. Owing to the small extent of potential habitat to be removed and the mobility of the species, the Proposed Project is unlikely to affect its long-term survival.

Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

Critical habitat refers to those areas of land listed in the Register of Critical Habitat kept by the Director General of OEH. No critical habitat has been listed for this species, nor is the study area critical for its survival.

Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

A recovery plan has not been prepared for White-fronted Chat. As the extent of potential habitat to be removed is relatively low and potential habitat of similar or greater quality is available in the study area and locality, it is unlikely that the proposed Project will interfere with the recovery of this species.

Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

With respect to the White-fronted Chat, the Proposed Project is consistent with one key threatening process under the TSC Act:

- clearing of native vegetation

The extent of native vegetation clearing and habitat removal associated with the Proposed Project is considered relatively minor in terms of available habitat for these species within the study area and surrounding landscape.

Conclusion

Recent field surveys recorded White-fronted Chat in close proximity to the study area, foraging within the Coastal Saltmarsh vegetation community. Whilst this community will not be impacted, the Proposed Project will modify or remove approximately 2.70 ha of *Phragmites australis* and *Typha orientalis* Coastal Freshwater Wetlands, which provide potential habitat for this species.

Vegetation removal associated with the Proposed Project will be linear in nature, predominately clearing areas of vegetation adjacent to the existing rail reserve. Potential habitat within the study area is in moderate condition but does not represent significant habitat for this species. Furthermore, the area of potential habitat to be removed is relatively small in terms of the extent of similar or greater quality habitat available in the study area and surrounding landscape.

As such, the Proposed Project is not considered to have a significant impact on these species.

12. Threat-listed aquatic birds

The following aquatic birds have been grouped for assessment owing to similarities in ecology, habitat preference, threats that affect their recovery and potential impacts from the Proposed Project:

- Australian Painted Snipe (*Rostratula australis*).
- Australasian Bittern (*Botaurus poiciloptilus*).
- Black Bittern (*Ixobrychus flavicollis*).
- Magpie Goose (*Anseranas semipalmata*).
- Black-necked Stork (*Ephippiorhynchus asiaticus*).

Table 12-1 Details of threat-listed aquatic birds

Common Name	TSC Act ¹	EPBC Act ²	Habitat and distribution	Threats
Australian Painted Snipe	V	V	Inhabits shallow, vegetated, temporary or infrequently filled wetlands, including where there are trees such as <i>Eucalyptus camaldulensis</i> (River Red Gum), <i>E. populnea</i> (Poplar Box) or shrubs such as <i>Muehlenbeckia florulenta</i> (Lignum) or <i>Sarcocornia quinqueflora</i> (Samphire). Feeds at the water's edge and on mudflats on seeds and invertebrates, including insects, worms, molluscs and crustaceans. Males incubate eggs in a shallow scrape nest (Garnett & Crowley 2000).	Threats for this species include drainage of breeding sites in wetlands. Reduced water quality from siltation and pollution. Predation by foxes and feral cats. Use of herbicides, insecticides and other chemicals near wetlands. Grazing and associated frequent burning of wetlands (Office of Environment and Heritage 2011).
Australasian Bittern	E	E	This species forages in shallow, vegetated freshwater or brackish swamps. The Australasian Bittern requires permanent wetlands with tall dense vegetation, particularly bulrushes and spikerushes for breeding and shelter. When breeding, pairs are found in areas with a mixture of tall and short sedges but will also feed in more open territory. This species occurs in swamp habitats throughout the majority of NSW.(Garnett & Crowley 2000; NSW National Parks and Wildlife Service 2002).	Threats for this species include drainage of wetlands and ponds. Reduced water quality due to siltation, pollution and salinity. Predation by foxes and cats. Pollution of wetlands and ponds from the use of herbicides, pesticides and other chemicals. Grazing and associated frequent burning of wetland areas (Office of Environment and Heritage 2011).

Common Name	TSC Act ¹	EPBC Act ²	Habitat and distribution	Threats
Black Bittern	V	-	Inhabits both terrestrial and estuarine wetlands, generally in areas of permanent water and dense vegetation. Where permanent water is present, the species may occur in flooded grassland, forest, woodland, rainforest and mangroves. In NSW, records of the species are scattered along the east coast, with individuals rarely being recorded south of Sydney or inland (Office of Environment and Heritage 2011).	Threats for this species include clearing of riparian vegetation, predation by foxes and feral cats on eggs and juveniles and grazing and trampling of riparian vegetation by stock (Office of Environment and Heritage 2011).
Magpie Goose	V	-	Mainly found in shallow wetlands (less than 1 m deep) with dense growth of rushes or sedges. The Magpie Goose is still relatively common in the Australian northern tropics, but had disappeared from south-east Australia by 1920 due to drainage and overgrazing of reed swamps used for breeding. Since the 1980s there have been an increasing number of records in central and northern NSW. Vagrants can follow food sources to south-eastern NSW (Office of Environment and Heritage 2011).	Threats for this species include inappropriate hydrological regimes, degradation of habitat through water pollution (e.g. salinity, chemicals, eutrophication), modification of habitat and nest loss from trampling and overgrazing, predation on eggs and goslings and too-frequent burning of wetlands (Office of Environment and Heritage 2011).
Black-necked Stork	V	-	Feed in shallow water up to 0.5 m deep on fish, reptiles and frogs. Build nests in trees close to feeding sites (Garnett & Crowley 2000).	Removal of remnant vegetation and individual trees is regarded as one of the major threats to this species. The scarcity of nest sites also increases competition for those available with other species of bird. Modifications to wetlands also threaten this species and while artificial water sources do provide new areas of habitat, such habitat is often sub-optimal for Black-necked Stork (NSW Scientific Committee 1998).

Notes: 1) Listed as Vulnerable (V) or Endangered (E) under the TSC Act
2) Listed as Vulnerable (V) or Endangered (E) under the EPBC Act

Recovery actions

Specific measures to help recover these species are listed in Table 12-2.

Table 12-2 Recovery measures for threat-listed aquatic birds

Measure	Australian Painted Snipe	Australasian Bittern	Black Bittern	Magpie Goose	Black-necked Stork
Control foxes, feral dogs and cats	X	X	X	X	
Protect swamps from fire during burning-off or hazard reduction activities	X	X		X	
Protect wetlands and watercourses from pollution	X	X			
Limit the use of pesticides and other chemicals near wetlands and consider alternatives where available	X				X

Measure	Australian Painted Snipe	Australasian Bittern	Black Bittern	Magpie Goose	Black-necked Stork
Protect wetlands and associated marshy areas from clearing or disturbance	X	X			X
Fence wetlands to exclude grazing and trampling by stock		X	X	X	X
Protect wetlands from water pollution by reducing the use of chemicals, monitoring of salinity levels and nutrient loading near wetlands				X	
Maintain or restore natural flow regimes in wetlands				X	X
Route or re-route powerlines away from wetlands and floodplains and potential nesting areas on floodplains, and attach discs to existing powerlines where Storks, and other birds, regularly fly					X
Prevent widespread clearance of tall isolated paddock trees that provide or potentially provide suitable nesting sites for the species, and also avoid widespread clearance of floodplain vegetation					X

Specific impacts

Recent field surveys recorded Black-necked Stork foraging in coastal saltmarsh, within the vicinity of the study area. Australian Painted Snipe, Australasian Bittern, Black Bittern and Magpie Goose have a moderate likelihood of occurring intermittently in *Phragmites australis* and *Typha orientalis* Coastal Freshwater Wetlands located within the study area. The proposed Project will modify or remove 2.70 ha of potential habitat for these species.

12.1 EP&A Act assessment

In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

The area of potential foraging habitat proposed to be removed is relatively small in terms of the extent of similar habitat available within the study area and surrounding landscape. As such the Proposed Project is unlikely to have an adverse effect upon the lifecycle of these species such that a viable local population is likely to be placed at risk of extinction.

In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable

In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

- i) **is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction**

Not applicable

- i) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction**

Not applicable

In relation to the habitat of a threatened species, population or ecological community:

- i) the extent to which habitat is likely to be removed or modified as a result of the action proposed**

The Proposed Project will modify or remove approximately 2.70 ha of *Phragmites australis* and *Typha orientalis* Coastal Freshwater Wetlands, which provide potential habitat for these species. No coastal saltmarsh will be affected by the Proposed Project.

- ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and**

The proposed Project is linear in nature, effectively increasing the width by approximately 50 m at the widest point of an existing rail corridor that is situated on the eastern boundary of Hexham Swamp Nature Reserve, and bordered immediately to the east by industrial developments (along part of the alignment) and the Pacific Highway (Maitland Road).

Given these species are highly mobile and that similar and potentially more significant habitat occurs widely in the locality, it is considered not likely that habitat would become further isolated or fragmented significantly beyond that currently existing within the study area. The ability to access adjacent habitat occurring outside the study area would remain. Therefore, it is unlikely that local populations of these species would become fragmented or isolated from other areas of habitat.

- iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.**

The area of potential habitat to be removed does not constitute primary habitat and is likely to only provide a limited foraging resource. The area to be removed is relatively small in terms of the extent of similar or greater quality habitat within the surrounding landscape.

Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

Critical habitat refers to those areas of land listed in the Register of Critical Habitat kept by the Director General of OEH. No critical habitat has been listed for these species, nor is the study area critical to their survival.

Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

A recovery plan has not been prepared for these species. As the extent of potential habitat to be removed is relatively low and potential habitat of similar or greater quality is available in the study area and locality, it is unlikely that the proposed Project will interfere with the recovery of these species.

A recovery plan has not been developed for the three threat-listed aquatic birds.

The Proposed Project is not inconsistent with any specific measures identified by OEH for the recovery of these species.

Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

With respect to threat-listed aquatic birds, the Proposed Project is consistent with two key threatening processes under the TSC Act:

- clearing of native vegetation
- alteration to the natural flow regimes of rivers, streams, floodplains and wetlands.

The extent of native vegetation clearing and habitat removal associated with the proposed Project is considered relatively minor in terms of available habitat for these species within the study area and surrounding landscape.

Conclusion

Recent field surveys recorded Black-necked Stork foraging in coastal saltmarsh, within the vicinity of the study area. Australian Painted Snipe, Australasian Bittern, Black Bittern and Magpie Goose have a moderate likelihood of occurring intermittently in *Phragmites australis* and *Typha orientalis* Coastal Freshwater Wetlands located within the study area.

Marginal potential foraging habitat exists within the proposed Project Area at the edges of these wetlands and where they interface with Swamp Oak Forest Fringing Estuaries. It is estimated that the Proposed Project would remove 2.70 ha of potential foraging habitat for these species which represents a very small proportion of available habitat in the locality. Owing to the mobility of these species and small extent of potential foraging habitat to be removed, the Proposed Project is unlikely to significantly impact upon these species or interfere with their recovery.

12.2 EPBC Act significance assessment for the Australian Painted Snipe

The Australian Painted Snipe is listed as Vulnerable under the EPBC Act. The following assessment has been undertaken following the Matters of National Environmental Significance, Significant Impact Guidelines 1.1 (Department of the Environment Water Heritage and the Arts 2009a). Under the Act, important populations are:

- likely to be key source populations either for breeding or dispersal
- likely to be necessary for maintaining genetic diversity, and/or
- at or near the limit of the species range.

Is this part of an important population?

The Australian Painted Snipe occurs widely in wetland habitats across eastern Australia and, to a lesser extent, extending across the wetlands of northern Australia to the Kimberly coast (Simpson 2004) (Marchant & Higgins 1993). It prefers the shallow edges and exposed mudflats of freshwater and sometimes brackish wetlands where it forages on vegetation,

seeds, molluscs, crustaceans and other invertebrates (Marchant & Higgins 1993). This species is highly nomadic and dispersive in response to rainfall events and may return to areas not inundated for some time (Marchant & Higgins 1993).

The study area contains marginal suitable habitat at the edges of freshwater wetland habitat and very shallow areas where these habitats are not choked by emergent vegetation. The proposed Project Area is unlikely to contain key breeding or dispersal habitats due to its degraded nature and as such is not considered likely to be necessary for maintaining genetic diversity within the population. Potential habitat within the proposed Project Area does not occur at the limit of the Australian Painted Snipe's range.

Therefore, potential habitat within the proposed Project Area is not considered significant for supporting an important population of Australian Painted Snipe.

An action is likely to have a significant impact on an endangered species if there is a real chance or possibility that it will result in one or more of the following.

Lead to a long-term decrease in the size of an important population

The Australian Painted Snipe was not recorded during bird surveys completed for this assessment. Limited suitable foraging habitat existed in the study area, due to the degraded nature of the proposed Project Area. Habitat opportunities occur in shallow wetland edges and where Swamp Oak stands occur proximate to wetland edges. However, a far greater abundance of higher quality habitat occurs throughout the Hexham floodplain and the Hunter River estuary. Thus, the proposed Project is not likely to lead to a long-term decrease in the size of a locally occurring population.

Reduce the area of occupancy of an important population

Approximately 2.70 ha of *Phragmites australis* and *Typha orientalis* Coastal Freshwater Wetlands will be modified or removed by the Proposed Project, although the area which may be suitable for use by Australian Painted Snipe is considerably less, due to large areas rendered unsuitable, by excessive water depth or clogging with emergent vegetation such as Cumbungi (*Typha orientalis*).

Therefore the proposed Project is likely to affect relatively small areas of potential foraging habitat, which are considered marginal due to the disturbed nature of the proposed Project Area. As such potential habitat to be removed during the proposed Project will not reduce the area of potential occupancy for an important population of Australian Painted Snipe.

Fragment an existing important population into two or more populations

The Australian Painted Snipe has not been recorded within the study area. Owing to the small extent of potential habitat to be removed and the mobility of this species, the Proposed Project is unlikely to fragment any important populations potentially present.

Adversely affect habitat critical to the survival of an important population

No critical habitat for this species is listed under the EPBC Act, nor is the study area critical to the survival of this species.

Habitat critical to the survival of a species may also include areas that are not listed on the Register of Critical Habitat if they are necessary:

- For activities such as foraging, breeding, roosting, or dispersal.
- For the long-term maintenance of the species or ecological community (including the maintenance of species essential to the survival of the species or ecological community, such as pollinators).
- To maintain genetic diversity and long-term evolutionary development, or
- For the reintroduction of populations or recovery of the species or ecological community.

Habitat within the proposed Project Area is not considered to be important to locally occurring Australian painted Snipe individuals, due to the small extent of habitat within the proposed Project Area, its degraded open nature and its isolation from large areas of higher quality habitat. Therefore habitat within the proposed Project Area is not considered critical to the survival of the species.

Disrupt the breeding cycle of an important population

No Australian Painted Snipe were recorded within the study area during the field surveys. The study area represents a small proportion of the potential foraging habitat for the species in the locality and habitats that occur within the proposed Project Area are not considered to be extensive or secluded enough for breeding purposes. Therefore, the proposed Project is considered unlikely to disrupt the breeding cycle of an important population for this species.

Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that an important population is likely to decline

The Proposed Project will modify or remove approximately 2.70 ha of marginal potential foraging habitat for this species. This area of potential habitat is relatively small in terms of the extent of similar or greater quality habitat within the wider locality. As such, it is unlikely that the Proposed Project would cause the Australian Painted Snipe to decline.

Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat

It is not likely that invasive species (such as introduced predators) that are potentially harmful to the Australian Painted Snipe would become further established as a result of the Proposed Project.

Introduce disease that may cause the species to decline, or

No. It is not likely that disease would be increased by the Proposed Project.

Interfere with the recovery of the species.

The following recovery initiatives were taken from the Australasian Bittern species profile from the Department of Sustainability, Environment, Water, Population and Communities website (Department of Sustainability 2011b).

In 2001, a project was initiated by the Threatened Bird Network and Australasian Wader Studies Group to improve knowledge of the Australian Painted Snipe so that meaningful conservation actions could be proposed (Rogers et al. 2005). Recovery actions implemented

as part of this study include (Garnett & Crowley 2000; D. Ingwersen 2007, pers. comm.; Rogers et al. 2005):

- the development of a database of records
- the introduction of national targeted surveys conducted twice per year at important historic and contemporary sites and other sites of interest
- an assessment of habitat preferences.

To supplement these measures, the following recovery actions have been recommended (Garnett & Crowley 2000; NSW NPWS 1999b):

- protect and manage habitat at principal breeding and wintering sites and, as a precautionary measure, identify and protect any additional habitat used by the Australian Painted Snipe in the last 10 years
- develop guidelines, in consultation with landholders, for the management of suitable wetlands
- initiate control programs for feral animals, and erect fencing to prevent grazing and trampling of wetlands by cattle, at suitable wetlands
- rehabilitate selected wetlands that were formerly used for breeding
- undertake further research to determine movements and improve knowledge of habitat preferences
- monitor the population at the landscape scale using, to begin with, the Atlas of Australian Birds, and determine the breeding range
- if deemed necessary, from the results of population monitoring, develop techniques to maintain a population in captivity
- encourage participation of community groups and other relevant bodies in the recovery effort.

Based on the potential ecological impacts of the Proposed Project on this species, as discussed above, it is unlikely that the Proposed Project would be in conflict with the recovery objectives above or the Australian Painted Snipe. Owing to the small extent of marginal potential habitat to be removed, it is considered that the Proposed Project will not interfere substantially with the recovery of the Australian Painted Snipe.

Conclusion

The Australian Painted Snipe was not recorded within the study during diurnal or nocturnal surveys undertaken for this assessment. Marginal potential foraging habitat exists within the proposed Project Area at the edges of shallow Freshwater Wetlands and where they interface with Swamp Oak Forest Fringing Estuaries. It is estimated that the Proposed Project would modify or remove approximately 2.70 ha of potential foraging habitat for the Australian Painted Snipe which represents a very small proportion of available habitat in the locality. Owing to the mobility of the species and small extent of potential foraging habitat to be removed, the Proposed Project is unlikely to significantly impact upon this species or interfere with its recovery. Australian Painted Snipe occurring in the vicinity of the study area is not listed as an important population.

12.3 EPBC Act significance assessment for the Australasian Bittern

The Australasian Bittern is listed as Endangered under the EPBC Act. The following assessment has been undertaken following the Matters of National Environmental Significance, Significant Impact Guidelines 1.1 (Department of the Environment Water Heritage and the Arts 2009a). Under the Act, important populations are:

- likely to be key source populations either for breeding or dispersal
- likely to be necessary for maintaining genetic diversity, and/or
- at or near the limit of the species range.

Is this part of an important population?

The Australasian Bittern occurs in wetland habitats across south-eastern and south-western Australia (Simpson 2004) (Marchant & Higgins 2004). The Australasian bittern frequents dense reed beds for foraging and breeding, but is most usually observed when it occasionally forages at the margins of reed beds or in more open wetland contexts (Marchant & Higgins 2004). It prefers nesting sites deep within reed bed habitat (Marchant & Higgins 2004). This species is considered to be generally sedentary, but there have been evidences of irruptive behaviour during very dry or very wet periods (Marchant & Higgins 2004).

The south-eastern Australian population is considered to be an important population (Department of Sustainability 2011a).

The study area lies within close proximity to the Hunter Floodplain wetlands on the Hexham floodplain and the Ash-Kooragang Island delta, within which the Australasian Bittern is known to occur (HBOC 2008). The proposed Project Area contains marginal areas of habitat, that exhibit limited suitability due to a lack of extensive reed beds offering sufficient cover to establish territories. However, there are shallow wetlands and moderately sized reed beds that may be used during possible local movements or post-breeding dispersals. Nevertheless, the proposed Project Area is unlikely to contain key breeding or foraging habitats due to its degraded nature and as such is not considered likely to be necessary for maintaining genetic diversity within the population. Potential habitat within the proposed Project Area does not occur at the limit of the Australasian Bittern's range.

Therefore, potential habitat within the proposed Project Area is not considered significant for supporting an important population of Australasian Bittern.

An action is likely to have a significant impact on an endangered species if there is a real chance or possibility that it will result in one or more of the following.

Lead to a long-term decrease in the size of an important population

The Australasian Bittern was not recorded during bird surveys completed for this assessment. Marginal foraging habitat existed in the study area, due to the small extent of the proposed Project Area's wetland habitats and their distance to high quality habitat elsewhere in the locality. Those habitat opportunities occurring within the proposed Project Area are limited to shallow wetlands and small to moderate sized reed beds. A far greater abundance of higher quality habitat occurs throughout the Hunter River floodplain. Thus, the

proposed Project is not likely to lead to a long-term decrease in the size of a locally occurring important population.

Reduce the area of occupancy of an important population

Approximately 2.70 ha of *Phragmites australis* and *Typha orientalis* Coastal Freshwater Wetlands will be modified or removed by the Proposed Project, although such habitat in its current form is unlikely to support this species in isolation, due to its small extent. Furthermore, the distance to higher quality habitat locally is such that access to many of the wetlands within the proposed Project Area is not convenient for this species.

Therefore the proposed Project is likely to affect relatively small areas of potential foraging habitat, which are considered marginal due to their extent and location. As such potential habitat to be removed during the proposed Project will not reduce the area of potential occupancy for an important population of Australasian Bittern.

Fragment an existing important population into two or more populations

The Australasian Bittern has not been recorded within the study area. Owing to the small extent of potential habitat to be removed and the mobility of this species, the Proposed Project is unlikely to fragment any important populations potentially present.

Adversely affect habitat critical to the survival of an important population

No critical habitat for this species is listed under the EPBC Act, nor is the study area critical to the survival of this species.

Habitat critical to the survival of a species may also include areas that are not listed on the Register of Critical Habitat if they are necessary:

- For activities such as foraging, breeding, roosting, or dispersal.
- For the long-term maintenance of the species or ecological community (including the maintenance of species essential to the survival of the species or ecological community, such as pollinators).
- To maintain genetic diversity and long-term evolutionary development, or
- For the reintroduction of populations or recovery of the species or ecological community.

Habitat within the proposed Project Area is not considered to be important to local Australasian Bittern individuals, due to the small extent of habitat within the proposed Project Area and its isolation from large areas of higher quality habitat. Therefore habitat within the proposed Project Area is not considered critical to the survival of the species.

Disrupt the breeding cycle of an important population

No Australasian Bitterns were recorded within the study area during the field surveys. The study area represents a relatively small area of the marginal potential foraging habitat for the species in the locality and habitats within the proposed Project Area are not considered to be extensive or secluded enough for breeding purposes. Therefore, the proposed Project is considered unlikely to disrupt the breeding cycle of an important population for this species.

Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that an important population is likely to decline

The Proposed Project will remove or modify approximately 2.70 ha of marginal potential foraging habitat for this species. This area of potential habitat is relatively small in terms of the extent of similar or greater quality habitat within the wider locality. As such, it is unlikely that the Proposed Project would cause the Australasian Bittern to decline.

Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat

It is not likely that invasive species (such as introduced predators) that are potentially harmful to the Australasian Bittern would become further established as a result of the Proposed Project.

Introduce disease that may cause the species to decline, or

No. It is not likely that disease would be increased by the Proposed Project.

Interfere with the recovery of the species.

The following recovery initiatives were taken from the Australasian Bittern species profile from the Department of Sustainability, Environment, Water, Population and Communities website (Department of Sustainability 2011a).

Conservation of the current population requires the maintenance of suitable wetland habitats. For many locations, the top priority is to ensure that a suitable water regime is maintained or established. At present, Fivebough Swamp in NSW, Bool Lagoon in South Australia and Lake Muir and its surrounding wetlands in Western Australia are managed to benefit the resident Bittern populations (Garnett & Crowley 2000; R. Jaensch June 2005, pers. comm.). Further recommended management actions include:

- Research to establish more accurate population estimates and to provide more detail on habitat and drought refuge requirements, diet, predators, breeding range and movements.
- Identification, protection and management of habitat, including principal breeding wetlands.
- Rehabilitation of selected former breeding habitats.
- Control of feral animals, particularly foxes and cats.
- Development of appropriate guidelines for wetland management.
- Involvement of community groups and bird associations in the collection of information (Garnett & Crowley 2000; Smith et al. 1995).

Based on the potential ecological impacts of the Proposed Project on this species, as discussed above, it is unlikely that the Proposed Project would be in conflict with the recovery objectives above of the Australasian Bittern. Owing to the small extent of marginal potential habitat to be removed, it is considered that the Proposed Project will not interfere substantially with the recovery of the Australasian Bittern.

Conclusion

The Australasian Bittern was not recorded within the study during diurnal or nocturnal surveys undertaken for this assessment. Marginal potential foraging habitat exists within the proposed Project Area within the shallow Freshwater Wetlands and associated reed beds. It is estimated that the Proposed Project would remove or modify approximately 2.70 ha of marginal potential foraging habitat for the Australasian Bittern, which represents a small proportion of available habitat in the locality. Owing to the isolation and small extent of potential foraging habitat to be removed, the Proposed Project is unlikely to significantly impact upon this species or interfere with its recovery. Australasian Bittern occurring in South-eastern Australia is considered to be an important population (Department of Sustainability 2011a).

13. Threat-listed waders

The following waders have been grouped for assessment owing to similarities in ecology, habitat preference, threats that affect their recovery and potential impacts from the Proposed Project:

- Great Knot (*Calidris tenuirostris*).
- Greater Sand Plover (*Charadrius leschenaultii*).
- Lesser Sand Plover (*Charadrius mongolus*).
- Broad-billed Sandpiper (*Limicola falcinellus*).
- Black-tailed Godwit (*Limosa limosa*).

Table 13-1 Details of threat-listed aquatic birds

Common Name	TSC Act ¹	EPBC Act	Habitat and distribution	Threats
Great Knot	V	-	Occurs within sheltered, coastal habitats containing large, intertidal mudflats or sandflats, including inlets, bays, harbours, estuaries and lagoons. In NSW, the species has been recorded at scattered sites along the coast to about Narooma. It has also been observed inland at Tullakool, Armidale, Gilgandra and Griffith (Office of Environment and Heritage 2011).	Threats for these species include hydrological changes to inland lakes and tourism or agricultural developments that reduce coastal and inland habitat areas (Office of Environment and Heritage 2011).
Greater Sand Plover	V	-	Almost entirely restricted to coastal areas in NSW, occurring mainly on sheltered sandy, shelly or muddy beaches or estuaries with large intertidal mudflats or sandbanks. The Greater Sand Plover breeds in central Asia from Armenia to Mongolia, moving further south for winter. In NSW, the species has been recorded between the northern rivers and the Illawarra, with most records coming from the Clarence and Richmond estuaries (Office of Environment and Heritage 2011).	

Common Name	TSC Act ¹	EPBC Act	Habitat and distribution	Threats
Lesser Sand Plover	V	-	Almost entirely coastal in NSW, favouring the beaches of sheltered bays, harbours and estuaries with large intertidal sandflats or mudflats; occasionally occurs on sandy beaches, coral reefs and rock platforms. The Lesser Sand Plover breeds in central and north eastern Asia, migrating further south for winter. In Australia the species is found around the entire coast but is most common in the Gulf of Carpentaria, and along the east coast of Queensland and northern NSW. Individuals are rarely recorded south of the Shoalhaven estuary, and there are few inland records (Office of Environment and Heritage 2011).	
Broad-billed Sandpiper	V	-	Broad-billed Sandpipers favour sheltered parts of the coast such as estuarine sandflats and mudflats, harbours, embayments, lagoons, saltmarshes and reefs as feeding and roosting habitat. The eastern form of this species breeds in northern Siberia before migrating southwards in winter to Australia. In Australia, Broad-billed Sandpipers overwinter on the northern coast, particularly in the north-west, with birds located occasionally on the southern coast. In NSW, the main site for the species is the Hunter River estuary, with birds occasionally reaching the Shoalhaven estuary. There are few records for inland NSW (Office of Environment and Heritage 2011).	
Black-tailed Godwit	V	-	Usually found in sheltered bays, estuaries and lagoons with large intertidal mudflats and/or sandflats (Office of Environment and Heritage 2011).	

Notes: 1) Listed as Vulnerable (V) or Endangered (E) under the TSC Act

Recovery actions

Specific measures to help recover these species are listed in Table 13-2.

Table 13-2 Recovery measures for threat-listed waders

Measure	Great Knot	Greater Sand Plover	Lesser Sand Plover	Broad-billed Sandpiper	Black-tailed Godwit
Control dogs on beaches and in estuaries	X				
Give way' to birds when walking, driving or riding on the beach	X				
Protect coastal areas from pollution	X				

Measure	Great Knot	Greater Sand Plover	Lesser Sand Plover	Broad-billed Sandpiper	Black-tailed Godwit
Protect and maintain known or potential habitat; implement protection zones around recent records	X	X	X	X	X
Raise visitor awareness about the presence of this and other threatened shorebird species; provide information on how their actions will affect the species' survival		X	X	X	X
Manage estuaries and the surrounding landscape to ensure natural hydrological regimes are maintained		X	X	X	X
Searches for the species should be conducted in suitable habitat in proposed development areas. Assess the importance of the site to the species' survival. Include the linkages the site provides for the species between ecological resources across the broader landscape. NPWS should be consulted when planning development to minimise impact on populations				X	X
Assess the importance of sites to the species' survival; include the linkages the site provides for the species between ecological resources across the landscape					X

13.1 EP&A Act assessment

In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

The Proposed Project would result in the removal of approximately 2.70 ha of habitat for waders in the form of *Phragmites australis* and *Typha orientalis* Coastal Freshwater Wetlands in moderate condition. Wetlands are necessary for the entire lifecycle of waders. The area of potential foraging habitat proposed to be removed is relatively small in terms of the extent of similar habitat available within the Study Area and surrounding Hunter River estuary. As such, the lifecycles of waders in the locality will continue and the Proposed Project is unlikely to have an adverse effect upon the lifecycle of the species such that a viable local population is likely to be placed at risk of extinction.

In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable.

In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

- i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction**

Not applicable.

- ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction**

Not applicable

In relation to the habitat of a threatened species, population or ecological community:

i) the extent to which habitat is likely to be removed or modified as a result of the action proposed

The Proposed Project would result in the removal of approximately 2.70 ha of habitat for waders in the form of *Phragmites australis* and *Typha orientalis* Coastal Freshwater Wetlands

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The Proposed Project will not result in the fragmentation of habitat *per se* (i.e. the breaking apart of one piece of habitat into two or more smaller pieces) for these species. A small increase in physical habitat isolation will occur through the incremental clearing of habitat at the interface of current rail easement. However, no functional loss of connectivity is likely to occur for these species as they are all highly mobile flyers capable of traversing large areas of less suitable habitat.

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

The Study Area provides a relatively small amount of moderately suitable habitat for these wader species. Approximately 2.70 ha of habitat for waders would be removed by the Proposed Project. When considered in the context of the available habitat in the locality (i.e. Hunter River Estuary), the potential habitat for these species in the Study Area is relatively unimportant for the long-term survival of these species in the locality.

Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

Critical habitat refers to those areas of land listed in the Register of Critical Habitat kept by the Director General of the OEH. No critical habitat has been listed for these species to date. Consequently, no adverse effect to any critical habitat for these species, as defined under the TSC Act, will occur due to the Proposed Project.

Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

A recovery plan has not been developed for any of these wader species. However, the OEH have identified actions to assist in the recovery of these species (refer Table 13-2). The Proposed Project is not inconsistent with any specific measures identified by OEH for the recovery of these species.

Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

The Proposed Project is consistent with two key threatening processes: clearing of native vegetation and alteration to the natural flow regimes of rivers, streams, floodplains and wetlands which are recognised as a threat to these wader species.

Conclusion

Suitable habitat for the threat-listed wader species is present in the Study Area. However, similar and better quality resources are abundant in the locality. The small area of moderate condition habitat to be removed is considered of little importance for the survival of these species' as a whole. No fragmentation of habitats will occur and the importance of the habitat to be removed is minor when compared to the available roosting and breeding habitat in the locality. Foraging and breeding habitat for these wader species will continue to exist in the locality and the local occurrence of these species is unlikely to be placed at risk of extinction by the Proposed Project. Therefore, the Proposed Project is unlikely to have a significant impact on these species.

14. Threat-listed raptors

The following raptors have been grouped for assessment owing to similarities in ecology, habitat preference, threats that affect their recovery and potential impacts as a result of the Proposed Project.

- Little Eagle (*Hieraaetus morphnoides*).
- Spotted Harrier (*Circus assimilis*).

Table 14-1 Details of threat-listed Raptors

Common Name	TSC Act	EPBC Act	Habitat and distribution	Threats
Little Eagle	V	-	The Little Eagle is distributed throughout the Australian mainland occupying habitats rich in prey within open eucalypt forest, woodland or open woodland. Sheoak or acacia woodlands and riparian woodlands of interior NSW are also used. For nest sites it requires a tall living tree within a remnant patch, where pairs build a large stick nest in winter and lay in early spring. Prey includes birds, reptiles and mammals, with the occasional large insect and carrion. Most of its former native mammalian prey species in inland NSW are extinct and rabbits now form a major part of the diet (Marchant & Higgins 1993).	Over 50 % of forest and woodlands in NSW have been cleared (NSW Scientific Committee 2010). Thus, the main threat affecting this species is further clearing and degradation of foraging and breeding habitat (NSW Scientific Committee 2009a). On the NSW tablelands and western slopes, important habitat is 53 – 84 % cleared and moderately to highly stressed (NSW Scientific Committee 2009a). Loss of breeding sites may bring this species into increasing interspecific competition with the larger and more dominant Wedge-tailed Eagle.
Spotted Harrier	V	-	The Spotted Harrier occurs throughout the Australian mainland in grassy open woodland including acacia and mallee remnants, inland riparian woodland, grassland and shrub steppe (e.g. chenopods) (Marchant & Higgins 1993). It is found mostly commonly in native grassland, but also occurs in agricultural land, foraging over open habitats including edges of inland wetlands. The diet of the Spotted Harrier includes terrestrial mammals, birds and reptiles, occasionally large insects and rarely carrion.	The main threat that affects this species is the clearing and degradation of foraging and breeding habitat, particularly where it affects prey densities. Other threats include the possibility of secondary poisoning from rodenticides and pindone used to control rabbits (NSW Scientific Committee 2009c).

Recovery actions

Specific measures to help recover these species are listed in Table 14-2.

Table 14-2 Recovery measures for threat-listed raptors

Measure	Little Eagle	Spotted Harrier
Buffer habitat areas from the impacts of other activities	X	
Protect known populations and areas of potential habitat from clearing, fragmentation or disturbance	X	
Rehabilitate known and potential habitat	X	
Retain and protect nesting and foraging habitat	X	X
Protect areas of habitat from overgrazing		X
Protect areas of habitat from development		X

Specific impacts

The Spotted Harrier was recorded over Hexham Swamp outside the Study Area during field surveys. Although not recorded, the Little Eagle has potential habitat in the Proposed Project Area. The Proposed Project will result in the removal of approximately 7.4 ha of wooded habitat and approximately 32.7 ha of exotic grassland, herbfields, and reedlands which may provide foraging habitat.

14.1 EP&A Act assessment

In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

The Spotted Harrier and Little Eagle both nest in trees in lightly forested areas and tend to avoid dense closed forests. The Proposed Project will result in the removal of approximately 7.4 ha of vegetation that may provide nesting opportunities for these species. However, the habitat to be removed showed no evidence of nesting from either species during the field surveys. The habitat to be removed is considered sub-optimal in terms of nesting suitability for these species as it is closed and dense. Both species forage by searching the ground for prey such as small birds, mice, rats, rabbits, lizards, and insects. The cleared areas of exotic grassland, the herbfields, and reedlands provide suitable foraging habitat for these species and the Spotted Harrier was observed hunting in Hexham Swamp outside the Study area during the survey period. Approximately 32.7 ha of foraging habitat will be removed by the Proposed Project. However, foraging habitat is abundant in the locality.

As no breeding habitat will be removed by the Proposed Project and foraging habitat in the form of cleared areas is abundant in the locality, it is unlikely that the Proposed Project would have an adverse effect on the lifecycle of the Spotted Harrier or Little Eagle such that a viable local population of these species is likely to be placed at risk of extinction.

In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable.

In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

- i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction**

Not applicable.

- i) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction**

Not applicable.

In relation to the habitat of a threatened species, population or ecological community:

- i) the extent to which habitat is likely to be removed or modified as a result of the action proposed**

The Proposed Project would remove approximately 7.4 ha of wooded habitat that is sub-optimal for breeding and approximately 32.7 ha of exotic grassland, herbfields, and reedlands which may provide foraging habitat for these species.

- ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and**

The Proposed Project will not result in the fragmentation of habitat *per se* (i.e. the breaking apart of one piece of habitat into two or more smaller pieces) for these species. A small increase in physical habitat isolation will occur through the incremental clearing of habitat at the interface of current rail easement. However, no functional loss of connectivity is likely to occur for these species as they are all highly mobile flyers capable of traversing, and utilising, large cleared areas.

- iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.**

The Study Area provides a relatively small amount of moderately suitable nesting habitat for these two species and larger areas of cleared land suitable for foraging. Approximately 7.4 ha of wooded habitat that is sub-optimal for breeding and approximately 32.7 ha of exotic grassland, herbfields, and reedlands suitable for foraging would be removed by the Proposed Project. . When considered in the context of the available foraging habitat in the locality and the presence of more suitable roosting sites in more open woodland and forest, the potential habitat for these species in the Study Area is relatively unimportant.

Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

Critical habitat refers to those areas of land listed in the Register of Critical Habitat kept by the Director General of the OEH. No critical habitat has been listed for these species to date. Consequently, no adverse effect to any critical habitat for these species, as defined under the TSC Act, will occur due to the Proposed Project.

Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

A recovery plan has not been developed for the Little Eagle or Spotted Harrier. However, the OEH have identified actions to assist in the recovery of these species (refer Table 14-2). The Proposed Project is not inconsistent with any specific measures identified by OEH for the recovery of these species.

Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

The Proposed Project is consistent with one key threatening process: clearing of native vegetation which is recognised as a threat to these three species.

Conclusion

Suitable foraging habitat for the Little Eagle or Spotted Harrier is present in the Study Area. Sub-optimal nesting habitat is also present in the wooded areas. However, similar and better quality resources are abundant in the locality. The habitat to be removed is considered of little importance for the survival of these species as only sub-optimal breeding habitat will be affected, no fragmentation of habitats will occur, and the importance of the habitat to be removed is minor when compared to the available roosting and breeding habitat in the locality. Foraging habitat for these species will continue to occur in the locality and the local occurrence of these three species is unlikely to be placed at risk of extinction by the Proposed Project. Therefore, the Proposed Project is unlikely to have a significant impact on these species.

15. Threat-listed opportunistic blossom nomads

The following opportunistic blossom nomads have been grouped for assessment owing to similarities in ecology and habitat preference:

- Swift Parrot (*Lathamus discolor*).
- Little Lorikeet (*Glossopsitta pusilla*).
- Grey-headed Flying-fox (*Pteropus poliocephalus*).

The Swift Parrot, Little Lorikeet and Grey-headed Flying-fox have been assessed together as they generally share similar habitat requirements in terms of foraging resources; threats that affect their recovery; and potential impacts as a result of the Proposed Project.

Table 15-1 Details of threat-listed opportunistic blossom nomads

Common Name	TSC Act	EPBC Act	Habitat and distribution	Threats
Swift Parrot	E	E	Breeding occurs in Tasmania, majority migrates to mainland Australia in autumn, over-wintering, particularly in Victoria and central and eastern NSW, but also south-eastern Queensland as far north as Duaringa. Until recently it was believed that in New South Wales, swift parrots forage mostly in the western slopes region along the inland slopes of the Great Dividing Range but are patchily distributed along the north and south coasts including the Sydney region, but new evidence indicates that the forests on the coastal plains from southern to northern NSW are also extremely important. In mainland Australia is semi-nomadic, foraging in flowering eucalypts in eucalypt associations, particularly box-ironbark forests and woodlands. Preference for sites with highly fertile soils where large trees have high nectar production, including along drainage lines and isolated rural or urban remnants, and for sites with flowering <i>Acacia pycnantha</i> , is indicated. Sites used vary from year to year. (Garnett & Crowley 2000),(Swift Parrot Recovery Team 2001).	On mainland Australia, the main threat affecting this species is the loss of habitat through clearing for agriculture and urban and industrial development. During the breeding season and winter migration, collisions with wire netting fences, windows and cars, threaten this species, particularly where such obstacles are in close proximity to suitable habitat (NSW National Parks & Wildlife Service 2002).

Common Name	TSC Act	EPBC Act	Habitat and distribution	Threats
Little Lorikeet	V		The Little Lorikeet inhabits forests and woodlands, with most associations occurring in dry, open eucalypt forest and woodlands (Gibson Roy 2008).	Most breeding records come from the western slopes, a region that has extensive habitat loss from historic clearing. Coupled with the fact that in NSW, over 50 % of forests and woodlands have been cleared (Lunney & Burgin 2004), the main threat that affects the species is the further loss and degradation of foraging and breeding habitat from land clearing (NSW Scientific Committee 2009b). Furthermore, nest hollows are not being recruited at a rate that compensates the loss of breeding habitat (Courtney J. 2006) and the loss of eucalypt woodland results in large reductions in food availability, particularly White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland, an important habitat for Little Lorikeet, which is listed as Critically Endangered under the EPBC Act.
Grey-headed Flying-fox	V	V	Occurs in subtropical and temperate rainforests, tall sclerophyll forests and woodlands, heaths and swamps. Urban gardens and cultivated fruit crops also provide habitat for this species. Feeds on the flowers and nectar of eucalypts and native fruits including lilly pillies. It roosts in the branches of large trees in forests or mangroves (Churchill 2008; NSW National Parks and Wildlife Service 2001).	Key threats to this species include: <ul style="list-style-type: none"> ▪ loss of foraging habitat ▪ disturbance of roosting sites ▪ unregulated shooting ▪ electrocution on powerlines.

Recovery actions

Specific measures to help recover these species are listed in Table 15-2.

Table 15-2 Recovery measures for threat-listed opportunistic blossom nomads

Measure	Swift Parrot	Little Lorikeet	Grey-headed Flying-fox
Reduce collisions in foraging areas by closing window blinds or letting windows get dirty. Alternatively hang wind chimes, mobiles etc in front of windows. Hang strips of fabric across wire mesh fences	X		
Retain stands of winter-flowering feed-trees, particularly large mature individuals	X		
Revegetate with winter-flowering tree species where appropriate	X		
Participate in biannual surveys to locate the winter foraging areas for this species	X		
Retain large old trees, especially those that are hollow-bearing		X	

Measure	Swift Parrot	Little Lorikeet	Grey-headed Flying-fox
Ensure recruitment of trees into the mature age class so that there is not a lag period of decades between the death of old trees and hollow formation in younger trees		X	
Protect large flowering Eucalyptus trees throughout the habitats frequented by this species. Manage remnant woodlands and forest for recovery of old-growth characteristics		X	
Where natural tree recruitment is inadequate, replant local species to maintain foraging habitat and breeding sites		X	
Reduce the abundance of feral Honeybees and limit the exploitation of nectar by domestic bees where resources are spatially or temporally sparse (e.g. in years of drought)		X	
Document nest sites and ensure their protection		X	
Protect roost sites, particularly avoid disturbance September through November			X
Identify and protect key foraging areas			X
Manage and enforce licensed shooting			X
Investigate and promote alternative non-lethal crop protection mechanisms			X
Identify powerline blackspots and implement measures to reduce deaths			X

Specific impacts

The Grey-headed Flying-fox was recorded during field surveys completed for this assessment. Two additional threat-listed opportunistic blossom nomads, the Swift Parrot and Little Lorikeet are considered likely to occur within the proposed Project Area with a moderate likelihood. The Proposed Project will remove approximately 1.12 ha of Swamp Mahogany Swamp Forest on Coastal Lowlands vegetation which potentially provides habitat for these species.

15.1 EP&A Act assessment

In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

The life cycle of these three species is similar in terms of foraging requirements. Each species required access to seasonally available blossom from trees and in the case of the Grey-headed Flying-fox, fruits. The Swift Parrot breeds in the forests of Tasmania and as such this region is important for this stage of its lifecycle. The Little Lorikeet breeds in tree hollows while the Grey-headed Flying-fox breeds in camps which are usually established near a source of water.

The Proposed Project will result in the removal of approximately 1.12 ha of vegetation (Swamp Mahogany Swamp Forest on Coastal Lowlands) that contains some suitable foraging habitat for these species. No habitat for breeding in the form of hollow-bearing trees or Grey-headed Flying-fox camps will be affected. Due to the abundance of foraging resources in the locality in the form of eucalypts in forested areas and flowering and fruiting trees planted in parks, gardens, and as urban street trees, it is unlikely that the Proposed

Project would have an adverse effect on the lifecycle of these three species such that a viable local population is placed at risk of extinction.

In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable

In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

- i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction**

Not applicable

- ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction**

Not applicable

In relation to the habitat of a threatened species, population or ecological community:

- i) the extent to which habitat is likely to be removed or modified as a result of the action proposed**

The Proposed Project will remove approximately 1.12 ha of vegetation (Swamp Mahogany Swamp Forest on Coastal Lowlands) that contains some suitable foraging habitat for these three species.

- ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and**

The Proposed Project will not result in the fragmentation of habitat *per se* (i.e. the breaking apart of one piece of habitat into two or more smaller pieces) for these species. A small increase in physical habitat isolation will occur through the incremental clearing of habitat at the interface of current rail easement. However, no functional loss of connectivity is likely to occur for these species as they are all highly mobile flyers capable of traversing large cleared areas to move between more suitable habitats.

- iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.**

The Study Area provides a relatively small amount of moderately suitable foraging habitat for these four species. Approximately 1.12 ha of vegetated foraging habitat (Swamp Mahogany Swamp Forest on Coastal Lowlands) will be removed by the Proposed Project. When considered in the context of the available habitat in the locality and the fact that no roosting resources for any of these species will be affected by the Proposed Project, the potential habitat for these species in the Study Area is relatively unimportant.

Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

Critical habitat refers to those areas of land listed in the Register of Critical Habitat kept by the Director General of the OEH. No critical habitat has been listed for these species to date. Consequently, no adverse effect to any critical habitat for these species, as defined under the TSC Act, will occur due to the Proposed Project.

Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

A recovery plan has not been developed for the Little Lorikeet or Swift Parrot. However, the OEH have identified actions to assist in the recovery of these species (refer Table 15-2). The Proposed Project is not inconsistent with any specific measures identified by OEH for the recovery of these species.

A draft national recovery plan for the Grey-headed Flying-fox has been prepared (see Department of Environment Climate Change and Water NSW 2009). The Proposed Project is not inconsistent with any specific measures identified within the draft recovery plan.

Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

The Proposed Project is consistent with one key threatening process: clearing of native vegetation which is recognised as a threat to these three species.

Conclusion

Moderately suitable foraging habitat (~1.12 ha) for the Swift Parrot, Little Lorikeet and Grey-headed Flying-fox is present in the Study Area. However, similar and better quality resources are abundant in the locality. The habitat to be removed is considered of little importance for the survival of these species as no breeding habitat will be affected, no fragmentation of habitats will occur, and the importance of the habitat to be removed is minor when compared to the available roosting and breeding habitat in the locality. Foraging habitat for these species will continue to occur in the locality and the local occurrence of these three species is unlikely to be placed at risk of extinction by the Proposed Project. Therefore, the Proposed Project is unlikely to have a significant impact on these species.

15.2 EPBC Act significance assessment for the Swift Parrot

The Swift Parrot is listed as both Endangered and a Marine species under the EPBC Act. The following assessment has been undertaken following the Matters of National Environmental Significance, Significant Impact Guidelines 1.1 (Department of the Environment Water Heritage and the Arts 2009a).

An action is likely to have a significant impact on an endangered species if there is a real chance or possibility that it will result in one or more of the following.

Lead to a long-term decrease in the size of a population

The Swift Parrot was not recorded during bird surveys completed for this assessment. A limited amount (1.12 ha) of suitable winter foraging habitat (*Eucalyptus robusta* – Swamp Mahogany) existed in the study area. Potential habitat within the proposed Project Area occurred in a relatively isolated context in relation to larger stands of suitable habitat elsewhere in the locality. Due to its small area and isolated nature it is unlikely that potential habitat within the proposed Project Area would be significant to Swift Parrots visiting the Hunter Region. The removal of approximately 1.12 ha of foraging habitat is unlikely to reduce the carrying capacity of the Swift Parrot population. Thus, the proposed Project is not likely to lead to a long-term decrease in the size of the locally occurring nomadic population.

Reduce the area of occupancy of the species

The proposed Project is likely to affect approximately 1.12 ha of potential foraging habitat, which occurs as small remnant linear stands in the Study Area. The removal of potential habitat will reduce the area of occupancy (for foraging habitat) for this species by 1.12 ha. The species may still occupy the area while moving between foraging grounds.

Fragment an existing population into two or more populations

The Proposed Project will not result in the fragmentation of habitat *per se* (i.e. the breaking apart of one piece of habitat into two or more smaller pieces). Owing to the small extent of potential habitat to be removed and the great mobility of this species, functional connectivity will remain and the Proposed Project is unlikely to fragment any populations that may potentially forage in the Study Area on a seasonal basis.

Adversely affect habitat critical to the survival of a species

No critical habitat for the Swift Parrot is listed under the EPBC Act, nor is the Study Area critical to the survival of this species. Habitat critical to the survival of a species may also include areas that are not listed on the Register of Critical Habitat if they are necessary:

- For activities such as foraging, breeding, roosting, or dispersal.
- For the long-term maintenance of the species or ecological community (including the maintenance of species essential to the survival of the species or ecological community, such as pollinators).
- To maintain genetic diversity and long-term evolutionary development, or
- For the reintroduction of populations or recovery of the species or ecological community.

The Swift Parrot breeding grounds in Tasmania and large areas of woodland and forest with reliable winter nectar flows on the mainland are critical to the survival of the Swift Parrot, neither of which occurs in the Study Area.

Disrupt the breeding cycle of a population

The entire Swift Parrot population breeds in Tasmania during the spring and summer with no individuals occurring on the mainland during their breeding cycle. Therefore the proposed Project will not disrupt the breeding cycle of this species.

Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

The Proposed Project will remove approximately 1.12 ha of potential foraging habitat for this species. The area of potential habitat is relatively small and isolated in comparison with similar or greater quality habitat within the locality. As such, it is unlikely that the Proposed Project would cause the Swift Parrot to decline.

Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat

It is not likely that invasive species (such as introduced predators) that are potentially harmful to the Swift Parrot would become further established as a result of the Proposed Project, due to the occurrence of invasive species throughout the proposed Project Area.

Introduce disease that may cause the species to decline, or

No. It is not likely that disease would be increased by the Proposed Project.

Interfere with the recovery of the species.

The following is a summary of proposed actions for the National Swift Parrot Recovery Plan 2006 - 2010 (Saunders 2005).

Action 1. Identify the extent and quality of habitat.

- Action 1a. Identify the extent and quality of nesting and foraging habitat in Tasmania.
- Action 1b. Identify the extent and quality of foraging habitat on private property in Victoria.
- Action 1c. Identify priority foraging habitat within New South Wales.
- Action 1d. Identify the extent and quality of foraging habitat within Queensland, Australian Capital Territory and South Australia.
- Action 1e. Monitor the flowering patterns of blue gum and Swift Parrot breeding.
- Action 1f. Identify migration and non-migration movement patterns.

Action 2. Manage Swift Parrot habitat at a landscape scale

- Action 2a. Mapping of post-breeding and nesting habitat.

- Action 2b. Mapping of priority mainland habitats.
- Action 2c. Mapping of roosting habitat.
- Action 2d. Management and protection of habitat with on ground actions in relevant catchments throughout the range of the species.

Action 3. Reduce the incidence of collisions

Action 4. Population and habitat monitoring

- Action 4a. Ongoing population monitoring.
- Action 4b. Ongoing winter volunteer surveys.
- Action 4c. Monitoring the effectiveness of management prescriptions in conserving habitat in production forests.

Action 5. Community education and information

- Action 5a. Provide advice and support to community members, Catchment Management Authorities and landowners, including Indigenous landowners.
- Action 5b. Aboriginal consultation.
- Action 5c. Swifts Across the Strait Newsletter (Saunders 2002a).

Action 6. Manage the recovery process

- Action 6a: Management by recovery team, including Catchment Management Authority representatives.
- Action 6b: Recovery database management.

Based on the potential ecological impacts of the Proposed Project on this species, as discussed above, it is unlikely that the Proposed Project would be in conflict with the objectives of the Swift Parrot Recovery Program. Owing to the small extent of potential habitat to be removed, it is considered that the Proposed Project will not interfere with the recovery of the Swift Parrot.

Conclusion

The Proposed Project would remove approximately 1.12 ha of potential foraging habitat for the Swift Parrot, which represents a small proportion of available habitat in the locality. Owing to the mobility of the species and small extent of isolated potential foraging habitat to be removed, the Proposed Project is unlikely to significantly impact upon this species or interfere with its recovery. When considering the context and intensity of the disturbance to Swift Parrot habitat that may be caused by the Proposed Project, it is considered to be insignificant.

15.3 EPBC Act significance assessment for Grey-headed Flying-fox

The Grey-headed Flying-fox is listed as Vulnerable under the EPBC Act. The following assessment has been undertaken following the Matters of National Environmental Significance, Significant Impact Guidelines 1.1 (Department of the Environment Water Heritage and the Arts 2009a). Under the Act, important populations are:

- likely to be key source populations either for breeding or dispersal
- likely to be necessary for maintaining genetic diversity, and/or
- at or near the limit of the species range.

Is this part of an important population?

Grey-headed Flying-foxes occur across a range of wooded habitats and urban areas where their favoured food, eucalypt blossom and fruits of planted trees (i.e. figs and date palms) occur. They set up roosting camps (sub-populations) in association with blossom availability, which are usually situated in dense vegetation and associated with water. Grey-headed Flying-foxes can migrate up to 50 km north during the winter and during this time young flying-foxes establish camps. The Grey-headed Flying-fox in Australia may be part of one large population which interbreeds. Consequently, the Grey-headed Flying-fox individuals that may frequent the Study Area are considered to be part of an important population.

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will result in one or more of the following.

Lead to a long-term decrease in the size of an important population of a species

No Grey-headed Flying-fox roosting camps will be affected by the Proposed Project and only a small area (~1.12 ha) of vegetation that contains some suitable foraging habitat (i.e. *Eucalyptus robusta*) trees would be removed. This amount of habitat disturbance and modification is unlikely to reduce the carrying capacity of the Australian Grey-headed Flying-fox population such that it would lead to a long-term decrease in population size. Abundant foraging resources for the Grey-headed Flying-fox are present in the forested and urban areas of Newcastle.

Reduce the area of occupancy of an important population

The Grey-headed Flying-fox is a highly mobile species capable of migrating up to 50 km. The Grey-headed Flying-fox will still be able to utilise the Study Area as part of its home range after the Proposed Project has been implemented. Consequently, the area of occupancy of the population will not be reduced by the Proposed Project.

Fragment an existing important population into two or more populations

The Proposed Project will not result in the fragmentation of habitat *per se* (i.e. the breaking apart of one piece of habitat into two or more smaller pieces). Owing to the small extent of potential habitat to be removed and the great mobility of the Grey-headed Flying-fox, functional connectivity will remain. The Proposed Project will not fragment the Australian Grey-headed Flying-fox population and genetic exchange will continue for this species.

Adversely affect habitat critical to the survival of a species

No critical habitat is listed for the Grey-headed Flying-fox under the EPBC Act. Habitat critical to the survival of a species may also include areas that are not listed on the Register of Critical Habitat if they are necessary:

- For activities such as foraging, breeding, roosting, or dispersal.
- For the long-term maintenance of the species or ecological community (including the maintenance of species essential to the survival of the species or ecological community, such as pollinators).
- To maintain genetic diversity and long-term evolutionary development, or
- For the reintroduction of populations or recovery of the species or ecological community.

The Proposed Project would remove approximately 1.12 ha of vegetation that contains suitable foraging habitat for this species. As the species is highly mobile, with individuals foraging up to 50 km from roost sites, it is likely that suitable foraging resources could be accessed in the locality. Therefore, this would not meet the above criteria. No roosting camps, which are critical to the survival of the species, will be disturbed by the Proposed Project.

Disrupt the breeding cycle of an important population

No roosting camps, which are critical for breeding and rearing of young, will be disturbed by the Proposed Project. Foraging opportunities will only be reduced by a small amount and not to an extent that is likely to alter the carrying capacity of the Grey-headed Flying-fox population. Consequently, it is unlikely that the Proposed Project would disrupt the breeding cycle of the Australian Grey-headed Flying-fox population.

Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

The Proposed Project would only affect approximately 1.12 ha of suitable foraging habitat for the Grey-headed Flying-fox. As this species is known to forage up to 50 km from roost sites, the Proposed Project is not likely to significantly affect the availability of quality habitat for this species to the extent that it likely to decline.

Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat

It is not likely that invasive species (such as introduced predators) that are harmful to the Grey-headed Flying-fox would become further established as a result of the Proposed Project.

Introduce disease that may cause the species to decline

No. There are no known diseases that are likely to increase in the area as a result of the Proposed Project.

Interfere substantially with the recovery of the species.

A draft national recovery plan for the Grey-headed Flying-fox has been prepared (see Department of Environment Climate Change and Water NSW 2009). The Proposed Project is not inconsistent with any specific measures identified within the draft recovery plan. Due to the limited foraging habitat likely to be affected by the Proposed Project (approximately 1.12 ha) and as no roost camps are located in the vicinity of the Study Area, the Proposed Project is not likely to interfere with the recovery of this species.

Conclusion

The Grey-headed Flying-fox was recorded during the field surveys undertaken for this assessment. A relatively small amount of suitable foraging habitat (~1.12 ha) will be removed by the Proposed Project, although this is unlikely to be significant to the population, due to the abundance of similar and greater quality foraging habitat elsewhere within the wider locality. No Grey-headed Flying-fox camps will be affected by the Proposed Project. This is an important reason why the Proposed Project is not considered likely to have a significant impact on the Grey-headed Flying-fox.

16. Microchiropteran bats

Microchiropteran bats fall into two broad groups based on their roosting requirements, hollow-dwelling species and cave-dwelling species. Each group is dealt with separately within the following test of significance.

Hollow-dwelling microchiropteran bats

The following species of microchiropteran bat were considered to have potential foraging habitat only in the proposed Project Area:

- Eastern False Pipistrelle (*Falsistrellus tasmaniensis*).
- East-coast Freetail bat (*Mormopterus norfolkensis*).
- Yellow-bellied Sheathtail Bat (*Saccolaimus flaviventris*).
- Greater Broad-nosed Bat (*Scoteanax rueppellii*).

These species have been assessed as a guild because of their similarity of habitats and habits, which are described in Table 16-1.

Table 16-1 Details of Threatened species of hollow-dwelling microchiropteran bat

Common Name	TSC Act	EPBC Act	Habitat and distribution	Threats
Eastern False Pipistrelle	V		Usually roosts in tree hollows in higher rainfall forests. Sometimes found in caves (Jenolan area) and abandoned buildings (Churchill 2008).	Its population and distribution are suspected to be reduced. It faces severe threatening processes. It is an ecological specialist (it depends on particular types of diet or habitat).
Eastern Free-tail Bat	V		Thought to live in Sclerophyll forest and woodland. Small colonies have been found in tree hollows or under loose bark. It feeds on insects above the forest canopy or in clearings at the forest edge (Churchill 2008).	Vulnerable to loss of tree hollows and loss of feeding grounds by forestry activities, clearing for agriculture and housing. Its population is suspected to have been reduced. It is an ecological specialist and depends on particular types of diet or habitat (Churchill 2008).
Yellow-bellied Sheathtail Bat	V		A wide-ranging species across northern and eastern Australia. In the most southerly part of its range (Victoria, south-western NSW South Australia), it is a rare visitor in late summer/autumn. This species flies high and fast over forest canopies foraging for insects in most habitats across its wide range. Generally roosts in tree hollows (Churchill 2008).	Vulnerable to loss of tree hollows and clearing and fragmentation of forest and woodland habitat.

Common Name	TSC Act	EPBC Act	Habitat and distribution	Threats
Greater Broad-nosed Bat	V		The preferred hunting areas of this species include tree-lined creeks and the ecotone of woodlands and cleared paddocks but it may also forage in rainforest. Typically it forages at a height of 3-6 m but may fly as low as 1 m above the surface of a creek. It feeds on beetles, other large, slow-flying insects and small vertebrates. It generally roosts in tree hollows but has also been found in the roof spaces of old buildings (Churchill 2008).	Its population is suspected to have been reduced. It is an ecological specialist (it depends on particular types of diet or habitat).

Recovery actions

No recovery plan has been prepared for any microchiropteran bat under the TSC Act. The OEH has however; identified 25 priorities action statements to help recover these species (refer Table 16-2).

Table 16-2 Priorities action statements for microchiropteran bats

Priority action
Objective 1: Promote bats throughout the rural community as ecologically interesting and important, but sensitive to disturbance at caves/disused mine tunnels.
Objective 2: Compile register of all known roost sites in natural and artificial structures including current and historical data and identify significance of roost, e.g. maternity, hibernation, transient roost.
Objective 3: Control foxes and feral cats around roosting sites, particularly maternity caves and hibernation sites.
Objective 4: Control goats around roosting sites, particularly maternity caves and hibernation sites.
Objective 5: Exclude prescription burns from 100m from cave entrance, ensure smoke/flames of fires do not enter caves/roosts in artificial structures.
Objective 6: Prepare fire management plans for significant roost caves, disused mines, culverts, especially maternity and winter roosts.
Objective 7: Prepare management plans for significant bat roosts especially all known maternity colonies and winter colonies.
Objective 8: Ensure protection of known roosts and forest within 10 km of roosts in PVP assessments (offsets should include nearby remnants in high productivity) and other environmental planning instruments.
Objective 9: Identify and protect significant roost habitat in artificial structures (e.g. culverts, old buildings and derelict mines).
Objective 10: Restrict access where possible to known maternity sites. (e.g.: signs).
Objective 11: Restrict caving activity during critical times of year in important roosts used by species, particularly maternity and hibernation roosts.
Objective 12: Search for significant roost sites and restrict access where possible. (e.g. gating of caves). Significant includes maternity, hibernation and transient sites including in artificial structures.
Objective 13: Undertake non-chemical removal of weeds (e.g. lantana, blackberry) to prevent obstruction of cave entrances.
Objective 14: Promote the conservation of these significant roost areas using measures such as incentive funding to landholders, offsetting and biobanking, acquisition for reserve establishment or other means.
Objective 15: Monitor the breeding success of maternity colonies in cave roosts over a number of years to determine the viability of regional populations.
Objective 16: For roost caves vulnerable to human disturbance, monitor their visitation by people, particularly during winter and spring/summer maternity season and in school holidays.
Objective 17: Identify types of winter roosts used by species. Winter roosts suspected to be banana palms and tree hollows
Objective 18: Determine the effectiveness of PVP assessment, offsets and actions for bats.
Objective 19: Establish a gating design for disused mines across species range that will not adversely impact species.
Objective 20: Identify important foraging range and key habitat components around significant roosts.
Objective 21: Identify the susceptibility of the species to pesticides.
Objective 22: Measure genetic population structure among cave roosts of maternity colonies to estimate dispersal and genetic isolation, and vulnerability to regional population extinction.
Objective 23: Study the ecological requirements of maternity colonies and their environs and migratory patterns.
Objective 24: Study the effect of different burning regimes on cave disturbance and surrounding foraging habitat.
Objective 25: Undertake a regular census of maternity colonies (e.g. Willi Willi) and other key roosts in network, especially where there are population estimates from banding in the 1960s.
Note: priorities action statements taken from Little Bent-wing Bat threatened species profile (Department of Environment and Climate Change 2005).

16.1 EP&A Act assessment for hollow-dwelling microchiropteran bats

In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

The Proposed Project will not result in the removal of any hollow-bearing trees which would provide suitable resources for a female maternity roost or non-breeding roost for the four hollow dependant microchiropteran bat species that are subject to this assessment. Additionally, the Proposed Project is unlikely to adversely affect foraging resources for any of the species as they are all relatively large fast flying species that readily forage in open space or along the edges of vegetation. As these four microchiropteran bat species are capable of moving large distances over cleared land from roosting sites to foraging areas, the Proposed Project is unlikely to have an adverse effect on habitat connectivity for these species. Consequently, the Proposed Project is unlikely to have an adverse effect on the lifecycle of these species as breeding, foraging or commuting habitat is unlikely to be interrupted by the Proposed Project.

In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable.

In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

- i) **is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction**

Not applicable.

- ii) **is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction**

Not applicable.

In relation to the habitat of a threatened species, population or ecological community:

- i) **the extent to which habitat is likely to be removed or modified as a result of the action proposed**

Approximately 7.4 ha of vegetated foraging habitat (planted vegetation, Swamp Mahogany Swamp Forest on Coastal Lowlands, and Swamp Oak Swamp Forest Fringing Estuaries) for the four hollow-dwelling microchiropteran bat species will be removed by the Proposed Project. This habitat is of moderate condition and consequently, may not be optimal for the persistence of these species in the locality.

- ii) **whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and**

The Proposed Project will not result in the fragmentation of habitat *per se* (i.e. the breaking apart of one piece of habitat into two or more smaller pieces) for the four microchiropteran bat species subject to this assessment. A small increase in physical habitat isolation will occur through the incremental clearing of habitat at the interface of current rail easement. However, no functional loss of connectivity is likely to occur for these species as they are capable of traversing cleared areas to move between habitats.

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

The Study Area provides a relatively small amount of moderately suitable foraging habitat for these four species. Approximately 7.4 ha of vegetated foraging habitat (planted vegetation, Swamp Mahogany Swamp Forest on Coastal Lowlands, and Swamp Oak Swamp Forest Fringing Estuaries) will be removed by the Proposed Project. When considered in the context of the available habitat in the locality and the fact that no roosting resources (particularly roosting resources suitable for maternity colonies) will be affected by the Proposed Project, the potential habitat for these species in the Study Area is relatively unimportant.

Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

Critical habitat refers to those areas of land listed in the Register of Critical Habitat kept by the Director General of the OEH. No critical habitat has been listed for any microchiropteran bat species to date. Consequently, no adverse effect to any critical habitat for microchiropteran bat species, as defined under the TSC Act, will occur due to the Proposed Project.

Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

Recovery plans have not been prepared for any microchiropteran bat species under the TSC Act. The OEH has however; identified 25 priorities action statements within 11 recovery strategies to help recover these species (refer Table 16-2). The Proposed Project is not likely to adversely affect any of these recovery actions.

Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

With respect to hollow-dwelling microchiropteran bats, the Proposed Project is consistent with one key threatening process: clearing of native vegetation.

Conclusion

Moderately suitable foraging habitat for the hollow dependent Eastern False Pipistrelle, East-coast Freetail bat, Yellow-bellied Sheath-tail Bat, Greater Broad-nosed Bat is present in the Study Area and approximately 7.4 ha of vegetated habitat will be removed by the Proposed Project. However, the habitat to be removed is considered of little importance for the survival of these species as no breeding habitat will be affected, no fragmentation of habitats will occur, and the importance of the habitat to be removed is minor when compared to the available roosting and breeding habitat in the locality. Foraging habitat including ecotonal edge habitats that these four species prefer will continue to occur in the Study Area. Therefore, the Proposed Project is unlikely to have a significant impact on these species.

Cave-dwelling microchiropteran bats

The following species of microchiropteran bat were considered to be limited to foraging potential within the proposed Project Area, due to the lack of suitable cave roosting opportunities:

- Little Bent-wing Bat (*Miniopterus australis*).
- Eastern Bent-wing Bat (*Miniopterus schreibersii oceanensis*).
- Southern Myotis (*Myotis macropus*).

These species have been assessed as a guild because of their similarity of habitats and habits, which are described in Table 16-3.

Table 16-3 Details of Threatened species of cave-dwelling microchiropteran bat

Common Name	TSC Act	EPBC Act	Habitat and distribution	Threats
Little Bent-wing Bat	V		Feeds on small insects beneath the canopy of well-timbered habitats including rainforest, Melaleuca swamps and dry Sclerophyll forests. Roosts in caves and tunnels and has specific requirements for nursery sites. Distribution becomes coastal towards the southern limit of its range in NSW. Nesting sites are in areas where limestone mining is preferred (Strahan 1995).	The species is an ecological specialist (it depends on particular types of diet or habitat) and it concentrates (individuals within populations of the species congregate or aggregate at specific locations).
Eastern Bent-wing Bat	V		Distributed across the east coast of Australia, rests in caves, old mines, stormwater channels and comparable structures including occasional buildings (Dwyer 1998),. Typically found in well-timbered valleys where it forages, above tree canopy on small insects (Churchill 2008).	Loss of habitat, feral predators such as cats and foxes, disturbances of winter roosts, relies on very few nursery caves at high density (Dwyer 1998).
Large-footed Myotis	V		Found in roosting caves, tunnels, tree hollows and possibly dense vegetation (Churchill 1998). Roosts have been located in hanging trees. Buildings and underneath bridges have also been listed as roost sites for the species. The species is always associated with permanent, usually slow-flowing water bodies. Forages over small creeks, coastal rivers, estuaries lakes and inland rivers. Records come from a wide range of vegetation communities associated with water (Richards 1998).	Not certain. Is likely to be susceptible to changes in water quality, which may result from vegetation clearing and logging (sedimentation), sewage and fertilizer run-off (eutrophication), pesticide/herbicide leakage (chemical pollution) and altered flow regimes (changes to river ecology). Where populations concentrate in roosts which are susceptible to disturbance, human activities such as recreational use of caves and removal of old wooden bridges would also be a threat (Duncan <i>et al.</i> 1999). The species may have been subject of over-collection in the past (Richards 1998)

Recovery actions

Refer to Table 16-2.

16.2 EP&A Act assessment for cave-dwelling microchiropteran bats

In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

There are no roosting opportunities within the Study Area for cave-dwelling microchiropteran bat species. Foraging opportunities for these species exist within the proposed Project Area within the vegetated areas and open space. The Proposed Project will not result in the removal of any caves or old man-made structures (i.e. buildings, culverts, tunnels, or bridges) which may provide suitable resources for a female maternity roost or non-breeding roost. Additionally, the Proposed Project is unlikely to adversely affect foraging resources for any of the species as they are all relatively large fast flying species that readily forage in open space or along the edges of vegetation. In particular, the Eastern Bent-wing Bat is known to be disturbance tolerant and persists in urban areas as it is able to exploit foraging resources in human altered landscapes. These microchiropteran bat species are capable of moving large distances over cleared land from roosting sites to foraging areas. As such, the Proposed Project is unlikely to have an adverse effect on habitat connectivity for these species. Consequently, the Proposed Project is unlikely to have an adverse effect on the lifecycle of these species as breeding, foraging or commuting habitat is unlikely to be interrupted.

In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable

In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

- i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction**

Not applicable

- ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction**

Not applicable

In relation to the habitat of a threatened species, population or ecological community:

- i) the extent to which habitat is likely to be removed or modified as a result of the action proposed**

Approximately 7.4 ha of vegetated foraging habitat (planted vegetation, Swamp Mahogany Swamp Forest on Coastal Lowlands, and Swamp Oak Swamp Forest Fringing Estuaries) for the three cave-dwelling microchiropteran bat species will be removed by the Proposed Project. This habitat is of moderate condition and consequently, may not be optimal for the persistence of these species in the locality.

ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The Proposed Project will not result in the fragmentation of habitat *per se* (i.e. the breaking apart of one piece of habitat into two or more smaller pieces) for the three microchiropteran bat species subject to this assessment. A small increase in physical habitat isolation will occur through the incremental clearing of habitat at the interface of current rail easement. However, no functional loss of connectivity is likely to occur for these species as they are capable of traversing cleared areas to move between habitats.

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

The Study Area provides a relatively small amount of moderately suitable foraging habitat for these three species. Approximately 7.4 ha of vegetated foraging habitat (planted vegetation, Swamp Mahogany Swamp Forest on Coastal Lowlands, and Swamp Oak Swamp Forest Fringing Estuaries) will be removed by the Proposed Project. When considered in the context of the available habitat in the locality and the fact that no roosting resources of any type (i.e. buildings, culverts, tunnels, or bridges) will be affected by the Proposed Project, the potential habitat for these species in the Study Area is relatively unimportant and is freely available in the locality.

Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

Critical habitat refers to those areas of land listed in the Register of Critical Habitat kept by the Director General of the OEH. No critical habitat has been listed for any microchiropteran bat species to date. Consequently, no adverse effect to any critical habitat for microchiropteran bat species, as defined under the TSC Act, will occur due to the Proposed Project.

Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

No recovery plan has been prepared for any microchiropteran bat species under the TSC Act. The OEH has however; identified 25 priorities action statements within 11 recovery strategies to help recover these species (refer Table 16-2). The Proposed Project is not likely to adversely affect any of these recovery actions.

Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

With respect to cave-dwelling microchiropteran bats, the Proposed Project is consistent with one KTP, being clearing of native vegetation. This KTP is not likely to significantly affect these species in the locality. A threat abatement plan has not been prepared for this process.

Conclusion

Moderately suitable foraging habitat for the cave dependent Little Bent-wing Bat, Eastern Bent-wing Bat, and Southern Myotis is present in the Study Area and approximately 6.4 ha of vegetated habitat will be removed by the Proposed Project. However, the habitat to be removed is considered of little importance for the survival of these species as no roosting habitat (i.e. caves, buildings, culverts, tunnels, or bridges) will be affected, no fragmentation of habitats will occur, and the importance of the habitat to be removed is minor when compared to the available roosting and breeding habitat in the locality. Therefore, the Proposed Project is unlikely to have a significant impact on these species.

17. Red-backed Button-quail (*Turnix maculosa*)

Status

The Red-backed Button-quail is listed as Vulnerable under the TSC Act.

Description and habitat

The Red-backed Button-quail is a small, cryptic ground-dwelling bird ranging in size from 12 cm to 16 cm in length and 35 g to 45 g in weight, with females being typically larger than males (NSW Scientific Committee 2005). This species is dark grey above, densely barred and blotched with rufous and with buff to cream streaking on the back. In flight, this species has a buff-yellow wing panel with black spots, a buff stripe across the top of the head and a rufous collar and shoulder (NSW Scientific Committee 2005; Pizzey & Knight 2007). The sides of the head and most of the under body are buff to a rich rusty colour, boldly patterned with black spots and bars on the sides of the breast and flanks. Females are more brightly coloured than the males, with a much brighter and broader rufous collar and brighter yellow bill.

Red-backed Button-quails can be distinguished from other button-quail, and quail, by their finer, more pointed and yellow bill, rufous collar and black spotting and barring on the side of the under body (Marchant & Higgins 1993).

In NSW the Red-backed Button-quail is considered to inhabit grasslands, heath and crops and said to prefer sites close to water, especially when breeding. Observations in other parts of its range suggest the species prefers sites close to water, including grasslands and sedgeland in creeks, swamps and wetlands, but has utilises open and savannah woodlands with a grassy understorey, pastures and crops (NSW Scientific Committee 2005; Pizzey & Knight 2007).

Ecology

Red-backed Button-quail breed in dense grass near water, with nests usually consisting of a scantily lined hollow under grass tussock or shrub. While the timing of breeding is not well known in NSW, the Red-backed Button-quail is thought to breed from late spring to summer, with clutches recorded from October to February. In other parts of its range clutches have been recorded from late November through to May and June. The male usually incubates the clutch and tends to the precocial young. This species is nocturnal and crepuscular in their activity, actively foraging for seeds and insects on the ground (NSW Scientific Committee 2005; Pizzey & Knight 2007).

Distribution

The Red-backed Button-quail extends discontinuously from coastal north and eastern Australia from the Kimberley region of Western Australia through the Top End of the Northern Territory, Cape York Peninsula and eastern Queensland and central-eastern and north-eastern NSW. In NSW, the Red-backed Button-quail is recorded on infrequently with most records occurring in the North Coast bioregion, with historical records occurring as far south as Sydney (NSW Scientific Committee 2005; Pizzey & Knight 2007).

Threats

Threats currently operating, and those that have operated historically are not certainly known. However, possible reasons contributing to the apparent decline of this species include (NSW Scientific Committee 2005):

- The ground-dwelling nature of this species and its defensive habit of freezing when disturbed render this species susceptible to predation by introduced and native predators. However, the extent of predation by introduced animals, and its impact on populations of this species remains unclear.
- Inappropriate burning and grazing regimes that destroy extensive areas of ground-layer vegetation.
- Drainage or coastal wetlands and riparian grasslands for agriculture, particularly for sugar cane and urban development reduces available breeding habitat.
- Trampling and disturbance by livestock and feral herbivores, may alter habitat quality and could directly affect nesting birds.

Recovery actions

No recovery plan has been prepared for the Red-backed Button-quail under the TSC Act. The OEH (NSW Scientific Committee 2005) has, however, identified several broad priority action statements to help recover this species, including:

- Protect and restore Red-backed Button-quail habitats, especially preventing drainage or destruction of key wetlands and habitats, as the species shows some preference for nesting near water. Also promote conservation incentives and agreements to improve management and protection of unreserved populations.
- Raise awareness in the general community on the habitat requirements and threats to Red-backed Button-quail and their habitat, and foster community based programs to manage and restore wetlands and other habitats. Also raise awareness of the threats of habitat alteration and trampling of nestlings by livestock and feral Pigs, and ways to reduce threat.
- Develop sustainable burning regimes, specifically reviewing the hazard reduction conditions on the NSW Threatened Species Hazard Reduction List; and providing maps of known occurrence to the NSW Rural Fire Service.
- Reduce habitat destruction pressures from agriculture and urban development.
- Develop appropriate agricultural management practices to protect habitat, by excluding stock or reducing grazing pressure, and controlling weeds. Exclude livestock from areas used for nesting.
- Control introduced predators, especially Red Foxes.

Specific impacts

The proposed Project has the potential to modify and or remove approximately 31.95 ha of aquatic habitat and cleared land (grassland), which together provide potential habitat for this species.

17.1 EP&A Act assessment for Red-backed Button-quail

In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction

The Red-backed Button-quail was not recorded in the Study Area during field surveys; however, their cryptic nature and nocturnal/crepuscular habits make it difficult to detect this species. The proposed Project is likely to affect approximately 31.95 ha of potential habitat, including areas that potentially provide important breeding habitat. The area of potential habitat likely to be affected, however, is relatively small in proportion similar or better quality habitat in the locality (i.e. Kooragang Island National Park and Hexham Swamp Nature Reserve). Furthermore, potential habitat in the proposed Project Area and greater Study Area, has historically and is still currently under pressure from intensive agricultural practices, including trampling and disturbance from livestock (potential threat).

As such the proposed Project is not likely to have an adverse effect upon the lifecycle of the species' such that a viable local population is likely to be placed at risk of extinction.

In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

Not applicable.

In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

- i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction**

Not applicable.

- ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction**

Not applicable.

In relation to the habitat of a threatened species, population or ecological community:

- i) the extent to which habitat is likely to be removed or modified as a result of the action proposed**

Approximately 31.95 ha of potential habitat (Aquatic habitat and Cleared Land/grassland), including areas that potentially provide important breeding habitat, are likely to be affected by the proposed Project.

- ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and**

Due to existing infrastructure occurring in close proximity to the proposed Project, including the existing rail corridor, the Pacific Highway, industrial developments and the south arm of the Hunter River, the proposed Project would not fragment or severe connectivity of habitats in the locality; rather, the proposed Project would add incrementally to those processes, which have previously fragmented the surrounding landscape. Over the full extent of the proposed Project Area, the proposed Project is not likely to further fragment or isolate potential habitat any more than that currently occurring in the Study Area; given its location adjacent to already disturbed areas.

Furthermore, Aquatic habitats and Cleared Land habitats (grasslands) in the Study Area are an extension of land connected to similar habitats occurring in Hexham Swamp Nature Reserve. However, intensive agricultural practices still occur in this buffer.

iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

While the Study Area provided potential habitat for this species, such habitat has historically been, and is currently under pressure from intensive agricultural practices, which is considered a potential threat affecting the apparent decline of this species. Furthermore, potential habitat in the proposed Project Area and Study Area is connected to similar or better quality habitat occurring in the greater Hexham Swamp Nature Reserve. Therefore, potential habitat likely to be affected in the proposed Project Area is not considered to be critical for the long-term survival of this species in the locality.

Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

Critical habitat refers to those areas of land listed in the Register of Critical Habitat kept by the Director General of the OEH. No critical habitat has been listed for the Red-backed Button-quail to date. Consequently, no adverse effect to any critical habitat for this species, as defined under the TSC Act, will occur due to the proposed Project.

Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

No recovery plan has been prepared for the Red-baked Button-quail under the TSC Act. The OEH has however, identified seven priority action statements to help recover this species. The proposed Project is not consistent with two of these recover actions, being:

- Protecting and restoring Red-backed Button-quail habitats especially preventing drainage or destruction of key wetlands and habitats, as the species shows some preference for nesting near water.
- Reduce habitat destruction pressures from urban development.

Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

With respect to the Red-backed Button-quail, the proposed Project is consistent with one key threatening process: clearing of native vegetation. This KTP is not likely to significantly affect this species in the locality. A threat abatement plan has not been prepared for this process.

Conclusion

Approximately 31.95 ha of potential habitat, including potential breeding habitat, will be affected by the proposed Project. However, the proposed Project is not likely to have an adverse effect upon the lifecycle of the species with similar or better quality habitat occurring in the locality, including Kooragang Island National Park and Hexham Swamp Nature Reserve. Furthermore, potential habitat in the proposed Project Area and greater Study Area has historically and is still currently under pressure from intensive agricultural practices, including a listed potential threat; trampling and disturbance from livestock.

Due to existing infrastructure occurring in close proximity to the proposed Project, over the full extent of the proposed Project Area, the proposed Project is not likely to further fragment or isolate potential habitat any more than that currently occurring in the Study Area; given its location adjacent to already disturbed areas. Thus, the proposed Project is not likely to have a significant impact on this species.

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Appendix F

Fauna survey effort

Attachment F – Fauna survey effort and weather conditions

Describes detailed fauna survey effort completed in June, September and November 2011.

Table F.1 Total fauna survey effort

Time (24 hr)	Survey method	Effort (person minutes)	Survey site	Temperature °C (max) ¹	Rainfall (mm) ¹	Wind km/h (max) ¹	Location (MGA94 Zone 56)	
							Easting	Northing
20 June 2011								
	Opportunistic survey	240 minutes	S1	18.8	0	NA ²	376398	6367811
	Habitat assessment	30 minutes	S1	18.8	0	NA ²	376398	6367811
	Habitat assessment	30 minutes	S2	18.8	0	NA ²	376616	6367416
	Bird survey	20 minute standard search	S2	18.8	0	NA ²	376616	6367416
	Bird survey	120 minutes	S3	18.8	0	NA ²	376697	6367060
	Spotlighting	90 minutes	S3	18.8	0	NA ²	376697	6367060
	Call playback	30 minutes	S3	18.8	0	NA ²	376697	6367060
21 June 2011								
	Opportunistic survey	120 minutes	S1	19.9	0	93	376398	6367811
	Bird survey	20 minute standard search	S2	19.9	0	93	376616	6367416
	Bird survey	20 minute standard search	S3	19.9	0	93	376697	6367060
	Habitat assessment	60 minutes	S3	19.9	0	93	376697	6367060
	Bird survey	30 minutes	S4	19.9	0	93	377017	6366280

Time (24 hr)	Survey method	Effort (person minutes)	Survey site	Temperature °C (max) ¹	Rainfall (mm) ¹	Wind km/h (max) ¹	Location (MGA94 Zone 56)	
							Easting	Northing
	Habitat assessment	30 minutes	S4	19.9	0	93	377017	6366280
	Bird survey	120 minutes	S5	19.9	0	93	377356	6365382
	Habitat assessment	30 minutes	S5	19.9	0	93	377356	6365382
	Spotlight (drive transect)	60 minutes	Entire alignment	19.9	0	93		
	Call playback	15 minutes	S4	19.9	0	93	377017	6366280
22 June 2011								
	Bird survey	40 minutes	S4	15.7	0.8	61	377017	6366280
	Bird survey	160 minutes	S5	15.7	0.8	61	377356	6365382
	Bird survey	90 minutes	S6	15.7	0.8	61	376887	6366712
	Habitat assessment	30 minutes	S6	15.7	0.8	61	376887	6366712
	Bird survey	60 minutes	S7	15.7	0.8	61	377008	6366021
	Habitat assessment	30 minutes	S7	15.7	0.8	61	377008	6366021
	Bird survey	120 minutes	S8	15.7	0.8	61	377043	6365421
	Habitat assessment	30 minutes	S8	15.7	0.8	61	377043	6365421
	Bird survey	60 minutes	S9	15.7	0.8	61	376763	6366774
	Habitat assessment	30 minutes	S9	15.7	0.8	61	376763	6366774
5 September 2011								
1400-1700	Targeted Green and Golden Bell survey	360 minutes	Reference site (Ash Island)	21.9	0	33	NA ²	NA ²
1735-1820	Targeted Green and Golden Bell survey	90 minutes	S5	21.9	0	33	377361 377232	6365345 6365620

Time (24 hr)	Survey method	Effort (person minutes)	Survey site	Temperature °C (max) ¹	Rainfall (mm) ¹	Wind km/h (max) ¹	Location (MGA94 Zone 56)	
							Easting	Northing
1820-1920	Targeted Green and Golden Bell survey	120 minutes	Supplementary	21.9	0	33	377161 377217	6365718 6365713
1935-1955	Targeted Green and Golden Bell survey	30 minutes	Supplementary	21.9	0	33	376885	6366611
1955-2010	Targeted Green and Golden Bell survey	30 minutes	S9	21.9	0	33	376815	6366829
2010-2020	Targeted Green and Golden Bell survey	30 minutes	Supplementary	21.9	0	33	376665	6367135
2020-2035	Targeted Green and Golden Bell survey	30 minutes	Supplementary	21.9	0	33	376629	6367374

6 September 2011

1400-1700	Targeted Green and Golden Bell survey	360 minutes	Reference site (Ash Island)	24.9	0	41	NA ²	NA ²
1830-1845	Targeted Green and Golden Bell survey	30 minutes	S5	24.9	0	41	377361	6365345
1845-1915	Targeted Green and Golden Bell survey	60 minutes	Supplementary	24.9	0	41	377130 377184	6365779 6365779
1935-1945	Targeted Green and Golden Bell survey	30 minutes	S6	24.9	0	41	376853	6366657
1945-2000	Targeted Green and Golden Bell survey	30 minutes	S9	24.9	0	41	376764	6366853
2000-2030	Targeted Green and Golden Bell survey	60 minutes	S2 S3	24.9	0	41	376616 376689	6367416 6367005
2030-2045	Targeted Green and Golden Bell survey	30 minutes	S1	24.9	0	41	376396	6367855

4 November 2011

0950-1010	Targeted Green and Golden Bell survey	20 minutes	Supplementary	22.3	0.6	28	375002	6368772
NA ²	Habitat assessment	10 minutes per site	Supplementary Supplementary Supplementary	22.3	0.6	28	NA ²	NA ²

Time (24 hr)	Survey method	Effort (person minutes)	Survey site	Temperature °C (max) ¹	Rainfall (mm) ¹	Wind km/h (max) ¹	Location (MGA94 Zone 56)	
							Easting	Northing
			Supplementary Supplementary Supplementary					
NA ²	Bird surveys	20 minutes per site	Supplementary Supplementary Supplementary Supplementary Supplementary	22.3	0.6	28	NA ²	NA ²
NA ²	Opportunistic surveys	NA ²	Supplementary Supplementary Supplementary Supplementary Supplementary	22.3	0.6	28	NA ²	NA ²

7 November 2011

1500-1800	Targeted Green and Golden Bell survey	360 minutes	Reference site (Ash Island)	32.3	0	56	NA ²	NA ²
1915-1945	Targeted Green and Golden Bell survey	60 minutes	Supplementary	32.3	0	56	377396	6365257
1950-2020	Targeted Green and Golden Bell survey	60 minutes	Supplementary	32.3	0	56	377156	6365767
2130-2200	Targeted Green and Golden Bell survey	60 minutes	Supplementary	32.3	0	56	377052	6366047
2200-2230	Targeted Green and Golden Bell survey	60 minutes	Supplementary	32.3	0	56	377069	6365947
2230-2300	Targeted Green and Golden Bell survey	60 minutes	Supplementary	32.3	0	56	377103	6365855
2300-2330	Targeted Green and Golden Bell survey	60 minutes	Supplementary	32.3	0	56	376797 376721	6366859 6367149

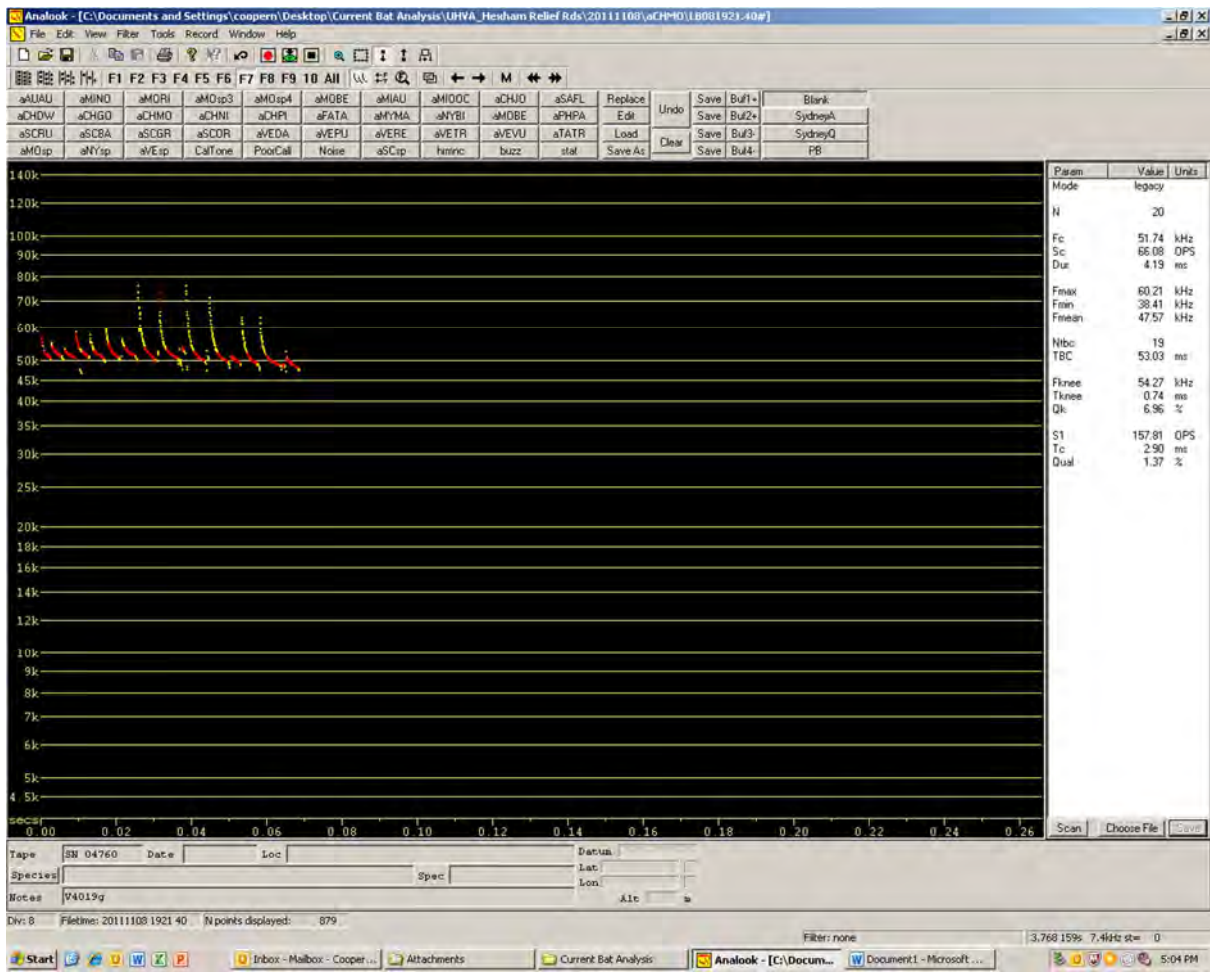
Time (24 hr)	Survey method	Effort (person minutes)	Survey site	Temperature °C (max) ¹	Rainfall (mm) ¹	Wind km/h (max) ¹	Location (MGA94 Zone 56)	
							Easting	Northing
							376642	6367340
8 November 2011								
1740-1815	Targeted Green and Golden Bell survey	60 minutes	Supplementary	32.7	28.6	28	375379	6368816
1840-1900	Targeted Green and Golden Bell survey	40 minutes	Supplementary	32.7	28.6	28	376971	6366323
1910-1925	Targeted Green and Golden Bell survey	30 minutes	Supplementary	32.7	28.6	28	377184	6365779
1925-1945	Targeted Green and Golden Bell survey	30 minutes	Supplementary	32.7	28.6	28	377143	6365898
1945-2030	Targeted Green and Golden Bell survey	90 minutes	Supplementary S5	32.7	28.6	28	377217 377444	6365713 6365233
2055-2110	Targeted Green and Golden Bell survey ²⁸	30 minutes	Supplementary	32.7	28.6	28	376846	6366679
2110-2155	Targeted Green and Golden Bell survey	90 minutes	Supplementary	32.7	28.6	28	376788	6366812
2155-2230	Targeted Green and Golden Bell survey	60 minutes	SEPP14 wetland	32.7	28.6	28	376674	6367265
2230-2300	Targeted Green and Golden Bell survey	60 minutes	SEPP14 wetland to Pacific H'way	32.7	28.6	28	376394 376425 375601	6367861 6368109 6368710

Note:

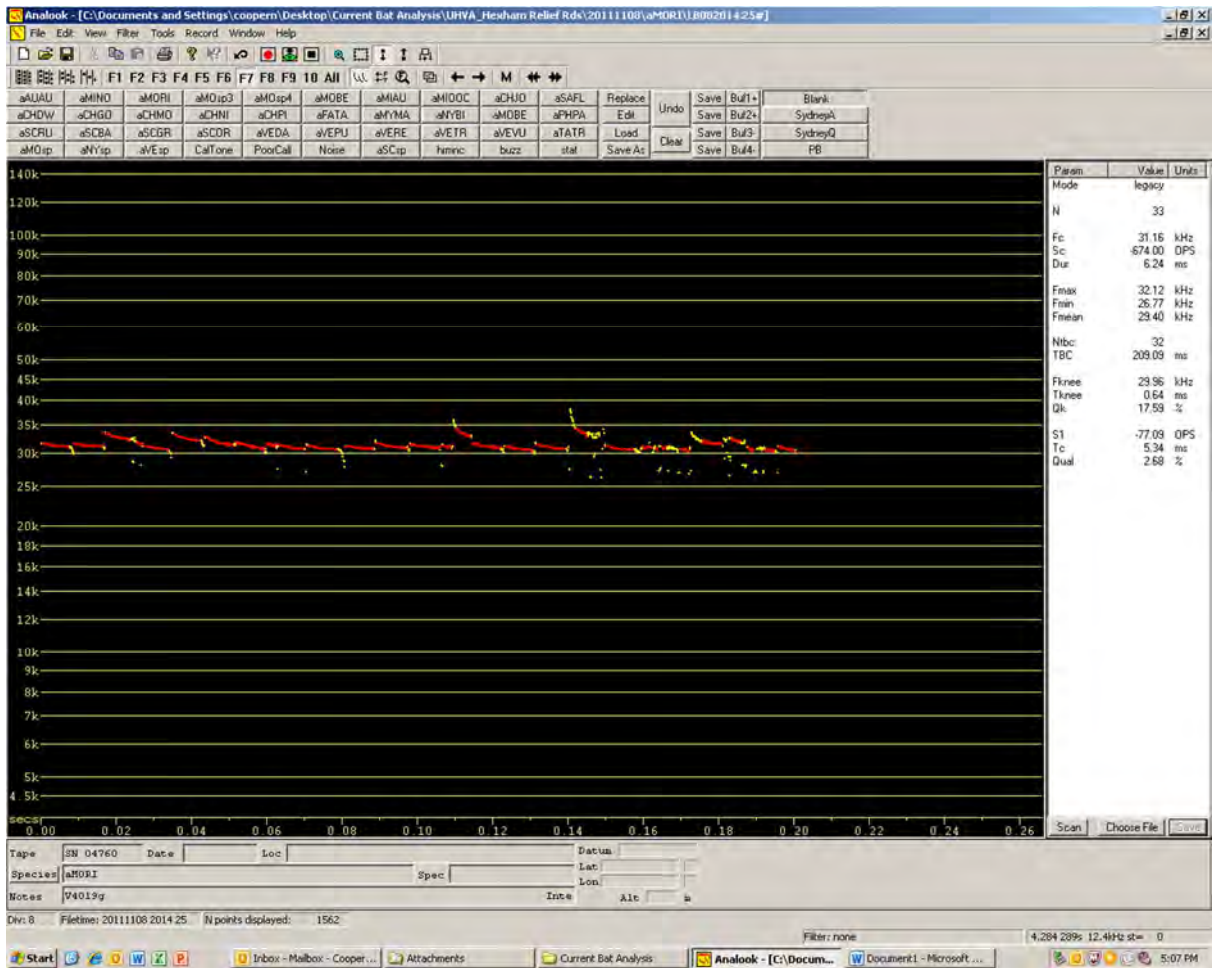
1. Weather data collated from Newcastle University Signal Station (061390) (Bureau of Meteorology 2011). Newcastle Nobbys Signal Station (061055) was used for information where Newcastle University Signal Station data was deficient.
2. NA: Not available

Appendix G

Bat call sonograms



Chalinolobus morio Chocolate Wattled Bat



Mormopterus ridei Eastern Freetail Bat

Appendix H

Aquatic and Marine Flora and
Fauna recorded

Table H-1 Aquatic and Marine Flora Species List

Common Name	Species Name	Site Number
Grey Mangrove	<i>Avicennia marina</i>	1, 8,10
Samphire	<i>Sarcocornia quinqueflora</i>	1,2,9
Saltwater Couch	<i>Sporobolus virginicus</i>	1,2
Streaked Arrowgrass	<i>Triglochin striata</i>	1,2,9
Water Button	<i>Cotula coronopifolia</i>	2
Sea Bite	<i>Suaeda australis</i>	9
Common Rush	<i>Juncus usitatus</i>	4
Common Cotula	<i>Cotula australis</i>	4, 6
Scurvy Weed	<i>Commelina cyanea</i>	4
Common Reed	<i>Phragmites australis</i>	5, 7
Native Carrot	<i>Daucus glochidiatus</i>	6
Water Primrose	<i>Ludwigia peploides</i>	6
Lantana	<i>Lantana camara</i>	7
River Mangrove	<i>Aegiceras corniculatum</i>	8

Table H-2 Aquatic and Marine Fauna Species List

Common Name	Family/Species Name	Site Number
	Phallomedusidae	1,2,9
	Ellobioidea	1,2,9
Sea Mullet	<i>Mugil cephalus</i>	1
Shrimp	<i>Acetes</i> sp.	1
Eastern Mosquitofish	<i>Gambusia holbrooki</i>	3

Appendix I

Summary of Marine Fish of the
Lower Hunter River and Newcastle
Harbour, Hexham Swamp,
Kooragang Island

The following list of species was taken from a record compiled by the Kooragang Wetland Rehabilitation Project on Fish and Crustacean species found in the Hunter River Estuary (* indicates a commercial/recreation species).

Table I-1 Estuarine Species:

Common name	Scientific name	Summary	Reference
Giant Herring	<i>Elops hawaiiensis</i>	Recognised by its silvery colour, slender body, relatively large mouth, single dorsal fin and strong forked tail. It is a schooling species found in coastal and estuarine waters.	Australian Museum
Castelnau's herring	<i>Herklotsichthys castelnau</i>	Schooling species found in estuarine and coastal marine waters. Adults undergo spawning migration from coastal waters into upper reaches of estuaries during summer and autumn	Encyclopedia of Life
Sandy Sprat*	<i>Hyperlophus vittatus</i>	Schools in large numbers in shallow sandy areas of bays and estuaries	Encyclopedia of Life
Australian Anchovy	<i>Engraulis australis</i>	Found mostly inshore: chiefly in bays, inlets and estuaries, sometimes in low salinities. Older individuals tend to move out to sea in winter and back in the spring. Forms compact schools much preyed upon by larger fishes, common dolphins and birds.	Encyclopedia of Life
Estuary Catfish	<i>Cnidoglanis macrocephala</i>	The Estuary Catfish has a large flattened head and a body that tapers to a pointed tail. It occurs in temperate marine waters (usually found in estuaries and silty bays) from southern Queensland to southern Western Australia.	Australian Museum
Striped Angler Fish	<i>Antennarius striatus</i>	Extremely variable in form and colour, and even fish from the same area can look quite different. Antennariids occur in coastal waters around the world. In Australia, it occurs around the north of the country, from the south-western Western Australia, across the north of the country, and south on the east coast to southern New South Wales	Australian Museum
Fortescue	<i>Centropogon australis</i>	Found in seagrass beds in estuaries and coastal bays, and sponge gardens on inshore reefs. Recognised by the presence of a large horizontal spine below the eye, a dorsal fin which originates just behind the posterior edge of the eye, and venomous dorsal spines.	Encyclopedia of Life
Dusky Flathead*	<i>Platycephalus fuscus</i>	Generally inhabit shallow bays and inlets and can be found in estuaries as far as tidal limits. Feed on small fish, crabs, prawns, small crustaceans, octopus, squid and polychaete worms.	Encyclopedia of Life
Port Jackson Glassfish	<i>Ambassis jacksoniensis</i>	Occurs in lentic and lotic freshwater, as well as in mangrove areas. A small schooling species also found in estuaries and coastal marine waters	Encyclopedia of Life
Estuary perchlet/ Ramsay's Glassfish	<i>Ambassis marianus</i>	Inhabits brackish mangrove estuaries, tidal creeks and lower reaches of freshwater streams. Aggregations are common among mangrove roots, log snags and aquatic vegetation. Occurs in lotic and lentic freshwater as well as in mangrove areas forming schools.	Encyclopedia of Life
Trumpeter/Fourlined Terapon	<i>Pelates quadrilineatus</i>	A coastal species often found in brackish waters; common in estuaries. Croaks when taken from the water. Usually forming schools. Feeds on small fishes and invertebrates.	Encyclopedia of Life
Sand Whiting*	<i>Sillago ciliata</i>	Commonly found in bays, estuaries and beyond the breakers off surf beaches. Has a short-based spiny dorsal fin and a long-based soft dorsal fin.	Australian Museum

Common name	Scientific name	Summary	Reference
Tailor*	<i>Pomatomus saltatrix</i>	Found in all oceanic and coastal waters except the eastern and northwest Pacific. The adults can be found in estuaries and brackish water, but are most common in clean, high-energy waters, such as surf beaches and rock headlands	Encyclopedia of Life
Silver Bidy*	<i>Gerres subfasciatus</i>	Found in estuaries, harbours, to fairly deep water along the shores and reported to congregate in schools.	Encyclopedia of Life
Yellowfin Bream*	<i>Acanthopagrus australis</i>	The species occurs throughout the Indo-West Pacific. In Australia it is found along the east coast from northern Queensland to eastern Victoria. Coastal fish are silver, but those living in estuaries are darker. Yellowfin Bream is a schooling species	Australian Museum
Tarwhine*	<i>Rhabdosargus sarba</i>	Tarwhine is a schooling species found in bays, harbours and coastal areas throughout the Indo-Pacific	Australian Museum
Silver Batfish	<i>Monodactylus argenteus</i>	Found in bays, mangrove estuaries, tidal creeks, and lower reaches of freshwater streams, occasionally in silty coastal reefs. Feeds on plankton and detritus and commonly seen in schools.	Encyclopedia of Life
Luderick*	<i>Girella tricuspidata</i>	They favour estuarine (including mangroves), rocky reef and inshore, coastal water habitats. They flourish in seagrass areas and are moderately sedentary, schooling fish.	Encyclopedia of Life
Striped Scat	<i>Selenotoca multifasciata</i>	Adults are usually found schooling in sandy areas of estuaries and river mouths. Juveniles commonly enter freshwater streams	Australian Museum
Flat-tail Mullet*	<i>Liza argentea</i>	Juveniles are often found in coastal streams. Adults live in estuaries and along sea beaches from northern Queensland, around the south of the country and north to the central coast of Western Australia	Australian Museum
Sea Mullet*	<i>Mugil cephalus</i>	In all tropical and subtropical seas; Mediterranean, Black Sea and Atlantic, reaching northward to Bay of Biscay. Introduced in Lake Trasimeno	Encyclopedia of Life
Fan-tail Mullet*	<i>Mugil georgii</i>	Also known as <i>Paramugil georgii</i> , this fish is endemic to Australia. It forms schools in coastal waters, estuaries, and bays; young may enter freshwater.	FishBase
Sand Mullet*	<i>Myxus elongatus</i>	Form schools in shallow coastal waters and lower estuaries. Found in freshwater during its first year, seldom thereafter.	Encyclopedia of Life
Bridled Goby	<i>Arenigobius bifrenatus</i>	Occur in estuarine and inshore waters. They live in burrows in muddy and sandy substrates often in seagrass beds	Australian Museum
Half- Bridled Goby	<i>Arenigobius frenatus</i>	Found in upper estuaries, in seagrass beds, and mangroves inhabits burrows	Encyclopedia of Life
Crested Oyster Goby	<i>Cryptocentroides gobioides</i>	The species is endemic to Australia, occurring from northern Queensland to southern New South Wales. It is usually found on muddy bottoms or under rocks in estuaries and inshore waters	Australian Museum
Exquisite sand-goby	<i>Favonigobius exquisitus</i>	Found in coastal bays and sandy estuaries sometimes in seagrass.	Encyclopedia of Life
Tamar River goby	<i>Afurcagobius tamarensis</i>	Inhabits quiet waters of brackish estuaries and coastal lakes; also in lower reaches of freshwater streams . Found on sand, silt or mud bottoms, usually in small aggregations.	Encyclopedia of Life
Glass Goby	<i>Gobiopterus semivestita</i>	Found in quiet coastal estuaries, enters fresh water, usually in small to large schools.	FishBase

Common name	Scientific name	Summary	Reference
Unknown Goby	<i>Gobiopterus sp.</i>	Gobies are primarily found in shallow marine habitats including tidal pools, coral reefs and seagrass meadows and are also very numerous in brackish water and estuarine habitats including the lower reaches of rivers, mangrove swamps and saltmarshes.	Australian Museum
Mangrove Goby	<i>Mugilogobius paludis</i>	Found in mangroves, entering the lower reaches of freshwater streams.	Encyclopedia of Life.
Blue-spot Goby	<i>Pseudogobius olorum</i>	It is often found in muddy areas and seagrass beds in the upper reaches of estuaries. It is also known to penetrate upstream into freshwater and may remain there for extended periods of time	Australian Museum
Checkered Mangrove Goby	<i>Mugilogobius stigmaticus</i>	Inhabits estuarine areas along the New South Wales and Queensland Coast	ABRS
Large-mouth goby	<i>Redigobius macrostoma</i>	Found in estuaries, harbors and entering lower reaches of freshwater streams	Encyclopedia of Life.
Mud Goby	<i>Taenioides mordax</i>	The long, thin eel gobies are burrowing species that live mainly in estuaries in Queensland and New South Wales	Australian Museum
Large-tooth Flounder	<i>Pseudorhombus arsius</i>	Sand or mud bottoms, occasionally in estuaries. Recorded to a depth of 100 m	Australian Museum
Smalltooth Flounder*	<i>Pseudorhombus jenynsii</i>	Occurs in estuaries and offshore over sand or mud bottoms on most coasts of Australia.	FishBase
Black Sole	<i>Synaptura nigra</i>	Occurs in muddy bottoms of coastal rivers, estuaries and shallow inshore waters of eastern Australia.	FishBase
Six-spine Leatherjacket	<i>Meuschenia freycineti</i>	Juveniles are found in shallow water, commonly in seagrass beds. Adults are found on coastal and offshore reefs, to depths of 50 m or more	Australian Museum
Yellowfin Leatherjacket	<i>Meuschenia trachylepis</i>	The species is commonly found in shallow estuaries, particularly during their juvenile and young adult stages. Large adults are often seen on rocky reefs	Australian Museum
Common Toadfish	<i>Tetractenos hamiltoni</i>	Found in shallow coastal waters and estuaries along the eastern Australian coastline. It is a schooling species that is often seen buried in sand with only the eyes exposed	Australian Museum
Empire Fish	<i>Hypseleotris compressa</i>	Inhabits lower reaches of rivers (also found further upstream) in flowing or still water. Juveniles often occur in swiftly flowing water or brackish estuaries. Tolerant of salinity levels equal to sea water, temperatures up to 35°C and pH 5.0-9.1	FishBase

Table I-2 Freshwater Species

Common Name	Scientific Name	Summary	Reference
Longfin Eel	<i>Anguilla reinhardtii</i>	A primarily carnivorous fish that has a broad head, large mouth with fleshy lips and dorsal fin origin that is well forward of the anal fin origin. In Australia, it is found along the entire east coast. Lives in rivers, lakes and swamps, but appears to prefer flowing water. Migrates to the sea to breed at spawning grounds near New Caledonia.	Australian Museum
Shortfin Eel	<i>Anguilla australis</i>	Can be distinguished from the similar-looking Longfin Eel by the dorsal fin origin which is above the anal fin origin and uniform colour and without a blotched pattern. Occur in streams, lakes and swamps. More likely inhabits slow flowing streams or still waters, and migrates to the sea to breed.	Australian Museum. Encyclopedia of Life.

Common Name	Scientific Name	Summary	Reference
Common Jollytail	<i>Galaxias maculatus</i>	Usually found in low elevation still or slow-flowing waters like streams, rivers and lakes. They migrate downstream to spawn during new or full moons, mostly in Autumn, larvae leave the estuary and spend 5 to 6 months at sea as juveniles before returning to freshwater.	Australian Museum
River Garfish*	<i>Hyporhamphus regularis</i>	Pelagic species, found inland from Burnbank to Shark Bay, WA and Gladstone, QLD to Lakes Entrance, Vic in fresh to brackish water.	FishBase
Australian blue-eye	<i>Pseudomugil signifier</i>	Occurs in clear, cool, fast-flowing streams and also brackish mangrove estuaries. Inhabits tidal mangrove creeks or fringing coastal mangrove and around offshore islands. Also common in clear, forest streams.	Encyclopedia of Life.
Crescent Perch/Crescent Grunter	<i>Terapon jarbua</i>	Can be identified by curved stripes on the body and across the tail. The species occurs in shallow coastal waters, mangroves and freshwaters.	Australian Museum
Striped Gudgeon,	<i>Gobiomorphus australis</i>	The species is mostly found in slow-flowing, often muddy water streams	Australian Museum
Cox's Gudgeon	<i>Gobiomorphus coxii</i>	The species is found in coastal freshwaters and inland up to about 700 m altitude	Australian Museum
Flathead Gudgeon	<i>Philypnodon grandiceps</i>	A benthic species that is primarily found on muddy bottoms, often amongst vegetation. The species occurs in freshwaters, but is also recorded from estuarine and protected areas in coastal bays	Australian Museum
Dwarf Flathead Gudgeon	<i>Philypnodon</i>	The Dwarf Flathead Gudgeon is endemic to Australia. It is found in freshwater and brackish to full strength seawater in the upper reaches of estuaries	Australian Museum

Table I-3 Invasive Species

Common Name	Scientific Name	Summary	Reference
Goldfish	<i>Carassius auratus</i>	Freshwater species. Originated in China, but have now spread worldwide in aquariums, ornamental pools, and into the wild.	Encyclopedia of Life
Mosquitofish	<i>Gambusia holbrooki</i>	Freshwater species. Introduced worldwide. Observed to inhabit warm, still waters, typically seen shoaling at the edges of streams and lakes	Encyclopedia of Life
Oriental Goby	<i>Acanthogobius flavimanus</i>	A benthic species that is usually found on muddy seabeds in estuarine and inshore areas. It occurs naturally in Japan but has been introduced to Australia.	Australian Museum

Appendix I references

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