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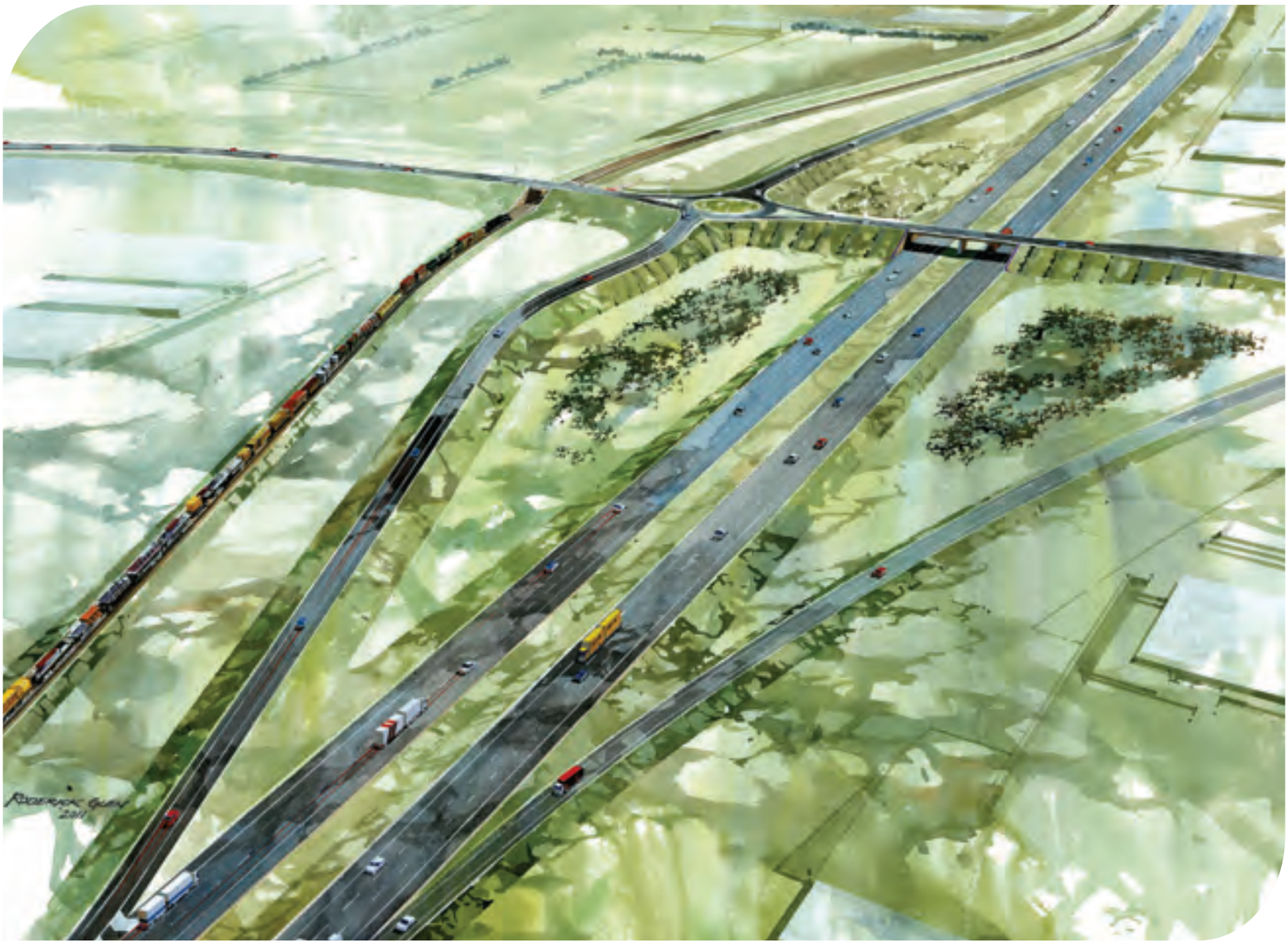


Project Impact Report Volume 2

An environmental, social and economic assessment

Government of South Australia
Department for Transport,
Energy and Infrastructure

DELIVERING OUR TRANSPORT FUTURE NOW

north-south corridor

northern connector

Part E. Effects of the project on the physical and biological environment

Part E

17 Flora

17.1 Introduction

The existing flora environment, investigated through background research and field surveys, is described in more detail in Technical Report 3 – Flora.

17.1.1 Assessment approach

The approach to the flora component of the study undertook:

- extensive background research — literature review on all available relevant reports and database search
- vegetation mapping and verification of flora values through field surveys across the entire project area and in surrounding areas, during spring and summer 2008–09 to identify the range of flora values
- assessed all vegetation types in the project area to establish the vegetation communities present, their condition and the overall biological significance of the vegetation.

17.1.2 Policy and legislative requirements

Environment Protection and Biodiversity Conservation Act 1999

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) was developed to provide a legislative framework for the protection and management of matters of national environmental significance. The primary objectives of EPBC Act relevant to the project are to:

- provide for the protection of the environment, especially matters of national environmental significance
- conserve Australian biodiversity
- provide a streamlined national environmental assessment and approvals process
- enhance the protection and management of important natural and cultural places
- promote ecological sustainable development through the conservation and ecologically sustainable use of natural resources.

The seven matters of national environmental significance are:

- world heritage properties
- national heritage properties
- wetlands of international importance (Ramsar wetlands)

- threatened species and ecological communities (relevant to this project)
- migratory species (relevant to this project)
- Commonwealth marine areas
- nuclear actions (including uranium mining).

If a proponent believes that a project may impact on any of the matters of national environmental significance then an EPBC Act Referral must be prepared and submitted to the Australian Government Department of Sustainability, Environment, Water, Population and Communities.

A referral will be submitted for this project.

National Parks and Wildlife Act 1972

South Australia's *National Parks and Wildlife Act 1972* (NPW Act) principally provides for the establishment and management of reserves, the conservation of wildlife in a natural environment, and for other purposes such as permits for the keeping of native animals and compliance.

The NPW Act protects all native flora and fauna in South Australia and lists species of State conservation significance in Schedule 7 (Endangered), 8 (Vulnerable) and 9 (Rare) of the Act. A number of species listed under these schedules are considered likely to occur in the project area. However, there are no approval requirements under this legislation if a listed species is likely to be impacted upon by a project. If native vegetation is to be removed on a project, the impacts are assessed under the *Native Vegetation Act 1991*.

Native Vegetation Act 1991

The South Australian Native Vegetation Act ensures that native vegetation is protected in South Australia. It applies to all terrestrial and marine native vegetation, with the exception of defined areas in the Adelaide metropolitan area.

Approval is required to clear native vegetation: an application must be submitted to the Native Vegetation Council and an offset or significant environmental benefit (SEB) provided. The SEB can be on-ground works (e.g. revegetation, bush care) or payment to the Native Vegetation Fund.

Construction of the Northern Connector would affect or require the removal of areas of remnant vegetation. The Department for Transport, Energy and Infrastructure (DTEI) would submit an application to the Native Vegetation Council to seek removal of this native vegetation and outline measures to achieve the required SEB.

It is likely that the clearance of native vegetation in the project area would fall under regulation 5(1)(h) — works on behalf of the Commissioner of Highways. The aim of the regulation is to ensure that works avoid or minimise impacts on significant native vegetation. Approval for vegetation clearance (even under an exemption) is conditional on the achievement of an SEB.

Natural Resources Management Act 2004

In 2004 the South Australian Government enacted legislation to promote sustainable use and management of South Australia's natural resources. The *Natural Resources Management Act 2004* (NRM Act) established an integrated management arrangement that:

- recognises and protects the intrinsic value of natural resources
- seeks to protect biological diversity and support, and encourage restoration or rehabilitation
- provides for the protection and management of catchments and the sustainable use and restoration of land and water resources
- seeks to support sustainable primary and other economic production systems
- provides for the prevention or control of impacts caused by pest species
- promotes educational initiatives and provides support mechanisms to increase the capacity of people to be involved in the management of natural resources.

The principal relevance of the NRM Act to the Northern Connector project is the legislative requirements for the control of potential impacts caused by pest species.

Development Act 1993 — significant tree legislation

The Northern Connector project area is located in metropolitan Adelaide (in the City of Playford, City of Salisbury and City of Port Adelaide Enfield). Therefore the 'significant tree' provisions of the *Development Act 1993* apply to the project. The legislation states that development approval is required if any tree that meets the size requirements (see below), is either removed or impacted upon as part of the project and consent under the Native Vegetation Act, is not required. The significant tree definition is:

- any tree with a trunk circumference of 2.0 m or more – or, in the case of trees with multiple trunks, that have trunks with a total circumference of 2.0 m or more and an average circumference of 625 mm or more – measured at a point 1.0 m above natural ground level; or
- any tree identified as a significant tree in a Development Plan.

The significant tree provisions of the Development Act will be relevant to the project if construction requires the clearance or causes an impact to a significant tree (any tree meeting the requirements above and not requiring approval under the Native Vegetation Act). The current route is likely to impact upon some significant trees. Any significant trees requiring removal or major pruning will require approval from the Development Assessment Commission.

Fisheries Management Act 2007

The *Fisheries Management Act 2007* provides for the conservation and management of the aquatic resources of South Australia, the management of fisheries and aquatic reserves, the regulation of fishing and the processing of aquatic resources, the protection of aquatic habitats, aquatic mammals and aquatic resources, and the control of exotic aquatic organisms and disease in aquatic resources.

The relevance of the Fisheries Management Act to this project mainly relates to the protection of mangroves in aquatic reserves.

17.2 Existing conditions

17.2.1 Biodiversity overview

The Northern Connector projects area is located on the Northern Adelaide Plains and sits in a highly modified environment. Major land uses in the area are Cheetham Salt Ltd salt fields, Bolivar Wastewater Treatment Plant (WWTP), and horticultural and residential areas. Environmentally significant areas are also present.

The structural vegetation description for the Northern Adelaide Plains is a mixture of:

- inland low open box woodlands
- riparian red gum woodlands
- samphire shrublands in low-lying saline depressions
- chenopod shrublands on sandy rises
- coastal shrublands on low dune rises
- low sedgelands in seasonally inundated freshwater depressions
- tall reedbeds
- open grasslands on vast open plains.

Pre-European vegetation

Historically, the landscape supported large expanses of coastal saltmarsh communities (Kraehenbuhl 1996; Graham et al. 2001; Coleman and Cook 2008) and shrublands subject to periodic shallow freshwater inundation from flooding events. These floristically intact riparian ecosystems (Gawler, Light and Little Para rivers) provided a suite of wetland and woodland habitat areas. The extensive floodplain shrublands such as lignum and chenopod shrublands coexisted with other shrublands on slightly higher ground (including Nitre-Bush, Marsh saltbush and Short-Leaved Bluebush).

Terrestrial vegetation types also included sedgelands (*Gahnia filum*), grasslands (*Lomandra effusa*, *Austrodanthonia* spp., *Austrostipa* spp.) with River Red Gum

woodlands along the major rivers, creeks and extending out to flood wash plains (Berkinshaw 2004). Open grassy box woodlands inland from the coast featured on rises and plains. It is suggested that native pine woodlands would have also featured on sandy rises (Kraehenbuhl 1996).

Current landscape

The current landscape has been highly modified by intensive human landuse, although some of the historical ecosystem features, such as dense mangrove forests, are still present. Extending from the Mount Lofty Ranges, westerly flowing rivers with riparian areas, ephemeral ponds and wetlands still extend to floodplains, although the drainage patterns in the landscape now include constructed wetlands, levee banks, drains and shallow open water surfaces managed for commercial salt harvesting.

Remnant coastal landscape features include tidal flats and creeks, saltmarsh, ridges, dunes, intertidal coastal areas and extensive mangroves (especially at North Arm Creek). The modification of the landscape to improve stormwater management at Barker Inlet and Greenfields wetlands has replicated some of the historical ecosystems and now provides extensive wetland habitat for a range of species. The construction of water drainage channels and pondage systems associated with salt harvesting provides areas of permanent surface water storage dams. This 'artificial' physical characteristic is noticeable in the landscape and offers a replication of some wetland habitat types for waders.

The Northern Adelaide Plains is a region of high ecological importance (Berkinshaw 2004). The presence of remnant vegetation patches with flora and fauna species of conservation significance highlight this, although there is a high level of disturbance and modification from various land uses. Due to the historical broad-scale clearance of the Adelaide Plains (from Hallett Cove to Gawler River), the presence of remnant vegetation in the project area is considered to be of conservation significance at a landscape scale to the whole Adelaide Plains region (EBS 2007).

The Northern Adelaide Plains is classified as 'fragmented' (McIntyre and Hobbs 2000), indicating that 40–90% of the remnant vegetation has been destroyed. The original vegetation cover has been isolated, structural and species diversity lost, habitat value reduced, and remnant habitats becoming vulnerable to invasion by environmental weeds and feral animals.

Landscape modifications have most noticeably been the loss of sedgeland, grassland and woodland habitat. Extensive mangrove forests still remain because of the low landscape value of saline areas for agricultural development.

The project area occurs on three different associations in the Interim Biogeographic Regionalisation of Australia (Figure 17.1):

- Northern section — Rosedale Association: undulating to rolling plain on shale with broad floodplains supporting open Blue Gum, River Red Gum woodlands or exotic conifer plantations on hard pedal red duplex soils, reddish friable loams and brown self-mulching cracking clays

- Central section —Mallala Association: undulating plain with occasional dunes supporting mainly grasslands on brown calcareous loams, hard pedal red duplex soils and brownish sands
- Southern section — Parham Association: a coastal complex of tidal flats, dunes, swamps and sandy beaches, backed by a gently sloping plain supporting low woodlands of mangrove, chenopod shrubland of samphire and open heath of Coast Daisy Bush, Coast Beard Heath and Coastal Wattle on grey non-cracking plastic clays, grey duplex soils, whitish sands, grey calcareous loams and greyish calcareous sands.

Two major landscape features in the project area are the zones of remnant mangroves and coastal saltmarsh.

Mangroves

Only one species of mangrove, Grey Mangrove (*Avicennia marina*), is represented in South Australia (Graham et al. 2001). The Port River Barker Inlet has the most extensive area of mangroves (17.7 km^2) in the Adelaide coastal region. No mangroves extend south of Barker Inlet in South Australia.

Mangrove communities, particularly those in Barker Inlet, are under threat from the high level of nutrients entering the ocean from stormwater, wastewater treatment plants and soda products factory outfall (Baker 2004). High nutrient loads have resulted in significantly increased production of *Ulva lactuca* (green algae) offshore. The *Ulva* washes ashore and smothers mangrove seedlings, pneumatophores and small seagrass seedlings (Baker 2004). Over 250 ha of mangroves between St Kilda and Port Gawler have been lost since 1956 and many more areas are in poor health (MLR INRM Group 2003).

It is predicted that mangrove vegetation (along with other intertidal vegetation) will respond to climate change-induced sea-level rise by migrating upslope, or increase their elevation through processes of vertical accretion or sedimentation so that they remain in the same tidal range. Without such a response, mangroves will contract in extent at the shoreline due to erosion, or submergence and death (OzCoasts 2008).

Importantly, studies have also found that Grey Mangrove populations have a low level of genetic variation, and populations can be genetically distinct within each estuary (NSW Department of Primary Industries 2008), indicating it is a conservation priority to retain populations at a variety of sites. Mangrove vegetation in South Australia is geographically isolated from other mangrove forests in Australia and this stand is the southernmost extent of its range in South Australia

The importance of mangrove areas is also highlighted by their role in the fishing industry, as a major part of the food web. They also protect the coast against storms and play a slow but continuous role of land building (City of Salisbury 2008c).

Mangrove forests are very productive areas and important habitats for many juvenile and adult marine species that are probable food sources for dolphins (Adelaide Dolphin Sanctuary 2007). Mangroves trap sediment, they are a nursery area for a wide range of fish and invertebrates, and they protect the fragile and important saltmarsh habitats from wave action. Aerial roots (pneumatophores) act to stabilise

Source: DEH, DTEI, DPLG, Geoscience Australia

NORTH

0 1 2

Kilometres

Figure 17.1 **Environmental (Interim Biogeographic Regionalisation of Australia) associations**

Northern Connector road
Northern Connector rail
Spur line to Port Flat siding
Northern Expressway
South Road Superway
Existing railway
Existing roads
Parham
Mallala
Rosedale

the mangrove tree, and also play a significant role in stabilising surrounding sediment by helping to reduce wave action and providing an environment for sediments to settle (Edyvane 1995).

Mangroves also provide nutrients and organic material to the food web in the form of litter (leaves, twigs, bark, fruit and flowers). Decomposition of leaves is facilitated by fungi and mud bacteria. Decomposing leaf material, or detritus, acts as the bottom level of the mangrove food chain and is eaten by worms, crabs, shrimps and snails (Edyvane 1995). Marine fauna species use mangrove forests for a variety of habitat functions, including spawning and shelter (Adelaide Dolphin Sanctuary 2007).

Coastal saltmarsh

Saltmarsh is a valuable coastal habitat that creates a critical buffer zone between the mangrove community and land, regulates freshwater runoff, and provides new habitat for colonising mangroves (Department for Environment and Heritage 2007a). Saltmarsh habitats provide food for foraging fish at high tide, nutrients for adjacent food webs, and shelter for a range of marine animals, especially juvenile fish and crabs when inundated at high tide (Department for Environment and Heritage 2007a). They are also an important roosting place for shorebirds.

17.2.2 Terrestrial vegetation associations

A total of 55 native flora species were recorded in the project area during the vegetation survey. A further 70 native species have been previously recorded in proximity to the project area.

Remnant vegetation in the landscape is still evident and indicative of the presence of the former extensive coastal fringe vegetation, such as mangrove forests, samphire and chenopod shrublands, and open grassy woodlands. Small areas of remnant Mallee Box woodlands still occur in this region but only a very small portion were recorded in the project area. This area has had infill plantings which have altered the former chenopod shrubland with overstorey native trees to enhance local visual amenity and assist with midge control (SA Water and United Water 2008).

The understorey condition of the Red Gum creek lines has been altered dramatically through weed invasion, especially from exotic perennial grasses such as Kikuyu. Changes in the landscape ecology, especially from altered drainage patterns and influences from tracks, salt fields and loss of vegetation cover have all degraded the remnant vegetation.

The vegetation in the best condition in the project area is the mangrove forests as they have been able to persist and colonise mudflat areas and are not prone to extensive weed invasion.

A total of 19 vegetation associations were mapped in the project area; 12 of them represent native vegetation. No remnant native vegetation associations are listed as threatened ecological communities under the EPBC Act, nor provisionally listed in South Australia (Department for Environment and Heritage 2009).

Table 17.1 outlines and describes the 19 vegetation associations. Technical Report 4 includes more detailed descriptions and photographs of these associations.

Table 17.1 Vegetation associations in the Northern Connector project area

	Plant association	Vegetation type	Description	Location	Project section
1	Grey Mangrove (*Avicennia marina* var. *resinfera*) Low Open Forest	Remnant native vegetation	Mangroves on mudflats of delta environments on a firm muddy to clayey soil with tidal flows	North Arm Creek, Dry Creek	Southern
2	River Red Gum (*Eucalyptus camaldulensis* var. *camaldulensis*) Woodland over Low Closed Chenopod Shrubland (*Maireana decalvans, M. brevifolia, M. aphylla, M. enchylaenoides*)	Remnant native vegetation (see 8)	Terrestrial woodland ecosystem	Bolivar	Central
3	Planted woodland of *Eucalyptus* spp., wattle (*Acacia* spp. including *Acacia pendula*), Paperbark (*Melaleuca* spp.), Sheoak (*Allocasuarina verticillata* and *Casuarina cunninghamiana*), Old Man Saltbush (*Atriplex nummularia* ssp*. nummularia*)	Planted vegetation	Roadside amenity planting	Bolivar, Swan Alley, Little Para, Dry Creek, Perkins Drive to Whicker Rd, reserve parallel with Whicker Rd, north of Cormack Rd & Greenfields, Barker Inlet South	Central and Southern
4	River Sheoak (*Casuarina cunninghamiana*) Low Closed Forest	Planted vegetation	Shrubland revegetation at constructed wetlands and roadside amenity planting	Grand Junction Road to Cormack Road	Southern
5	Cottonbush (*Maireana aphylla*) Low Chenopod Shrubland with scattered native grasses (*Austrodanthonia* sp. *Austrostipa sp and Eragrostis* sp.)	Remnant native vegetation	Dryland coastal zone ecosystem	Jobson Road	Northern and Southern

	Plant association	Vegetation type	Description	Location	Project section
6	Samphire (*Tecticornia blackiana +/- T. quinqueflora, +/- T. arbuscula, +/- Suaeda australis, +/- T. halocnemoides +/- T. pergranulata*) Very Low Open Shrubland	Remnant native vegetation	Saltwater wetlands in delta environments on firm muddy to clayey soil; intertidal (submergent) samphire in tidal zones and supratidal (emergent) samphire on seasonally inundated flats, saline depressions, chenier ridges and dune rises	Barker Inlet, North Arm, Swan Alley, Little Para, Dry Creek, North Arm to Grand Trunkway, reserve parallel with Whicker Road	Southern
7	Nitre Bush (*Nitraria billardierei*), Marsh Saltbush (*Atriplex paludosa*), Ruby Saltbush (*Enchylaena tomentosa*) Open Shrubland	Remnant/ planted native vegetation	Terrestrial low open shrubland with scattered grasses	Barker Inlet	Southern
8	Common Reed (*Phragmites australis)* and Bulrush (*Typha* sp.*)* Reedbeds	Remnant/ planted/ colonising native vegetation	Freshwater tall reedbed	Barker Inlet	Southern
9	Flat-sedge (*Cyperus vaginatus*) / Water-buttons (*Cotula coronopilfolia*) Sedgeland	Remnant/ planted/ colonising native vegetation	Freshwater low sedgeland on shorelines	Barker Inlet	Southern
10	River Red Gum (*Eucalyptus camaldulensis* var. *camaldulensis*) Open Woodland over exotic grasses	Planted vegetation	Revegetation area adjoining remnant native woodland	Swan Alley, Little Para	Southern

	Plant association	Vegetation type	Description	Location	Project section
11	Planted Mixed Shrubland (*Melaleuca brevifolia, M. halmaturorum, M. lanceolata, M. oraria, M. quinquinervia, M. styphellioides, Acacia notabilis, A. paradoxa, A. pycnantha, A. sophorae, A. victoriae A. stenophylla*)	Planted vegetation	Shrubland revegetation at constructed wetlands	Barker Inlet	Southern
12	Exotic Grassland	Planted vegetation		Perkins Drive to Whicker Rd, reserve parallel with Whicker Rd, Grand Junction Road to Cormack Road, north of Cormack Road, Greenfields, Barker Inlet South, parallel with Grand Trunkway	Southern

Figures 17.2–4 show the above vegetation associations in the context of the three project sections — Northern, Central and Southern.

17.2.3 Aquatic flora

Aquatic plants in the Northern Connector project area are associated with mangroves, saltmarsh and wetland habitats. Known aquatic plants include seagrasses and hypersaline tolerant seagrasses such as *Ruppia* spp. and *Lepilaena* spp. In areas of high salinity, green and red macroalgae grow. Benthic mats of algae and bacteria crust the exposed mud surface and the floors of shallow pools. Pelagic plankton including diatoms, chlorophytes, dinoflagellates and filamentous cyanobacteria are found in samphire pools as well as in the mangrove creeks and freshwater reed swamps.

At the freshwater–saltwater interface, floating plants such as duckweeds (*Lemna* spp. and *Wolffia* spp.) and water-buttons (*Cotula crassifolia*) are common. *Azolla* spp. are generally only found in the freshest areas. Submerged saltwater/ freshwater species include algae such as *Enteromorpha* spp. and *Chaetomorpha* spp. Pondweeds (e.g. *Potamogeton* spp., *Myriophyllum* spp.) prefer the freshwater end of the zones (Coleman 1996).

Source: DEH, DTEI,DPLG, EBS

Figure 17.2 **Vegetation map within corridor Northern section**

Source: DEH, DTEI, DPLG, EBS

NORTH

0 0.5 1

Kilometres

Figure 17.3 **Vegetation map within corridor Central section**

Northern Connector boundary

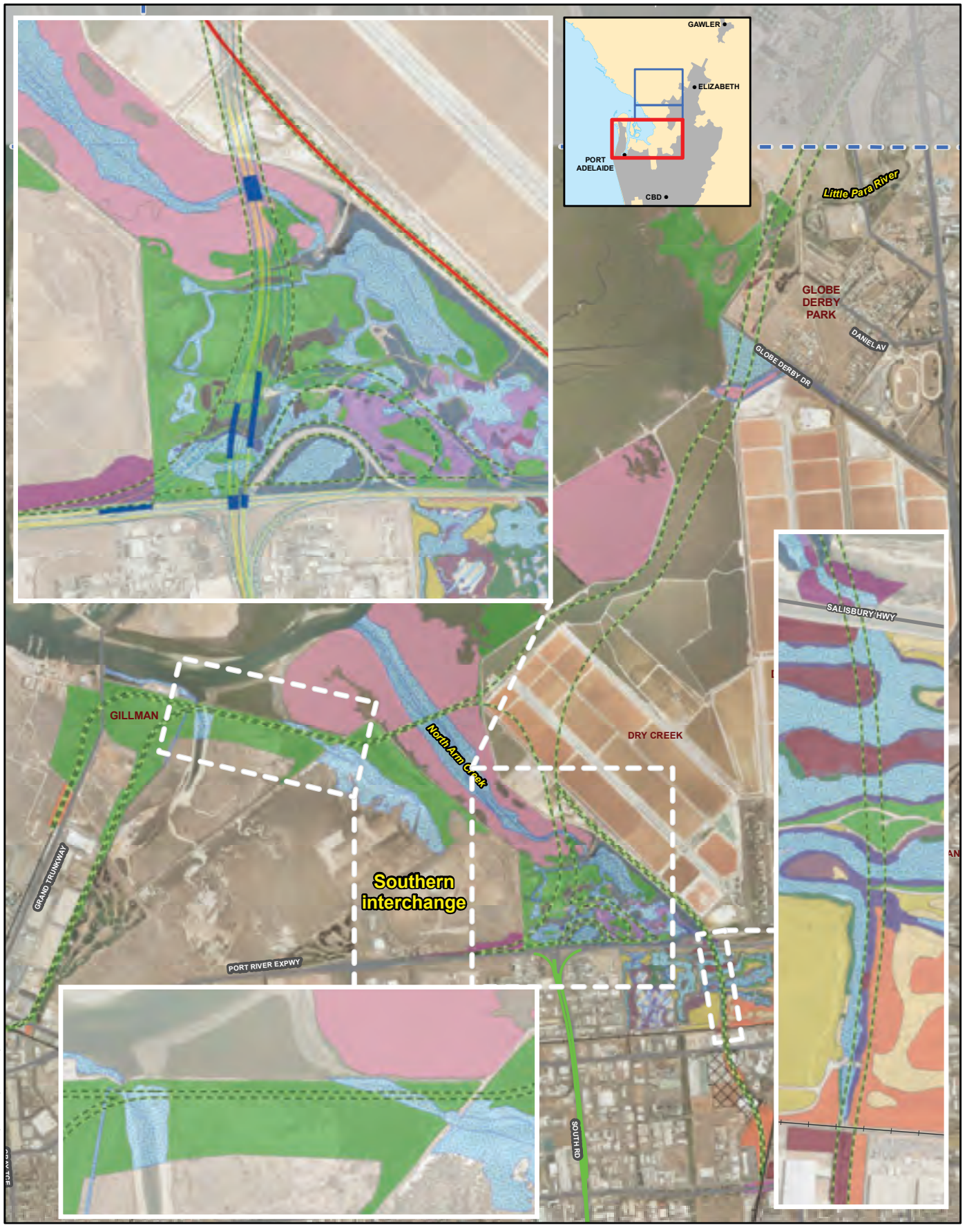
Embankment

Existing roads

2, River Red Gum

3, Planted eucalypt woodland

5, Cotton-bush



Source: DEH, DTEI, DPLG, EBS

Figure 17.4 **Vegetation map within corridor Southern section**

17.2.4 Species of conservation significance

National threatened species

No flora species of national conservation significance were recorded in the Northern Connector project area during the current flora assessment. One species of national significance, the Vulnerable Bead Glasswort (*Tecticornia flabelliformis*), is known to occur in the region; the nearest known records are from Middle Beach, Parham and Light Beach to the north of the project area (South Australian Herbarium 2009).

Bead Glasswort is a woody, perennial saline area low shrub that grows to approximately 20 cm high (Department of the Environment and Heritage 2006). It is found on the margins of some salt lakes and on low ground that is subject to flooding. Bead Glasswort flowers and fruits between January and May. The plant dies back when flooded in winter and then regenerates after the water dries out (Department of the Environment and Heritage 2006).

No other flora species of national conservation significance are likely to occur in the Northern Connector project area.

South Australian threatened species

A total of five flora species of State conservation (NPW Act) significance have been recorded either in or adjacent to, the project area, two in the project area during the current survey (Table 17.2). These plants occur in the cotton bush vegetation association, a patch of terrestrial remnant native vegetation near Jobson Road and Summer Road.

The remaining three flora species of State conservation significance are considered likely to occur in the project area due to the proximity of known records and similar habitat to previously recorded locations.

In addition to the flora species of State significance, a total 49 species of regional significance (Southern Lofty Botanical Region) have been previously recorded in or adjacent to the project area.

Table 17.2 Flora species of State conservation significance

Scientific name	Common name	NPW Act*	Regional (Southern Lofty)
Eragrostis infecunda	Barren Cane-grass	R	V
Juncus radula	Hoary Rush	V	E
Maireana decalvans	Black Cotton-bush	E	E
Myoporum parvifolium	Creeping boobialla	R	V
Sclerolaena muricata var. *villosa*	Five-spine Bindyi	R	

* as listed in the Schedules of the NPW Act (Version 21.2.2008) grey highlight: recorded during field surveys in project area. Source: DEH database (Berkinshaw 2004; Coleman and Cook 2008)

Status: E = Endangered, V = Vulnerable, R = Rare

17.2.5 Weed species

A number of introduced weed species were recorded during the flora surveys, some declared under the NRM Act and/or considered to be serious environmental weed species (Table 17.3). Weeds (declared, environmental and agricultural) and non-indigenous native plants are common across the project area, particularly along roadsides and in ornamental plantings. A range of introduced species have been planted for their visual amenity value, although some species, such as Athel Pine (*Tamarix aphylla*), are declared species and serious environmental weeds.

A total of 21 introduced species are considered to be serious environmental weeds and a further 11 are declared under the NRM Act (Table 17.3).

Table 17.3 Declared and environmental weed species recorded in the project area

Scientific name	Common name	Status
Acacia saligna	Golden Wreath Wattle	E
Agave sp.	Century Plant	E
Arctotheca calendula	Capeweed	E
Conyza bonariensis	Flaz-leaf Fleabane	E
Cynara cardunculus ssp. *flavescens*	Artichoke Thistle	D
Cyperus brevifolius	Mullumbimby Couch	D
Emex sp.	Three-cornered Jack	D
Eragrostis curvula	African Lovegrass	D
Euphorbia paralias	Sea-spurge	E
Galenia pubescens	Coastal Galenia	E
Gazania rigens	Gazania	E
Heliotropium europaeum	Common Heliotrope	E
Hypochaeris radicata	Deep-rooted cats ear	E
Lactuca serriola	Prickly Lettuce	E
Lagurus ovatus	Hare's-tail Grass	E
Limonium lobatum	Statice	E
Lophopyrum ponticum	Tall Wheatgrass	E
Lycium ferocissimum	African Boxthorn	D
Malva parviflora	Small-flowered Mallow	E
Marrubium vulgare	Horehound	D
Mesembryanthemum crystallinum	Common Ice-plant	E
Olea europaea ssp. *europaea*	Olive	D
Oxalis pes-caprae	Soursob	D
Pennisetum clandestinum	Kikuyu	E
Piptatherum miliaceum	Rice Millet	E
Polygonum aviculare	Wireweed	E
Schinus molle	Pepper-tree	E
Solanum elaeagnifolium	Silver-leaf Nightshade	D
Solanum nigrum	Blackberry Nightshade	E
Sonchus oleraceus	Common sow-thistle	E
Tamarix aphylla	Athel Pine	D

Scientific name	Common name	Status
Tribulus terrestris	Caltrop	D

Status: D = declared plant under the NRM Act; E = environmental weed

17.3 Potential impacts

17.3.1 Construction impacts

Clearance of both native and non-native vegetation would be necessary for construction of the project. The level of impact identified in this chapter is based on a concept design and is a conservative indication of potential vegetation clearance levels. A detailed vegetation survey during the detailed design phase of the project will more accurately identify the impacts of the Northern Connector project. Detailed design would also identify measures to minimise vegetation clearance that have not been taken into account in this assessment (e.g. ability to retain existing vegetation where possible and incorporate it into the landscape design).

Any native vegetation clearance would further contribute to the loss of native vegetation in a region already highly modified by human use. The landscape is already significantly fragmented with very little remnant native vegetation remaining, even with the moderate levels of remnant fringing samphire and mangrove habitats.

A large proportion of the planted vegetation in the constructed stormwater management wetlands, established 10–15 years ago, has reached maturity and is now colonising the area. Its value as a natural feature in the landscape is highlighted by the direct benefit of habitat provisions, water quality and other ecosystem services.

The planted vegetation around Bolivar WWTP contains mature trees, some of which are now of a size to be classified as ‘significant’ under the *Development Act 1993*. Some trees requiring removal may contain hollows. This would result in the loss of habitat for a range of avifauna and mammal species but the exact impact has not yet been quantified. Removal of vegetation in this area may also impact on the size and integrity of the remnant/planted River Red Gum (*Eucalyptus camaldulensis* var. *camaldulensis*) woodland patch on SA Water land, which also contains a number of very old, pre-European settlement River Red Gums.

Vegetation clearance

Based on the concept design approximatelyf 49.79 ha of native vegetation, as defined by the *Native Vegetation Act 1991* would need to be cleared for the Northern Connector road and rail corridors. This vegetation includes mangrove forest, samphire shrubland, reedbeds, open shrublands and chenopod shrublands with very small areas of River Red Gum woodland. Native vegetation in the project area was assigned a condition rating and a corresponding SEB ratio (Table 17.4).

Clearance of remnant native vegetation and naturally regenerating local native species would require approval under the Native Vegetation Act. Clearance or

impact on any significant trees would require approval under the *Development Act 1993.*

Potential impacts and risks to native and planted vegetation are:

- direct removal of remnant native chenopod and samphire shrubland, woodland, mangroves and reedbeds
- fragmentation of vegetation by the traverse of an wide road and rail corridor and a rail link in the southern section of the project area at ground level, especially resulting in the division and fragmentation of wetland vegetation and ecosystems
- fragmentation of the plantation vegetation at Bolivar WWTP
- potential introduction and spread of weeds and or soil pathogens.

The project would impact on sections of Barker Inlet north and south wetlands, and an area of mangroves. However, the proposed corridor has the lowest potential impact on habitats of all corridor options investigated in the planning phase. Given the extent of mangroves in Barker Inlet, the impact to a relatively small amount of mangroves was considered preferable to the loss of a larger area of more diverse habitat in north east quadrant of the Barker Inlet north wetlands.

Table 17.4 Native vegetation type and condition to be cleared

Condition (SEB ratio)	Vegetation association number	Vegetation association description
Excellent (10:1)	1	Mangrove (*Avicennia marina* var. *resinfera*) Low open forest
	6	Samphire (*Tecticornia* spp. Samphire, *Sclerostegia arbuscula*, *Suaeda australis, Tecticornia* spp.) Low Shrubland
Good (8:1) (7:1)	8	Common reed (*Phragmites australis*) and Bulrush (*Typha domingensis*) reedbeds on shallow channels
	6	Samphire (*Tecticornia* spp., *Sclerostegia arbuscula*, *Suaeda australis*, *Tecticornia* Samphire spp.) Low Shrubland
Moderate (6:1)	8	Common reed (*Phragmites australis*) and Bulrush (*Typha domingensis*) reedbeds on shallow channels
	3	Planted woodland of eucalypt (*Eucalyptus* spp.), wattle (*Acacia* spp. including *Acacia pendula*), Paperbark (*Melaleuca* spp.). Sheoak (*Allocasuarina verticillata* and *Casuarina cunninghamiana*) and Old Man Saltbush (*Atriplex nummularia*)
	5	Cottonbush (*Maireana aphylla*) low chenopod shrubland with mixed Eucalypt Low woodland remnant and revegetation
	7	Nitre Bush (*Nitraria billardierei*), Marsh Saltbush (*Atriplex paludosa*), Ruby saltbush (*Enchylaena tomentosa*) Open shrubland

Condition (SEB ratio)	Vegetation association number	Vegetation association description
	9	Flat-sedge (*Cyperus vaginatus*) / Water-buttons (*Cotula coronopilfolia*) Sedgeland
	6	Samphire (*Tecticornia* spp., *Sclerostegia arbuscula*, *Suaeda australis*, *Tecticornia* spp.) Low Shrubland
	2	River Red Gum (*Eucalyptus camaldulensis*) Woodland over Low Chenopod Shrubland (*Maireana decalvans*, *M. brevifolia, M. enchylaenoides, M. aphylla*)
	6	Samphire (*Tecticornia* spp., *Sclerostegia arbuscula*, *Suaeda australis*, *Tecticornia* Samphire spp.) Low Shrubland
	3	Planted woodland of eucalypt (*Eucalyptus* spp.), wattle (*Acacia* spp. including *Acacia pendula*), Paperbark (*Melaleuca* spp.). Sheoak (*Allocasuarina verticillata* and *Casuarina cunninghamiana*) and Old Man Saltbush (*Atriplex nummularia*)
	7	Nitre Bush (*Nitraria billardierei*), Marsh Saltbush (*Atriplex paludosa*), Ruby saltbush (*Enchylaena tomentosa*) Open shrubland
Very poor (2:1) (1:1)	5	Cottonbush (*Maireana aphylla)* low chenopod shrubland with mixed Eucalypt Low woodland remnant and revegetation
	6	Samphire (*Tecticornia* spp. Samphire, *Sclerostegia arbuscula* Shrubby Samphire, *Suaeda australis* Austral Seablite, *Tecticornia* spp.) Low Shrubland
	2	River Red Gum (*Eucalyptus camaldulensis*) Woodland over Low Chenopod Shrubland (*Maireana decalvans*, *M. brevifolia, M. enchylaenoides, M. aphylla*)
	3	Planted woodland of eucalypt (*Eucalyptus* spp.), wattle (*Acacia* spp. including *Acacia pendula*), Paperbark (*Melaleuca* spp.). Sheoak (*Allocasuarina verticillata* and *Casuarina cunninghamiana*) and Old Man Saltbush (*Atriplex nummularia*)
	7	Nitre Bush (*Nitraria billardierei*), Marsh Saltbush (*Atriplex paludosa*), Ruby saltbush (*Enchylaena tomentosa*) Open shrubland
	10	River Red Gum (*Eucalyptus camaldulensis* var. *camaldulensis*) Open Woodland over exotic grasses
	11	Planted Mixed Shrubland (*Melaleuca brevifolia, M. halmaturorum, M. lanceolata, M. oraria, M. quinquinervia, M. styphellioides, Acacia notabilis, A. paradoxa, A. pycnantha, A. sophorae, A. stenophylla, A. victoriae*)

17.4 Management and mitigation

Management of project impacts to flora have followed a general principle (in order of preference) of:

- avoiding impacts
- minimising impacts
- mitigating impacts
- compensating for residual impacts.

17.4.1 Planning and design

Impacts on flora in the project area have been minimised through the corridor selection process and development of the proposed alignment. Initial environmental studies helped guide the corridor alignments through the project area, particularly in relation to issues such as flora.

The outcomes of the preliminary environmental studies contributed to several changes to the proposed original project corridor, including the:

- route through the Northern section chosen to avoid the patch of *Gahnia filum* habitat
- identification of possible wetland offset areas
- the road and rail corridors through the Southern section chosen to avoid the higher value Greenfields Stage 3 wetlands and sections of Barker Inlet north and south wetlands; the road corridor was moved further west over the North Arm Creek mangroves, to conserve more of Barker Inlet north wetlands eastern habitat areas and thus a larger area of wetland.

Overall, the corridor selected for the project is considered to have a lower impact on flora across the project area than the alternative options (see Chapter 7).

17.4.2 Construction

Best practice environmental management would be required for the duration of the pre-construction and construction phases of the project to minimise any impacts on the local environment. This includes development of a detailed project environmental management plan and a contractor's environmental management plan. The construction area would be clearly identified with the extent of works pegged and flagged to minimise the risk of inadvertent damage to remaining vegetation. Specific management plans, such as a detailed weed management plan and a soil erosion and drainage management plan, would also be developed to ensure all issues are addressed and managed accordingly.

It is vital to minimise the width of the construction corridor and limit the loss or damage of vegetation at the edges of the construction zone. A contractor's activity zone would be developed for the construction phase which would confine construction activities to the corridor. Any vegetation that requires protection in the corridor would be flagged off using bunting to prevent access or accidental removal/damage.

17.4.3 Operation

A range of measures would be implemented to minimise/compensate for impacts during operation of the Northern Connector. These measures include off-setting the loss of vegetation by achieving an SEB for the project (under the Native Vegetation Act*)* and completing appropriate revegetation and landscaping.

Vegetation offsets – *Native Vegetation Act 1991*

All native vegetation in South Australia is protected under provisions of the Native Vegetation Act. Clearance of vegetation is prohibited unless it is approved by the Native Vegetation Council or the activity requiring the clearance is exempted by regulations under the Act. For clearance of native vegetation, an SEB must be achieved.

The primary aim of the SEB is to achieve a net environmental gain, which contributes to improving the biodiversity values of the region, rather than simply off-setting the clearance. The required SEB for the project would be calculated once the final detailed design is complete.

The SEB can be achieved in several ways. A combination of the following options may also be considered:

- a payment to the Native Vegetation Fund as established under the Native Vegetation Act
- provision of an appropriate offset through the identification of land that can be protected and managed as a set-aside (conservation) area
- alternative offset activities such as revegetation or bushcare.

Extensive landscaping and revegetation would be undertaken as part of the project which, in addition to its amenity value, may be used to offset some vegetation clearance. Revegetation components are likely to incorporate revegetation and rehabilitation of wetland areas; landscaping is likely to focus on improving biodiversity and amenity in the corridor.

18 Fauna

18.1 Introduction

Initial fauna surveys were undertaken across the entire project area and in surrounding areas during spring and summer 2008–09 by Environment and Biodiversity Services (EBS). These initial assessments included avifauna (birds), herptofauna (reptiles and amphibians) and fish and were used to inform the route selection and early planning phase of the project.

Following these assessment and further environmental, planning, social, economic and engineering investigations, the location and position of the rail corridor was significantly changed in the Southern section of the project to avoid the high quality habitat areas of the Greenfields Wetlands Stage 3 (Figure 7.2). This has significantly reduced the type and amount of environmental effects of the project and mean the initial avifauna assessments are no longer relevant or appropriate for the Southern section of the project area. Additional avifauna assessments were undertaken by KBR in 2010–11. The relevant fauna assessments of both investigations (EBS 2008–09 and KBR 2010–11) are used in the following fauna assessment. Further detail is provided in Technical Report 4 — Fauna.

18.1.1 Assessment approach

The initial fauna assessments by EBS (2009) and further assessments in 2010–11 by KBR built on fauna surveys previously commissioned by the Department for Transport, Energy and Infrastructure (DTEI) in the project area in 2004, 2007–08 and 2008–09.

To better define the assessment, the study area was considered using two categories, terrestrial and marine. Terrestrial sites are the land areas with soil substrates and include freshwater sites, such as watercourses and constructed wetlands. Marine sites are those subject to daily tidal inundation with few or no artificial controls (e.g. levees or other barriers).

Where species (or their habitat) of national conservation significance were identified, an assessment of the likely impacts of the project in line with the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) Significant Impact Guidelines (Department of the Environment and Heritage 2006) was undertaken.

Terrestrial

The assessment included detailed mapping of habitats from aerial photography and field validation of habitats and species using these habitats.

Avifauna

The avifauna surveys for the Northern Connector by KBR in 2010–11(and previous surveys) used the ‘2 ha 20 minutes or longer’ procedure of Birds Australia (Barrett et

al. 2003). Assessments were generally carried out for one to three hours at dawn or dusk, on days with minimal wind (to reduce background disturbance which can inhibit the identification of bird calls). Surveys were also undertaken at other times of the day and early evening to provide some assessment of the diurnal variation in species and populations using particular sites.

Opportunistic sightings in the study area and region, including road killed animals, were recorded. Particular attention was focused on the presence or absence of specialised wetlands species that are cryptic, such as rails, crakes and bitterns; trans-equatorial migratory shorebirds; and nationally threatened species.

Additional data from Birds SA were obtained and records on Birdpedia were consulted.

Assessed locations were recorded on a recent aerial photograph of the project area and/or by using a Garmin 12 Geographic Positioning System (GPS).

Field notes were recorded for each location, especially on habitat type and composition, species use, the presence of threatened species, abundance and threats, and photographs were used to record many locations.

Avifauna survey locations used as part of the Northern Connector planning study from 2008 to 2011 are shown in Figure 18.1.

Mammals and other fauna

A desktop assessment of the project area and surrounding areas to determine fauna habitat availability, was complemented by site visits (building on EBS (2009) preliminary investigations). The Biological Database of South Australia maintained by the Department of Environment and Natural Resources (DENR) were searched. The Commonwealth protected matters database was also searched to determine the species and communities of national significance that may use the project area. Previous reports for the region were reviewed and anecdotal species locations investigated.

The habitat was assessed by ranking the different vegetation communities for their suitability for a range of fauna. Key habitat features such as leaf litter, fallen timber, refuge sites and disturbance were assessed.

The fauna habitat assessment, combined with the background research and database results, was used to determine the likelihood of fauna species occurring in the project area. Each species known to occur or previously recorded in the region was classed as having a low, medium or high likelihood of occurring in the project area. For all species considered to be of medium or high likelihood of occurrence, the broad habitat they would use in the project area was identified.

Observations during field surveys in 2010–11 provided opportunistic records of mammals, reptiles and amphibians. No other specific survey methods were used during the assessment period. No specific surveys were undertaken of fish or invertebrates.

Figure 18.1 **Bird survey sites 2008, 2009, 2010 and 2011**

1 Bolivar paddocks
2 Bolivar dry ponds
3 Cheetham Salt samphire shrublands
4 Bolivar open water ponds
5 Little Para River
6 Whites Road wetlands
7 Whites Road shrublands
8 Whites Road mangroves
9 Swan Alley saltmarsh/mangroves
10 Cheetham Salt saltfields / mangroves
11 Barker Inlet Wetlands north saltwater wetlands / mangroves
12 Barker Inlet Wetlands north freshwater wetlands
13 Greenfields Wetlands Stage 3 Wetlands
14 Barker Inlet south freshwater wetlands
15 north Arm Creek
16 Range wetlands
17 Magazine wetlands

Amphibians

An initial desktop assessment of frog species potentially occurring in the Northern Connector project area reviewed data from the Frogwatch program of the EPA and gathered information on species known to occur or likely to occur in the area.

Frog surveys by EBS (2009) in and adjacent to the Northern Connector project area used the survey techniques of recording calls at different locations in a wetland for later identification, active searches of the fringing vegetation and shallow water of a wetland during dusk, and playing calls of the species likely to be present to stimulate a call response.

The frog surveys at the four wetland areas of Barker Inlet north and south wetlands, Greenfields Stage 3 wetlands and Whites Road wetlands (Table 18.1), totalled 10 hours survey time, with at least two field staff present. The survey was during summer, which is towards the end of the frog breeding season. The most appropriate survey time is during spring when most species are breeding. The survey dates were selected based on the weather conditions on the day. Non-windy nights were selected to ensure weather did not impact upon the ability to hear or see frogs.

Table 18.1 Frog survey for the Northern Connector project (EBS 2009)

Survey date	Start time	End time	Survey time (hours)	Location(s)
10.12.2008	1800	2100	3	Barker Inlet south wetlands, Greenfields Stage 3 wetlands, Whites Road wetlands
09.01.2009	2030	2200	1.5	Barker Inlet north and south wetlands, Greenfields Stage 3 wetlands
16.01.2009	2030	2200	1.5	Barker Inlet north wetlands, Whites Road wetlands
21.01.2009	2030	2200	1.5	Barker Inlet north and south wetlands
27.01.2009	2000	2230	2.5	Barker Inlet north and south wetlands, Greenfields Stage 3 wetlands

Marine

Avifauna

Field surveys included marine waterways and wetlands. Regional information was obtained from a range of sources, including historical information and databases for the region. There is some overlap between species using marine areas and other wetlands, such as freshwater, in the region and the project area.

Other fauna

Even though no specific marine mammal surveys were conducted, comprehensive reports and literature are available. The relevant reports, summarised in Technical

Report 5 — Fauna, provide information on the types of fauna present and identify those issues that may or are likely to impact on these fauna.

Data on fish and invertebrate species were collected by EBS (2009) and some additional considerations of these groups were made in later studies.

18.1.2 Policy and legislative requirements

The following policies and legislation apply to the project.

Environment Protection and Biodiversity Conservation Act 1999

The EPBC Act was developed as a legislative framework for the protection and management of Matters of National Environmental Significance (MNES). Its primary objectives relevant to the project are to:

- provide for the protection of the environment, especially MNES
- conserve Australian biodiversity
- provide a streamlined national environmental assessment and approvals process
- enhance the protection and management of important natural and cultural places
- promote ecological sustainable development through the conservation and ecologically sustainable use of natural resources.

The seven matters of national environmental significance are:

- world heritage properties
- national heritage properties
- wetlands of international importance (Ramsar wetlands)
- threatened species and ecological communities (relevant to this project)
- migratory species (relevant to this project)
- Commonwealth marine areas
- nuclear actions (including uranium mining).

If a proponent believes that a project may impact on any of the MNES then an EPBC Act referral must be prepared and submitted to the Department of Sustainability, Environment, Water, Population and Communities (DSEWPC).

MNES relevant to the Northern Connector include nationally threatened fauna species, migratory bird species and marine species and their habitats. A search of the EPBC Act Protected Matters databases indicated that some EPBC Act listed species, or their habitat, may occur in the project area.

As the project may impact MNES, a referral will be made to DSEWPC by DTEI.

Once a project has been assessed, the DSEWPC makes a recommendation to the Minister or delegate about whether or not the project should be approved to proceed and whether any specific conditions need to be attached to that approval. In addition to considering potential impacts on MNES in making the decision, the Minister also considers the social and economic impact of any project.

National Parks and Wildlife Act 1972

The *National Parks and Wildlife Act 1972* (NPW Act) principally provides for the establishment and management of reserves and other areas controlled by the South Australian Department of Environment and Natural Resources, the conservation of wildlife in a natural environment and for other purposes such as permits for the keeping of native animals and compliance.

The Act protects native flora and fauna in South Australia and lists species of State conservation significance in Schedules 7, 8 and 9, respectively classified as endangered, vulnerable and rare. A number of species listed under these schedules are known or are considered likely to occur in the project area. If native vegetation is to be removed on a project, the impacts on native vegetation are usually and primarily assessed under the *Native Vegetation Act 1991*.

Native Vegetation Act 1991

The Native Vegetation Act and Regulations 2003 provide for the protection, enhancement and control the clearance of native vegetation in South Australia. The Act applies throughout the State, except some areas of metropolitan Adelaide, and covers both private and public land. The Act covers all native vegetation and dead trees that provide habitat for threatened native fauna species. The Act applies to some, not all, of the Northern Connector project site. Much of the southern section of the project area is not within the jurisdiction of the Native Vegetation Council.

It is an offence to clear native vegetation unless the clearance is in accordance with the Act. Approval to clear native vegetation can be granted by the Native Vegetation Council, a statutory body established under the Act. In other cases, clearance may be undertaken pursuant to ‘exemptions’ in the Native Vegetation Regulations 2003.

Natural Resources Management Act 2004

The *Natural Resources Management Act 2004* (NRM Act) repeals the Animal and Plant Control (Agricultural Protection and Other Purposes) Act 1986, the Soil Conservation and Land Care Act 1997 and the Water Resources Act 1997 and incorporates the functional requirements of these Acts. The NRM Act establishes provisions for management of the State’s natural resources and also includes the management of pest plants and animals, and land and water resources. The project area lies in the regional jurisdiction of the Adelaide and Mount Lofty Ranges NRM Board; a number of reports, plans, policies, work schedules and other documents prepared by the Board are relevant to this project.

Development Act 1993

The Northern Connector project area is located in metropolitan Adelaide and the *Development Act 1993* applies to the project as a whole in relation to submission of an environmental report and the need for a development approval. The provisions of the significant tree legislation under the Act also apply to the project, but this matter is primarily relevant to native and planted vegetation and it is considered in the Flora Technical Report.

Fisheries Management Act 2007

The *Fisheries Management Act 2007* provides for the conservation and management of the aquatic resources of the State, the management of fisheries and aquatic reserves, the regulation of fishing and the processing of aquatic resources, the protection of aquatic habitats, aquatic mammals, some aquatic species and aquatic resources and the control of exotic aquatic organisms and disease in aquatic resources. Approval is required to disturb benthic flora and fauna in an aquatic reserve. Barker Inlet is an aquatic reserve.

Adelaide Dolphin Sanctuary Act 2005

The *Adelaide Dolphin Sanctuary Act 2005* provides for the conservation of dolphins and their habitat in the Port Adelaide River and Barker Inlet by protecting dolphins, key dolphin habitat and necessary habitat for the food resources used by dolphins. It formally delineates a sanctuary boundary that extends from North Haven Marina to Port Gawler Conservation Park.

If approval is required under other legislation for activities in the sanctuary, the approving authority is required to refer the application to the Sanctuary Minister for comment.

Mining Act 1971

The purpose of the *Mining Act 1971* is to regulate and control mining operations in South Australia. It covers prospecting, exploring and mining for minerals, quarrying/ extractive industries, and includes operations where minerals are recovered from the sea or a natural water supply. The Act covers mining claims, leases and licences.

The Mining Act is relevant to the current project, due to the presence of the Cheetham salt fields. Impacts of the operating mine are managed through a mining and rehabilitation plan, which includes broad environmental impacts and management actions. Biodiversity issues and their management are part of the plan.

Policy

State policies, plans and strategies that are applicable to fauna related aspects of the project are:

- *South Australia's Strategic Plan 2007* (Government of South Australia 2007a) contains both a vision and objectives for the State. Objective 3: Attaining Sustainability includes four targets for biodiversity.

- *No Species Loss: A Biodiversity Strategy for South Australia 2007–2017* (Department for Environment and Heritage 2007b) is the key policy for protection of biodiversity in the State and is applicable to the project.
- *Tackling Climate Change: South Australia's Greenhouse Strategy 2007–2020* (Department of the Premier and Cabinet 2007) also relates to the sustainable management of natural resources and includes requirements to assess the potential risks associated with climate change influences on native and invasive species.
- The S*outh Australian Biosecurity Strategy 2008–2013* (Draft for public consultation) (Government of South Australia 2008b) is a risk management framework that reviews threats posed by pests in the State, plus potential implementation requirements.
- The draft *Estuaries Policy and Action Plan for South Australia* (Department for Environment and Heritage 2005) was developed to improve the management and health of South Australia's estuaries.
- The C*oast Protection Board Strategic Plan 2009–2014* (Government of South Australia 2009) was established to ensure that new development is not at risk from current and future hazards and plan for resilience in coastal ecosystems to adapt to the impacts of climate change.

In addition to these policies, DTEI has a range of environmental policy, planning and management documents which will apply to the project in relation to assessments and protection of natural resources.

18.2 Existing conditions

Both past and present conditions can influence the distribution of species. In particular, the past distribution of species available from historical accounts can help in understanding changes in current native and introduced fauna populations and provide data with which to assess future predictions. This section discusses both past and present information relevant to the distribution of fauna.

18.2.1 Current land use

The Northern Adelaide Plains, on which the project is located, are the most southern parts of the Eyre and Yorke Block bioregion and in the Flinders Lofty Block bioregion (IBRA 6.1; Thackway and Cresswell 1995). For the project, the Adelaide Plains region is defined as Onkaparinga Estuary to Port Wakefield and east to the foothills of the Mount Lofty Ranges.

Much of the southern section of the region was originally used as holding paddocks for livestock before processing in the adjacent abattoir and in other industries associated with processed livestock. Most of the region is now urban or commercial–industrial in character, with major road and rail transport corridors connecting Port Adelaide and other areas of Adelaide and South Australia. As the

urbanisation of Adelaide increases, the pressure on the natural environment also increases. *The 30-Year Plan for Greater Adelaide* outlines some future possibilities for development, including the area in and around the Northern Connector project (Department of Planning and Local Government 2010a).

Mining of salt at the Cheetham Salt Ltd (Cheetham) salt fields is a major land use in the southern section; smaller areas for conservation and recreation are also present (Laut et al. 1977). Horticulture and agricultural land uses were the major land use (historically) and continue to occur in northern and central parts of the project area. The formal areas reserved for nature conservation in the region are Torrens Island Conservation Park, Port Gawler Conservation Park, Adelaide Dolphin Sanctuary, Barker Inlet Aquatic Reserve and St Kilda–Chapman Creek Aquatic Reserve.

The current highly modified regional and local landscape has few natural historical ecosystem features remaining except along its western boundary. Extending from the Mount Lofty Ranges, westerly flowing watercourses with riparian areas, ephemeral ponds and wetlands still extend to floodplains and coastal marine areas. However, drainage patterns are now altered and include constructed wetlands, levee banks, drains and shallow open water areas managed for commercial salt harvesting.

Remnant coastal landscape features include tidal flats and creeks, saltmarshes, ridges, intertidal coastal areas and extensive mangrove woodlands, including along most of the tidal inlets, such as North Arm Creek. The landscape was modified to improve stormwater management at the southern end of the project area, especially the complex mosaic of Greenfields and Barker Inlet wetlands completed in the 1990s, followed by Range and Magazine wetlands. These have replicated some of the coastal wetland ecosystems historically associated with the wider region from Port Adelaide south to Glenelg (Twidale et al. 1976). The wetlands were specifically designed to biologically clean stormwater and detain floodwater but all wetlands are now equally important as habitat for a range of faunal groups, especially bird species.

The site of Barker Inlet wetlands was originally severely degraded due to its low lying elevation and levees were developed to limit marine incursions. At the time of construction of the wetlands, the site had salt scalds, stranded and supra-tidal samphire low shrubland and anthropogenic grassland and herbland.

The water drainage channels and pond systems constructed for salt harvesting (at Dry Creek) and wastewater treatment (at Bolivar) provide areas of permanent surface water storage. These commercially operated artificial dams and ponds occupy large areas and are very noticeable in the landscape. They provide wetland and other habitats for faunal groups, especially birds, although their actual use varies considerably according to water quality and location.

Current landscape features include levee banks as access routes throughout most low lying areas, largely for the control and maintenance of salt evaporation ponds, sewerage treatment areas and protection of low lying areas from flooding. These levee banks allow for a range of habitats influenced by factors such as access to fresh or saline water or elevation above low lying areas.

18.2.2 Current natural environments

The Northern Adelaide Plains is classified as 'fragmented' (McIntyre and Hobbs 2000), indicating that 40% to 90+% of the remnant vegetation has been destroyed. Much of the project is located in the 53.5% remnant of the Parham environmental association (Figure 17.1). The amount of remnant vegetation appears to be large but is almost entirely the relatively intact coastal fringe of mangrove and samphire associations. All other areas of native vegetation are highly fragmented, isolated, reduced in structural and species diversity, reduced in habitat value, and vulnerable to invasion by environmental weeds and feral animals.

Although the Northern Adelaide Plains are considered to be fragmented, they have also been highlighted as a region of high ecological importance (Berkinshaw 2004). According to Caton et al. (2009), the coastal area in and around Barker Inlet has a medium conservation priority, and a high threat value associated mainly with sea level rise and disturbance to native vegetation. The remnant vegetation in the project area is considered to be of conservation significance at a landscape scale to the whole Adelaide Plains region (KBR 2007; EBS 2009).

The narrow band of relatively intact to intact coastal vegetation from the southern section of the project area north to Port Wakefield along Gulf St Vincent is continuous (Figure 18.2). It is predominately a mixture of samphire and mangrove vegetation communities with small areas of bare ground, shrubland and woodland vegetation, providing a number of habitats for fauna species. This region, especially the Barker Inlet to St Kilda coastal area, is particularly important for a range of avifauna, with over 120 species recorded from both marine and terrestrial areas.

Mangrove areas are important to the fishing industry as they provide breeding areas for a range of marine species, including a number of fish and crustacean species of commercial and recreation significance. They also protect the coast against storms and play a slow but continuous role in 'land building' (City of Salisbury 2008c). Mangrove communities, particularly those in the Port River and Barker Inlet region, have been and are under pressure from various threats, such as the high level of nutrients and other contaminants entering the ocean from stormwater, wastewater treatment plants and industrial outfalls (Baker 2004).

Landscape modifications across the region have most noticeably been the almost total loss of terrestrial habitats, especially native sedgeland, grassland and woodland. The extensive mangrove forests remain because of the low value of saline areas for agricultural and industrial development. For example, the loss of Thatching Grass (*Gahnia filum*) sedgelands in the region has led to a suspected local extinction of the Yellowish Sedge-skipper Butterfly (*Hesperilla donnysa donnysa*) (Coleman and Coleman 2000).

Parts of the salt fields and Port River estuary have been identified as areas of international importance in South Australia for shorebirds (Watkins 1993). The salt fields, ranked fourth in importance in South Australia, have two types of habitat: the concentration ponds north of Dry Creek along the coast to Middle beach adjacent to and north of the project area (the northern areas provide important habitat); and the crystallisation ponds at Dry Creek, which are of limited habitat value (Day 1997).

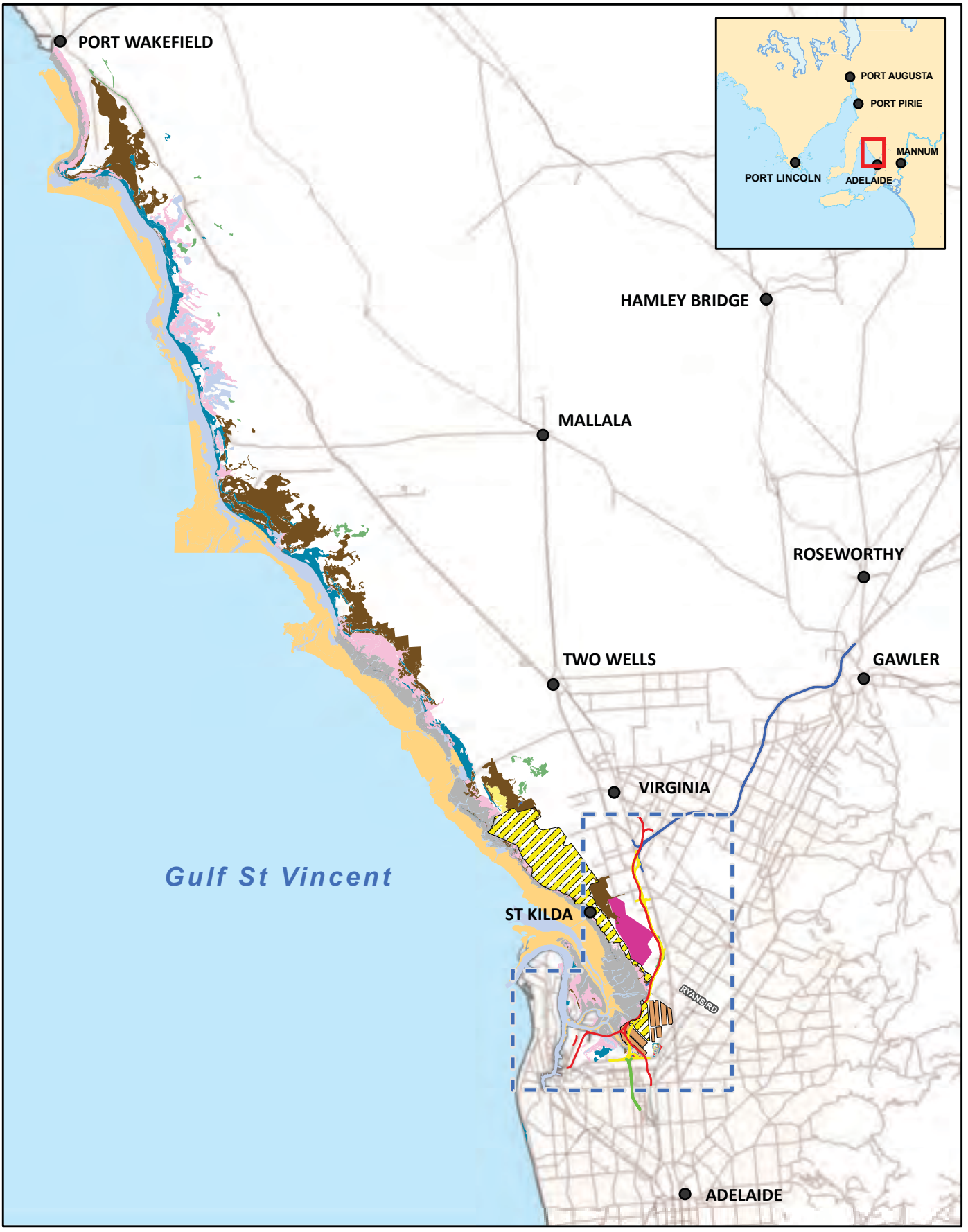


Figure 18.2 **Regional fauna habitats**

Wilson (2000) identified the Port River–Barker Inlet area as an important site for wading birds. Artificial wetlands, such as the salt ponds and Bolivar WWTP areas, are valued for supplying habitat for a variety of species, mainly waders and waterbirds. These areas have thus been included in the boundary of the Barker Inlet and St Kilda Wetland of National Importance [SA005] (Environment Australia 2001).

Relatively large areas with conservation values close to the project site include (Berkinshaw 2004; City of Port Adelaide Enfield 2007; Coleman and Cook 2009; KBR 2004):

- Little Para Estuary
- Greenfields wetlands
- Bolivar WWTP
- the northern section of the Dry Creek salt fields
- Thompson Creek
- Little Para Linear Park.

Other areas in the wider region with important conservation values include:

- Buckland Park (grassland, chenopod shrubland)
- Buckland Park Lake (aquatic ecosystem)
- Gawler River — banks and western floodplain (River Red Gum and Black Box woodlands)
- Port Gawler Conservation Park (mangrove woodland and coastal shrublands)
- Samphire Coast region from about Light Beach to Port Parham.

Small marine and terrestrial areas, including remnant roadside vegetation and stormwater treatment freshwater wetlands used for conservation are present in local council areas, especially the City of Port Adelaide Enfield and City of Salisbury.

Biodiversity values for the region therefore include a diversity of fauna, and especially avifauna habitat areas. Areas of known ecosystem conservation value and species, especially birds and marine species, of national and state conservation significance are present.

18.2.3 Pre-European settlement habitats

Historically, the landscape supported large expanses of swamps and coastal saltmarsh communities, including saline aquatic, semi-aquatic and supra-tidal chenopod and samphire low shrublands in areas that are subject and adjacent to tidal inundation (Kraehenbuehl 1996; Graham et al. 2001; Coleman and Cook 2008). Shrublands subject to periodic shallow freshwater inundation from flood events with relatively intact riparian ecosystems (Dry Creek and the Gawler and Little Para rivers) also provided a suite of wetland and woodland habitats areas. Floodplain shrublands such as those dominated by lignum and chenopods, were

extensive; other shrublands occupied a mosaic of niches (including *Nitraria billardierei*, *Atriplex paludosa* ssp. *paludosa* and *Maireana* spp.).

Terrestrial vegetation types included sedgelands (*Gahnia filum*) and grasslands (*Lomandra effusa, Austrodanthonia* spp., *Austrostipa* spp. and a range of summer growing species) with River Red Gum (*Eucalyptus camaldulensis)* and Black Box (*E. largiflorens*) woodlands and grassy woodlands along the major rivers, creeks and extending out into floodplains (Berkinshaw 2004). Open grassy Mallee Box (*E*. *porosa*) woodlands and mallee dominated scrublands inland from the coast featured on rises and plains. Native pine woodlands would have also occurred on sandy rises (Kraehenbuehl 1996).

With European settlement, many of the smaller to medium sized mammals, plus a number of bird species from in and around Adelaide, including the project area, became extinct. Major causes were habitat clearance and other direct pressures and competition, the loss of habitat and/or predation by introduced species. Micro-chiropteran bats and some groups of birds are some of the few faunal groups to have survived relatively unscathed.

18.2.4 Terrestrial fauna habitats

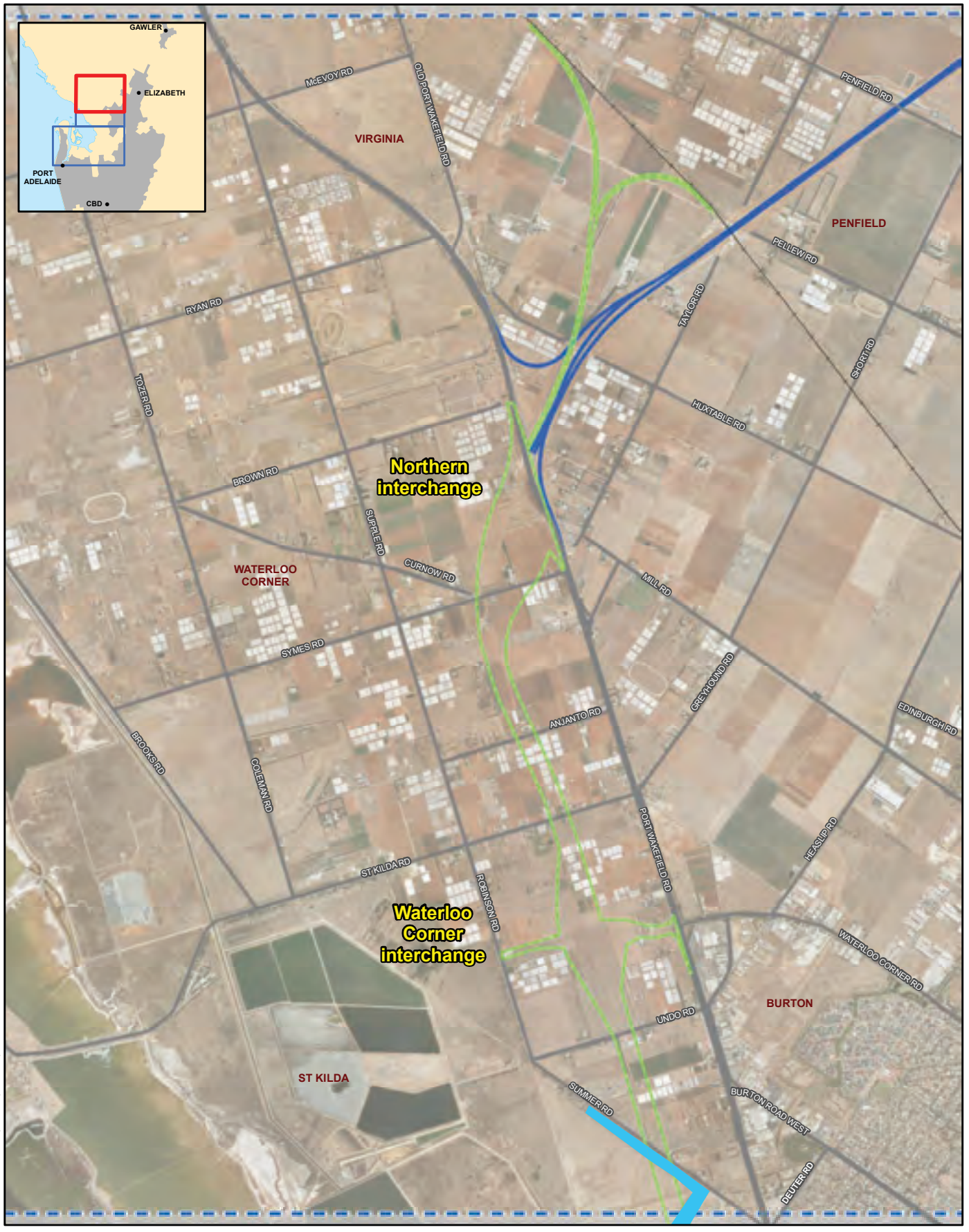
Limited remnant terrestrial habitat is available in the region and the project area. Most woodland habitat with native species has been planted and remnant shrubland habitat is not extensive and is generally in small, isolated patches. Terrestrial fauna habitats in the Northern Connector corridor are shown in Figures 18.3–18.6. Photos of habitat types are shown below and can also be found in Technical Report 4 – Fauna, Appendix A.

Woodlands

Of the eucalypt woodlands across the project area, the largest patch of remnant woodland is along Little Para River. Many of the trees at this site are large remnant River Red Gums (*Eucalyptus camaldulensis*). A wide range of other eucalypt tree species has been planted at this site and around the adjoining wetlands. The younger eucalypts scattered among the older growth trees have recreated a multi-aged woodland, further enhancing the ecological value of this habitat. This patch of riparian woodland constitutes a regionally significant habitat, given that most old growth native trees on the Adelaide Plains occur as individuals or in small patches associated with parklands or roadside vegetation (Paton 2001).

The larger trees provide a multitude of different sized hollows, used as breeding and/or shelter sites by a range of bird and mammal species such as bats, possums and parrots. The smaller younger eucalypts planted in the area also provide breeding habitat to tree nesting birds and feeding resources to other woodland bird species. The groundcover through much of this woodland also provides valuable habitat to woodland birds.

A larger area of planted eucalypt woodland along the eastern boundary of Bolivar WWTP has little groundcover at its southern end due to livestock grazing. This plantation is linked to the riparian woodland along Little Para River by a strip of

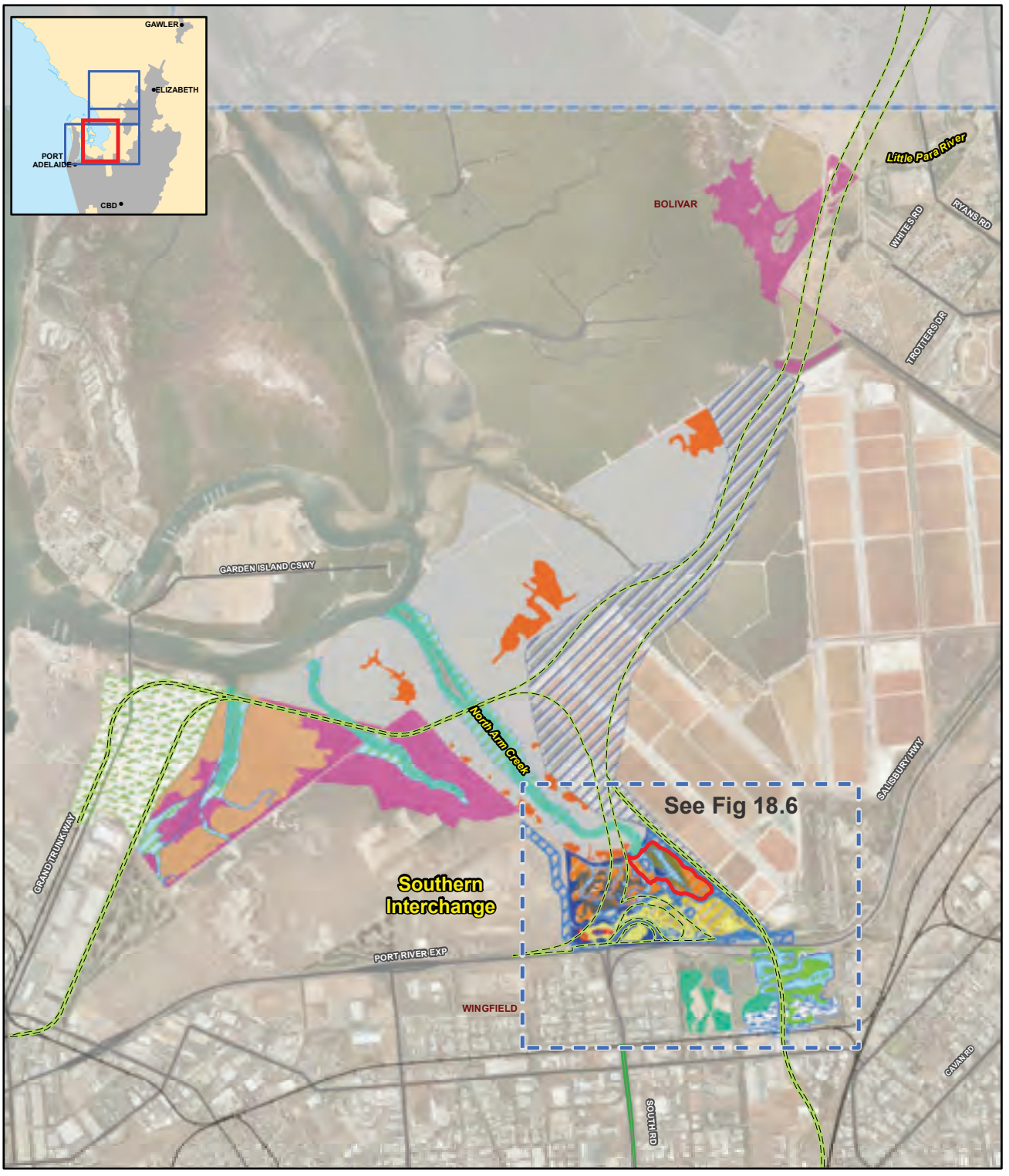


Source: DEH, DTEI,DPLG, EBS

Figure 18.3 **Fauna habitat within corridor Northern section**

Source: DEH, DTEI, DPLG, EBS

Figure 18.4 **Fauna Habitats within corridor Central section**



NORTH

0 1

Kilometers

Figure 18.5 **Fauna Habitat within corridor Southern section**

- Northern Connector boundary
- Existing railway
- Existing roads
- Deep open water (freshwater)
- Important bird roosting areas - Non EPBC Act (bare ground)
- Salt fields
- Samphire very low shrubland (Sarcocornia)
- Planted woodland and shrubland
- Tall aquatic grassland (Typha and Phragmites)
- Anthropogenic grassland and herbland +/- shrubs
- Shallow water and sedgeland (important bird habitat)
- Samphire low shrubland and bare ground (salt scalds) (important bird habitat)
- Anthropogenic grassland and shrubland
- Samphire low shrubland (supratidal) and anthropogenic grassland
- Bare ground and salt scalds with occasional Tecticornia
- Deep freshwater with areas of tall aquatic grassland
- Planted shrubland +/- woodland species
- Shallow freshwater drying to mudflats, with aquatic grassland and sedgeland
- Shallow marine and freshwater flow paths
- Grey mangrove woodland
- Important habitat area (marine)
- Shallow salt water and intertidal mudflats and salt flats
- Shallow water and mudflats
- Supratidal samphire
- Samphire low shrubland (Tecticornia +/- Sarcocornia) (supratidal and intertidal)
- Deeper salt water (channel)
- Intertidal samphire (Sarcocornia and Tecticornia)

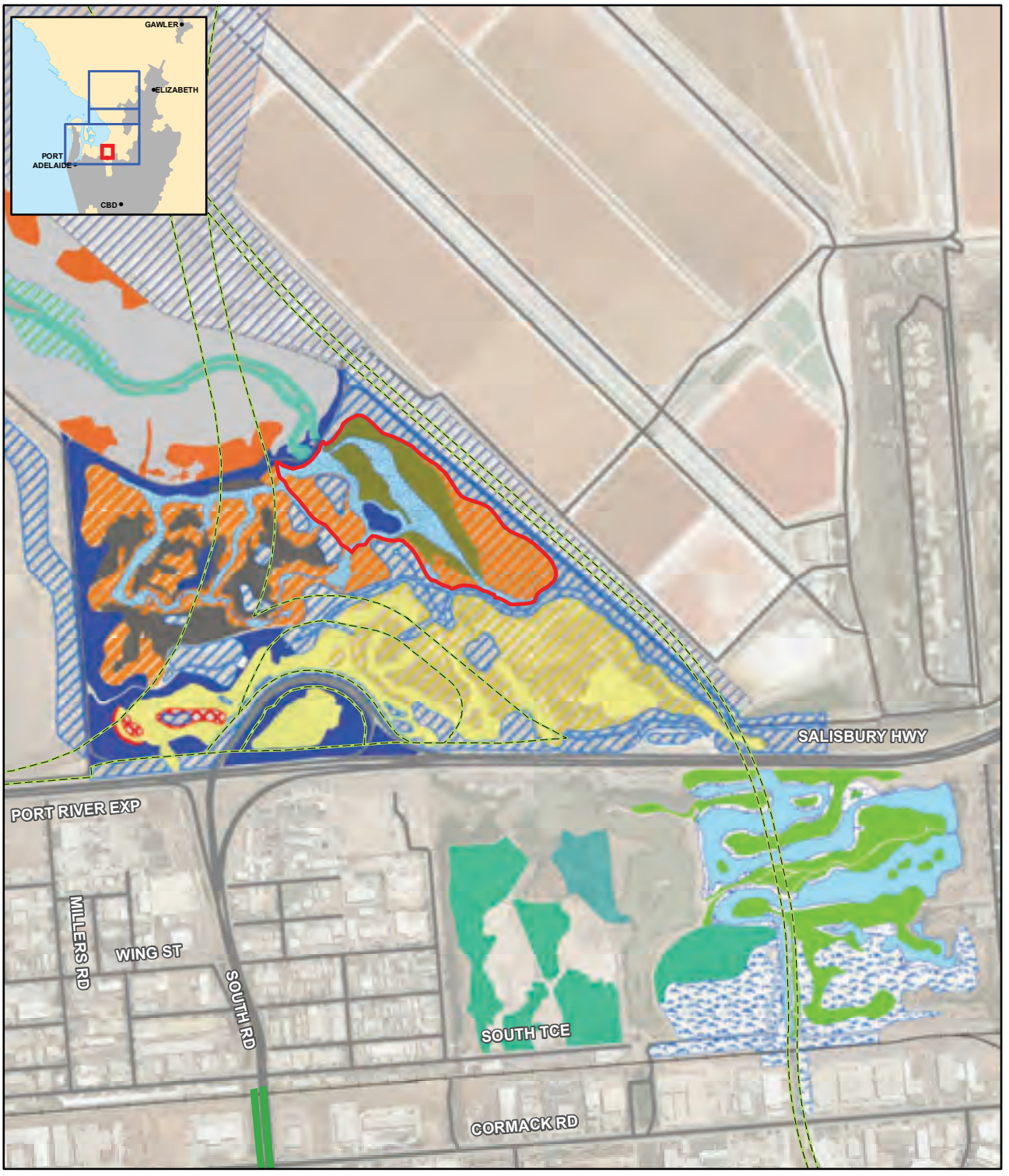


Figure 18.6 **Fauna Habitat Barker inlet wetlands and North Arm Creek**

younger plantation eucalypts. Numerous old growth River Red Gums are also scattered through the paddocks between these sites. Bird use of each of these

woodland habitats will depend on roosting, feeding and breeding requirements of each bird, and age, species composition and structure of the woodland.

Important tracts of remnant woodland occur along the Gawler River and on the Gawler River floodplain to the north of the project area, especially around Buckland Park and to the east of the project area along Little Para River, which includes Kaurna Park (Burton wetlands) and The Paddocks wetlands.

Areas of woodland planted in the wetlands in the project area vary in composition and function. Large numbers of *Casuarina glauca* (Grey (Swamp) She-oak) have been used to screen areas and provide habitat along waterways. A range of other native tree species, mostly dryland eucalypts, have been used in other sites.

Shrublands

Native shrubland habitat across the project area is interspersed with exotic pasture grasses between saltmarsh areas to the west and suburbs to the east. Numerous small patches of Cottonbush (*Maireana aphylla*) are also scattered throughout this area in the central section of the project area. On the flat plains further south between wetland and saltmarsh habitat is another small patch of low shrubland which contains Nitre Bush (*Nitraria billardierei*) and Coastal Saltbush (*Atriplex paludosa*). There are only a few other small patches of shrublands in the region. Low shrublands are primarily located north of St Kilda and inland from Port Gawler near Middle Beach.

Shrubland habitat makes useful feeding and nesting habitat for a number of birds on the Adelaide Plains. Clearing of shrublands has led to the decline or loss of a number of native birds from the area. It is likely that fragmentation and isolation of these patches of habitat in the project area have made them unsuitable for use by the bird species that would have originally inhabited them. Despite their degraded and fragmented state, this habitat still provides shelter, feeding and breeding resources for a range of small passerines such as fairy wrens and thornbills.

Most large areas of shrublands in the region and at the stormwater treatment freshwater wetlands across the project area have been planted and their understorey is dominated by introduced grasses and herbs. Areas of higher ground include remnant supra-tidal samphire shrublands; and supplementary salt tolerant species, especially various saltbush and other chenopod species, have been planted. Areas of planted woodland are interspersed between shrublands at some sites, such as through the Barker Inlet south wetlands.

Anthropogenic grasslands and herbfields

Paddocks and open areas containing introduced annual and perennial pasture grasses and herbs are dominant across the project area, between the saltmarsh/salt fields/sewage settling ponds to the west and suburbs to the east. This habitat type supplies a food resource for some native bird species such as pigeons and pipits and a number of introduced bird species. Open grasslands near wetlands can also

be used as feeding areas by the Australian Shelduck, Australian Wood Duck, Black-tailed Native-hen and Cape Barren Goose.

Freshwater habitats

Freshwater wetland is now a major habitat type in the project area. Most of the wetlands have been constructed since the early 1990s for water quality treatment, stormwater storage and recovery, flood mitigation and habitat enhancement. The largest wetlands are the wastewater ponds at Bolivar WWTP located in the northern section of the project area. The plant's large open water areas are extensively used by waterbirds. There are smaller freshwater wetlands in the southern section of the project area and a cluster of much smaller freshwater wetlands adjacent to Little Para River.

The size and structure of wetlands, as well as the diversity and condition of the plant communities present, influence the suitability and resultant use of these sites by birds and other fauna. The availability of different habitat types, such as open water, shallow water and vegetated or open banks, influences the presence or absence of particular groups and species of birds. Freshwater wetland habitats in the wider region are shown in Figure 18.7.

Open freshwater

Most open water habitat (as part of the constructed wetlands) is present, usually as relatively deep water, when a wetland is at full capacity. The extent of open, deep water and shallow water in a wetland is dependent on their function and construction. The ratio is variable as the wetland dries out and refills — largely influenced by the seasons and inflow of stormwater but also by management of the wetland.

Open water is used as foraging habitat by a range of aquatic waterfowl (e.g. Black Swan, Pacific Black Duck, Chestnut and Grey Teal, Hardhead, Eurasian Coot, grebes, and Little Pied and Little Black Cormorants). Areas of semi-permanent water are available in most freshwater wetlands in the project area. The largest area of open water is at the Bolivar WWTP sewage settling ponds. Smaller areas of open water are present in Greenfields wetlands, Barker Inlet wetlands, and Magazine and Range wetlands where there is a complex system of channels and pools.

In the greater region, a wide range of other freshwater wetlands provide open water habitat suitable for waterfowl. The only other substantial freshwater habitat on the Adelaide Plains is Buckland Park Lake at the mouth of the Gawler River. This lake, north of the project area, is part of a wetland system of national significance that supports a high abundance and diversity of waterfowl and other birds (Morelli and de Jong 1995; Paton et al. 1991). Filling of Buckland Park Lake depends mostly on winter flows from Gawler River, with the lake usually drying out through most of spring and summer. In recent years the lake has not filled due to lower rainfall and diversion of water upstream. Other smaller freshwater wetlands in the Adelaide Plains with areas of open water are the stormwater Paddocks wetlands in Para Hills and other smaller stormwater wetlands. An example of open freshwater habitat in the project area is shown in Figure 18.8.

Source: DEH, DTEI, DPLG, EBS

NORTH

0 0.5 1

Kilometres

- Northern Connector road
- Northern Connector rail
- Spur line to Port Flat siding
- Northern Connector boundary
- South Road Superway
- Existing railway
- Existing roads
- Embankment

Freshwater:-

- Magazine Wetlands
- Range Wetlands
- Barker Wetlands South
- Greenfield Wetlands Stage 1,2 and 3
- Barker Wetlands North (fresh)

Marine:-

- Barker Wetlands North (marine)

Figure 18.7 **Wetland Habitats in the project area Southern section**

Figure 18.8 Open water habitat at Whites Road wetlands [Photo: EBS 2009]

Shallow freshwater and mudflats

The suitability of a freshwater wetland to a wide range of birds is influenced by the extent of shallow water and mudflats available. These areas are used as foraging habitat by a range of birds including waders, herons, egrets and stilts. EBS (2009) recorded that the sewage settling ponds at Bolivar WWTP provided the largest areas of shallow freshwater in the region and project area (and the largest number of birds recorded) in addition to the largest open water habitat. These data are similar to the results of Paton (2001) who recorded this site being used regularly and extensively by many thousands of aquatic and migratory bird species.

Greenfields Stage 3 wetlands and parts of the adjacent Barker Inlet north wetlands have the second largest area of shallow freshwater in the project area. Both are managed specifically for stormwater treatment but both also provide areas of shallow water and suitable foraging habitat, albeit smaller than Bolivar WWTP. Smaller areas of shallow freshwater habitat are also available at Greenfields Stage 1 wetlands and Barker Inlet south wetlands. All these constructed wetlands also have deeper water channels, which are habitat for species that prefer open water and areas of reeds, such as ducks, swans and coots.

Buckland Park Lake, the largest area of freshwater wetland in the region (when it contains water, such as during in 2010–11), is regularly visited by a large range and number of wading birds and many other aquatic and terrestrial species during spring and summer (Paton et al. 1991). At its maximum, Buckland Park Lake extends to

approximately 1.5 km^2 of freshwater feeding habitat for aquatic and wading birds, including shorebirds and up to 16 species of raptors (Close and McCrie 1986).

Tall grassland (reeds)

Reeds at the water's edge in shallow water or above the high water mark in wet areas, grow to 2–4 m in height and provide dense grassland habitat; they are components of both open and shallow water habitats (Figure 18.9). Aquatic birds such as moorhens, swamp hens, crakes, grebes, rails and bitterns use reeds, especially when flooded, as breeding, foraging and roosting habitat. Common Reed (*Phragmites australis*) and Bulrush, Cumbungi (*Typha domingensis*) are the dominant plant species. This habitat is also used by non-aquatic bird species such as Clamorous Reed-warbler and Little Grassbird. The presence or absence of open, protected and sheltered areas along the bank of a wetland also influences the use of a site as a roosting area for a range of waterfowl and other birds. Generally wetlands with a mix of reedbeds and open areas attract the largest diversity and number of birds.

Reed habitat is available across the region and project area. Although Bolivar WWTP provides suitable foraging habitat for waterfowl, the absence of vegetation means that few waterbirds breed at this site. Birds that prefer to forage among reeds and other aquatic vegetation are mostly absent.

The Greenfields Stages 1, 2 and 3 wetlands, and Barker Inlet north and south wetlands contain a diverse array of reedbeds along their banks. Reeds also occur along the Little Para River wetlands. The breeding activity of birds is best documented from Greenfields Stages 1 and 3 wetlands, where 53 bird species have been recorded breeding (Cox 1993).

Large areas of reeds also occur at Buckland Park Lake, which is considered to be the most important breeding site in the Adelaide region for a range of waterfowl (Morelli and de Jong 1995). Other smaller freshwater wetlands with aquatic grasslands are present in the region, such as the Paddocks wetlands in Para Hills. Tall dense reedbeds fringe and occur throughout the constructed freshwater and estuarine wetlands along the Onkaparinga Estuary. They provide the most important habitat for avifauna of conservation significance in that region (EBS 2009).

Figure 18.9 Reedbed habitat at Whites Road wetlands [Photo: EBS 2009]

Low sedgeland

Sedgeland communities typically occupy floodplain areas and riparian zones along watercourses and the banks of freshwater wetlands (Figure 18.10). Consequently they are primarily a component habitat of shallow water wetlands. Sedge species such as *Bolboschoenus* sp., the dominant species in the project area, grow up to 50 cm in height and most often occur in and adjacent to the taller reed beds near the water's edge. Some bird species such as Ballion's Crake, Painted Snipe and Australasian Shoveler use sedgeland habitats for breeding. Many other species also forage in or along the edge of this habitat type, including bitterns, rails and other crake species.

Most sedgelands in the project area have been planted or allowed to colonise wetlands for the purpose of wetland restoration to assist in the control of stormwater pollution. A diverse sedgeland community is located in the freshwater wetlands in the project area, especially at Greenfields Stage 3 wetlands. Smaller patches of sedge also occur along parts of Little Para River, Dry Creek and along some drains, with small areas at Buckland Park Lake, and most of the other freshwater wetlands in the region. Most naturally occurring sedgeland habitat across the broader Adelaide Plains has been cleared.

Figure 18.10 Sedgeland habitat in Barker Inlet north wetlands [Photo: EBS 2009]

Shrubland

Most shrublands across the project area, including at the stormwater treatment freshwater wetlands, have been planted. The Adelaide Plains region has little remnant native shrubland vegetation in total and even less in association with wetland habitats. However, a small area occurs in the western area of Gawler River and Buckland Park Lake region. At the most extensive shrubland community, Greenfields wetlands and Barker Inlet, a wide range of native shrubs line the banks, the outer perimeter of the sites and in areas of higher elevation constructed as part of deepening of aquatic pathways. Two of the dominant planted tall shrub species are Swamp Paperbark (*Melaleuca halmaturorum*) and Lignum (*Muehlenbeckia florulenta*). Shrublands along the margins of wetlands provide breeding habitat (especially when partly flooded) for a range of wetland bird species. For example, the Australian Shoveler, Blue Billed Duck and Freckled Duck are known to breed in shrublands elsewhere, although this has not been recorded in the project area. This vegetation type also provides foraging and breeding habitat for a range of terrestrial bird species such as Magpie Lark, Willie Wagtail, Silvereye and a number of honeyeater and fairy wren species. Introduced species such as Common Starling, Rock Dove and Spotted turtle-dove use these areas extensively and are common species of this habitat in the project area.

18.2.5 Marine fauna habitats

Marine fauna habitats found the Northern Connector road and rail corridor are shown in Figures 18.5 and 18.6.

Saline environments

Saline wetlands along the western side of the project area support a number of different habitats such as open salt(saline) water, shallow salt water and mudflats, rocky banks, intertidal samphire flats, samphire shrublands and mangroves. The size and structure of these environments, as well as the diversity and condition of the plant community present, influences the suitability and resultant use of these sites by birds and other fauna. The availability of different habitat types in a saline wetland typically indicates its value to different bird species and thus the importance of each site.

Open salt water

Extensive areas of open saline water in the project area are mostly found in the crystallisation fields, concentration ponds, channels and drains of the Cheetham salt fields. The value of the salt fields varies markedly. The crystallisation ponds (highly saline) at Dry Creek offer little habitat to bird species; the habitat value for birds from the concentration ponds increases to the north towards St Kilda (as they become less saline). Large numbers of shorebirds can be observed in the three large ponds directly south of St Kilda and around Chapman Creek. Other smaller areas include the middle of the channel of Swan Alley Creek. A much larger extent of open saline water habitat is available off-site in neighbouring Barker Inlet and Port River, and in the lower reaches of North Arm Creek and Swan Alley Creek, and elsewhere in the northern salt fields.

Open areas of salt water are used for feeding by a range of bird species, including Banded Stilt, Red-necked Phalarope, Australian Pelican, Silver Gull, Little Pied Cormorant, Great Cormorant and Little Black Cormorant. Numerous tern species forage in this habitat. White-bellied Sea-eagle, Whistling Kite and Osprey also hunt over open water in coastal marine environments.

Shallow salt water and mudflats

Large areas of shallow saline water occur in the salt fields, which contain water that is pumped from the sea through a series of artificial lagoons of progressively greater salinity (Crawford 1975). Water at the northern end is of a similar salinity to seawater; at the southern end, the water is highly saline.

Parts of the salt fields are heavily used as foraging areas by a wide range of local shorebirds, as well as a large number of northern hemisphere and Australian seasonal migrants (Close and McCrie 1986). The largest concentration of shorebirds is found in the central part of the salt fields between St Kilda and Port Gawler (well to the north and west of the project area); bird use of the more saline salt fields in and near the crystallisation fields and the southern part of the project area is much lower to almost nil.

The shallow foraging habitat created in parts of the salt fields resemble that available naturally on the coastal mudflats of Barker Inlet at the Port River mouth to the west of the project area. These tidal mudflats provide vast areas of potential foraging habitat for a wide range of wading birds at low tide. Due to their use by a large number of resident and migratory waders this salt field habitat and the mudflats of the Port River estuary and mouth have been identified as areas of international importance for shorebirds (Watkins 1993), and part of a Wetland of National Importance (Barker Inlet and St Kilda) (Environment Australia 2001).

Other extensive areas of shallow saltwater occur along the tidal channels between the western boundary of Bolivar WWTP and the salt fields and along the entire eastern coastline of Gulf St Vincent.

Figure 18.11 shows an example of shallow saltwater and mudflats.

Figure 18.11 Shallow saltwater/mudflat habitat (foreground) and open saltwater habitat (background), Barker Inlet north wetlands [Photo: EBS 2009]

Elevated bare areas, rock outcrop and rocky banks

Large areas of bare ground and small areas of rocky banks, mostly as calcrete but including the salt field embankments and small shell-grit islands across the salt fields, provide resting and roosting habitat for aquatic and shorebirds. They are also actual or potential breeding habitat for species such as Red-capped Plover and Masked Lapwing.

Intertidal samphire low shrubland

This habitat is usually adjacent to open shallow water areas and it is vegetated with salt tolerant saltmarsh plant species dominated by samphires as *Tecticornia* spp. and *Sarcocornia* spp., with the distribution of each species controlled by elevation and the amount of inundation. The former is subject to less frequent inundation and the latter is subject to inundation on a daily basis.

All samphire habitats are at least partly inundated by the sea at high tide and will also tolerate inundation by freshwater. Much of this habitat type has been cleared or reclaimed for the Dry Creek salt fields and other uses in the southern part of the region around Port Adelaide, Dry Creek and Gillman, but remnant patches are scattered across the project area (Figure 18.12). Intertidal samphire habitat occurs in the zone parallel to the coastline, between the mangroves to the west and the land to the east. About 80% of this habitat type has been lost across the north-eastern section of Gulf St Vincent (Edyvane 1999).

The largest areas of intertidal samphire in the project area occur along the western boundary of the salt fields where it is regularly inundated by high tide waters and appears to be in relatively good condition. Areas of intertidal samphire habitat lie in Barker Inlet north wetlands between the constructed freshwater wetlands and the mangroves of North Arm Creek, as well as in North Arm Creek. This saltmarsh is surrounded by a sea wall and tidal activity is regulated by control structures. The low-lying parts of the saltmarsh at this site are regularly inundated by saltwater and by freshwater as part of management of floods. Saltmarsh also exists along parts of other marine creeks, such as Swan Alley Creek throughout open areas in the mangrove woodlands. Patches of saltmarsh further north, sit adjacent to the saltponds and Bolivar WWTP in the project area and along the gulf coastline.

Some areas of tidal saltmarsh habitat can be used by a similar range of species that forage on tidal mudflats; some marine, aquatic, migratory shorebirds and local resident wading birds use these areas, primarily the bare mud areas exposed at high tide. By observation, the number and diversity of species is relatively small.

Areas of intertidal samphire along the coastline to the north include a large area at Clinton Conservation Park around 100 km north of the project area, which is considered to resemble much of the original habitat of the area occupied by Dry Creek salt fields (Close and McCrie 1986).

Figure 18.12 Intertidal samphire habitat, western edge of Cheetham salt fields at Swan Alley Creek [Photo: EBS 2009]

Supratidal samphire low shrubland

This habitat is more akin to a terrestrial habitat than marine and in many cases in the region is part of the terrestrial environment. It is dominated by samphire species such as *Tecticornia* spp. (especially *T. pergranulata* in the project area) and it is not regularly inundated by high tides or marine incursions. In some cases, it is completely cut off from seawater by levees and sea walls and remains stranded inland on salty land which receives freshwater as rainfall and runoff as the only water source. This type of samphire habitat exists in numerous areas across the project area and, like intertidal saltmarsh, is fragmented. Relatively large areas of supratidal samphire and stranded supratidal samphire in the project area at Barker Inlet north wetlands (Figure 18.13), lie in the triangle of land to the south-west of the intersection of Salisbury Highway and Port Wakefield Road (land adjacent to Greenfield Connector wetlands) and around Gilman. The condition of much of this area of samphire habitat is relatively poor and by observation, only a few fauna species are resident or use the habitat intermittently. Supplementary shrubs have been planted in this habitat in Barker Inlet wetlands.

Smaller patches of supratidal and stranded samphire in similar condition are present in other wetlands in the region, between the settling ponds of Bolivar WWTP and between the boundary road and Dry Creek salt fields.

This type of samphire habitat is of limited value to most faunal groups. However, it can be a wildlife corridor from the coastal fringe to terrestrial habitats and is used as part of the air space by a wide range of bird species that overfly the habitat.

It is not used as primary habitat by species such as Slender-billed Thornbill (Gulf St Vincent subspecies), which is confined to the better quality areas of samphire habitat, but this species may use it as a link between better quality areas during expansion of its population. It is a potential, though marginal, foraging habitat of the migratory Orange-bellied Parrot and other *Neophema* parrots elsewhere. It may also be used as an occasional breeding site for species such as stilts, plovers and dotterels.

When low lying mud-flats are covered by high tides, waders may use some areas of supratidal samphire to roost, although they invariably chose bare areas in shrubland. In the project area, this habitat is of low value for most fauna, especially birds.

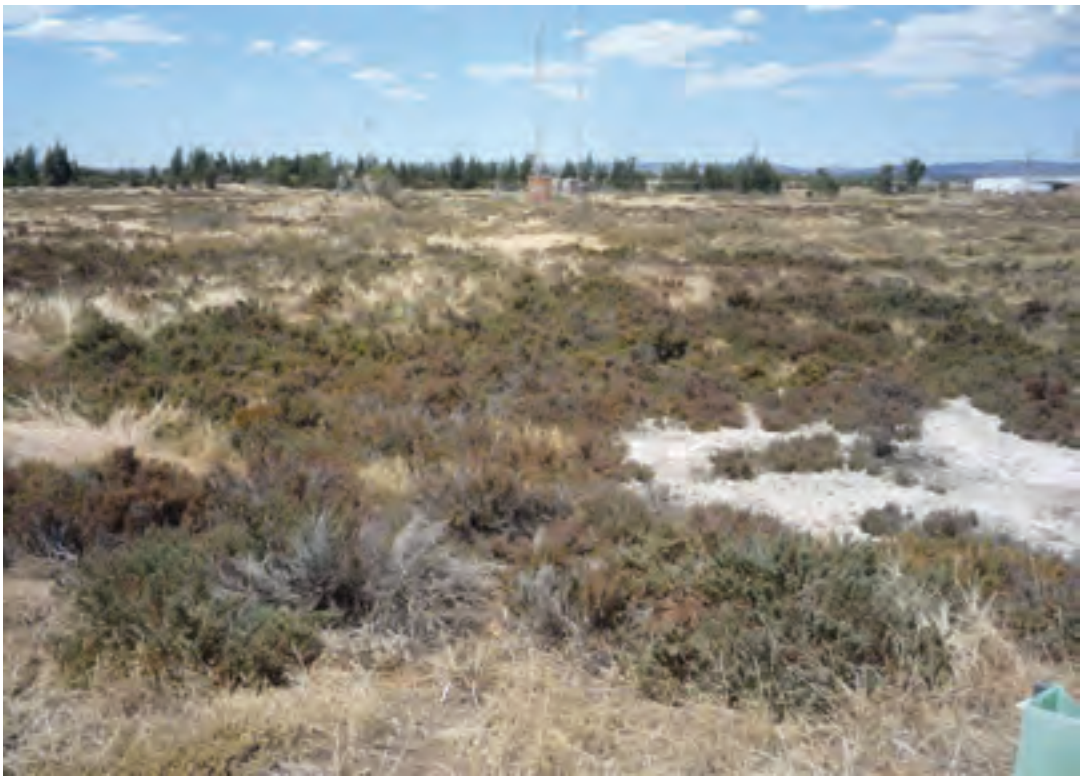


Figure 18.13 Supratidal samphire shrubland, north-east boundary, Bolivar WWTP [Photo: EBS 2009]

Grey Mangrove woodland

The most extensive area of mangroves in Gulf St Vincent occurs in the Barker Inlet–Port River mouth, which fringes the western side of the project area. The woodland is a monospecific stand of Grey Mangrove (*Avicennia marina* var. *resinifera*). This habitat provides roosting, foraging and breeding sites for a wide range of marine and terrestrial birds. Corridors of mangrove extend inland in the project area, at North

Arm Creek and Swan Alley Creek. At North Arm Creek tall old-growth mangrove forest and woodland is interspersed with saltmarsh habitat; at Swan Alley the mangroves appear to have recolonised the narrow drainage line, as the plants are of a range of ages and are thinly spread along the banks. Areas of mangrove are colonising at a range of sites, such as the western end of Dry Creek drain and around parts of the marine section of Barker Inlet north wetlands.

Mangroves provide essential ecosystem functions that contribute to the status of the area as a site of international and national significance for coastal and wading birds (Watkins 1993; Morelli and de Jong 1995). One of the key threatening processes to mangrove communities is habitat fragmentation through clearance (Berkinshaw 2004). Additional pressures of effluent disposal and increased nutrient loads have contributed to the loss of mangroves along the metropolitan coast (Edyvane 1999). The mangrove habitat that extends north along the coast around the Port Gawler and Buckland Park Lake region to the head of the gulf is of similar value for birds. However, the close proximity of mangrove habitat to saltmarsh and freshwater habitats in the project area is an important factor for the bird community at the site.

18.2.6 Areas of significance for fauna

Based on historical and current survey data, the project area has a number of areas of recorded importance for a range of avifaunal groups: Greenfields Stages 1 and 3 wetlands, Barker Inlet north wetlands (marine section), Barker Inlet north wetlands (freshwater section, primarily as two roosting areas and some of the areas of shallow water), Little Para River woodlands, including the SA Water revegetation areas and, possibly, North Arm Creek (for marine fauna). Some of these areas are important for species of national conservation significance, primarily the Greenfields wetlands.

In the region and wider region, the salt fields, especially around and north of about St Kilda, particularly around Chapman Creek, parts of the Port River estuary and Barker Inlet, Buckland Park Lake (when it contains water), the coastal fringe of the eastern side of Gulf St Vincent, Bolivar WWTP ponds and surrounds, and the western area of the Gawler River, are the most important locations for avifauna.

Range wetland and Barker Inlet south wetlands are of lower value but still provide useful habitat for some avifauna, particularly aquatic species.

The terrestrial areas adjacent to most of the project corridor (including almost all of the Gillman region), Magazine Creek, Magazine wetland, the dryland areas around both sections of Barker Inlet wetlands and the salt ponds around Dry Creek are relatively insensitive for fauna species and habitat.

18.2.7 Terrestrial fauna groups and species

Avifauna

Over 200 bird species have been recorded in the wider region historically, with about 140 species in the region, and probably, in the project area. About 128

species have been recorded in the constructed Greenfields and Barker Inlet wetlands since the 1990s. Some are vagrants with one to a few records for each species. Sites assessed in 2010–11 included both terrestrial (freshwater) and marine habitats; observations in Barker Inlet north wetlands by EBS (2009) (Technical Report 5; Attachment B) provide additional data for this site.

The sites impacted by or immediately adjacent to the Northern Connector corridor with the highest diversity observed were Barker Inlet north wetlands, freshwater (29 species) and the northern part of the marine section (32 species) and Magazine Creek wetlands (28 aquatic and 13 terrestrial species). The highest number of birds (abundance) was recorded at Barker Inlet north wetlands (freshwater as aquatic species and the northern part of the marine area as aquatic and marine species). Based on previous data and current observations, the shallow water marine section of this wetland provides habitat for at least 15 species and larger numbers of migratory shorebirds than most other habitats (EBS 2009) and all 7 species of shorebirds recorded in 2010–11 were in this habitat or along the margin of the marine and freshwater wetlands. This particular area provided habitat for the largest number of marine, aquatic and shorebird species recorded in 2010–11.

Barker Inlet south wetlands had moderate species diversity and abundance (32 species in the aquatic areas), primarily due to the large amount of deep water and limited number of aquatic habitats present. Very few wading or shorebirds were recorded here. However, the area of bare ground, supratidal samphire shrubland and shallow water in and adjacent to the communications antennae paddock and the area of land to the east is important resting and roosting habitat for some birds. During the limited observations made over 2009 to 2011, up to about 5,000 birds have been recorded here, especially Silver Gull but also Welcome Swallow, Fairy Martin, Australian Pelican, White Ibis and some tern and duck species.

The sites with the least bird species, both diversity and abundance, were the dryland, supratidal samphire shrublands (8 species, of which 5 were terrestrial), anthropogenic grasslands and herblands (1 marine,13 terrestrial species), bare salt flat sites throughout the project area (9 species, of which 5 were terrestrial) and along North Arm Creek (14 aquatic species, 12 terrestrial species).

Of the sites surveyed, Greenfields Stage 3 wetland was observed to be the most important in the region, with areas being used for feeding, roosting, breeding and nesting of a range of aquatic, shorebird and terrestrial species (45 species). Barker Inlet north wetlands was of less importance for species of conservation significance but had many more ‘common’ species.

Observations and past records indicate that Barker Inlet north wetlands (freshwater) include two important roost and rest areas for various bird species (AECOM and KBR 2009). However, relatively few shorebirds have been recorded here, with small numbers only present (up to about 35 birds from 6 species over 2003 to 2011). Consequently, these do not constitute important habitat for species of national conservation significance.

EBS (2009) data indicated that the largest number and greatest diversity of bird species in the project area were recorded on the WWTP ponds at Bolivar (more

than 9,000 birds and 59 species). A relatively large number of birds were recorded at the freshwater section of Barker Inlet north wetlands, with an average of 738 birds recorded per survey. Species diversity at the Barker Inlet north wetlands was relatively high, with 47 species recorded. At the neighbouring Greenfields Stage 3 wetlands, an average of 524 birds was sighted per survey in a total of 36 species.

Of the saltwater wetlands, the highest abundance and diversity of birds was recorded in the large area of shallow saltwater of the northern part of Barker Inlet north wetlands (not including North Arm Creek), with an average 739 birds recorded per survey. This observation accords with regional observations of others (Cowley 2002) and observations during 2010–11. A comparable number of birds (715) were recorded per survey in the tidal samphire–saltmarsh habitat along the western boundary of the salt fields to the north of the project area. However, bird diversity was much higher in Barker Inlet north saltwater wetland, with 27 species recorded, than in the tidal saltmarsh on the salt fields boundary where 11 species were recorded. This is clearly indicative of the local value of Barker Inlet north area of marine wetland.

In contrast, a lower diversity of birds was recorded in the crystallisation ponds of the salt fields. These ponds are hypersaline and very few birds are recorded using this habitat (Cox 1994). Bird use of the ponds increased north of Bolivar WWTP, where an average of 344 birds of 7 species was recorded per survey. These concentration ponds provide extremely valuable shallow water and mudflat habitat for a wide range of shorebirds, and the rocky banks and islands provide roosting habitat.

Data for 2009 and 2010–11 show some interesting differences. The most obvious is the lack of some bird species in 2010–11, especially tern species, banded stilt and most species of migratory shorebirds, this observation is corroborated by Birds SA data. The abundance of freshwater available in other regions from the above average rainfall over 2010–11 is considered to have dispersed many species.

Threatened species observed, known to occur or potentially present in the project area and region are listed in Table 18.2. Of the species observed, many are vagrants, occasional visitors or rare birds for this region.

Table 18.2. Threatened bird species present or potentially present in the project area and region

Scientific name	Common name	EPBC Act listed	NPW Act listed
Actitis hypoleucos	Common Sandpiper	Ma, Mi	R
Anhinga novaehollandiae	Australasian Darter		R
Apus pacificus	Fork-tailed Swift	Mi	
Ardea alba	Great Egret	Ma, Mi	
Ardea ibis	Cattle Egret	Ma, Mi	R
Ardea intermedia	Intermediate Egret	Ma, Mi	R
Arenaria interpres	Ruddy Turnstone	Ma, Mi	R
Biziura lobata	Musk Duck	Ma, Mi	R
Botaurus poiciloptilus	Australasian Bittern	EN	V

Scientific name	Common name	EPBC Act listed	NPW Act listed
Calidris acuminata	Sharp-tailed Sandpiper	Ma, Mi	
Calidris alba	Sanderling	Ma, Mi	R
Calidris ferruginea	Curlew Sandpiper	Ma, Mi	
Calidris melanotos	Pectoral Sandpiper	Ma, Mi	R
Calidris ruficollis	Red-necked Stint	Ma, Mi	
Calidris subminuta	Long-toed Stint	Ma, Mi	R
Calidris tenuirostris	Great Knot	Ma, Mi	R
Cereopsis novaehollandiae	Cape Barren Goose		R
Cladorhynchus leucocephalus	Banded Stilt		V
Charadrius bicinctus	Double-banded Plover	Ma, Mi	
Charadrius leschenaultii	Greater Sand Plover	Ma, Mi	R
Charadrius mongolus	Lesser Sand Plover	Ma, Mi	R
Charadrius ruficapillus	Red-capped Plover	Ma	
Chlidonias leucopterus	White-winged Black Tern	Ma, Mi	
Coturnix ypsilophora	Brown Quail		V
Egretta garzetta	Little Egret	Ma, Mi	R
Egretta sacra	Eastern Reef Egret	Ma, Mi	R
Falco peregrinus	Peregrine Falcon		R
Falcunculus frontatus	Crested Shrike-tit		R
Gallinago hardwickii	Latham's Snipe	Ma, Mi	R
Glareola maldivarum	Oriental Pratincole	Ma, Mi	
Haematopus fuliginosus	Sooty Oystercatcher		R
Haematopus longirostris	Australian Pied Oystercatcher		R
Haliaeetus leucogaster	White-bellied Sea-Eagle	Ma, Mi	E
Heteroscelus brevipes	Grey-tailed Tattler	Ma, Mi	R
Hirundapus caudacutus	White-throated Needletail	Mi	
Lewinia pectoralis	Lewin's Rail		V
Limicola falcinellus	Broad-billed Sandpiper	Ma, Mi	
Limosa lapponica	Bar-tailed Godwit	Ma, Mi	R
Limosa limosa	Black-tailed Godwit	Ma, Mi	R
Macronectes giganteus	Southern Giant-Petrel	EN, Ma, Mi	V
Macronectes halli	Northern Giant-Petrel	V, Ma, Mi	
Neophema chrysogaster	Orange-bellied Parrot	CR, Ma, Mi	E
Neophema chrysostoma	Blue-winged Parrot		V
Neophema elegans	Elegant Parrot		R
Neophema petrophila	Rock Parrot		R
Numenius madagascariensis	Eastern Curlew	Ma, Mi	V
Numenius phaeopus	Whimbrel	Ma, Mi	R

Scientific name	Common name	EPBC Act listed	NPW Act listed
Oxyura australis	Blue-billed Duck		R
Pandion haliaetus	Eastern Osprey	Ma, Mi	E
Philomachus pugnax	Ruff	Ma	R
Plegadis falcinellus	Glossy Ibis	Ma, Mi	R
Pluvialis fulva	Pacific Golden Plover	Ma	R
Podiceps cristatus	Great Crested Grebe		R
Porzana tabuensis	Spotless Crake		R
Rostratula australis	Australian Painted Snipe	VU, Ma, Mi	V
Sternula albifrons	Little Tern	Ma, Mi	E
Sterna caspia	Caspian Tern	Ma, Mi	
Sterna hirundo	Common Tern	Ma, Mi	R
Sternula nereis	Fairy Tern		E
Stictonetta naevosa	Freckled Duck		V
Thinornis rubricollis	Hooded Plover	VU, Ma	V
Tringa nebularia	Common Greenshank	Ma, Mi	
Tringa stagnatilis	Marsh Sandpiper	Ma, Mi	
Tringa glareola	Wood Sandpiper	Ma, Mi	R
Xenus cinereus	Terek Sandpiper	Ma, Mi	R

Data source: BDBSA and observations in project area during past and present surveys

Conservation ratings: EPBC Act: CR= Critically Endangered, EN = Endangered, VU = Vulnerable, Ma=- marine (Cwlth), Mi = migratory (Cwlth); National Parks and Wildlife (NPW) Act Schedules: E = Endangered, V = Vulnerable, R = Rare

Other listed avifauna

According to the Protected Matters Search using the databases established under the EPBC Act, other bird species listed as marine or migratory or species use habitat that may occur in the project area. However, most are rare visitors to the region. Records of these species are likely to be due to the predictive nature of the databases or a rare occurrence in the region. Species in this category are Red Knot (*Calidris canutus*), Oriental Plover (*Charadrius veredus*), Gibson's Albatross (*Diomedea gibsonii*), Swinhoe's Snipe (*Gallinago megala*), Pin-tailed Snipe (*Gallinago stenura*), Little Curlew (*Numenius minutus*), Red-necked Phalarope (*Phalaropus lobatus*), Grey Plover (*Pluvialis squatarola*), Buller's Albatross (*Thalassarche bulleri*), Shy Albatross (*Thalassarche cauta*), Campbell Albatross (*Thalassarche impavida*), and Common Redshank (*Tringa tetanus*).

Mammals

Sixteen mammal species have been recorded in or adjacent to the Northern Connector project area (EBS 2009) (Table 18.3). Six are introduced; the remaining native species are predominantly bat species. Of the native mammal species recorded, some are likely to be present only in woodlands in the northern section of

the project area, such as the Common Brushtail Possum (*Trichosurus vulpecula*) and Common Ringtail Possum (*Pseudocheirus peregrinus*). There is minimal habitat available for larger mammals; most woodland has been removed in the past for agriculture and other developments. It is considered likely all introduced mammal species previously recorded or likely to occur in the project area would occur throughout the region and project area.

Table 18.3. Mammal species previously recorded in or adjacent to the project area and region

Scientific name	Common name	EPBC Act listed	NPW Act listed	Likelihood of occurrence	Likely habitat
Austronomus australis	White-striped Freetail-bat			High	Roosting – Woodland Foraging – Freshwater wetlands, Woodlands, Shrublands
Chalinolobus gouldii	Gould's Wattled Bat			High	
Chalinolobus morio	Chocolate Wattled Bat			Moderate	
**Felis catus*	Semi-feral and domestic Cat			High	All habitats except aquatic
**Lepus capensis*	Brown Hare			Observed	All habitats except aquatic
**Mus musculus*	House Mouse			High	All habitats except aquatic
Nyctophilus geoffroyi	Lesser Long-eared Bat			High	Roosting – Woodland Foraging – Freshwater wetlands, Woodlands, Shrublands
**Oryctolagus cuniculus*	European Rabbit			Observed	All habitats except aquatic
Pseudocheirus peregrinus	Common Ringtail Possum			Low	Dens (hollows and dreys) Foraging – Woodland
Rattus fuscipes	Bush Rat			Very Low	Marginal habitat along Little Para River
**Rattus norvegicus*	Brown Rat			High	Anthropogenic areas
**Rattus rattus*	Black Rat			High	All habitats except aquatic
Tachyglossus aculeatus	Short-beaked Echidna			Low	Foraging – Woodlands, Shrublands, Grasslands
Trichosurus	Common Brushtail		R	Low	Dens (hollows)

Scientific name	Common name	EPBC Act listed	NPW Act listed	Likelihood of occurrence	Likely habitat
vulpecula	Possum				Foraging – Woodland
Vespadelus darlingtoni	Large Forest Bat			High	Roosting – Woodland Foraging – Freshwater wetlands, Woodlands, Shrublands
**Vulpes vulpes*	European Red Fox			High	All habitats except aquatic

Based on EBS (2009) and DTEI (2007). Data sources: BDBSA; Coleman 2008; observations in project area during past and current surveys

Conservation ratings: EPBC Act: EN = Endangered; VU = Vulnerable; National Parks and Wildlife (NPW) Act: E = Endangered; V = Vulnerable; R = Rare

* introduced species

Reptiles and amphibians

Of the 34 reptile species previously recorded in or adjacent to the project area, many are from historical records in the region and are considered unlikely to occur in the project area (EBS 2009).

The reptile species considered to have a high or moderate likelihood of occurring in the project area are relatively common across the Adelaide region and are not listed as being of national or state conservation significance (Table 18.4). Several species are also considered to have a low likelihood of occurrence in the project area based on current known distribution and habitat preferences (EBS 2009).

Overall, the lack of remnant vegetation, previous disturbance to most of the project area, and current land uses in and adjacent to the project area, have had a significant adverse impact on reptile diversity and abundance. Woodland and shrubland habitats in the project area offer moderate–high quality habitat for reptiles. Areas of higher quality contain habitat features such as leaf litter, logs and dense shrubs that would be used as refuge sites (EBS 2009).

Table 18.4. Reptile species previously recorded in or adjacent to the project area and region

Scientific name	Common name	EPBC Act listed	NPW Act listed	Likelihood of occurrence	Likely habitat
Aprasia inaurita	Red-tailed Worm-lizard			Low	Woodland and shrubland areas
Aprasia striolata	Lined Worm-lizard			Low	Woodland and

Scientific name	Common name	EPBC Act listed	NPW Act listed	Likelihood of occurrence	Likely habitat
					shrubland areas
Bassiana duperreyi	Eastern Three-lined Skink			Low	Woodland and shrubland areas
Christinus marmoratus	Southern Marbled Gecko			High	areas All vegetation types and urban areas
Cryptoblepharus plagiocephalus	Desert Wall Skink			Moderate	Woodland areas
Ctenophorus pictus	Painted Dragon			High	Shrubland areas
Ctenotus orientalis	Eastern Spotted Skink			Low	Woodland and shrubland areas
Delma molleri	Adelaide Snake-lizard			Moderate	Woodland and Shrubland areas
Demansia psammophis	Yellow-faced Whipsnake			Low	Woodland and shrubland areas
Gehyra variegata	Tree Dtella			Low	Woodland areas
Hemiergis decresiensis	Three-toed Earless Skink			Moderate	Woodland and Shrubland areas
Hemiergis peronii	Four-toed Earless Skink			High	Woodland and Shrubland areas
Heteronotia binoei	Bynoe's Gecko			Moderate	Woodland and shrubland areas
Lampropholis guichenoti	Garden Skink			High	Woodland and Shrubland areas
Lerista bougainvillii	Bougainville's Skink			High	Woodland and Shrubland areas
Lerista dorsalis	Southern Four-toed			High	Woodland

Scientific name	Common name	EPBC Act listed	NPW Act listed	Likelihood of occurrence	Likely habitat
	Slider				and Shrubland areas
Lerista punctatovittata	Spotted Slider			Low	Woodland and Shrubland areas
Lialis burtonis	Burton's Legless Lizard			Low	Woodland and shrubland areas
Menetia greyii	Dwarf Skink			High	Woodland and Shrubland areas
Morethia adelaidensis	Adelaide Snake-eye			High	Woodland and Shrubland areas
Morethia boulengeri	Common Snake-eye			High	Woodland and Shrubland areas
Morethia obscura	Mallee Snake-eye			Moderate	Woodland and Shrubland areas
Pogona barbata	Eastern Bearded Dragon			High	Woodland and Shrubland areas
Pseudomoia entrecasteauxii	Southern Grass Skink			Low	Woodland and shrubland areas
Pseudonaja textilis	Eastern Brown Snake			High	Woodland shrubland and urbanareas
Pygopus lepidopodus	Common Scaly-foot			Moderate	Woodland and Shrubland areas
Ramphotyphlops australis	Southern Blind Snake			Low	Woodland and shrubland areas
Ramphotyphlops bituberculatus	Rough-nosed Blind Snake			Moderate	Woodland and shrubland

Scientific name	Common name	EPBC Act listed	NPW Act listed	Likelihood of occurrence	Likely habitat
					areas
Suta flagellum	Mallee Black-headed Snake			Low	Woodland and shrubland areas
Tiliqua adelaidensis	Pygmy Bluetongue Lizard	EN	E	Very Low	Grassland and shrubland areas
Tiliqua occipitalis	Western Bluetongue Lizard			Moderate	Woodland and shrubland areas
Tiliqua rugosa	Sleepy Lizard			High	Woodland, shrubland and urban areas
Tiliqua scincoides	Eastern Bluetongue Lizard			High	Woodland and Shrubland areas
Tympanocryptis lineata	Five-lined Earless Dragon			Low	Woodland and shrubland areas

Data source: EBS (2009), BDBSA, Walker Corporation (2009).

Conservation ratings: EPBC Act: EN = Endangered, VU = Vulnerable; National Parks and Wildlife (NPW) Act: E = Endangered, V = Vulnerable, R = Rare.

Five frog species are known to occur in the project area (Table 18.5) (EBS 2009). Both Common Eastern Froglet (*Crinia signifera*) and Spotted Grass Frog (*Limnodynastes tasmaniensis,* SCR) are abundant here subject to seasonal variation in conditions and both occupy a wide range of habitats from roadside drains to wetlands.

Table 18.5 Amphibian species recorded in the region and project area

Scientific name	Common name	EPBC Act	NPW Act	Likelihood of occurrence	Likely habitat
Crinia signifera	Common Eastern Froglet			High	Recorded during current surveys
Limnodynastes dumerili	Banjo Frog (SCR)			High	Recorded during current surveys
Limnodynastes tasmaniensis	Spotted Grass Frog (SCR)			High	Recorded during current surveys

Scientific name	Common name	EPBC Act	NPW Act	Likelihood of occurrence	Likely habitat
Litoria ewingi	Brown Tree Frog			High	Recorded during current surveys
Neobatrachus pictus	Painted Frog			High	In and adjacent to freshwater wetlands

Data source: BDBSA, EPA Frogwatch, Waterwatch, past and current surveys

Other fauna

No surveys were undertaken to specifically assess freshwater fish or invertebrates by EBS or KBR. Freshwater fish and invertebrate records for the region are available in Cowley (2002), Cox (1998), DTEI (2007) and various WaterWatch databases (2007, 2009) and publications. A number of native freshwater fish species have been recorded in the Greenfields wetlands (Cox 1998), including Common Galaxias (*Galaxias maculatus*) and Congolli (*Pseudaphritis urvilli*). Both are likely to be present in the Barker Inlet wetlands, with Cowley (2002) recording both species in Barker Inlet north wetlands. The introduced species, Plague Minnow (mosquitofish) (*Gambusia holbrooki*) and European Carp (*Cyprinus carpio*), are also present in most freshwater wetlands in the region (Cowley 2002).

18.2.8 Marine fauna groups and species

Avifauna

Tables 18.2 and 18.7 lists the marine avifauna species present or potentially present in the project area. Many of these species occur in both freshwater and marine habitats.

Other fauna

A population of Indo-Pacific Bottlenose Dolphin (*Tursiops aduncus*) lives in and around the Port Adelaide River estuary and Barker Inlet. About 30 or more individuals are frequently seen in this vicinity, with around 300 more thought to visit the area. The Adelaide Dolphin Sanctuary established for their protection and the protection of their habitat. The dolphin habitat and food requirements can all be found in the mangroves, seagrass, saltmarsh, tidal flats, tidal creeks and estuarine rivers in the region (Department of Environment and Natural Resources 2011).

Detailed fish surveys were not part of the project assessments but the region has been well studied in the past. Fish species known to occur in the Port River–Barker Inlet were considered in EBS (2009), which identified 53 species (Table 18.6). The Port River–Barker Inlet is a major nursery area for a number of species including King George Whiting (*Sillaginodes punctata*), Yellow-fin Whiting (*Sillago schomburgkii*), Southern Sea Garfish (*Hyporhamphus melanochir*), Yellow-eyed

Mullet (*Aldrichetta forsteri*), Jumping Mullet (*Liza argentea*), Black Bream (*Acanthopagrus butcheri*) and Blue Swimmer Crab (*Portunus pelagicus*) (BIPEC 2004).

Table 18.6 Fish species known to use Port River–Barker Inlet region

Scientific name	Common name	Type
Acanthopagrus butcheri	Bream, Black Bream	Commercial
Aldrichetta fosteri	Yellow Eye Mullet	Commercial
Mughil cephalus	Sea Mullet	Commercial
Myxus elongatus	Sand Mullet	Commercial
Arripis trutta	Australian Salmon	Commercial
Hyporhamphus melanochir	Garfish	Commercial
Liza argentea	Jumping Mullet	Commercial
Penaeus latisulcatus	Western King Prawn	Commercial
Portunus pelagicus	Blue Swimming Crab	Commercial
Sillaginodes punctatus	King George Whiting	Commercial
Sillago schomburgkii	Yellow-Fin Whiting	Commercial
Sillaginodes punctatus	Spotted Whiting	Commercial
Platycephalidae spp.	Flathead	Commercial
Platycephalus bassesnsi	Southern Sand Flathead	Commercial
Platycephalus fuscus	Flathead	Commercial
Platycephalus laevigatus	Rock Flathead	Commercial
Bothidae & *Pleuronectidae* spp.	Flounder	Commercial
Rhombosolea tapirina	Greenback Flounder	Commercial
Argyrosomus hololepidotus	Mulloway	Commercial
Hyporhamphus regularis	River Garfish	Commercial
Sillago bassensis, S. flindersi, S. robusta	School whiting	Commercial
Chrysophrys auratus	Snapper	Commercial
Sphyraena novaehollandiae	Snook	Commercial
Hyporhamphus melanochir	Southern Sea Garfish	Commercial
Arripis georgianus	Tommy Ruff	Commercial
Caranginae spp.	Trevally	Commercial
Arripis truttaceus	WA Salmon	Commercial
Christiceps australis	Crested Weedfish	Non-commercial
Spratelloides robustus	Blue Sprat*	Non-commercial
Pseudogobius olorum	Blue Spotted Goby	Non-commercial
Arenigobius bifrenatus	Bridled Goby	Non-commercial
Gobius lateralis	Long Fin Goby	Non-commercial
Gallogobius mucosus	Sculptured Goby	Non-commercial
Pseudaphritis urvillii	Congolli	Non-commercial
Gobiopterus semivestitus	Glass Goby	Non-commercial

Scientific name	Common name	Type
Rhombosolea tapirina	Greenback Flounder	Non-commercial
Monacanthidae spp.	Leatherjacket*	Non-commercial
Enoplosus armatus	Old Wife	Non-commercial
Atherinosoma microstoma	Smallmouth Hardyhead	Non-commercial
Pseudorhombus jenynsii	Smalltooth Flounder*	Non-commercial
Favonigobius lateralis	Southern Longfin Goby*	Non-commercial
Terapontidae spp.	Striped Perch	Non-commercial
Contusus brevicaudus, Torquigener pleurogramma, Tetractenos glaber	Prickly Toadfish, Weeping Toadfish, Smooth Toadfish	Non-commercial
Galaxias kayi	Minnow	Non-commercial
Gambusia affinis	Mosquito Fish**	Non-commercial
Gymnopistes marmoratus	SA Cobbler	Non-commercial
Kaupus costatus	Pipefish	Non-commercial
Melambaphes zebra	Zebra Fish	Non-commercial
Pelotes sexlineatus	Trumpeter/Striped Perch	Non-commercial
Scorpaena ergastulorum	Red Rock Cod, Gurnard	Non-commercial
Stigmatopora argus	Spotted Pipefish	Non-commercial
Stigmatopora nigra	Pipefish	Non-commercial
Trygonorhina guanerius	Southern Fiddler Ray	Non-commercial

Source: EBS (2009) Coleman (2008); DEH (multiple authors)

* considered to be temporary visitors into the estuary; ** introduced species

18.2.9 Fauna species of national and state conservation significance

Avifauna

A number of species of national and state conservation significance have been previously recorded in or adjacent to the project area or are considered likely to occur in the project area. These include species of national significance listed under the EPBC Act, including migratory species and marine species. A number of bird species of state conservation significance (listed under the National Parks and Wildlife Act) are also known or considered likely to occur in the project area (see Table 18.7). Further detail for each species and their habitat preference can be found in Technical Report 5 — Fauna.

Table 18.7 Bird species of national and state conservation significance occurrence in the Northern Connector project area

Scientific name	Common name	EPBC Act	NPW Act	Recorded during project surveys (2008–11)	Previously seen in project area (prior to 2008)

Scientific name	Common name	EPBC Act	NPW Act	Recorded during project surveys (2008–11)	Previously seen in project area (prior to 2008)
Acanthiza iredalei rosinae	Slender-billed Thornbill		V		✓
Actitus hypoleucos	Common Sandpiper	Mi, Ma	R	✓	
Anhinger melanogaster	Australasian Darter		R		✓
Anas rhynchotis	Australasian Shoveler		R	✓	
Apus pacificus	Fork-tailed Swift	Mi, Ma			✓ aerial only
Ardea alba	Great Egret, White Egret	Mi, Ma		✓	
Ardea ibis	Cattle Egret	Mi, Ma	R		✓
Ardea intermedia	Intermediate Egret	Mi, Ma	R	✓	
Arenaria interpres	Ruddy Turnstone	Mi, Ma			✓
Biziura lobata	Musk Duck	Mi, Ma	R	✓	
Botaurus poiciloptilus	Australasian Bittern	EN	V		✓
Calidris acuminata	Sharp-tailed Sandpiper	Mi, Ma		✓	
Calidris alba	Sanderling	Mi, Ma			✓ vagrant
Calidris ferruginea	Curlew Sandpiper	Mi, Ma		✓	
Calidris melanotus	Pectoral Sandpiper	Mi, Ma	R		✓
Calidris ruficollis	Red-necked Stint	Mi, Ma		✓	
Calidris subminuta	Long-toed Stint	Mi, Ma	R	✓	
Calidris tenuirostris	Great Knot	Mi, Ma			✓
Cereopsis novaehollandiae	Cape Barren Goose		R		✓
Charadrius bicinctus	Double-banded Plover	Ma			✓
Charadrius leschenaultii	Greater Sand Plover	Mi, Ma			✓
Charadrius mongolus	Lesser Sand Plover	Mi, Ma			✓
Childonias leucopterus	White-winged Black Tern	Mi, Ma		✓	
Cladorhynchus leucocephalus	Banded stilt		V	✓	
Coturnix ypsilophora	Brown Quail		V	✓	
Egretta garzetta	Little Egret	Mi, Ma	R	✓	

Scientific name	Common name	EPBC Act	NPW Act	Recorded during project surveys (2008–11)	Previously seen in project area (prior to 2008)
Egretta sacra	Eastern Reef Egret	Mi, Ma			✓ vagrant
Falco peregrinus	Peregrine Falcon		R		✓
Falcunculus frontatus	Crested Shrike-tit		V		×
Gallinago hardwickii	Latham‘s Snipe, Japanese Snipe	Mi, Ma	R	✓	
Glareola maldivarum	Oriental Pratincole	Mi, Ma			✓ vagrant
Haematopus fuliginosus	Sooty Oystercatcher		R		✓
Haematopus longirostris	Pied Oystercatcher		R		✓
Haliaeetus leucogaster	White-bellied Sea-Eagle	Mi, Ma	E	✓	
Heteroscelus brevipes	Grey-tailed Tattler	Mi, Ma			✓
Hirundapus caudacutus	White-throated Needletail	Mi, Ma			✓ aerial only
Ixobrychus minutes	Little Bittern		E		✓
Limicola falcinellus	Broad-billed Sandpiper	Mi, Ma			✓
Limosa lapponica	Bar-tailed Godwit	Mi, Ma			✓
Limosa limosa melanuroides	Black-tailed Godwit	Mi, Ma	R	✓	
Macronectes giganteus	Southern Giant-Petrel	EN, Mi, Ma			×
Melithreptus gularis gularis	Black-chinned Honeyeater		V		×
Neophema chrysogaster	Orange-bellied Parrot	CE, Mi, Ma			✓ 1 record
Neophema chrysostoma	Blue-winged Parrot		V	✓	
Neophema elegans	Elegant Parrot		R		✓
Neophema petrophila	Rock Parrot		R		✓
Numensis madascariensis	Eastern Curlew	Mi, Ma			✓
Numensis phaeopus	Whimbrel	Mi, Ma			✓
Oxyura australis	Blue-billed Duck		R	✓	
Pandion cristatus	Eastern Osprey	Mi, Ma	E		×

Scientific name	Common name	EPBC Act	NPW Act	Recorded during project surveys (2008–11)	Previously seen in project area (prior to 2008)
Philomachus pugnax	Ruff	Mi, Ma	R	✓	
Plegadis falcinellus	Glossy Ibis	Mi, Ma	R	✓	
Pluvualis fulva	Pacific Golden Plover	Mi, Ma			✓
Podiceps cristatus	Great Crested Grebe		R		✓
Porzana tabuensishave	Spotless Crake		V		✓
Rallus pectoralis	Lewin's Rail		V		✓
Rostratula australis	Australian Painted Snipe	VU			✓
Sterna albifrons	Little Tern	Mi, Ma			✓
Sterna caspia	Caspian Tern	Mi, Ma			✓
Sterna hirundo	Common Tern	Mi, Ma			✓
Sterna nereis	Fairy Tern	Mi, Ma			✓
Stictonetta naevosa	Freckled Duck		V		✓
Thinornis rubricollis	Hooded Plover	VU			✓ vagrant
Tringa glareola	Wood Sandpiper	Mi, Ma	R	✓	
Tringa nebularia	Common Greenshank, Greenshank	Mi, Ma		✓	
Tringa stagnatilis	Marsh Sandpiper, Little Greenshank	Mi, Ma		✓	
Xenus cinereus	Terek Sandpiper	Mi, Ma		✓	

Conservation ratings: EPBC Act: CE = Critically Endangered, EN = Endangered, VU = vulnerable, Mi = Migratory, Ma = Marine; NPW Act: E = Endangered, V = Vulnerable, R = Rare
× = species with no records for the project area, but could occur there as vagrant.

Mammals

No mammal species of national conservation significance have been recorded in the Northern Connector project area.

Only one state listed rare mammal species, the Common Brushtail Possum (*Trichosurus vulpecula*), has been recorded in the site. It would mostly use the woodland areas in and around the Little Para River corridor of the project area.

Reptiles and amphibians

One species of national conservation significance, the endangered Pygmy Bluetongue Lizard (*Tiliqua adelaidensis*), has been previously recorded in the wider region, well to the north of the project area (DTEI 2007). It has not been recorded on the Adelaide Plains since the 1950s. The species is now confined to the Mid North

Region of South Australia with the nearest known population occurring near Kulparra north of Port Wakefield (Duffy et al. 2008). The project area lacks suitable habitat as this species relies on native grassland areas with spider holes which are used as refuges (Duffy et al. 2008). The age of the record, ongoing assessment of habitats across the project area since 2001, past land use and urban encroachment suggest that it is very unlikely this species is present in the project area (EBS 2009).

None of the five frog species recorded in the freshwater wetlands across the project area (Table 18.5) is of national conservation significance (EBS 2009).

Other species

Of the marine species recorded in the Port River estuary-Barker Inlet, six are of formal conservation significance. Five species of the Syngnathinae (pipefish, seahorses and seadragons) are listed under section 248 of the EPBC Act as listed marine species. All six species are listed as protected species under the South Australian *Fisheries Management (General) Regulations 2007* (Regulation 6). Table 18.8 lists the species of conservation significance.

Table 18.8 Fish species of national and State conservation significance recorded in Port River–Barker Inlet

Scientific name	Common name	Type	Conservation listing
Portunus pelagicus	Blue Swimming Crab	Commercial	Protected species (FMR)
Kaupus costatus	Deepbody Pipefish	Non-commercial	Protected species (FMR), EPBC
Stigmatopora argus	Spotted Pipefish	Non-commercial	Protected species (FMR), EPBC
Stigmatopora nigra	Widebody Pipefish	Non-commercial	Protected species (FMR), EPBC
Phycodurus eques	Leafy Seadragon	Non-commercial	Protected species (FMR), EPBC
Phyllopteryx taeniolatus	Weedy Seadragon	Non-commercial	Protected species (FMR), EPBC

EPBC: Environment Protection and Biodiversity Conservation Act 1999 section 248, listed marine species; FMR: Fisheries Management(General) Regulations 2007 (SA)

Thatching Grass (*Gahnia filum*) sedgelands in the region once supported the Yellowish Sedge-skipper Butterfly (*Hesperilla donnysa donnysa*) (Coleman and Coleman 2000). However, this species is suspected to be locally extinct due to major reductions in its habitat.

18.3 Potential impacts of the project

The project area and surrounding region are located in a mostly highly disturbed and degraded environment. The effects on fauna are predominantly associated with the

marine and wetland environment, where the extent of the effects will largely depend on the construction methodology chosen.

There are relatively few national threatening processes as listed under the EPBC Act. Semi-feral Cat and European Red Fox are present in the region and control programs have been undertaken in the past.

The operation of roads and rail are known to have adverse impacts on wildlife. The effects of roads are variable, from the most obvious impacts such as collision and road-kills, to less obvious impacts like genetic isolation of populations. The major mechanisms of impact are:

- loss of habitat due to installation of infrastructure
- degradation of habitats by pollution from stormwater runoff and litter
- spread of weeds
- fragmentation of habitats resulting in greater edge effects in the longer term
- mortality due to vehicle strike
- disturbance (noise, visual stimuli, light)
- human access.

These impacts can result in road-avoidance zones, where wildlife avoids using areas alongside roads. These disturbance zones can extend to more than 1000 metres for some species, which could result in the loss of a population from an area. However, other species readily adapt to these disturbances and can occupy areas very close to the disturbance source.

The construction of roads and rail often leads to increased fragmentation of habitat. This increases the length of edge habitat and subsequently reduces the size of interior habitat. Edges of roads increase areas where disturbance effects to fauna can occur and the location of a road can cause many animals to move to more intact habitat areas. The increased fragmentation of habitat by the Northern Connector project could confine animals to smaller areas of core habitat, increasing the value of some habitat areas that act as refuges. This increases the pressure on these habitats, which may or may not be able to support increased numbers of individuals. This will certainly be true for part of the Barker Inlet north wetlands, where ecologically important areas of resting and roosting habitat will be removed. Based on observations from 2004 these areas are not known to be important for populations of migratory wading and shoebirds.

However, by observation, the constructed wetlands in the project area and this region are adjacent to some of the busiest highways in South Australia and they are being used by up to 120 bird species in large numbers. This indicates that the species, including threatened species, are able to adapt to these conditions, including threatened species, and will use areas of high quality habitat adjacent to major thoroughfares.

The construction and operation of roads also increases the potential for introducing alien species. Roads act as dispersal corridors, enabling exotic species to penetrate previously inaccessible areas. Vehicles or vehicular effects may introduce exotic species whose impacts are particularly damaging in wetland areas or other habitats with a relatively fragile ecosystem.

18.3.1 Construction and operation

Avifauna (terrestrial and marine)

Construction of the project is likely to cause some disruption and impact to birds, mainly in the constructed wetland habitat in the Southern section. Currently, these wetlands provide habitat for numerous bird species, including migratory, state and nationally listed species.

Operation of the project is likely to contribute to the disturbance of a range of birds in a broad area around the development. One of the most obvious sources of disturbance is the visual impact of cars and trucks using the road. The speed of vehicles moving past birds foraging or roosting in a nearby habitat may startle them, causing them to move further away or seek habitat elsewhere, if possible. However, based on current observations, some amount of habituation to movement takes place, for example in the south area of the Barker Inlet north wetlands, where roosting birds use areas about 60–70 m from the edge of the Port River Expressway. The noise produced by vehicles may also affect birds from using otherwise suitable habitat alongside the road.

AECOM and KBR (2009) investigated the effect of traffic noise on wetland birds by comparing bird numbers and species diversity before and after construction of the Port River Expressway and the South Road–Salisbury Highway ‘loop’ within and immediately adjacent to the Barker Inlet north wetlands. The study showed that despite increased traffic noise exposure (two important habitat islands received increased traffic noise levels by 6 d(B) to approximately 63 d(B)) there were no obvious changes in abundance or species diversity. This suggests that birds using these sites have tolerated, or habituated to, increased traffic noise exposure (as well as visual impacts).

Noise impacts from roads on wetland bird communities have been studied in Northern Hemisphere countries, with varying results. Specialist habitat species, such as European Bittern (*Botaurus stellaris*), and waders, such as the Ruff (*Philomagnus pugnax*), were most heavily impacted by noise. Their abundance and breeding activities in proximity of a two-lane highway reduced dramatically after its operation began. In contrast, population abundance of passerine birds did not show any direct response to disturbance by the highway, regardless of noise level (Hirvonen 2001).

Existing conditions in the project area suggest that a number bird species have adapted to noise levels on high volume arterial roads (such as Port Wakefield Road and Salisbury Highway). These roads were present before the wetlands were constructed and the bird species in these areas had to adapt to the noise and traffic

before using this previously unavailable habitat. Avifauna use in areas close to the Port River Expressway, built after the wetlands were constructed, indicates no significant change in bird species or abundance (AECOM and KBR 2009).

The Northern Connector project would introduce additional major arterial road and rail lines that bird species would need time to adapt to. The main issue with the lag time between construction of the project and bird adaptation, which would vary depending on the species, is the availability of suitable habitat outside the project area. The capacity of habitats to accommodate additional birds displaced from the project area is unknown. For some species, such as those reliant on aquatic grasslands and sedgelands, the available habitat is relatively small across the Adelaide Plains region. If species, for which limited suitable habitat is available, cannot adapt quickly, they may be forced to move to different regions in search of that habitat. There is, therefore, potential for a long-term impact on some bird species as a result of this project in operation. Mitigation measures, to provide alternative and other rehabilitated areas of vegetation/habitat could be implemented to reduce this type of impact.

Noise and visual disturbance would be most evident for resident birds during the breeding season, when sensitivity to disturbance often increases. Negative effects of traffic on the breeding success of birds have been documented in a range of woodland and wetland bird species (Reijen and Foppen 2006). The response of resident and migratory species in the project area to auditory and visual disturbance during their breeding season has not been quantified for any species. The extent of these indirect impacts would vary between bird species based on their sensitivity or tolerance and availability of alternative habitat locations. It is noted however that this does not appear to be true for the existing wetlands adjacent to the Port River Expressway and Salisbury Highway where many aquatic species have been recorded to successfully breed in these areas.

Birds may collide with moving vehicles or infrastructure as they fly over the road or they may be struck by passing vehicles as they run across the road. This issue is of particular concern, as a wide range of bird species travel daily between coastal habitats to the west, and grassland, woodland and wetland habitats to the east. In particular, large bodied birds, such as Australian White Ibis and Australian Pelican, commonly fly at heights of 15–50 m from east to west across the site. Light poles associated with the road could also increase the incidence of bird strike. It is possible some birds could also nest on the edges of the road/rail track, especially as they would have good thermal properties and would be sufficiently open. Red-capped Plover is known to nest in the Dry Creek salt fields where there is sufficient open area to detect and avoid predators.

By observation, the most common road kill victims in freshwater wetlands in the region are usually introduced species and some aquatic species such as swamphens, coots and crakes (Cowley 2002). These birds mainly travel on foot, so must dodge traffic as they run across the road when moving between wetlands. Birds are often killed as they cross the existing highway between Barker Inlet north and south wetlands. The use of culverts and bridges in the wetland system to allow continued water flow may provide safe passage, and reduce the risk of bird strike,

for some species. Gates across culverts and weirs to control water levels would reduce their effectiveness as passageways.

The project area could directly impact on marine birds by the loss and/or degradation of habitat. Many of the most important bird habitats are those on or at the water's edge, including mud flats, wetlands and shallow saline waters. These habitats supply resident birds with all their needs, including food, shelter and breeding sites, while many migratory species rely on the good habitat to supply them with enough food to travel back to their breeding grounds, most of which are in the Northern Hemisphere.

These habitats and areas can also be disturbed indirectly by the turbidity of the water being increased (Coleman and Cook 2009) by runoff from hard surfaces. This has implications for the birds' food sources, which could be impacted by changes to water quality and hence food resources. Many of the issues outlined above also apply to marine birds.

Nonetheless, the most important areas for avifauna, Greenfields wetlands and the marine portion (north-east) of Barker Inlet wetlands (Figure 18.6) are avoided by this project.

Table 18.9 summarises the estimated area of disturbance according to habitat type (see also Figures 18.3–18.7).

Table 18.9. Areas of habitat to be affected

Habitat type	Area affected (ha). Southern section	Area affected (ha). Central and northern sections
Terrestrial habitat		
Open, deep fresh water	3.60	
Shallow fresh water drying to mudflats	0.58	
Dryland roosting/resting sites	0.44	
Tall grassland (reeds)	0.21	
Sedgeland	0.11	
Supratidal (stranded) samphire shrubland	2.22	
Planted vegetation (shrubland)	3.66	
Planted vegetation (woodland)	0.22	45.37
Remnant woodland		0.41
Anthropogenic vegetation	3.54	101.3
Anthropogenic infrastructure	1.16	45.1
Salt field areas	27.1	
Marine habitat		

Open and deep salt water	0.42	
Shallow water flats	0.67	
Mudflats (tidal)	0.48	0.51
Bare flats and saline flats (no tidal influence)	1.69	
Intertidal samphire shrubland	3.28	
Supratidal samphire shrubland	0.72	
Mangrove woodland	3.33	0.54

Mammals

The most obvious direct operational impacts of roads on mammals are collision with traffic and potential affects from increased noise. Numerous studies in Australia have investigated the impact of road kill on local native fauna. Important populations of terrestrial mammal species of conservation significance are not present in the project area, so no significant impacts are expected. Implications for the Common Brushtail Possum are expected to be minimal, due to the lack of habitat and small populations present along Little Para River. For relatively common animals, road kills do not exert significant pressure on population dynamics or conservation status. They still have impacts on local populations of native species.

Reptiles and amphibians

Collision with traffic is the most likely direct impact of the project on reptiles and amphibians. Indirect impacts would be due to habitat loss. It is possible, depending on the remediation measures, that habitat will actually be improved as a condition of approval for the project. No state or nationally listed reptile or amphibian species is recorded for the project area, so the project is unlikely to have any major impact on these fauna. All reptile species recorded are considered to be common.

Other fauna

Fish and other aquatic species may be affected by runoff from roads contaminating wetlands and other adjacent environments.

No direct impacts to marine mammal species are likely from the project providing suitable management planning and operation is in place during construction. However, should the mangroves, seagrass, saltmarsh, tidal flats, tidal creeks and/or estuarine rivers suffer major deterioration, then the resident population of Indo-Pacific Bottlenose Dolphins may be threatened.

Fish, including species of Syngnathids protected under the EPBC Act, and aquatic invertebrates, could be impacted if there is direct removal of marine habitat or if water quality changes, especially during construction. This could be from contamination of the water by runoff, increased turbidity and/or changes in water temperature (if bridges shade and shelter sections of the water or the amount of open/unprotected water dramatically changes). Changes to vegetation along the

water's edge may also impact fish, crustaceans and/or invertebrates through the loss or alteration of their breeding grounds.

18.3.2 Potential impacts to fauna species of national conservation significance

Fourty eight threatened bird species listed under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth, EPBC Act) occur in or adjacent to the project area. All are migratory and/or marine species and five are threatened species listed under Schedules of the EPBC Act. Twenty five species of international migratory shorebirds have been recorded in the project area or region in varying numbers. Some of these have not been recorded in the project area and the remainder occur in small numbers not exceeding the flyway population thresholds. It is concluded that all would experience few to minimal adverse effects from the removal of small areas of habitat associated with the project.

The project may affect small areas of potential parrot foraging habitat Orange-bellied Parrot (*Neophema chrysogaster*), listed as critically endangered under the EPBC Act. Currently, the condition of most samphire shrublands in the project impact zones is poor and unlikely to be suitable as feeding habitat for the species. Small areas of intertidal samphire in better condition are present, although most will not be affected by the project. Any area of potentially suitable foraging habitat adjacent to the Northern Connector project area may become unsuitable for the species due to visual and noise disturbance during construction and operation.

According to the latest surveys and trends, it is unlikely that any Orange-bellied Parrots will be seen this far north of South Australia, if at all, due to their very low population numbers in the state. Numbers of individuals in the wild are low, currently estimated at about 50 birds, with limited chance of recovery. The wider coastal part of the region was in the parrot's traditional foraging range. However, very few sightings of the species have been recorded in the past 20 years; the most recent was at Chapman Creek in 2006 well to the north of the north-most section of the project area. Any damage to better quality samphire vegetation could hamper future efforts or reduce the possibility that the species could recover from its low numbers.

It is considered that there is a relatively low risk of a significant impact, as defined by EPBC Act Significant Impact Guidelines (Department of the Environment and Heritage 2006) on the Orange-bellied Parrot.

One breeding pair of White-bellied Sea-Eagles is reported to be resident in the region, possibly the wider region, although their nest and roost locations are unknown. They are known to forage in the region and the southern part of the project area. It is considered that any impact on this species will be confined to the construction phase of the project directly associated with Barker Inlet north wetlands and that this would be relatively small due to the very large range and foraging habitat available to and used by the species. It is considered very unlikely that the project would create a long term or significant impact, as defined by the EPBC Act Significant Impact Guidelines (Department of the Environment and Heritage 2006) on the species.

Investigations also determined that there are relatively small populations only of some migratory shorebirds and marine and aquatic birds of specific conservation significance that use the Barker Inlet Wetlands and North Arm Creek. These would be unlikely to be affected by the project due to their limited use of the affected sites plus the range and large areas of other suitable habitats present adjacent to the project area and elsewhere in the region.

Additional species will lose small areas of habitat, primarily through direct impacts and fragmentation but not enough to significantly affect their population or abundance. Some of these species use more than one habitat type, so they have the ability to move to other preferred or similar sites in the area that are less affected (if at all) by the development. Whether these habitats can support the additional numbers of birds can not be determined. Those species whose habitat is primarily unaffected with the loss of relatively small areas of potential habitat and which are considered to have the ability to adapt to the development or to have a wide range of suitable habitats available for use elsewhere during construction and operation include Long-toed Stint, Australian Painted Snipe, Pectoral Sandpiper, Latham's Snipe, Wood Sandpiper, Marsh Sandpiper, Broad-billed Sandpiper, White-winged Black Tern, Glossy Ibis, Cattle Egret, Great Egret, Little Egret, Intermediate Egret, Sharp-tailed Sandpiper, Common Sandpiper and Black-tailed Godwit. It is considered that there is a relatively low risk of a significant impact, as defined by the EPBC Act Significant Impact Guidelines (Department of the Environment and Heritage 2006) on these species.

Some habitat areas will not be significantly impacted (if at all) as a result of the project and the species in these areas are unlikely to be directly affected by the loss of habitat. However, species such as Freckled Duck and Musk Duck could be impacted indirectly through noise and visual disturbance factors during construction.

Species that are entirely aerial when in Australia and over-fly the area, such as Fork-tailed Swift and White-throated Needletail, are unlikely to be affected by the project.

Three species (Southern Giant-Petrel, Osprey and Ruff) are vagrant or very rare visitors to the area and will not be affected significantly by the project.

Additional species, although of listed conservation significance, currently have very little suitable habitat present in the area, if at all (they are found in other areas of South Australia, outside the project area) and hence will not be impacted by the project. These species include Hooded Plover and Sanderling and are considered to be rare visitors to the area..

As the Pygmy Bluetongue Lizard and its habitat is not considered to occur in the project area, significant impacts are not expected to this species.

18.3.3 Potential impacts to fauna species of state conservation significance

Impacts to fauna vary according to their requirements and tolerance to disturbance. State listed species have been grouped according to the type of effect, if any, likely to occur due to the project.

The loss and/or degradation of habitat and hence feeding, roosting and or breeding grounds will impact the local population, but will not adversely impact on regional or state populations. Species in this category include Australasian Shoveler, Musk Duck, Blue-billed Duck and Banded Stilt.

Loss of small areas of freshwater, aquatic grassland (reed and sedge habitat) could impact the following species to a small extent: Little Bittern, Australasian Bittern, Spotless Crake and Lewin's Rail. However, the most important areas for these species, Greenfields Stages 1 and 3 wetlands, are outside the areas affected by the project. Neither Little Bittern nor Australasian Bittern has been confirmed as living in Barker Inlet north wetlands.

Some habitat areas used by other species, such as Peregrine Falcon and Great Crested Grebe, will not be affected as a result of the project. Hence, these species are unlikely to be directly affected by the loss of habitat. However, they could be impacted indirectly.

Additional species, such as Pied Oystercatcher, Sooty Oystercatcher and other marine species, such as albatross, although listed, currently have very little suitable habitat present in the area (they are found in other areas of South Australia, outside the project area) and hence will not be impacted by the development.

Very few individuals of Australasian Darter, Blue-winged Parrot, Elegant Parrot, Rock Parrot Black-chinned Honeyeater, Crested Shrike-tit, Slender-billed Thornbill (*Acanthiza iredalei rosinae*) and Brown Quail, occur in the project area (most of the population is outside the region), therefore the project is unlikely to have an adverse effect on their local populations.

18.3.4 Summary

Much of the project area is likely to experience environmental effects to some degree. Given that most of the natural environment is already disturbed and fragmented, impacts to fauna should be minimal in most sections of the route, especially fauna of state and or national conservation significant.

The areas of greatest importance to various bird species, including the northern part of the salt fields, Bolivar WWTP, and Port River estuary and Barker Inlet, are distant from the areas affected by the works and operation of the transport corridors. Consequently, no adverse effects apply to these areas.

Within the project area, the most important areas of bird habitat, including Greenfields Stage 3 (often referred to unofficially as Magazine Road wetlands), the northern section of the marine shallow water and intertidal samphire shrubland in

the north-east of Barker Inlet north wetlands and the roosting areas in Barker Inlet south wetlands, will not be affected.

Disturbance to the current areas of important habitat would implicate some fauna species. Of these, the most important impacts that will require offset, are considered to be the removal of:

- two important roosting areas, a small area of shallow water wetland and a smaller area of useful marine wetland habitat in Barker Inlet north wetlands
- mangrove woodland, intertidal samphire and mudflats at two locations along North Arm Creek.

There are other impacts, which are considered to be less important, such as the removal of anthropogenic areas, salt fields, planted native vegetation and areas dominated by poor quality supra-tidal samphire shrubland.

18.4 Management and mitigation

Management of project impacts to fauna and fauna habitat have followed a general principle (in order of preference) of:

- avoiding impacts
- minimising impacts
- mitigating impacts
- compensating for residual impacts.

A range of management and mitigation measures developed during the planning and design phase, would be implemented during construction and operation.

18.4.1 Planni ng and design

Impacts on vegetation and fauna in the project area have been avoided and/or minimised through the corridor selection process and development of the proposed alignment. Initial environmental studies helped guide the corridor alignment through the project area, particularly in relation to issues such as fauna.

The outcomes of the preliminary and draft environmental studies (especially EBS 2009) have contributed to changes being made to the proposed original project corridors:

- The road and rail corridors through the Southern section were chosen to avoid some of the higher value sections of Barker Inlet north wetlands and redesigned to completely avoid Greenfields Stage 3 wetlands. The road corridor has been moved further west over the North Arm Creek mangroves, to conserve more of the Barker Inlet north wetlands shallow freshwater habitat areas and avoid the most important area of marine habitat in these wetlands (north-east quadrant). This will mean the removal of approximately 3.3 ha of mangroves but will conserve a larger area of wetland habitat of known

significance for a range of avifaunal groups and species. Most of the revised rail corridors are located through relatively insensitive areas of terrestrial and wetlands habitat.

- Avoiding a patch of *Gahnia filum* habitat in the Northern section contributed to the chosen route.

18.4.2 Construction

Best practice environmental management would be required for the duration of the pre-construction and construction phases of the project to minimise any impacts on the local environment. This includes development of a detailed project environmental management plan and a Contractor's Environmental Management Plan (CEMP). The construction area would be clearly identified with the extent of works pegged and flagged to minimise the risk of inadvertent damage. Specific management plans, such as a detailed fauna management plan, weed management plan, and a soil erosion and drainage management plan, would also be developed to ensure all issues are addressed and managed accordingly.

The CEMP would also incorporate and detail mitigation measures. It should include the outcomes of the environmental assessments and incorporate DTEI's environmental management policies. The CEMP would also outline the process and contingency measures for sightings of conservation significant species on or around the construction site.

The impact of construction activities on bird species could be reduced by timing habitat removal for the winter months. During winter, bird numbers at the freshwater and saltwater wetlands are lower and resident birds would have either finished or not begun breeding; migratory shorebirds would have left the area and resident birds may have dispersed to other areas.

If construction must proceed during the spring and summer periods, impacts could be reduced by providing alternative habitats for birds, to compensate for the loss of foraging, roosting and breeding habitat. For waterbirds and shorebirds, suitable wetland habitats could be constructed in artificial wetlands. The construction of additional (artificial) intertidal and freshwater wetlands in and around the project area would offset the loss of wetland habitat.

Loss of shallow freshwater habitats has been minimised and the largest impact on birds in the project area is the loss of foraging habitat. There are alternative foraging habitats in the project areas, region and wider region (e.g. Buckland Park Lake) but their use and value for birds at the time of construction is difficult to predict as some of these areas are annual to ephemeral.

The loss of aquatic grassland and sedgeland habitat associated with the margins of freshwater wetlands could be mitigated during the construction period for waterbirds and shorebirds by constructing and expanding artificial wetlands before construction. Planted habitats take a number of years to establish but will also eventually provide suitable feeding, roosting and nesting habitat for waterbirds.

It is vital to minimise the width of the construction corridor and limit the loss and damage of habitat at the edges of the construction zone as part of the detailed design and during actual construction activities. A construction footprint minimised by containing and removing all waste products, and securing all building materials, would reduce impacts to bird and habitat areas. It will also avoid contaminating important fresh and salt water wetland areas.

The likely effect of the project will vary according to annual and seasonal conditions prevailing during construction. Before and during 2009 (at the end of a prolonged drought period) migratory species made far greater use of the stormwater treatment wetlands in the region. This was not the case in 2010 and 2011 (to date), thus these wetlands are an important drought refuge. Nonetheless, resident and short range aquatic and shorebird species use the wetlands on a permanent basis or visit the wetlands regularly.

Continued monitoring (fauna assessments) during construction will be required to help contractors identify issues not previously recognised. This will also provide data for future projects on the impacts of various construction methods, timing and mitigation measures (as occurred during the Port River Expressway construction).

18.4.3 Operation

A range of measures can be implemented to minimise and compensate for impacts during the operation of the project. These measures include offsetting the loss of vegetation and habitats by achieving a significant environmental benefit (SEB) for the project, constructing compensatory habitat in or adjacent to the project area, completing appropriate revegetation and landscaping and/or adopting a range of environmental management actions to help obtain specific goals in regional wetlands (e.g. control of pest species).

18.4.4 Potential wetland development sites

Potential wetland offset sites and existing wetland rehabilitation and revegetation sites being considered by DTEI are identified in Section 8.13 and Figure 8.10.

Modification of parts of Barker Inlet north wetland adjacent to the construction sites is an option available to offset loss or damage to habitat. This type of modification, specifically to enhance particular habitats used by birds, was undertaken successfully in these wetlands as part of the Port River Expressway project following construction of the access road from South Road on to Salisbury Highway. The exact type of modification would depend on the detailed design and would also need to include consideration of water treatment detention times and stormwater ponding volumes, both of which are key operational criteria for this wetland. This specific area, especially northern parts that are currently part of the marine habitat of this wetland, could be planned to incorporate, and be developed into, specific habitat areas suitable for avifauna, such as roosting sites.

Construction of resting and roosting habitat undertaken in the past has proven to be successful. Two areas of this habitat will be removed and a program will establish suitable replacement roosting habitat for species before construction. Suitable

locations are along the western boundary of the wetlands, especially in the south-west corner of the site.

The first potential regional habitat management site is to the north of Range wetlands and includes the basin of Magazine Creek. This area has already been disturbed in the past and could be used to create ideal avifauna habitat. The drainage channel could be modified into a freshwater habitat and a mixing zone of fresh and saline habitats. The site is also used as a storage basin for floodwater, so detailed consideration of design would be needed for its use as an avifauna habitat wetland.

A second potential rehabilitation site exists on currently disturbed land, to the north and west of Magazine wetlands and Wingfield. The small constructed wetlands could be extended and/or the mostly saline wetlands south of North Arm Creek could be expanded.

Other smaller sites with potential for rehabilitation or modification could be explored further as part of the detailed planning and design process for the project.

19 Air quality

19.1 Introduction

This air quality assessment was undertaken in accordance with Environment Protection Authority, South Australia guidelines (EPA 2006).

19.1.1 Assessment approach

Existing conditions

Existing air quality conditions adjacent to the Northern Connector corridor were monitored at Site A, Waterloo Corner (Figure 19.1).

Particulates (PM_{10} and $PM_{2.5}$), nitrogen dioxide (No_2) and sulfur dioxide (SO_2) monitoring at this site was supplemented by data from nearby EPA air quality monitoring stations to determine levels of other pollutants (Section 19.2.3).

Monitoring was also undertaken at two other locations (Figure 19.1): adjacent to Port Wakefield Road (Site B) and adjacent to the existing rail line (Site C). Monitoring results from these locations were used to calibrate the air quality model to accurately represent the likely air quality impact from the project.

The monitoring stations were sited in accordance with requirements of Australian Standard (AS) 2922-1987 — *Ambient air: Guide for the siting of sampling units*. This standard assesses the objectives of ambient air monitoring, spatial and temporal variability in air quality, and types of ambient air monitoring stations.

Construction air quality assessment

Construction air quality is assessed by:

- assessing likely impacts
- recommending mitigation and management measures that would assist in meeting the goals of the National Environment Protection (Ambient Air Quality) Measure 2003 (Ambient Air Quality NEPM) and the Air Toxics NEPM 2004 during construction.

The results of the assessment are outlined in Section 19.3.1 and recommended mitigation measures for the construction phase are listed in Section 19.5.1.

Source: DEH, DTEI, DPLG

Figure 19.1 **Air quality monitoring sites**

- Air monitoring location
- Northern Connector road
- Northern Connector rail
- Spur line to Port Flat siding
- South Road Superway
- Northern Expressway

Site A - Gun Club (ambient monitoring)
Site B - Port Wakefield Road
Site C - Bolivar Road railways site