Adelaide & Mt Lofty Ranges NRMB: Shorebird Conservation & Management

Delta Environmental Consulting

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Adelaide & Mt Lofty Ranges Natural Resources Management Board:

Shorebird Management and Conservation

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GLOSSARY

alien	not native to Australia
AMLR NRM Board	Adelaide & Mt Lofty Ranges Natural Resources Management Board
Bonn Convention	a common term for the Convention on Migratory Species
CAMBA	China-Australia Migratory Bird Agreement
CMS	Convention on Migratory Species
conservation interest	a taxon with status of uncertain, uncommon or poorly known
conservation significance	a taxon with status of extinct, endangered, vulnerable or rare
crystallising pan	shallow final ponds in a solar saltfield where salt is deposited
DEH	Dept for Environment & Heritage (SA) or Dept of Environment & Heritage (Comm)
DLWBC	Dept for Land, Water & Biodiversity Conservation
endangered	in serious risk of disappearing in the wild within 10-20 years
EPA	Environment Protection Authority
EPBC	Environment Protection & Biodiversity Conservation Act
eutrophic	an environment with high availability of nutrients
exotic	not native to Australia
extinct	not collected or verified in the past fifty years
flyway	a general route followed by migratory birds
habitat	a broad classification based on vegetative/geomorphic/locational aspects
JAMBA	Japan-Australia Migratory Bird Agreement
migratory	a bird that breeds in one country/region but overwinters in another
MOSS	Metropolitan Open Space System
native	as for indigenous - native to Australia
NPW (SA) Act	National Parks and Wildlife Act of SA
oligotrophic	an environment with low availability of nutrients
poorly known	little is known about the population
rare	rare within Australia but not facing any identifiable threat
resident	a bird that spends its entire life within a region
ROKAMBA	Republic of Korea-Australia Migratory Bird Agreement
sabkha	coastal salt flats occurring behind salt marshes in arid areas
salina	the ponds of a solar salt facility
Scheduled	endangered, vulnerable or rare within South Australia
shorebird	member of the order Charadriiformes
taxon	a taxonomic group of plants or animals (usually species but not necessarily)
vulnerable	not presently endangered but at risk over 20-50 years
WCP	wildlife conservation plan (under the EPBC Act)
WQIP	water quality improvement program
WWTP	waste water treatment plant

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1. Executive summary

The Adelaide and Mount Lofty Ranges Natural Resources Management Board (AMLR NRM Board) manages a large area of coastal land that provides significant shorebird habitat in the northern Adelaide and Mt Lofty Ranges NRM Region.

This discussion paper will provide information regarding the AMLR NRM Board's options for the long-term management and conservation of shorebird sites and habitats of international significance between the Barker Inlet in the City of Port Adelaide Enfield and the northern boundary of the District Council of Mallala, near Middle Spit.

The landscape of the study area comprises flat low-lying intertidal and supratidal land. A band of tidal flats, saltmarsh and mangroves occupies the intertidal zone. East of this, large salinas (operating ponds of saltfields), sewage treatment works and stormwater treatment wetlands cover an extensive area between Dry Creek and Middle Beach. East of these facilities there are agricultural and residential areas. These areas have been extensively levelled and sometimes filled. Areas north of Middle Beach contain a range of coastal salt marshes, mangroves, sabkas, dunes, ridges and tidal creeks.

Mapping of nineteen 'habitats' that occur in the intertidal and near-coastal zone of the study area has been undertaken and is attached to this discussion paper as Map 001 in Appendix 3 and on the CDROM that accompanies this discussion paper. The CDROM also contains tables detailing flora and fauna records for each 'habitat'.

The fifty-one species of shorebirds to which this discussion paper relates include migratory and resident, common and rare species. The individual species are variously protected by international conventions and treaties, Federal and State legislation, and some species have no specific protection at all.

An assessment of the value of different habitats for shorebird use has been undertaken within this discussion paper. A presence/absence approach was taken that highlights those habitats preferred by most species. The derived scores have been used to develop a shorebird biodiversity value index that was applied to the habitat map to develop a values map showing shorebirds' preferred habitats. The map is provided as Map 002 in Appendix 3. It graphically illustrates the diurnal distribution of shorebird preferred habitat into 'low-tide' and 'high-tide' habitats.

After reviewing the preferred habitats it would appear that **features** that provide shorebird value include:

- Shallow waters and exposed mud with a range of water depths that allow a range of different sized birds to feed,
- Extensive feeding areas that allow a large population of birds to forage,

- Large populations of appropriately sized aquatic invertebrate species. While specific bird species prefer different sized food and some are quite selective in their preferences, many appear to have a wider range of prey species,

- Open areas for roosting and nesting (resident species), where the birds can observe the approach of predators,

- A source of freshwater may be appreciated by some species in summer, although many shorebird species forage in very hypersaline brines if appropriate food sources are present,

- Low levels of human disturbance. Many of the preferred habitats in the study area are relatively inaccessible – the tidal flats, low saltmarsh and flooded sabkhas have a boggy substrate that deters visitation, while the salinas have access controlled by the mining company.

One aspect of the analysis of shorebird habitat preferences that is immediately apparent is the use, by the birds, of different habitats for different stages of the tide. At low tide the extensive tidal flats would appear to be the habitat of choice for most species of shorebirds. At high tide shorebirds either rest in roosts close by the low-tide feeding grounds, or feed if high tide feeding grounds are available.

Site significance varies according to whether one is concerned about habitat for migratory birds that use a specific flyway, all shorebirds, or all shorebirds and some other waterbirds. The approach can consider the population usage of specific species of concern at a site, or the site's usability for the greatest diversity of species of concern. Despite these variations in approach, many of the same areas (albeit by differing nomenclature) keep appearing on lists of significant shorebird sites.

The study area is recognised as containing sites of international, as well as national, significance to shorebirds. Sites within the study area host a significant portion of the world's population of Red-necked stints and Sharp-tailed sandpipers.

Author	Site	Int'nat	National	State
Bamford (2008)	Site 47 - Penrice [Cheetham] Dry Creek Saltfields	x		
	Site 99 - Port Wakefield to Webb Beach	x		
Lane (1987)	Gulf St Vincent		x	x
Watkins (1993)	Penrice (now Cheetham) Dry Creek Saltfields	x	x	
	Great Sandy Point to Port Parham	x	x	
	Port River Mouth	x	x	
	Port Prime	x	x	
Environment Australia (2001) - Wetlands of National Importance	Clinton		x	
	Port Gawler & Buckland Park Lake		x	
	Barker Inlet & St Kilda		x	

Land tenure and management in the near-coastal portions of the study area is varied. Land tenure is separated into land with titles (freehold) and land without titles (Crown lands). Overlying the land tenure there may be other types of tenure. In the study area much freehold and Crown land in the State domain is overlaid with mining tenure, in the form of 7-year or 21-year leases. Near-coastal land within the study area is variously zoned as Coastal, Rural, Industry (including mining), Special uses, Metropolitan Open Space System (MOSS), Recreation, Conservation, Residential, Country townships, Rural living, Commercial and Mixed uses. The area is subject of a wide range of biodiversity-based strategies while at the same time it is subject to an array of proposed developments.

Current land uses have created a range of existing impacts on shorebirds and their habitats, including predation and powerline/roadway bird strike, threats to the carrying capacity of the habitats resulting from pollution, exotic marine pests and mangrove incursion, as well as direct competition for food resources and disturbance.

Potential developments are likely to create a further range of impacts. The proposed developments discussed in this report include new residential developments at Buckland Park and Dry Creek, new industrial precincts at Outer Harbor and Gillman, new road and rail infrastructure, altered recreational access and the expansion or relocation of the Dry Creek saltfields. Individually, each development appears reasonably small. However if all proposed developments were to go ahead a significant area of shorebird habitat would be altered. The developments directly affect about 25% of the mapped high-tide habitats. Map 018 in Appendix 3 displays the areas of habitat that could be impacted if all proposed developments were to eventuate.

Few areas of very high habitat value seem to be impacted directly by proposed developments. On the other hand, approximately 6% of high and 49% of medium value habitat could be directly impacted. In addition to direct impacts it is likely that there would be a range of indirect impacts through changes in salinity/depth, higher visitation rates, increased traffic noise and more frequent pollution events. A major concern is the reduction in the value of low-tide feeding habitat to shorebirds if there are significant losses of, or indirect impacts on, close proximity high-tide roosting habitats.

Quantative determination of the impacts on shorebird species abundance of any proposed developments should be required prior to any development occurring. The analysis could consider the developments in isolation and in combination with other developments. The Shorebird 2020 project's count data and refined counting area mapping, when available, should helpfully inform such studies, as would other, long-term data held in the private domain (Day 2004).

A qualitative assessment of risks for shorebirds and their known and potential habitat, resulting from proposed developments in the study area, has been presented in this discussion paper.

With no implementation of mitigation or risk controls, the following present an extreme level of risk to the shorebird use of the study area:

- disturbance,

- loss of high tide habitat to development and
- potential loss of low-tide habitat to sea level change.

If all possible mitigation approaches are implemented:

- disturbance remains a moderate risk in the immediate term, while
- loss of low-tide habitat remains a moderate risk in the longer term.

In order to meet Australia's obligations under the existing international arrangements, **conservation actions** are undertaken by Commonwealth, State/Territory and Local Governments. While not all shorebirds are migratory, the management and conservation of both migratory & resident species is similar in many respects. The EPBC Act's *Wildlife Conservation Plan for Migratory Shorebirds* (WCP) provides a mechanism for national agencies, State agencies and local bodies to work cooperatively to approach the conservation and management needs of shorebirds. The WCP envisages that State agencies will have the lead for on-ground conservation actions.

A range of actions that could be conducted at a State, regional or local level to meet the Objectives of the WCP, while addressing specific regional risks to shorebirds and their habitats, have been provided for discussion.

Possible legislative & policy change actions	**WCP Objective**	**WCP Action**
Implement protective covenants for shorebird habitat on government land within the study area	Objective 2	Action 2.7, 2.12
Create decisive policy on redistribution of state lands when leases are relinquished within shorebird habitat areas	Objective 2	Action 2.7
Prepare a regional shorebird habitat management plan, following the *Guidelines for Management Planning*, and *Community-based Management Planning Brief* developed by the Shorebirds 2020 program, which documents threats and tabulates agreed conservation measures	Objective 2	Action 2.7
Develop appropriate management arrangements for shorebird habitats of medium or higher habitat value	Objective 2	Action 2.7
Nominate medium to very high value shorebird habitat for recognition or protection under international, national, state and regional policies or plans, where appropriate	Objective 2	Action 2.12
Encourage Local Councils and Planning Authorities to regulate land use where shorebird habitat exists	Objective 2	Action 2.5, 2.7
Include maximization of shorebird habitat value as an approval condition for all major developments within the study area	Objective 2	Action 2.7

Possible legislative & policy change actions	WCP Objective	WCP Action
Liaise with Local and State government bodies to identify and implement other existing strategies and plans to avoid significant impacts on migratory shorebird populations. Seek input into plans currently under development that could provide further avenues for protecting shorebirds and their habitats	Objective 2	Action 2.5, 2.7
Seek listing of moderate to very high value shorebird habitat within the study area as Caring for Our Country High Conservation Value Aquatic Ecosystems (HCVAE), Wetlands of International Importance under the Ramsar Convention on Wetlands, Flyway Partnership sites, or for inclusion in protected areas such as conservation reserves or protected zones within marine parks	Objective 2	Action 2.10, 2.11

Possible community education & capacity building actions	WCP Objective	WCP Action
Increase landholder awareness of shorebird habitat issues with a regular newsletter, educational flyers and media releases	Objective 4	Action 4.1
Assist landholders identify, protect (by covenant or otherwise) and enhance shorebird habitat on their properties	Objective 2	Action 2.5, 2.7, 2.12

Possible on-ground works	WCP Objective	WCP Action
Coordinate fox control measures within a buffer zone around areas of moderate to very high shorebird habitat value	Objective 2	Action 2.7
Limit disturbance in areas of moderate to very high shorebird habitat, potentially by restricting visitors or controlling noise during the months that shorebirds are present	Objective 2	Action 2.7
Restrict harvesting of shorebird food sources within areas of shorebird habitat value	Objective 2	Action 2.7
Develop extensive storm water treatment wetlands in the near-coastal zone for the catchments of the Helps Road drain, Smith & Adams Creeks, and Gawler River and in the Gillman area	Objective 2	Action 2.7
Assist in the development of access controls to areas of high-tide feeding and roosting habitat	Objective 2	Action 2.7

Possible climate change precautions	WCP Objective	WCP Action
Protect existing samphire retreat zones using planning or other measures and provide additional, adequate, area for samphire retreat	Objective 2	Action 2.5, 2.7
Open or partially-open tidal crossings restricting tidal flows in stranded salt marshes	Objective 2	Action 2.7
Where development is approved in near coastal areas and allowance for floodwater escape to the sea is required, allow additional width for the flood escape routes to provide area for shorebird habitat and a path for landward migration of salt marshes	Objective 2	Action 2.7

2. Introduction

The Adelaide and Mount Lofty Ranges Natural Resources Management Board (AMLR NRM Board) manages a large area of coastal land that provides significant shorebird habitat in the northern Adelaide and Mt Lofty Ranges NRM Region.

This discussion paper will provide information regarding the AMLR NRM Board's options for the long-term management and conservation of shorebird sites and habitats of international significance between the Barker Inlet in the City of Port Adelaide Enfield and the northern boundary of the District Council of Mallala near Middle Spit.

Throughout this discussion paper the term "significant shorebird sites or habitat" has been interpreted as relating principally to shorebird sites identified as of international significance (Bamford *et al* 2008). Nationally significant shorebird sites, as identified by the register of wetlands of national importance have also been identified and areas of regional significance have been flagged for further investigation.

3. Study area

The study area (Figure 1) lies on the Northern Adelaide Plains within the Flinders Lofty Block IBRA region (*Interim Biogeographic Regionalisation for Australia*, version 5.1, Environment Australia, 2000) and is located on the eastern shores of Gulf St Vincent, which is the estuary of the St Vincent Basin. The extent of the Basin is demarcated in the west by The Hummocks. In the east the Willunga, Eden, Para, Alma and Redbanks Faults mark the boundaries of the Basin. Weathered bedrock underlies Tertiary sediments over much of the Basin. Close to the edges of Gulf St Vincent, Quaternary sediments overly the bedrock (Drexel and Preiss, 1995). The near-coastal saline swamps and mangroves are underlain by the St Kilda Formation. This is described as calcareous, fossiliferous sand and mud of intertidal sand flats, beaches and tidal marshes, as well as gypseous clay found on supratidal flats (Cowley and Freeman, 1993).

The recent geological high stand of the sea has resulted in an increasing volume of water overlying the continental shelf. This has caused differing degrees of coastal warping and resulted in a geographically variable, apparent sea-level fall around the much of the state's shoreline over the past 6,000 years (Drexel and Preiss, 1995). In parts of the study area closer to the northern extent of Gulf St Vincent the apparent sea-level fall over that period is in the order of 3-5 metres. This is in contrast to southern parts of the study area (Barker Inlet), which is one of the few areas of the state displaying a distinct sea-level rise (related to compaction of loose estuarine sediments and decarbonisation resulting from the formation of acid sulfate soils) over the same period.

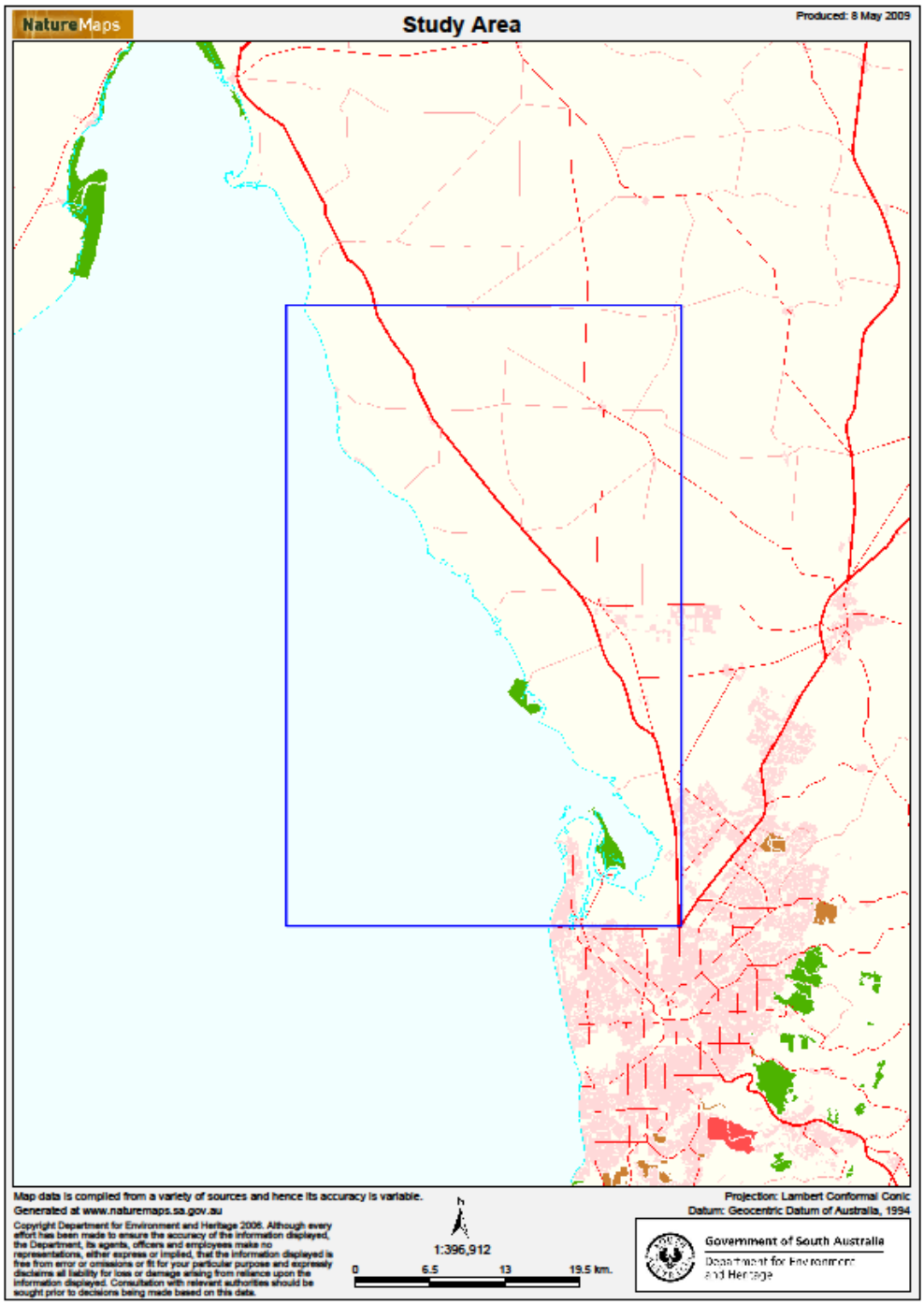

Figure 1 – Study area

The landscape of the study area comprises flat low-lying intertidal and supratidal land. A band of tidal flats, saltmarsh and mangroves occupies the intertidal

zone. East of this, large salinas (operating ponds of saltfields), wastewater treatment works and stormwater treatment wetlands cover an extensive area between Dry Creek and Middle Beach. East of these facilities there are agricultural and residential areas. These areas have been extensively levelled and sometimes filled. Areas north of Middle Beach contain a range of coastal salt marshes, mangroves, sabkas, dunes, ridges and tidal creeks.

Through the southern area there is less than 5m of topographic relief. This increases in northern areas where larger dune ridges result in up to 10m of topographic variation.

The climate of the Northern Adelaide Plains is described as Mediterranean, with cold, wet winters and hot dry summers, with rainfall decreasing from south (average of 420 mm of rain annually) to north (approximately 300mm per annum). Most rainfall occurs between May and September. Strong south-westerly winds occur during autumn and spring, with hot northerly winds occurring during summer. In winter a light northerly breeze (the hibernal breeze) blows in the early mornings. Lightning storms occur though out the year, but with higher intensity in mid to late spring.

3.1 Near-coastal habitats in the study area

A general description of the near coastal habitats in the study area follows. This is supplemented in Appendix 3 with photographs of each habitat type.

3.1.1 Tidal habitats

The area between the highest and lowest tides contains a range of habitats – tidal mudflats, tidal creeks, mangrove forests and salt marshes (Fig 2).

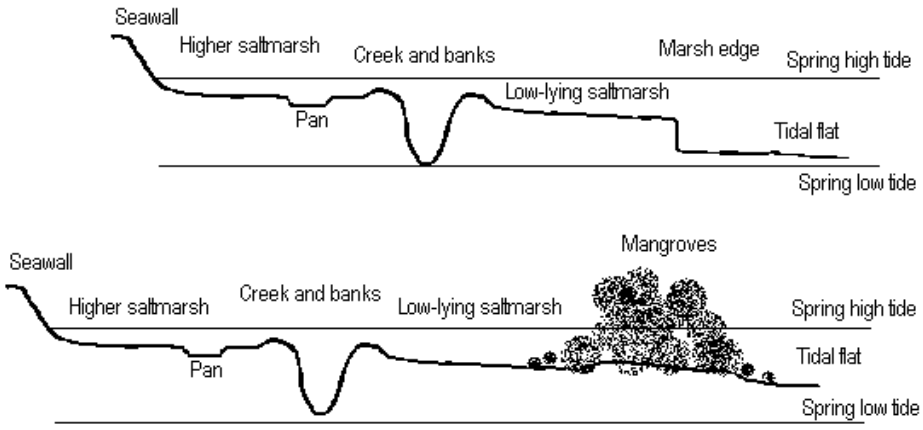

Figure 2 – Zonation and habitats within the tidal zone

Tidal flats are known to have high invertebrate biodiversity and are settlement sites for larvae, providing food resources for prawns, fish and birds. The mudflats are exposed daily by the ebbing tide, and with the recession of the tide the most obvious components of the vegetation of the tidal flats are the seagrasses and various green algae. Large flocks of shorebirds are a common sight feeding in the shallow, but wide, band of water and exposed mud at the edge of the tide, while black swans graze the seagrasses in deeper water

In South Australia they comprise about 9% of the coastal shores. The tidal flats are narrower in the southern part of the Gulf and widen out to the north, a result of the 'terrestrialisation' of seagrass banks. This process has resulted in the shoreline of the northern Gulf migrating seaward by several kilometres since the sea level stabilized about 6,000 years ago Shepherd and Sprigg (1976). Over geological time, should no other changes intervene, the top portions of the Gulf would gradually become shallower, eventually transforming into coastal wetlands.

Mangrove forests in South Australia comprise monospecific open woodlands of *Avicennia marina* in the intertidal zone of sheltered gulfs and estuaries. While the woodlands provide habitat for fishing birds and some birds that like shelter, they do not provide habitat for many species of shorebirds.

Salt marshes in Gulf St Vincent are dominated by chenopod species, particularly the samphires. They form extensive meadows that border the sea, or they may form in a band between a mangrove forest and the higher land.

Salt marshes exhibit zonation that is related to inundation, and they may (for simplicity) be divided into low-lying (submergent) and upper (emergent) salt marshes. **Low-lying salt marsh** is inundated on a daily basis and the plant associations within this area are dominated by the genera *Sarcocornia* and *Tecticornia.* The low-lying salt marshes provide an important juvenile fish feeding ground (Technical Reference Group 1998) and are utilised heavily by shorebirds.

In areas where less frequent tidal inundation occurs, a **high salt marsh** develops that is dominated by *Tecticornia pergranulata, T. halocnemoides*, *Maireana oppositifolia*, *Frankenia pauciflora* and *Wilsonia humilis.* Being considerably drier than the low-lying salt marshes, the upper saltmarsh supports a wide variety of more "terrestrial" species, both plant and animal. Reptiles are common, along with colonial web-sharing spiders and marsh terns that feed on the hatching samphire galls.

Tidal creeks criss-cross the mangroves and salt marshes. Marine algae and seagrasses grow in these creeks, which also support a variety of marine invertebrates. Once again, the close presence of dense mangroves and deeper, fast flowing waters, deters shorebirds from using this habitat.

3.1.2 Swamplands & constructed wetlands

Estuarine swamplands of several varieties occur in small pockets throughout the study area. Extensive constructed wetland habitats are also present, in the form of wastewater treatment works, stormwater treatment wetlands and salinas.

Back swamps and freshwater tidal swamps are estuarine wetlands that develop where creeks and rivers enter the tidal zone. Such wetlands are typically dominated by rushes and sedges that can tolerate an occasional inundation with tidal water. *Bolboshoenus* spp and *Phragmites australis* are the dominant species, with areas of *Juncus kraussii* and the introduced *Juncus acutus*. *Triglochin* spp and *Cotula* spp grow in the water, and there is a diverse plankton flora. Depending upon seasonal variations in salinity, numerous insect larvae can be found in the deeper ponds and around the bases of the reeds.

Trees are not common in the backswamps and estuarine freshwater swamps of the study area, with the exception of **Buckland Park Lake and surrounds.** This man-made impoundment of the Gawler River hosts *Eucalyptus camaldulensis* where the river enters the Lake on its east, and a dense stand of the introduced *Casuarina glauca* around the Lake's western edge. A remnant stand of the swamp paperbark, *Melaleuca halmaturorum,* occurs north-west of the Lake on a small chenier. Dense stands of lignum (*Muehlenbeckia florulenta*) mark the flooded extents of the Lake (its surrounds).

Stormwater treatment wetlands are a more recent development. Over 600 hectares of stormwater treatment wetlands have been built in the areas north of Adelaide that drain to the Barker Inlet. The wetlands provide a range of habitats that enable large numbers of fish to thrive, as well as a rich invertebrate fauna. Shorebirds have "adopted" the wetlands, and can be seen roosting and feeding there. Some resident species are known to breed in the stormwater wetlands.

Wastewater treatment plants (WWTP) provide an additional year-round source of freshwater. The main treatment ponds are often too deep to provide shorebird feeding habitat, but vegetated drains and low-lying paddocks surrounding the treatment ponds are frequented by a range of shorebirds.

Salinas are artificially controlled saline ponds used to produce common salt. The salinas of the Dry Creek Saltfields are maintained at controlled salinities, creating a range of lagoonal biomes with salinities varying from seawater salinity (the very first ponds) through to extremely hypersaline (the final ponds). Each biome contains a range of algal and faunal species specific to its salinity range.

Packham and Willis (1997) reported that conservation values are frequently high in salinas. Depending to a large extent of the depth of individual ponds, they are attractive to migratory shorebirds. The networks of sheltered ponds, islands and embankments form good feeding, roosting and nesting habitats.

Marine salinas in the Dry Creek salinas are fed by pumps. The rocky pumping basins replicate a high-impact coast, with oxygen-rich waters flowing rapidly past the rock walls. These pumping basins contain high densities of rocky shore marine species. The ponds themselves are shallow and sheltered, with salinities ranging from 39-65 g/L Total Dissolved Salts (TDS). They support seagrass meadows and a wide diversity of invertebrates and piscifauna. Mangroves readily colonise these ponds, despite the lack of tides.

As the succeeding salinas develop **low hypersalinity** (65-110 g/L TDS), the species change. While some species of small fish occur in these ponds, gradually crustaceans, molluscs and insects become the dominant fauna, with an ever-changing array of plankton. In the **medium hypersaline** ponds (110-175 g/L TDS) where flos ferri (calcium carbonate) and gypsum (calcium sulfate)

begin to precipitate, the remaining macrofauna are the brine shrimps, *Artemia franciscana* and *Parartemia zietziana*, along with larval stages of the brine flies (*Ephydrella* sp.).

Benthic microbial mats start to become a dominant feature of the salinas that are **highly hypersaline** (175-287 g/L TDS). Microbial mats contain layers of microalga, mainly cyanobacteria (blue-green algae), diatoms and bacteria. In many salinas the mats grow into balls, and are referred to (incorrectly) as stromatolites as they resemble the fossil structures. The different layers of the microbial mats consist of a top layer of diatoms, a lower layer of cyanophyta and a lowest layer of purple bacteria. Benthic mats and planktonic microalgae provide food sources for brine shrimp. The two species of brine shrimp move between the ponds in response to salinity changes over the season. *Parartemia zietziana* dominates in the lower salinity hypersaline ponds while *Artemia franciscana* is the sole crustacean in areas of highest salinity.

Artemia franciscana continues to be present in salinas where brines are almost **saturated** for sodium chloride, even up to the crystallisation point of salt (330 g/L TDS). The halotolerant green microalga *Dunaliella salina* and several types of pink bacteria are found in the crystallizing pans.

3.1.3 Higher land

Seawalls and other embankments are frequently found marking the boundary between salt marshes and grazing or farming land. Adam (1990) stated that "under appropriate management conditions, seawalls support a very rich flora, including a number of rare species."

The main vegetation found along embankments in the study area has much in common with that found on dunes or on naturally occurring adjoining saltbush areas. *Nitraria billardieri*, *Myoporum insulare* and various *Atriplex* species are the dominant plants on seawalls along Gulf St Vincent. Other plants are represented on the embankments as they occur naturally in contiguous areas. For example, in the Barker Inlet area, embankments that are contiguous with chenier ridges or stranded dunes frequently have *Alyxia buxifolia*, *Olearia* spp and *Acacia* spp growing on them.

Embankments provide safe nesting areas for many birds including locally resident shorebirds such as the Red-capped Plover, as well as providing habitat for vertebrates such as the Water Rat.

Chenier ridges, beach berms and dunes mark the retreat of the Flandrian Transgression, starting from about 6,000 years ago (Daily *et al* 1976). Some of the older of these chenier ridges are over a kilometre inland.

Chenier ridges and the more modern dunes and beach berms share similar vegetation of shrubbery over native grasses. These dunal areas are well drained, and host a wide variety of both vertebrate and invertebrate species. Reptiles are common, as are rabbits and predatory foxes.

Sabkhas are extensive natural salt pans that form in the supratidal area of low-lying, relatively arid regions. Sabkas are the dominant landform and habitat type

north of Middle Beach. The hydrologic regime in such areas is interesting. There is usually a saline, shallow water table underlying the sabkha itself. Any large (over 15 metres high) dunal “islands” on the sabkha surface may have a brackish freshwater lens perched on top of the saline water table, but the majority of such “islands” support a sparse plant population with no more than the moisture from precipitation, held interstitially (EPA 1991). Little grows on the sabkha surface other than the cyanobacterial mats and occasional occurrences of the nationally vulnerable samphire *Tecticornia flabelliformis*, however they are often edged with saltmarsh vegetation.

The dominant hydrologic process in many sabkhas is evaporative pumping during the drier months. Water lost from the subsurface brines is replenished by subsurface flow, from the sea (Flood and Walbran 1986), leading to a horizontal concentration gradient under the soil surface.

Sabkha environments are harsh, with evaporation during the summer months greatly exceeding the rainfall. Surface soil temperatures in the high 40^{o}C range are not uncommon. Marine flooding may occur during storm surge events, or freshwaters may flood over them from nearby rivers.

During the short periods the sabkhas are inundated, cyanobacterial mats form on the surface and drive a food web that culminates with shorebirds as the top level consumers.

Grassland and saltbush zones are dominated by *Atriplex paludosa* and the various *Maireana* species (bluebushes). *Nitraria billardieri* is also found in the more saline areas. In open spaces native grasslands dominated by *Austrostipa* spp, *Chloris truncata, Austrodanthonia caespitosa* and the tiny stonecrops are common.

Saltbush and grassland areas within the study area are nearly all grazed, and some areas have been cultivated. Once cultivation has ceased the areas revert quite rapidly to a dense cover of *Atriplex paludosa* and *Maireana brevifolia*, however what effect this form of management has on the faunal biodiversity is unknown.

Mallee woodlands are found on higher ground, east of the coastal wetlands and chenier ridges. Common species are the yorrell (*Eucalyptus gracilis*), red summer mallee (*Eucalyptus socialis*) and white mallee (*Eucalyptus dumosa*).

3.2 Habitat mapping

Mapping of nineteen ‘habitats’ that occur in the intertidal and near-coastal zone of the study area has been undertaken and is attached to this discussion paper as Map 001 in Appendix 3 and on the CDROM that accompanies this discussion paper. The ‘habitats’ presented in the attached mapping represent combined geomorphic-vegetative classes, rather than vegetation associations *per se*, and include locally specific ‘habitats’ such as ‘Buckland Park Lake and surrounds’ that are not transferable outside the study area.

The approximate areas of the mapped ‘habitats’ are summarised in Table 1.

Table 1– Summary of habitat areas

	Area (ha)	% of mapped area
Tidal creeks	198	0.66%
Tidal flats	10473	35%
Mangroves	3184	11%
Mid to Low saltmarsh)	1962	6.5%
High saltmarsh	2172	7.2%
Back swamp	20	0.07%
Buckland Park lake and surrounds	566	1.9%
Chenier or dune	1654	5.5%
Embankment	267	0.89%
Salina – Marine salinity	956	3.2%
Salina – Low hypersaline	1010	3.4%
Salina – Medium hypersaline	1069	3.6%
Salina – Highly hypersaline	458	1.5%
Salina – Saturated for NaCl	686	2.3%
Wastewater treatment plants	503	1.7%
Stormwater treatment wetlands	351	1.2%
Sabkas	3482	12%
Grassland and saltbush	922	3.1%
Mallee and treelots	75	0.25%
Total mapped area	30006	

The map datum is GDA94 and we estimate that the positional accuracy of the mapping varies between +/- 20m to +/- 50m. Spatial resolution is similarly variable, being derived from projects using differing resolutions. It varies from 0.05-1ha.

Constructed habitats can be precisely measured (±5%), however there is always a degree of interpretive error in more natural habitats (±20%). The area of tidal flats and tidal creeks delineated in the mapping is a relatively poor estimate based on aerial photography (could be up to additional 50%). Accurate measurement of the extent of this habitat would require the use of a coastal digital elevation model (DEM) such as the one being proposed by the Commonwealth as part of Australia's preparation for eventual sea-level rise.

Tables containing flora and fauna records for each 'habitat' are available on the CDROM that accompanies this discussion paper.

4. Shorebird use of the study area

4.1 The species

Shorebirds are a group of birds that occur within the order Charadriiformes. The order includes about three hundred and fifty species and is further divided into suborders including the waders or shorebirds (Charadrii), gulls (Lari) and auks (Alcae).

In Australia there are over seventy (>70) species of shorebirds using a range of shallow wet habitats on the coast and inland. Within the study area there are reliable records of at least fifty-one (51) species of shorebird, with older, unconfirmed records of possibly two or three more species (Day 2004, Cox 1994, Birdpedia 2009).

The fifty-one species of shorebirds to which this discussion paper relates include migratory and resident, common and rare species. The individual species are variously protected by international conventions and treaties, Federal and State legislation, and some species have no specific protection at all:

- The majority of these birds are migratory and their migration route passes along the East Asian Flyway. As a result they are listed on treaties Australia has signed with China, the Republic of Korea and Japan (see Table 2 for treaty details), are listed as migratory and marine under the *Environment Protection & Biodiversity Conservation Act* (EPBC Act) and under the *Convention on Migratory Species* (CMS or Bonn Convention) to which Australia is a party.

- About a dozen species of locally recorded shorebirds are either resident or migrate only within Australia or nearby islands. Many of these species breed regularly or sporadically within the study area, with the notable exception of the Australian Pratincole. Favoured habitats vary between species but include beaches, the crystallising pans & embankments of the saltfields, grasslands and freshwater wetlands. These 'resident' species have no protection under migratory bird treaties, but some may have protection under the *National Parks & Wildlife Act* (NPW Act) or Federal legislation (EPBC Act) if they are classed as vulnerable to extinction, endangered or rare.

- One species (Double-banded Plover) migrates east-west between Australia and New Zealand (breeding in New Zealand) and is listed as migratory and marine under the EPBC Act and Bonn Convention.

- Three species (White-rumped Sandpiper, Hudsonian Godwit and Lesser Yellowlegs) are very rare visitors that normally migrate through the Americas, so are not listed under treaties arranged with countries of the East Asian Flyway and are not specifically protected under the EPBC Act. They are, however, listed under the Bonn Convention.

Details of the 51 locally-occurring species are provided in Table 2, along with information on their status under various conventions and legislative instruments.

Table 2 – Species considered in this discussion paper

Common Name	***Scientific Name***	**EPBC Act**	**NPW Act**	**CAMBA**	**ROKAMBA**	**JAMBA**	**BONN**
Australian Pratincole	*Stiltia isabella*						
Baird's Sandpiper	*Calidris bairdii*	Mi/Ma				✓	✓
Banded Lapwing	*Vanellus tricolor*						
Banded Stilt	*Cladorhynchus leucocephalus*		V				
Bar-tailed Godwit	*Limosa lapponica*	Mi/Ma	R	✓	✓	✓	✓
Black-fronted Dotterel	*Elseyornis melanops*						
Black-tailed Godwit	*Limosa limosa*	Mi/Ma	R	✓	✓	✓	✓
Black-winged Stilt	*Himantopus himantopus*						
Broad-billed Sandpiper	*Limicola falcinellus*	Mi/Ma		✓	✓	✓	✓
Buff-breasted Sandpiper	*Tryngites subruficollis*	Mi/Ma			✓	✓	✓
Common Greenshank	*Tringa nebularia*	Mi/Ma		✓	✓	✓	✓
Common Redshank	*Tringa totanus*	Mi/Ma		✓	✓		✓
Common Sandpiper	*Actitis hypoleucos*	Mi/Ma	R			✓	✓
Curlew Sandpiper	*Calidris ferruginea*	Mi/Ma		✓	✓	✓	✓
Double-banded Plover	*Charadrius bicinctus*	Mi/Ma					✓
Eastern Curlew	*Numenius madagascariensis*	Mi/Ma	V	✓	✓	✓	✓
Great Knot	*Calidris tenuirostris*	Mi/Ma	R	✓	✓	✓	✓
Greater Sand Plover	*Charadrius leschenaultii*	Mi/Ma	R	✓	✓	✓	✓
Grey Plover	*Pluvialis squatarola*	Mi/Ma		✓	✓	✓	✓
Grey-tailed Tattler	*Heteroscelus brevipes*	Mi/Ma	R			✓	✓
Hudsonian Godwit	*Limosa haemastica*						✓
Latham's Snipe	*Gallinago hardwickii*	Mi/Ma	R	✓	✓	✓	✓
Lesser Sand Plover	*Charadrius mongolus*	Mi/Ma	R	✓	✓	✓	✓
Lesser Yellowlegs	*Tringa flavipes*						✓
Little Curlew	*Numenius minutus*	Mi/Ma		✓	✓	✓	✓
Little Ringed Plover	*Charadrius dubius*	Mi/Ma		✓	✓		✓
Little Stint	*Calidris minuta*	Mi/Ma			✓		✓
Long-toed Stint	*Calidris subminuta*	Mi/Ma	R	✓	✓	✓	✓
Marsh Sandpiper	*Tringa stagnatilis*	Mi/Ma		✓	✓	✓	✓
Masked Lapwing	*Vanellus miles*						
Oriental Plover	*Charadrius veredus*	Mi/Ma			✓	✓	✓

Common Name	*Scientific Name*	EPBC Act	NPW Act	CAMBA	ROKAMBA	JAMBA	BONN
Oriental Pratincole	*Glareola maldivarum*	Mi/Ma		✓	✓	✓	
Pacific Golden Plover	*Pluvialis fulva*	Mi/Ma	R	✓	✓	✓	✓
Painted Snipe	*Rostratula benghalensis*	Mi/Ma	V	✓			
Pectoral Sandpiper	*Calidris melanotos*	Mi/Ma	R		✓	✓	✓
Pied Oystercatcher	*Haematopus longirostris*		R				
Red Knot	*Calidris canutus*	Mi/Ma		✓	✓	✓	✓
Red-capped Plover	*Charadrius ruficapillus*						
Red-kneed Dotterel	*Erythrogonys cinctys*						
Red-necked Avocet	*Recurvirostra rufogularis*						
Red-necked Phalarope	*Phalaropus lobatus*	Mi/Ma		✓	✓	✓	✓
Red-necked Stint	*Calidris ruficollis*	Mi/Ma		✓	✓	✓	✓
Ruddy Turnstone	*Arenaria interpres*	Mi/Ma	R	✓	✓	✓	✓
Ruff	*Philomachus pugnax*	Mi/Ma	R	✓	✓	✓	✓
Sanderling	*Calidris alba*	Mi/Ma	R	✓		✓	✓
Sharp-tailed Sandpiper	*Calidris acuminata*	Mi/Ma		✓	✓	✓	✓
Sooty Oystercatcher	*Haematopus fuliginosus*		R				
Terek Sandpiper	*Xenus cinereus*	Mi/Ma	R	✓	✓	✓	✓
Whimbrel	*Numenius phaeopus*	Mi/Ma	R	✓	✓	✓	✓
White-rumped Sandpiper	*Calidris fuscicollis*						✓
Wood Sandpiper	*Tringa glareola*	Mi/Ma	R	✓	✓	✓	✓

EPBC Act: Mi = Migratory listing, Ma = Marine listing (Commonwealth waters)

NPW Act: R = Rare, V = Vulnerable

CAMBA: China-Australia Migratory Bird Agreement

ROKAMBA: Republic of Korea-Australia Migratory Bird Agreement

JAMBA: Japan-Australia Migratory Bird Agreement

4.2 Mapping habitat value for shorebirds

Table 3 – Shorebird use of specific habitat areas

Common Name	*Scientific name*	Tidal flats	Mangroves	Mid and low saltmarsh	Higher saltmarsh	Back swamps, sedgelands, freshwater tidal	Buckland Park Lake and surrounds	Chenier ridges & dunes	Embankments	Tidal creeks	Salina - M (marine)	Salina - low hypersaline	Salina -mid hypersaline	Salina - highly hypersaline	Salina - Saturated for NaCl)	Grasslands and saltbush country	Mallee	Sabkhas	Stormwater treatment wetlands	Wastewater treatment lagoons
Australian Pratincole	*Stiltia isabella*											1				1		1		
Baird's Sandpiper	*Calidris bairdii*					1	1													
Banded Lapwing	*Vanellus tricolor*	1							1		1	1				1			1	
Banded Stilt	*Cladorhynchus leucocephalus*	1		1							1	1	1	1				1	1	1
Bar-tailed Godwit	*Limosa lapponica*	1					1					1		1						1
Black-fronted Dotterel	*Elseyornis melanops*	1				1	1						1	1					1	1
Black-tailed Godwit	*Limosa limosa*	1				1	1					1							1	
Black-winged Stilt	*Himantopus himantopus*	1		1		1	1				1	1	1	1	1			1	1	1
Broad-billed Sandpiper	*Limicola falcinellus*	1		1		1						1	1						1	
Buff-breasted Sandpiper	*Tryngites subruficollis*	1										1	1			1				
Common Greenshank	*Tringa nebularia*	1		1		1	1				1	1	1	1				1	1	1
Common Redshank	*Tringa totanus*	1		1		1														
Common Sandpiper	*Tringa (Actitis) hypoleuca*	1		1	1	1	1			1	1	1	1	1					1	1
Curlew Sandpiper	*Calidris ferruginea*	1		1		1						1	1					1	1	
Double-banded Plover	*Charadrius bicinctus*	1		1							1	1	1	1		1				
Eastern Curlew	*Numenius madagascariensis*	1	1	1								1								
Great Knot	*Calidris tenuirostris*	1										1						1		
Greater Sand Plover	*Charadrius leschenaultia*	1		1																

Common Name	*Scientific name*	Tidal flats	Mangroves	Mid and low saltmarsh	Higher saltmarsh	Back swamps, sedgelands, freshwater tidal	Buckland Park Lake and surrounds	Chenier ridges & dunes	Embankments	Tidal creeks	Salina - M (marine)	Salina - low hypersaline	Salina -mid hypersaline	Salina - highly hypersaline	Salina - Saturated for NaCl)	Grasslands and saltbush country	Mallee	Sabkhas	Stormwater treatment wetlands	Wastewater treatment lagoons
Grey Plover	*Pluvialis squatarola*	1		1							1	1						1		
Grey-tailed Tattler	*Tringa brevipes*	1	1						1		1	1								
Hudsonian Godwit	*Limosa haemastica*	1					1					1								
Latham's Snipe	*Gallinago hardwickii*					1	1												1	
Lesser Sand Plover	*Charadrius mongolus*	1	1								1	1								
Lesser Yellowlegs	*Tringa flavipes*												1							
Little Curlew	*Numenius minutus*	1														1				1
Little Ringed Plover	*Charadrius dubius*						1											1		
Little Stint	*Calidris minuta*	1		1		1				1		1	1						1	
Long-toed Stint	*Calidris subminuta*	1				1	1						1						1	
Marsh Sandpiper	*Tringa stagnatilis*	1		1		1	1				1	1	1	1				1	1	1
Masked Lapwing	*Vanellus miles*	1		1	1	1	1	1	1	1	1	1	1		1	1		1	1	1
Oriental Plover	*Charadrius veredus*			1			1									1				
Oriental Pratincole	*Glareola maldivarum*											1				1		1		
Pacific Golden Plover	*Pluvialis fulva*	1	1	1								1								
Painted Snipe	*Rostratula benghalensis*					1	1													
Pectoral Sandpiper	*Calidris melanotos*			1		1	1					1	1	1					1	1
Pied Oystercatcher	*Haematopus longirostris*	1		1								1								
Red Knot	*Calidris canutus*	1		1								1							1	
Red-capped Plover	*Charadrius ruficapillus*	1		1					1		1	1	1	1	1			1	1	1
Red-kneed Dotterel	*Erythrogonys cinctus*	1		1		1	1		1									1	1	1

Common Name	*Scientific name*	Tidal flats	Mangroves	Mid and low saltmarsh	Higher saltmarsh	Back swamps, sedgelands, freshwater tidal	Buckland Park Lake and surrounds	Chenier ridges & dunes	Embankments	Tidal creeks	Salina - M (marine)	Salina - low hypersaline	Salina -mid hypersaline	Salina - highly hypersaline	Salina - Saturated for NaCl)	Grasslands and saltbush country	Mallee	Sabkhas	Stormwater treatment wetlands	Wastewater treatment lagoons
Red-necked Avocet	*Recurvirostra novaehollandiae*	1		1			1				1	1	1						1	1
Red-necked Phalarope	*Phalaropus lobatus*												1							
Red-necked Stint	*Calidris ruficollis*	1		1		1	1				1	1	1	1	1				1	1
Ruddy Turnstone	*Arenaria interpres*								1		1	1		1					1	
Ruff	*Philomachus pugnax*					1								1						1
Sanderling	*Calidris alba*	1						1	1			1								
Sharp-tailed Sandpiper	*Calidris acuminata*	1		1		1					1	1	1	1					1	
Sooty Oystercatcher	*Haematopus fuliginosus*	1		1					1			1								
Terek Sandpiper	*Tringa terek*	1				1					1	1	1					1	1	1
Whimbrel	*Numenius phaeopus*	1	1	1	1							1								
White-rumped Sandpiper	*Calidris fuscicollis*			1			1													
Wood Sandpiper	*Tringa glareola*			1		1	1						1	1					1	1
	No of species favouring this habitat	37	5	28	3	22	21	2	8	3	17	35	22	15	4	8	0	14	24	17
	Habitat diversity value for shorebirds	VH	L	H	L	H	H	I	L	L	M	VH	H	M	L	L	I	M	H	M

VH = Very High H = High M = Medium L = Lower I = Insignificant

For the purposes of this discussion paper it was desirable to develop a method to assess the potential value different habitats may present for shorebirds.

Data for the study area was sourced variously and each dataset had specific limitations. The information available to develop this assessment tool included local habitat mapping and observational records as well as information from the Shorebirds 2020 project.

4.2.1 Diversity data

Mapped 'habitats' of the near coastal zone of the study area were available with an accompanying dataset of records of flora and fauna species (including shorebirds) recorded in those habitats by various observers, but with little count data for most locations. Where count data existed, it was for varying spatial resolutions (for example, 'Dry Creek Saltfields' vs 'wader flat in pond XA2') over varying periods of time. This data is useful from a diversity perspective but provides little abundance information.

A habitat biodiversity score, rating each habitat according to the number of shorebird species that have been recorded within them, is provided at the bottom of Table 3. The scores were grouped to provide a shorebird biodiversity value index (Table 4). These index values were applied to the habitat map to develop a values map showing shorebirds' preferred habitats, provided as Map 002 in Appendix 3. It graphically illustrates the diurnal distribution of shorebird preferred habitat into 'low-tide' and 'high-tide' habitats.

Shorebird diversity (value) index class	**Number of shorebird species**
Very high	30-38 species
High	20-29 species
Medium	11-19 species
Lower	3-10 species
Insignificant	0-2 species

Table 4 - Shorebird diversity (value) index

The largest single habitat (over 10473 ha or 35% of the mapped area) of very high value (utilised by more than 33 species) is provided by the sheltered feeding grounds of the tidal flats. These are the 'low-tide' feeding grounds for a very wide range of shorebirds. As the tide moves in and out the birds are able to move with it, remaining in their preferred depth of water and hunting for their preferred size of prey.

Very high value potential habitat is also present in the low hypersaline salinas of the Dry Creek Saltfields (1010 ha or 3.4% of the mapped area) where the ponds are relatively shallow and support dense populations of invertebrates

ranging in size from minute ostracods to fairy shrimps of over 2cm length. This habitat is used at high-tide when access to the tidal flats is restricted, and provides both feeding and roosting opportunities. A similar range of prey exists in the adjacent ponds however they are deeper, narrowing the range of species attracted to them.

Habitats of high value, utilised by 21-33 species and used at high tide, include mid and low saltmarsh (1962 ha or 6.5% of the mapped area), back swamps, sedgelands & freshwater tidal swamps (20 ha or 0.07%), Buckland Park Lake and surrounds (566 ha or 1.9%), mid hypersaline salinas (1069 ha or 3.6%) and stormwater treatment wetlands (351 ha or 1.2%).

Habitats of medium value, utilised by 12-20 species, include the marine and highly hypersaline salinas (956 ha or 3.2% and 458 ha or 1.5% of the mapped area respectively), sabkhas (3482 ha or 12%) and wastewater treatment lagoons (503 ha or 1.7 %).

In the case of the marine salinas and wastewater treatment works the habitats are too deep for many species of shorebirds, although they provide excellent waterbird habitat and habitat for some larger species of shorebirds or those that feed while swimming, such as the Banded Stilts.

The highly hypersaline salinas, while shallow and hosting very large flocks of species that prefer these ponds, have a narrow range of invertebrates (*Artemia franciscana*) of one particular size, so they attract only those species that prefer this prey species.

The sabkha areas provide feeding grounds only during the limited periods when they have been flooded by storm surges or breakouts from the rivers. At these periods they may be very popular and the medium value may be an underestimation, resulting from under-sampling. The sabkhas are particularly difficult to access once they are flooded.

Habitats with a lower potential value for shorebirds, only utilised by 3-11 species, include mangroves (3184 ha or 11% of the mapped area), higher saltmarsh (2172 ha or 7.2%), embankments (267 ha or 0.89%), tidal creeks (198 ha or 0.66%), the saturated salinas of the Dry Creek crystallisers (686 ha or 2.3%) and coastal grasslands and saltbush country (922 ha or 3.1%). Most of these habitats have aspects that make obtaining food difficult or may be unsuitable roosting areas.

Habitats with trees or dense shrubbery are not preferred by shorebirds, who like to observe the approach of any predators. This makes the mangroves, tidal creeks and high saltmarsh areas unpopular with shorebirds, although they provide valuable habitat for other groups of birds.

The beaks of most shorebirds are not adapted to foraging in hard dry soils, and the few grassland species are uncommon near Adelaide, resulting in grasslands being classed as a relatively poor shorebird habitat locally.

The saturated salinas south of Dry Creek contain a limited range of prey species, although they provide excellent nesting sites for the resident Red-capped Plover during winter, when the crystallisers are empty. The Red-capped Plover also breeds prolifically on saltfield embankments.

Chenier ridges & dunes (1654 ha or 5.5% of the mapped area) and areas of mallee (75 ha or 0.25%) apparently provide habitat of insignificant value to shorebirds, being utilised by less than 3 species each. While the latter was an expected outcome, the former may be a function of under-sampling, due to difficulties accessing cheniers that are stranded in mangrove and saltmarsh habitats.

4.2.2 Abundance data

The Birds Australia Shorebird 2020 project provided 2008-9 count data from specific locations within the study area. An accompanying set of mapped polygons of 'count areas' was downloaded from the Shorebird 2020 web site.

There were fewer polygons (6) in the shape file than count areas (9) in the spreadsheet, limiting the applicability of the data. Additionally, some count areas listed in the spreadsheet contained subsidiary 'sites' bringing the number of different areas counted to a total of 15 separate 'sites'. These subsidiary sites were not defined in the count area mapping. Refinement of the mapping was being undertaken by Birds Australia at the same time this discussion paper was being developed. It appears that individual count areas may include a range of habitats and it is not known at this stage whether the 'sites' within the count areas are more habitat-specific.

Access across much of the study area is limited by infrequent access roads. For example, while access throughout the saltfields is easily obtained via an interconnecting system of embankments wide enough for vehicular use, access to the Light River delta and associated tidal flats is predominantly by foot. The lack of a count area in the Light River delta may not necessarily reflect anything about the delta's value for shorebirds; it may merely reflect the difficulty of access.

The count data for each count area was obtained over two to five counting days, and some count areas had up to four count records for the same day. The Shorebird 2020 data confirms that bird use of habitat is a patchy phenomenon and counts for single species at a single site vary widely from day to day and even within a single day. While very useful from a national perspective, this data set may be too limited to provide useful analysis at a site/species level. Additional monitoring should address this limitation.

Variations in bird use of a location may confound short-term datasets – besides the known diurnal variation relating to high and low tide, shorebird use of high tide feeding areas such as the Dry Creek Saltfields varies depending on the neap-spring tide cycle (Day, 2004). Strong winds and dodge tides also influence diurnal movement between the feeding and roosting grounds. And while the diurnal movements of birds between the tidal flats and ponds of the Dry Creek Saltfields is well understood, nocturnal usage of the habitat is more speculative, as permits for nocturnal observation have not been issued by saltfield operators.

Range summaries of the Shorebird 2020 count data and some comparative data from other observers are provided in Appendix 5. Of the nine count areas, a review of the totals of the means for each count area suggests that the Dry Creek count area is a very important shorebird habitat, followed in rank by

Section Banks at Outer Harbour, Light Beach, Port Gawler, Thompson's Beach, Saint Kilda, Port Parham & Baker Ck, Webb Beach and Middle Beach.

The dataset covered a few months (summer 2008-9) and had 9 counting areas with the number of counts per count area varying from 2 to 11. The limitations of this small dataset were highlighted when it was compared to results provided by two other, longer-term, datasets that exist for one of the count areas (Dry Creek Saltfields). A dataset for the same species provided by Cox (1994) covers 10 years and the sum of his mean counts is an order of magnitude larger than the numbers obtained in the recent, short-term monitoring.

The explanation for this discrepancy may be gleaned from the frequency data provide by Day (2004). Day's data covers the twenty-one year period from 1976-1996 and reports on 833 visits to the saltfields. It illustrates the patchy nature of shorebird presence, with some species always present (in all years and most visits) through some that are present sometimes, in some years, down to those species that have only been recorded in one year out of the two decades. This suggests the Shorebird 2020 data for 2008-9 is likely to have underestimated shorebird use of the surveyed sites.

As one of the aims of the Shorebird 2020 project is to reinvigorate the monitoring of shorebird numbers Australia-wide the current limitations of the dataset and mapping will be addressed in the short-term by a refinement of the mapping and in the longer term by the continued consistent collection of count data.

4.2.3 Summary of shorebird habitat usage

Neither the diversity nor the abundance data provide specific information on usage of habitat, such as breeding, feeding or roosting. It is also possible that a relatively unpopular habitat may be the preference of a single, rarer, species and not be detected. That said, habitats with shallow feeding areas, open roosting sites and clear visibility for observing predators are popular with a wide variety of shorebirds for the obvious benefits they provide.

Sites of most importance for shorebirds, as determined by the Shorebirds 2020 abundance data (Dry Creek Saltfield and Section Banks) contain habitats that have been assessed using the diversity (value) index as containing very high, high and medium potential value for shorebirds.

Reviewing the preferences revealed in the diversity and abundance data, it would appear that features of preferred shorebird habitat include:

- Shallow waters and exposed mud with a range of water depths that allow a range of different sized birds to feed,
- Extensive feeding areas that allow a large population of birds to forage
- Large populations of appropriately-sized aquatic invertebrate species
- Sheltered but open areas for roosting and nesting (resident species), where the birds can observe the approach of predators

- A source of freshwater is required by some species

- Low levels of human disturbance. Many of the preferred habitats in the study area are relatively inaccessible – the tidal flats, low saltmarsh and flooded sabkhas have a boggy substrate that deters visitation, while the salinas have access controlled by the mining company.

One aspect of the review of shorebird habitat preferences that is immediately apparent is the use, by the birds, of different habitats for different stages of the tide. At low tide the extensive tidal flats would appear to be the habitat of choice for many species of shorebirds. The extensive areas of tidal flat in the northern Gulf can support a significant number of shorebirds. At high tide shorebirds either roost (in areas where no additional high tide feeding grounds exist) or feed (in areas where there are high tide feeding grounds). The presence of extensive low tide feeding grounds and additional high tide feeding grounds within the study area explains the significance of this area for shorebirds.

4.3 Recognised sites of importance

The study area contains large areas of habitat that are used by shorebirds. Northern parts of study area have extensive tidal flats and seasonally wet sabkhas with smaller areas of low marsh. Southern parts of the study area have narrower, but still extensive, tidal flats and very large areas of high-tide feeding, roosting and nesting (for resident species) habitats.

4.3.1 International sites

South Australia has eighteen sites listed as internationally significant for migratory shorebirds that use the East Asian-Australasian flyway (Bamford *et al* (2008). Two (2) of these sites occur within the study area – Site 47 and Site 99:

- **Site 47 (Penrice [Cheetham] Dry Creek Saltfields)** is reported to host up to 9100 Red-necked stints and up to 2130 Sharp-tailed Sandpipers seasonally.

- **Site 99 (Port Wakefield to Webb Beach)** is reported to host up to 5550 Red-necked stints and up to 1970 Sharp-tailed Sandpipers seasonally.

Unfortunately, the geographic extents of the sites of international importance outlined by Bamford *et al* (2008) were made available to the consultants as points rather than as polygons, limiting understanding of the area encompassed. A map showing listed locations of Sites 47 and 99 from Bamford *et al* (2008) is attached as Map 003 in Appendix 3.

As these sites' international significance relates to their hosting of a significant portion of the world's population of Red-necked stints and Sharp-tailed sandpipers, two further maps, showing the habitat preferences of those species are also appended (Map 004 & Map 005). The two species have been recorded in widely across the mapped habitats of the study area and their preferred

habitats include most of the very high and high value habitats, along with some of the medium and low value habitats.

Prior to the release of Bamford's study, the East Asian-Australasian Shorebird Site Network contained only 16 Australian sites of international importance, with only 1 (the Coorong & Lakes) in South Australia. This earlier list of internationally important sites only included sites where the site manager was prepared to commit to the management of the sites for shorebird values, a problematic requirement for extensive sites with multiple owners.

4.3.2 National & State sites

The entirety of Gulf St Vincent (both the eastern and western shores) is reported to host significant numbers (as a percentage of the species' overall populations) of several migratory and resident shorebird species (Lane 1987) on a national and regional (State) basis, as shown in Table 5.

Table 5 – National & State significance for specific shorebird species

Species	Average Gulf St Vincent counts (1981-5)	Australian ranking	SA Ranking
Greenshank	1 130	4	1
Sharp-tailed Sandpiper	17 000	4	2
Red-necked Stint	24 000	4	2
Sooty Oystercatcher	120	5	2
Red Capped Plover	3 590	5	2
Red Knot	2 000	6	2
Grey Plover	390	7	3
Curlew Sandpiper	5 900	8	2
Whimbrel	90	9	1
Bar-tailed Godwit	1 240	9	1
Large Sand Plover	30	10	1
Ruddy Turnstone	180	12	6
Great Knot	520	13	3
Grey-tailed Tattler	60	15	1
Double Banded Plover	100	17	1
Eastern Curlew	130	17	1
Marsh Sandpiper	40	17	3
Black-tailed Godwit	90	17	3
Lesser Golden Plover	60	18	3
Mongolian Plover	20		2

Using smaller geographical areas, Watkins (1993) nominated thirty-three (33) South Australian sites as having international and national importance for both migratory and resident shorebirds. Four (4) of these occur within the study area:

- Penrice (now Cheetham) Dry Creek Saltfields ranked as significant for Red-necked stints, Sharp-tailed Sandpipers, Red-capped Plovers, Curlew Sandpipers, Banded Stilts, Greenshanks, Red-necked Avocets and Marsh Sandpipers.
- Great Sandy Point to Port Parham ranked as significant for Grey Plovers and Sharp-tailed Sandpipers,
- Port River Mouth ranked as significant for Sooty Oystercatchers, and
- Port Prime ranked as significant for Grey Plovers.

Once again, boundaries for these sites have not been determined by the consultants, and they remain general vicinity descriptions.

Another approach to denominating areas of national shorebird significance is the mapping of Wetlands of National Importance. Significant wetlands have been defined following the recommendations of Environment Australia (2001), based on their value to shorebirds and other wetland birds. Three (3) Wetlands of National Importance (WNI) occur within, or partially within, the study area – Clinton in the north, then immediately south of Clinton is the Port Gawler & Buckland Park Lake WNI, then immediately south of that is the Barker Inlet & St Kilda WNI. As can be seen in the mapping for the three WNI's, attached as Map 006 in Appendix 3, the delineated areas in each case include the tidal flats and the 'wetter' of the terrestrial habitats, both natural and constructed, in the near-coastal zone.

Mapping of shorebird count areas and shorebird feeding and roosting areas within the Shorebirds 2020 Gulf St Vincent region also provides some indication of important shorebird areas, however these areas do not have the same names as the recognised sites of international and international importance. The Shorebird 2020 mapping is currently being refined. Existing mapping (accessed from the internet) is attached to this report in Appendix 3 as Map 007 & Map 008.

4.3.3 Regionally significant sites

Regional significance, at the level of Natural Resources Management (NRM) Board regions, has not featured in the literature to date. The mapping developed for this discussion paper, and summarised here in Table 6, may form a useful tool for land managers determining regional significance. The habitat mapping and shorebird biodiversity value index developed in section 4.2 of this discussion paper, combined with information on abundance, the specific habitat preferences of different species of shorebirds, and an understanding of the periodicity of each habitat's usefulness (eg low tide, high tide, after flooding etc) could form the basis of any regional assessments.

Table 6 – Habitat value area summaries

	Insignificant value	Lower value	Medium value	High value	Very high value
Area (ha) of mapped habitat	1728	7886	4941	3967	11483
% of mapped habitat	5.8%	26.3%	16.5%	13.2%	38.3%
Area (ha) used at low tide	0	198	0	0	10473
Area (ha) used at high tide	1728	7689	4941	3967	1010

4.3.4 Significant sites – summary

Site significance varies according to whether one is concerned about habitat for migratory birds that use a specific flyway, all shorebirds, or all shorebirds and some other waterbirds. The approach can consider the population usage of specific species of concern at a site, or the site's usability for the greatest diversity of species of concern.

Despite these variations in approach, many of the same areas (albeit by differing nomenclature) keep appearing on the lists of significant sites.

Table 7 – Summary of significant sites

Author	Site	Int'nat	National	State
Bamford (2008)	Site 47 - Penrice [Cheetham] Dry Creek Saltfields	x		
	Site 99 - Port Wakefield to Webb Beach	x		
Lane (1987)	Gulf St Vincent		x	x
Watkins (1993)	Penrice (now Cheetham) Dry Creek Saltfields	x	x	
	Great Sandy Point to Port Parham	x	x	
	Port River Mouth	x	x	
	Port Prime	x	x	
Environment Australia (2001) - Wetlands of National Importance	Clinton		x	
	Port Gawler & Buckland Park Lake		x	
	Barker Inlet & St Kilda		x	

5. Current land management

5.1 Land tenure and management

Land tenure in the near-coastal portions of the study area is varied. Land tenure is divided up into land with titles (freehold) and land without titles (Crown lands). Freehold land may be owned by private citizens & corporations, but local authorities, State agencies or the Federal government may also hold some land

with freehold titles. Freehold land is usually developed or earmarked for development, whether it be held by private entities or government agencies.

Most government land managed by Federal, State or local authorities within the near-coastal portions of the study area is Crown (non-freehold) land. Much of this land is managed for conservation or recreational purposes.

Mapping is attached in Appendix 3 (Map 009) that identifies which parcels of land in the study area are held by government, without specifying whether this be as Crown land or freehold title. Lands in the study area with cadastre that are not marked as government lands are private freehold land.

Around 28,000 ha of the habitats mapped for this discussion paper have some value (lower through to very high) for shorebirds. Of this, around 39% comprises mainly tidal flats and mangroves that are outside the cadastral boundaries, 36% is Government land, while 25% is held as freehold title.

Overlying the land tenure there may be other types of tenure. In the study area much freehold and Crown land in the State domain is overlaid with mining tenure, in the form of 7-year or 21-year leases. The leaseholders include:

- Cheetham Salt Limited operates a solar saltfield that occupies Crown and freehold lands between Dry Creek and Middle Beach, with a further series of leases (to allow for expansion of the pond system) lying between Middle Beach and Port Parham. The company holds 21-year miscellaneous leases with a right to renewal for a further 21 years.

- Camberwarra Pty Ltd holds 7-year extractive leases for shell grit cheniers at Port Prime. The leases are operated by Unimin Australia Ltd.

- Clay Minerals (Clay & Mineral Sales Pty Ltd) holds 7-year extractive leases (shell grit) on cheniers at Port Parham

- Mineral Holdings (Clay & Mineral Sales Pty Ltd) holds 7-year extractive leases (shell grit) on cheniers at Port Gawler

In the far north of the study area, on Commonwealth land, there are a series of shell grit mines operated by Unimin Australia Limited (previously ACI) on cheniers inside the Port Wakefield Proof & Experimental Establishment. These mines do not have mining leases under the Mining Act 1971, as they occur on land outside the purview of State legislation. As a result, they have not been included in the mapping produced for this discussion paper.

Mapping showing mining tenure (under the *Mining Act 1971* of South Australia) in the near-coastal zone is attached in Appendix 3 as Map 010. Of the approximately 28,000 ha of mapped habitats with some shorebird value, around 32% is held under mining tenure.

5.2 Current zoning

Planning zones reflect the grouping of land uses within the landscape. Much of the northern portion of the study area is zoned as Coastal or Rural, with small nodal coastal townships. Much of the rural land use in the area is pastoral in nature, although there are several crop farms and feedlots.

South of the River Light, the number of zoning classes increases. This reflects the southern section's proximity to the metropolitan area. Industry (including mining), special uses (wastewater treatment plants (WWTPs) and the Commonwealth's Defence Science & Technology Organisation (DSTO) radar site), Metropolitan Open Space System (MOSS), recreation, conservation (other than dedicated conservation reserves), residential, country townships, rural living, commercial and mixed uses all occur close to the coastal area.

A generalised map showing the major zoning groups for the near-coastal area is provided in Appendix 3 (Map 011).

5.3 Current biodiversity-based strategies

5.3.1 Commonwealth

Under the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999*, wildlife conservation plans must be developed for species that are listed under the Act. The *Wildlife Conservation Plan for Migratory Shorebirds* (DEH 2006) is the Commonwealth strategy most relevant to this discussion paper. The plan includes 36 species of shorebird, of which 32 species are recorded as occurring in the study area. There are four objectives:

- Objective 1 - to increase international conservation co-operation,
- Objective 2 - identify and protect significant habitat,
- Objective 3 - increase knowledge of the populations and habitats, and
- Objective 4 - raise community awareness.

Each of the objectives has specified actions to undertake and criteria to measure the effect of the actions. Objective 1 is being addressed through the East-Asian Australasian Flyway projects. The Shorebirds 2020 project is meeting Objectives 3 & 4 as well as the identification of nationally and internationally significant sites for Objective 2.

Similarly, Bamford *et al* (2008) have undertaken considerable work on the identifying significant sites at an international level. Gaps remain in identifying regionally significant sites, although Shorebirds 2020 is likely to address this.

The most significant *Wildlife Conservation Plan for Migratory Shorebirds* objective yet to be achieved appears to be the habitat protection portions of Objective 2. Internationally and nationally significant sites within the study area for this discussion paper have very little formal protection.

In addition to the *WCP for Migratory Shorebirds*, the Commonwealth has identified wetland habitats of national significance (Environment Australia 2001) in order to flag areas of habitat of significance to shorebirds and other waterbirds.

Management plans for specific sites have been developed by individual Commonwealth agencies for lands under their control, for example the *Defence Environmental Strategic Plan 2006-2009* (DoD 2006). Within the study area, the Proof and Experimental Establishment has an environmental management plan that specifies the management of coastal sites of seasonal wader bird habitation (Kinhill, 2008, Section 6) to prevent impact on migratory shorebirds.

5.3.2 South Australia

South Australia has a number of State strategies that support shorebirds and protects habitat they use, however shorebirds are not the specific target of many of these strategies. The *No Species Loss* biodiversity strategy (DEH 2007b) is a case in point, with no specific actions relating to shorebirds, even though it has targets that require the survey, habitat mapping, assessment and classification of estuaries, which are typically shorebird habitat. The *Wetlands Strategy for South Australia* (DEH & DLWBC 2003) is more relevant to shorebirds, with references to the identification and conservation needs of wetlands of importance to migratory shorebirds.

The draft *Estuaries Policy & Action Plan for South Australia* (DEH 2005) does include specific targets to ensure water regimes on tidal flats are managed to maintain shorebird habitat and to develop best practice guidelines aimed at recreational users of shorebird habitats. This strategy differs from other State strategies in that there are regional information packs available that provide a range of baseline information about the estuaries in each Natural Resource Management region (DEH 2007, 2007a).

Within the study area Barker Inlet and the Port River estuary, in particular, have been the focus of several attempts to develop an integrated management plan. Attempts by the Barker Inlet Port Estuary Committee (previously the Northern Adelaide Coastal Wetlands Committee and the Barker Inlet Management Plan Committee) resulted in an unpublished draft plan. Many of the issues raised have been incorporated into the draft *Estuaries Policy & Action Plan for South Australia* (DEH 2005), *Adelaide Dolphin Sanctuary Management Plan* (DEH 2008a) the *Adelaide & Mt Lofty Ranges Regional Natural Resources Management Plan* (AMLRNRMB 2008), the *Port Waterways Water Quality Improvement Plan* (Pfennig 2008) and the *Adelaide Coastal Water Quality Improvement Plan* (in development by the EPA) and are likely to have beneficial impacts on the habitats utilised by shorebirds.

South Australia is currently developing a representative system of marine protected areas (DEH 2004, Baker 2004) under the *Marine Parks Act 2007*. The design principles for the outer boundaries (DEH 2008) specify consideration of the needs of shorebirds under Principle 10, "Seek to complement existing terrestrial and marine management practices and conservation agreements." Within the study area the proposed outer boundaries for the Upper Gulf St Vincent Marine Park clearly reflect this concern, with the landward boundaries

including Crown Lands that form shorebird habitat (see Map 021 in Appendix 3). The public consultation for the outer boundaries revealed considerable support from the District Council of Mallala for extending the boundary southwards to Port Gawler and landward to include all Crown Lands abutting the coast, based on the need to protect shorebird habitat. It will be interesting to see whether the final boundaries are expanded to include this additional area.

Within the study area there are several existing conservation and aquatic reserves (see Map 020 in Appendix 3). The largest of these is the Adelaide Dolphin Sanctuary, a multiple use conservation area set up under the *Adelaide Dolphin Sanctuary Act 2005*. While the Sanctuary and its Management Plan have a clear focus on protecting dolphins and their habitats, several of the management actions that improve habitat for dolphins also improve habitat for other species including shorebirds. The Dolphin Sanctuary's landward boundary includes many areas of shorebird habitat, including the Coastal Conservation reserve of Mutton Cove on LeFevre Peninsula. The reserve has a management plan (Cook & Coleman 2003) that includes actions designed to protect shorebird feeding areas within the reserve.

Conservation parks and reserves under the *National Parks and Wildlife Act 1972* occur within the near-coastal zone of the study area at Port Gawler and Torrens Island. These reserves are single use (conservation) and provide a good degree of formal protection to the habitats within them. They are, however, relatively small at 434 ha for the Port Gawler Conservation Park (NPWS 1983) and approximately 606 ha for Torrens Island. While Torrens Island does not yet have a management plan, a draft management plan exists for Port Gawler Conservation Park (NPWS 1983). The plan targets restoration and protection of the vegetative habitats and marine benthic & pelagic fauna, with little reference to shorebird use of the park, a somewhat surprising omission given the populations of birds using the wide tidal flats adjacent to the park.

Two aquatic reserves declared under the *Fisheries Act 1982* and now under the *Fisheries Management Act 2007* are located in the southernmost portion of the study area. These are the Barker Inlet-St Kilda and the St Kilda-Chapman Creek aquatic reserves. In the Barker Inlet-St Kilda aquatic reserve the only permitted 'fishing' is the taking fish by using a rod and line or hand line, or taking bloodworms (Class Polychaeta) for bait by using a hand net. In the St Kilda-Chapman Creek aquatic reserve the only permitted 'fishing' is the taking of Blue Swimmer Crab (*Portunus pelagicus*) by hand or by using a crab net or crab rake. These fishing restrictions, in combination with limited areas of access to the coast, ensure that large areas of the benthos of the tidal flats are relatively undisturbed, ensuring shorebirds have the feeding grounds largely to themselves.

Additionally, under the *Fisheries Management Act 200*8 a number of inshore waters netting closures are in place (Outer Harbor to Aldinga Reef Aquatic Reserve and Port Adelaide River (Port River/Barker Inlet/West Lakes estuaries).

Under the *Natural Resources Management Act 2004* the Adelaide & Mt Lofty Ranges NRM Board is required to develop a Natural Resources Management Plan for its region. This plan, which links to the State's NRM Plan, sets out a range of strategies and actions for the region. Volume A of the Plan is the 'State of the Region Report'. This report recognises the national and international importance of shorebird habitats in the region.

The AMLRNRM NRM Board's Investment Plan (Volume C) commits the board to specific actions related to shorebird conservation and management through a strategy to protect marine and coastal wildlife. This commitment includes specific actions to protect migratory shorebirds through local actions which support the *Wildlife Conservation Plan for Migratory Shorebirds* and the Shorebird Site Network.

Specific initiatives identified by the Regional NRM Plan to achieve this strategy include:

- Support monitoring and research at key shorebird locations
- Identify opportunities to manage and improve wading bird habitat (including artificial habitats)
- Liaise with local government and land managers to regulate land use
- Provide incentives for sustainable natural resources management on private land to improve shorebird conservation
- Offer community education programs and staff training
- Promote and demonstrate environmentally, ecologically and socially responsible behaviour
- Influence community behaviour through implementing biodiversity friendly regulations and planning provisions
- Support signage, fencing and community action programs at nest sites and access points

Current actions supported by the Board include regional implementation of two national Birds Australia projects concerning conservation and management of shorebirds (Shorebirds 2020) and beach nesting birds as well as developing this Shorebird Conservation and Management Discussion Paper.

Additionally actions undertaken through the Board's strategy to manage and protect coastal habitats and estuaries include specific actions for undertaking of on-ground works to conserve and protect coastal habitats and also the development of coastal action plans. The *Metropolitan Adelaide and Northern Coastal Action Plan* is being finalised which covers the study area. This plan incorporates a coastal conservation and threat assessment and identifies priority local actions.

The Gawler River Floodplain Management Authority (GRFMA) has a flood mitigation role within the near coastal portion of the study area. The GRFMA is an independent authority consisting of six Constituent Councils (Adelaide Hills, Barossa Council, Gawler, Light Regional, Mallala and City of Playford councils), chaired by a representative of the Adelaide Mount Lofty Ranges Natural Resources Management Board. One relevant strategy developed by the GRFMA is the *Gawler River Open Space Strategy* (Swanbury Penglase and Urban & Regional Planning Solutions 2008).

The strategy is currently in draft form and shows a range of proposed walking and environmental education activities within the estuarine end of the Gawler River and Buckland Park Lake complex (see Map 022 in Appendix 3). The

strategy reflects the importance of the area to both shorebirds and other waterbirds, with bird hides and interpretive signage along the proposed route. While the strategy meets the objective in the *Wildlife Conservation Plan* (DEH 2006) of raising community awareness about shorebirds, this strategy is not compliant with the requirements of the *Mining Act 1971* where areas delineated for walking trails occur within an operating mine.

In the northern part of the study area the State's planning strategy for the outer metropolitan area (MUDP 2007) notes the biodiversity values of the near-coastal region as including near-pristine estuaries at Port Gawler and the River Light, and extensive seagrass meadows that provide biodiversity (including waterbird), fishing, recreation and tourism values. The plan does not delineate any increase in population or industrial/commercial development in these areas. Further south the planning strategy for metropolitan Adelaide (MUDP 2007a) includes a policy to protect coastal, estuarine and marine habitats such as sand dunes, mangroves, seagrass and saltmarsh. This situation may change with the development of the new 30-year plan for Adelaide. Drafting directions provided to Planning SA for the development of the new plan indicate that near-coastal areas of the Cities of Playford and Salisbury occur in a zone earmarked for investigation of growth potential, as shown in Map 023 in Appendix 3 (MUDP 2008a).

The development of a '*Barossa Regional Spatial Framework*' is being undertaken by Planning SA to examine future growth opportunities and associated development in the Barossa, Gawler, Light, Mallala regions. The framework will include a coordinated regional strategy for future development and guide sequencing of land release / growth areas. The Framework may have implications for development in the coastal zone.

State government agencies such as SA Water have environmental management plans (EMPs) for specific sites. Within the study area the Bolivar Waste Water Treatment Plant is managed by United Water on behalf of SA Water. The plant has an EMP that focuses on discharge impacts of the site. However SA Water have conducted studies to determine the biodiversity values of the site.

5.3.3 Local government

Local governments have the care and control of some of the near-coastal land in the study area (see Map 009 in Appendix 3). Under the *Local Government Act 1999* councils can make plans and strategies to manage these lands.

In the north of the study area, the District Council of Mallala has developed a draft conservation strategy for their entire coast (DCM 2003), along with specific management plans for individual coastal reserves (Coleman & Eden 2005) and shorebird specific coastal trail plans (Jensen 2003). The Council's coastal strategic plan has, amongst its objectives, the establishment of a system of interconnected protected areas including land and marine based parks that incorporate the Light River delta, Light Beach, Port Prime, Bakers Creek and the tidal flats offshore of the Light River delta.

The City of Playford does not have specific strategies relating to the near-coastal portion of their region and are awaiting the finalisation of the proposed 30-year plan for Greater Adelaide (MUDP 2008a) before developing their own strategies. The near-coastal areas of Playford are considered to contain areas with population growth potential.

In the southern portion of the study area the City of Salisbury's city plan (CoS 2008a) includes environment and climate change strategies (CoS 2008) that focus on biodiversity conservation in several strategic corridors, including a coastal mangrove and samphire corridor (see Map 019 in Appendix 3). Council is currently drafting a management plan for these corridors (CoS 2009). The plan focuses on maintenance and restoration of habitat for fauna, and protection of shorebird breeding and feeding areas is specified in the actions for the coastal mangrove and samphire corridor. As Council recognises that much of the land within this corridor is managed under mining lease, the plan specifies developing co-operative agreements with landholders and managers. Salisbury also has a well-known commitment to managing their stormwater in constructed wetlands and these have become valuable, if small, high tide feeding and roosting areas for shorebirds.

The City of Port Adelaide Enfield is a densely developed region with only small areas of habitat of value to shorebirds. The *Northern LeFevre Peninsula Industry and Open Space Development Plan Amendment* (Minister for Urban Development and Planning, 2008), illustrated on Map 012 in Appendix 3, has some small areas designated for treating stormwater in constructed wetlands and these may create links between existing small areas of habitat in the Council.

5.3.4 Corporate

Some of the corporate organisations operating in the near-coastal region are likely to have environmental management systems or environmental management plans. Usually these will focus on pollution prevention rather than biodiversity.

The environmental impacts of operating mines in South Australia are managed under the *Mining Act 1971* using an instrument called a Mining and Rehabilitation Plan (MARP) and these have a broad environmental focus, including biodiversity issues.

Discussions with Cheetham Salt Limited, the largest mineral tenement holder in the study area have confirmed that they have an audited environmental management system as well as a MARP that specifies protection and restoration of remnant vegetation including saltmarsh habitats. The saltfield operators are aware of the value of the salinas as a shorebird habitat and, in discussions held during the development of this discussion paper, they have indicated a willingness to ensure any new salinas are designed with shorebird utilisation in mind. Over an extensive period of time the operators have worked with neighbouring land managers and agencies to undertake environmental improvement projects including several that have been focussed on improving habitat of value to shorebirds. Projects have included fencing to prevent off-road vehicle access to saltmarsh and sabkha habitats and a co-operative project to

develop a saltmarsh retreat zone landward of the salinas at the Little Para estuary.

Other mining interests in the study area have provided no details of their MARP's to the consultants. A review of the SARIG database maintained by Primary Industry and Resources SA (PIRSA) does not reveal any online operational or environmental plans for leases within the study area held or operated by Camberwarra Pty Ltd, Unimin Australia Ltd and Clay & Mineral Sales Pty Ltd. It is probable that they were submitted to PIRSA before the requirement for electronic versions of such plans was included in the departmental guidelines (Minerals Group 2007).

Unimin's operations in the Proof and Experimental Establishment are managed as required by the P&EE's environmental management plan (Kinhill 1998).

6. Existing usage and shorebirds

It may be a mistake to assume that because certain habitats are currently significant for shorebirds, the birds are not under threat from current land uses. A recent unpublished report (Close 2008) considering changes in shorebird populations in Gulf St Vincent over the last thirty years found a significant (50%) reduction in migratory shorebirds and a 12% reduction in the total number of Australian breeding shorebirds. The latter reduction was despite a large increase in the numbers of Banded stilts and Oystercatchers.

Close surmised that the causative factors may lie outside Gulf St Vincent because there had not been a substantial alteration in habitat availability within the Gulf. Factors outside the Gulf include massive clearing of coastal wetlands along the Flyway and the impact of new diseases such as avian flu. Recent reports from China (Xinhua 2009) report finding hundreds of dead migratory birds in Qinghai Province in North-Western China. While Australia has had no reports of bird flu deaths in migratory species so far, there are aspects of existing local land use that may impact on shorebird use of apparently suitable habitats and these are explored in the following sections.

The highly pathogenic H5N1 strain of avian influenza has not yet been detected in wild and domestic birds in Australia. The risk of migratory birds introducing the H5N1 strain of avian influenza into Australia, is considered substantially less in Australia than for most other countries because most migratory birds to Australia are shorebirds and not waterfowl, such as ducks, geese and swans, which are the normal host of avian influenza viruses overseas. The pathway for shorebirds to transmit a virus into domestic birds involves a number of intermediate steps. Migratory shorebirds would need to infect nomadic wild birds, such as water fowl and ducks, which, in turn, would need to pass it to production birds such as chickens. Surveillance to enable early detection will give the best chance of mounting an effective response (Murray 2006).

6.1 Shorebird threatening processes

Loss of confirmed habitat is a major threat to shorebird populations as many species display site fidelity. The factors that attract shorebirds are complex and some habitats that appear superficially suitable may not be utilised by shorebirds (DEH, 2006). Consequently it is important to manage appropriately those specific sites that support significant numbers of migratory shorebirds, in addition to ensuring protection for potential habitat.

Migratory shorebirds complete long flights each year and to do this they depend on the availability of adequate food sources and resting places. The ability of a specific area to support shorebirds is complex and is related to the types and quality of specific habitats, abundance and availability of food species, and level of disturbance & predation. The specialised feeding techniques and preferences of some shorebirds may make them sensitive to small changes to the feeding environment, or to prey abundance. This can reduce a site's usefulness.

A reduction in the food resources of a habitat can be the result of activities that:

- degrade the habitat (for example dredging or disturbing the benthic sediments where the food source (invertebrates) lives, or allowing turbidity to increase to the point where seagrass meadows die, erode and the depth and sediment type of the tidal flats changes, altering the invertebrate food sources)

- modify hydrological inundation regimes (for example by stranding low marsh from tidal inundation by building roads across estuaries and marshes), or

- directly compete for the food resource (for example digging baitworms on tidal flats).

Pollution is a particular threat as pollutants tend to accumulate and concentrate in wetlands, including seagrass meadows, tidal flats and other sedimentary habitats. Eutrophication may change the range of food species present in a wetland thereby altering its utility to shorebirds, while some organic pollutants may cause hatchability issues by making shorebird eggs thin-shelled, brittle or too hard.

Resting (roosting), breeding (resident species only) and feeding opportunities can be compromised by fishing and recreational activities that take place on tidal flats and beaches, and by allowing housing and industrial development to occur very near wetlands. Even when shorebirds remain and use a site in the face of ongoing disturbance, the energetic costs of the disturbance may be high enough that it prevents them building up energy reserves, putting their migration at risk (DEH 2006). For resident species, the destruction of eggs by trampling can cause gaps in age cohorts that, if repeated sufficiently often, may place entire local populations at risk.

Introduced plant species that could invade the low marshes and mud flats in the study area, such as Rice or Cord Grass *Spartina* hybrids, may alter the character of these habitat areas in unforseen ways. Similarly, exotic marine invertebrates such as the European fan worm *Sabella spallanzanii* may invade

seagrass meadows displacing other, more appropriately sized, benthic food sources at important intertidal migratory shorebird habitat.

6.2 Current impacts

Reduction in habitat area is a future threat and is discussed in detail in *Section 7 Potential future impacts*. Existing threats can be divided into direct threats to the birds and threats to the quality and capacity of the habitats they use.

Direct threats to the birds include predation and powerline/roadway bird strike. Threats to the carrying capacity of the habitats can occur as a result of pollution, exotic marine pests and mangrove incursion, direct competition for food resources, and disturbance.

Direct impacts such as fox predation and powerline strike account for regular small losses to shorebird populations in the study area, but may not be sufficiently large impacts as to pose a significant threat.

The carrying capacity of the habitat may be a more significant risk area. While water quality in the northern parts of the study area is high, the *Adelaide Dolphin Sanctuary Management Plan* (DEH 2008a) has identified several water quality issues of concern within the Sanctuary boundaries in the southern parts of the study area that may also have an impact on shorebirds.

Turbidity of the overlying waters is known to impact the health of seagrass meadows. The turbidity is sourced from suspended sediment in stormwater discharge and also from picoplankton blooms that occur in the Sanctuary as a result of eutrophication from wastewater treatment plant discharges. Death of seagrass has occurred widely in the area between St Kilda and Port Gawler. Where the meadows have died, wave action has increased, eroding the beds, deepening the offshore area and changing the size distribution of the sediments. Rectifying the causes of this turbidity is a high priority action in the *Port Waterways Water Quality Improvement Plan* (Pfennig 2008) and the *Adelaide Coastal Water Quality Improvement Plan* under development.

Until late in the 20th century, toxic wastes were controlled relatively poorly. As a result, the environment in Barker Inlet was a recipient of a variety of metal and organic pollutants, which have been sedimented in the tidal flats and seagrass meadows. Very little is known, quantitatively, about toxin release from sediments. There have been some studies undertaken that look at metal concentrations in the sediments and it is suspected that some of them may affect hatchability of shorebird eggs. While this could be an issue for those species that feed here and breed elsewhere, it may be an even larger issue for species that are resident and source all their food in the vicinity, such as the Red-capped plover.

Preliminary studies (Fernandes *et al* 2008) have highlighted possible concern about the contamination of Barker Inlet with anti-bacterial and endocrine disrupting chemicals present in pharmaceuticals and personal car products. Further investigations are underway. The implications for shorebird prey species is as yet unclear.

These pollution-related impacts could apply to the low tide feeding grounds of the tidal flats and also, to a lesser extent since the operation of the *Environment Protection Act 1993*, to the high-tide feeding grounds such as stormwater treatment wetlands and shallower wastewater treatment ponds.

Recent introductions of exotic marine pests including the seaweeds *Caulerpa taxifolia* & *Caulerpa racemosa* and the European fan worm *Sabella spallanzanii* may be having an as yet undetermined impact on shorebirds. They are definitely changing the biodiversity composition of the shallow sedimentary areas they are invading. An historic introduction of Rice or Cord grass in the study area appears to have been successfully eradicated from its recorded occurrence at Port Gawler (Fotheringham et al 1996).

Many invasive species expand rapidly, sometimes creating monocultures until, usually, the new habitat 'adjusts' to them and competition and predation controls them. The introduced European Shore Crab predates a range of intertidal organisms and may lead to change in densities of small invertebrates. This has potential to affect migrating shorebird populations (Jamieson *et al* 1998). The current status of the Shore Crab population in the region is unclear and appears to be subject to fluctuation.

In the southern parts of the study area mangrove incursion as a result of relative sea-level rise (ground subsidence) is evident (Coleman 1998). Mangroves themselves are a poor habitat for shorebirds, and Straw (2003) reports that where mangroves invade salt marsh they reduce its value for shorebirds as the birds will not use small remnant patches of marsh. They prefer to remain over 30m from the edge of the mangroves. Within the study area mangrove incursion is most obvious in Barker Inlet where salt marsh land was reclaimed from the sea by surrounding it with seawalls in the period 1890 to 1970. The drying marsh soils acidified, reacting with the carbonate-rich layers of the St Kilda formation and off-gassing carbon dioxide. In some areas this resulted in a reduction in surface elevations approaching 0.8m (CPB 2003). In the 1930's a large seawall (the St Kilda embankment) was breached, allowing tidal waters to re-enter the stranded marshes. However because of the elevation loss, the depth of the water was more suited to mangroves and these advanced across the salt marsh at rates approaching 18m per annum (Burton 1982). This rate has now slowed, but may well increase again in the future as a result of climate change.

Direct competition for food sources (benthic invertebrates) occurs in areas where bait digging is permitted and where brine shrimpers poach invertebrates from the salinas.

No bait digging is permitted in the aquatic reserves from Barker Inlet to Chapman Creek, however this protects less than a third of the tidal flats in the study area. It is common to see the tidal flats dug over in the Port River outside Mutton Cove. Seagulls take most of the non-target species exposed by the digging. Bait digging is not permitted on the tidal flats within the Cove itself. It is very likely that localised impacts from bait digging occur in the study area north of Port Gawler.

The invertebrate species targeted by poachers in the salinas is *Artemia franciscana*, a small species of fairy shrimp. Brine shrimp are sold to the aquarium trade across Australia. Other species are also netted, mostly as by-

catch. These include the larger fairy shrimp *Parartemia zietziana*, brine fly larvae (*Ephydrella* sp.), smaller harpacticoid copepods and very small ostracods. The saltfield operators attempt to control poachers by prosecuting them for trespass, however the poachers appear undeterred. When invertebrate poaching is undertaken concurrently with fish poaching, illegal activities under the *Fisheries Management Act 2008* may occur and Fisheries officers may become involved.

The most pressing issue for shorebirds using habitat so close to a metropolitan centre is disturbance. On the low-tide feeding grounds of the tidal flats there are crabbers and off-road vehicle users. The high-tide roosting and breeding (resident species) beaches are the province of more off-road vehicle users, horse riders and a range of passive recreational activities including walking and bird watching. This is particularly so at Port Gawler where an off-road vehicle park is located adjacent to beaches and tidal flats.

Industry and housing encircles the area of shorebird habitat. Certain industries (salt making, wastewater treatment plants and stormwater treatment wetlands) provide shorebird habitat themselves, control access and are relatively low intensity activities. However residential uses bring increased local recreation and the presence of dogs, walkers, joggers, and off-road vehicles.

A risk assessment of the potential impacts from current land usage is included in *Section 8.1 Assessment of specific risks*.

7. Potential future impacts

The study area contains several areas of national and international significance for shorebirds. Even so, there are reports of declines in wader numbers in Gulf St Vincent generally and in the study area in particular (Close, 2008). Further loss of shorebird habitat through direct and indirect modifications to their habitat could lead to declines in the species richness and abundance of shorebird populations in South Australia.

Occurring within the Greater Metropolitan Adelaide area, the study area is subject to high levels of development pressure. This type of pressure can result in:

- direct loss of intertidal and freshwater wetland feeding habitats that are filled or dredged for coastal development
- direct loss and fragmentation of higher land used for roosting areas by non-nodal coastal development
- increased levels of disturbance and predation adjacent to developments

In the longer term, changes in climate and water level predicted to occur because of the Greenhouse effect may cause significant changes to coastal habitats that are important to shorebirds.

7.1 Potential habitat loss – development

The consultants held discussions with a range of land managers with interests in the study area. There are a number of developments proposed for the near-coastal parts of the area. Many of the more distant eventualities exist only in the form of 'conceptual' designs that may or may not be feasible and so discussions here are relatively broad-brush. With a lack of confirmed areas of impact all analyses are necessarily speculative, leading to an inability to quantify the numbers of birds that could be impacted individual, or combinations of, developments.

On a strategic level, the drafting directions for the new 30 year plan for Adelaide (MUDP 2008a) *Better Planning, Better Future – Directions for Creating a New Plan for Greater Adelaide* show the near coastal parts of the Cities of Salisbury and Playford as areas to investigate for growth potential (Map 023 in Appendix 3). Similarly, there are unconfirmed suggestions of extending Coast Park to link with the Gawler River Open Space Strategy, and the possibility of a marina at Port Gawler or Middle Beach. These ideas appear merely to have been floated and there are no concept drawings or written proposals.

At a more concrete level there are several developments in various phases of conceptual design or implementation and they will be explored in more detail here.

Techport

Much of the northern areas of LeFevre Peninsula are earmarked for maritime and defence industry developments. While the developments will impact directly on only small areas of shorebird habitat (about a hectare), the developments could result in an increase in disturbance levels from the industries themselves, the increased human presence and an increase in shipping presence. Map 012 in Appendix 3 illustrates the areas proposed for these developments.

Gillman

The Land Management Corporation is preparing land at Gillman for industrial development. They have prepared a draft structure plan for this area (see Map 013 in Appendix 3) which includes a large area of open space to be managed for stormwater or intertidal wetlands, as the site receives runoff from extensive areas of Adelaide. Of the approximately 480 ha of the site (excluding the existing stormwater wetlands) about 22% has high potential value for shorebirds and 78% is of lower potential value. Most of the high value areas are to be incorporated into the area managed for stormwater detention, while the developments *per se* occur on the lower value habitat. In principal it should be possible to offset any loss of lower value habitat by the careful design of mitigation works in the stormwater management area to ensure this habitat's value for shorebirds is further improved.

As with Techport and its related developments, in addition to direct habitat loss impacts there are likely to be disturbance impacts from the increased activity on the developed sites and the increased visitation to the areas managed for stormwater detention.

Northern Connector

Parts of this road and rail corridor (Map 014 and Map 016 in Appendix 3) are still in the design phase. While construction is starting on the northern portions of the road, the final route through Cheetham Salt Limited's Dry Creek Saltfields has not yet been confirmed.

The footprint of the road/rail corridor itself is relatively small, however a major aspect of this road appears to be its impact on the operations of the saltfield, and it is quoted as being the trigger for Cheetham Salt's possible relocation of their crystallisers northwards.

Road/rail infrastructure immediately adjacent to shorebird habitat may have some additional direct impacts in the form of bird-strike deaths. Shorebirds sometimes use the graded edges of roads as a roosting area, because the flat surface provides excellent visibility, preventing predation. This occurs at St Kilda and occasionally the flocks roost on the road surface at night, as the tarmac holds some warmth. This can result in a very high rate of bird strike.

Cheetham Salt Limited

The Dry Creek Saltfields provide a range of habitats of potential, and proven, habitat value for shorebirds. They include areas of both International and National significance.

In the past, when expansion has occurred, it has taken the form of adding new salinas further north while retaining the salt crystallisation ponds (saturated salinas) in their current location. This method of expansion has the advantage of causing the smallest perturbation to the existing habitats within the salinas – a slight, slow change in the salinity gradient occurs while the pond levels and geomorphology remain the same. Previous expansions have resulted in the movement of shorebirds between neighbouring ponds (Day 2004). While the new ponds have other environmental impacts (such as the alienation of native vegetation) they rapidly develop into habitats with values of their own. These values include being of value to shorebirds for both feeding and roosting purposes.

The new road/rail infrastructure proposals would impact detrimentally on the operation of the crystallisation pans, and as a result the company is considering relocation of its crystalliser area. The options to achieve relocation while not interrupting supply to their customer (Penrice Soda Products) are complicated and are still conceptual. According to company representatives the most likely option would include placing crystallisers north of the Light River, rearranging flow paths in much of the existing salinas between St Kilda and Middle Beach and building additional salinas north of the Light River.

Representatives of the company are aware of habitat values that prevent the utilization of some of their leases in the River Light's delta, and have expressed an interest in understanding how best to design their salinas to maximize shorebird use.

The avoidance of the River Light's high value delta area minimises direct impacts. While the footprint of possible salinas north of the existing saltfield includes areas that already have some habitat value for shorebirds, the salinas

that replace these areas, if designed appropriately, could eventually develop higher values for shorebird use. Of the approximately 3250 ha that could be affected, about 7% currently has insignificant value to shorebirds, 27% is of lower value, 64% of medium value and 2% is of high value. Areas of very high value within the possible footprint are extremely small. An illustration of the potential footprint of any northern expansion is provided in Map 017, attached in Appendix 3.

Relocating the saltfield crystalliser area to the north would release land in the existing crystalliser area for road/rail infrastructure and housing development. Existing small salinas between Dry Creek and St Kilda (approximately 380 ha, most of which has medium value for shorebirds) may become surplus to salt making requirements.

Saltfields operate in South Australia under the *Mining Act 1971* and this Act has a requirement to control access to the operational areas of the mine. As a result of this requirement, saltfield developments result in very few disturbance impacts. Most salinas are visited on a daily basis by brine operators and infrequently by specific visitors such as ornithologists involved in bird counts.

Delfin

Freehold land, potentially released from the crystallising area at Dry Creek, is being assessed for future housing development. Most of the land currently has lower values for shorebirds, although the crystalliser and embankment areas provide nesting areas for Red-capped plovers and the surrounding hypersaline ponds provide some food sources for birds that predate swimming invertebrates (*Artemia franciscana*) of a specific size range. The development would alienate those values on something over 800ha of land. However, Delfin's representatives have suggested that development of the area could result in 80 ha of new wetlands, 98 ha of land returned to samphire/mangroves, 120 ha of internal water body and 17 ha of district open space. The remaining land would comprise roads and developed areas, as illustrated in Map 016 in Appendix 3.

To meet these objectives the developers have suggested a curving alignment for the Northern Connector that would form the boundary of their development. The developers are proposing that areas currently used for salt production north of the proposed alignment would be rehabilitated to allow for mangrove and salt marsh accession.

As with all residential developments, this proposal has the potential to increase the levels of disturbance occurring in adjacent high value habitats such as the Greenfields and Barker Inlet Wetlands. Design of internal open space to deflect people from these high value areas may possibly mitigate this impact.

Buckland Park Township

While the proposed Buckland Park township's footprint (Map 015 in Appendix 3) has little direct impact on habitat with shorebird values (less than 10 ha of high value habitat may be affected), the development has potential to increase disturbance levels in the adjacent high value areas including Buckland Park Lake, the Dry Creek Saltfield and Port Gawler beach. The concept drawing of the site shows housing development directly adjacent to salinas classed as having very high value to shorebirds. Disturbing activities presented by housing

in the close vicinity includes predation by feral or domestic cats. Based on international experience, (Dowding *et a*l 2001) predation or disturbance of shorebirds by feral and domestic cats is poses a significant threat to their conservation.

The Environmental Impact Statement for the proposed Buckland Park development appears to consider the adjacent saltfields as a "buffer" between the proposed development and the "coastal plains" and does not recognise the saltfields themselves as important coastal habitat, or their habitat value for migratory birds.

Whilst the EIS recognises noise impacts during construction which "may generate nuisance noise and disrupt breeding patterns of coastal fauna", it does not address potential impacts to non-breeding fauna, which would include the majority of migratory wading birds utilising the salt fields and surrounds. These migratory birds are not breeding, but seasonally feed and roost in the area. Disruption of migratory bird feeding patterns has the potential to compromise the return migration to northern hemisphere breeding grounds.

The proximity of this proposed major residential development to shorebird habitat of international significance is a key issue in the area.

7.1.1 Summary of proposals

Although each of the potential developments discussed in this report appear reasonably small, if all developments go ahead, a significant area of shorebird potential habitat would be altered. The total estimated areas of habitat involved amount to nearly 5000 ha (or 25%) of high tide habitat of some use to shorebirds. The values to shorebirds of these areas are provided in Table 8.

Although areas of very high habitat value appear to be directly impacted by few proposed developments, there are significant areas of high and medium value that could be directly impacted.

In addition to the directly impacted areas it is likely that there would be significant indirect impacts through changes in salina salinity/depth, and disturbance impacts including predation, higher visitation rates, increased traffic noise and more frequent pollution events.

Table 8 – Total areas directly impacted by proposed developments

Habitat value to shorebirds	Total direct impact area (ha)	% of mapped habitat value
Very high	1	<1%
High	228	6%
Medium	2418	49%
Lower	2040	27%
Insignificant	239	14%
Total	4922	16%

Map 018 in Appendix 3 displays the areas of habitat that could be impacted if all proposed developments were to eventuate.

While direct impacts from proposed developments on low tide habitat are very small, the indirect impacts could be large, as the alienation of large areas of high-tide habitat may force shorebirds away from the area. With no habitat available at high tide the birds may not be able to remain in the area to utilise the large and relatively undisturbed areas of low-tide habitat

Quantative determination of the abundance impacts to shorebird species of any proposed developments should be required prior to any development occurring. The analysis could consider the developments in isolation and in combination with other developments. The Shorebird 2020 project's count data and refined counting area mapping, when available, should helpfully inform such studies. The raw data from existing datasets for specific areas, held in the private domain (Day, 2004) may also assist in this regard.

7.2 Potential habitat loss – climate change

Global warming, whether anthropogenic or part of a larger natural cycle, will necessarily impact on sea levels. While thermal expansion will be a global phenomenon, its expression as sea level rise at any location will depend on the underlying geology as well as on the speed of change. The northern parts of the study area are undergoing isostatic rebound and apparent sea level in those areas may not be immediately affected. Further south, subsidence resulting from the exposure of coastal acid sulfate soils is already resulting in transgression of mangroves across salt marsh areas (Fotheringham & Coleman, 2008) and regular flooding of low-lying areas of Port Adelaide.

The Fourth Intergovernmental Panel on Climate Change (IPCC 2007) and more recent studies have confirmed that sea level is rising around the globe. Sea level records for southern Australia (including the SEAFRAME tide gauge at Port Stanvac) show sea levels over the last decade rising at or above the IPCC's projected rates for its "worst case" greenhouse gas emissions scenario. Currently the greatest uncertainty regarding future sea level rise relates to the contribution from the Greenland and West Antarctic ice sheets. As a result of this uncertainty the IPCC have recommended that their sea level rise projections should not be used by policy makers as an upper bound.

As well as the lack of understanding of the quantum of sea level rise, it remains to be seen whether sea level change will occur slowly or rapidly. In comparison to the long period of stable water levels over the last 6,000 years the change could be rapid, outpacing the ability of shorelines to accumulate sediment, leading to shoreline inundation and a large impact on coastal wetlands.

'Loss of habitat caused by anthropogenic emissions of greenhouse gases' has been declared a Key Threatening Process under the EPBC Act, and sea level rise may have a significant impact on extremely large areas of habitat. Deepening of areas that currently provide low-tide habitat is likely to be the

largest single impact. Other possible impacts include mangrove transgression across areas of high-tide habitat and a lack of retreat area for salt marsh are impacts that may affect most areas of value to shorebirds. Some areas of shorebird value that are protected by embankments with water levels that are artificially managed (the saltfield salinas, Mutton Cove and the stormwater wetlands) may continue to provide habitat. Areas where saltmarsh retreat is possible (the Little Para estuary, the River Light's delta and the northern sabkhas) may also provide valuable habitat. Whether the size of these areas is sufficient to replace areas of habitat loss is unknown.

8. Risk assessment

Qualitative assessment of risks for shorebirds and their known and potential habitat, resulting from proposed developments in the study area, is presented here following the process outlined in AS/NZS 4360.

In a qualitative risk assessment the risk associated with any particular event can be classified for comparative purposes using the following matrix:

			Likelihood of consequence				
			E	D	C	B	A
			Rare	Unlikely	Possible	Likely	Almost Certain
Severity of consequence	5	Insignificant	Low	Low	Low	Moderate	High
	4	Minor	Low	Low	Moderate	High	High
	3	Moderate	Moderate	Moderate	High	High	Extreme
	2	Major	High	High	Extreme	Extreme	Extreme
	1	Catastrophic	High	Extreme	Extreme	Extreme	Extreme

Figure 3 – Risk matrix

For this analysis, **Likelihood of consequence** is defined as:

- Almost certain - will occur, or is of a continuous nature, or the likelihood is unknown
- Likely - will probably occur
- Possible - could occur over a decade or so
- Unlikely - is not likely to occur in the average lifetime
- Rare - has never occurred but conceivably could

While **Severity of Consequences** are defined as:

- Insignificant - possible impacts but not easily noticed
- Minor - very local or temporary consequence
- Moderate - significant local or temporary changes, but can be rehabilitated, remediated or mitigated with difficulty at significant cost

- Major - substantial and widespread changes, only partially able to be rehabilitated or alleviated.
- Catastrophic – extreme, widespread permanent changes to natural environment (not able to be practically or significantly rehabilitated or alleviated)

In the analyses that follow, the risk of existing impacting events continuing and the risk of future impacting events occurring are assessed. It may be possible to reduce the likelihood of risks occurring, and risks that eventuate may be mitigated. If it is possible to take action to further reduce the likelihood of a risk eventuating or the severity of the consequences, it may be considered that the residual risk may be reduced, and this is reflected in the risk tables.

8.1 Assessment of specific risks

8.1.1 Turbidity

There is a risk that turbidity over the intertidal seagrass beds could continue, causing further seagrass death in the southern half of the study area leading to erosion of the beds themselves, deepening of the water offshore and leading to changes in sediment composition that may affect the range of invertebrate food species.

Research conducted as part of the *Adelaide Coastal Waters Study* identified nutrients from WWTPs and industry and sediments from stormwater as the causative factors (Fox *et al* 2007). These impacting factors are being addressed in the study area by the EPA's *Port Waterways Water Quality Improvement Plan* (WQIP) and several statutory environmental improvement plans (EIPs) under the Environment Protection Act that will see discharges from the major sources reduced. Modelling undertaken for the Port Waterways WQIP has identified the reductions necessary to reach a point where water quality impacts on seagrasses should become negligible, and these reductions formed the basis of those required in the EIPs. The *Adelaide Coastal Water Quality Improvement Plan* is currently under development by the EPA. It is anticipated that the current *Port Waterways WQIP* will be incorporated under this WQIP.

Stormwater capture and treatment is becoming more common in the study area and some Councils are requiring new housing subdivisions to treat stormwater to a higher level than past practice. Riparian and broad acre habitat restoration activities in the catchment, undertaken by community groups and agencies such as the Natural Resources Management Board and Department for Environment and Heritage's Urban Biodiversity Unit also have a role in reducing erosion and sediment migration. Over time such efforts should result in a reduction in sediment discharge to the intertidal zone.

It is not certain how long it may take for the effects of previous eutrophication to dissipate. There may be a period of some decades when occasional spring and summer microalgal blooms and seasonal stormwater turbidity events occur.

Table 9 – Risk assessment (turbidity)

Risk event	Risk prior to implementation of controls		Possible control or remediation methods	Residual risk if controls implemented		Residual level of risk
	Likelihood	Consequence		Likelihood	Consequence	
Turbidity over seagrass beds continues, causing further seagrass death in the southern half of the study area leading to erosion, deepening and changing sediment composition	C	3	Port Waterways WQIP Environment Protection Act Planning authority requirements for new subdivisions Stormwater capture & treatment Catchment management activities	D	4	Low

8.1.2 Sediment toxicity

The introduction of the *Environment Protection Act* in 1993 instituted a general environmental duty on individuals in South Australia. Since that time the discharge of toxic materials has been controlled to concentrations not known to produce environmental harm. Accidental discharges are dealt with by 'clean up orders' at the expense of the polluter.

As time passes, further clean sediment will accumulate, burying potentially contaminated layers of sediments further This should reduce the risk of their disturbance by meteorological or other events.

Table 10 – Risk assessment (sediment toxicity)

Risk event	Risk prior to implementation of controls		Possible control or remediation methods	Residual risk if controls implemented		Residual level of risk
	Likelihood	Consequence		Likelihood	Consequence	
Further deposits of toxic sediments continue to accumulate in sedimentary habitats of the Barker Inlet	C	4	Environment Protection Act	E	5	Low

8.1.3 Mangrove incursion

Mangrove incursion across the salt marshes of the southern area has slowed over the past decade (Fotheringham & Coleman 2008), presumably because no further reduction in soil surface elevations has occurred in the area since it was reflooded in the 1930's. There is potential for similar transgressions to occur in salt marsh areas that have been stranded by levees, if these are removed and no controls are placed to limit inundation. The stranded saltmarsh in Gillman is an area where there is potential for further mangrove transgression if no controls are incorporated into any change to the levee system.

A policy relating to the management of potential acid sulfate soils has been developed by the Coast Protection Board, and the draft Estuary Strategy includes recommendations relating to developments that alter tidal hydrology of estuarine and salt marsh areas. These should reduce the risk of changes that would encourage landward migration of mangroves.

Mangrove incursion could become a widespread impact in the event of significant and rapid sea-level change. Whether this would have an impact on the area of high-tide habitat available for shorebirds would depend on whether sufficient areas for salt marsh retreat were available.

Table 11 – Risk assessment (mangrove incursion)

Risk event	Risk prior to implementation of controls		Possible control or remediation methods	Residual risk if controls implemented		Residual level of risk
	Likelihood	Consequence		Likelihood	Consequence	
Further mangrove incursion across the salt marshes of the southern area	B	4	Development of salt marsh retreat zones to provide mitigation Implementation of Estuary Strategy to prevent hydrological changes to coastal wetland habitats Implementation of Coast Protection Board Policy on Coastal Acid Sulfate Soils Controlled reflooding of stranded salt marshes	C	5	Low

8.1.4 Exotic pests

The eventual impact of recent introductions of exotic marine pests is not yet understood. In the study area, one of two introduced *Caulerpa* species has established on some areas of shallow tidal flats and may be locally changing the invertebrate composition of the substrate. Flinders Ports has developed ballast water guidelines to minimise the introduction of further marine pests, but these do not address pests that may be brought into port by small recreational

vessels. Rice grass (Spartina spp) is a recognised threat to shorebird habitat, however the known occurrence of this plant at Port Gawler has been eradicated.

There is a relatively low probability that migrating shorebirds will spread diseases such as avian influenza into resident populations of shorebirds. The strain that has been found in migratory birds in Qinghai is virulent and sick birds are unlikely to survive the long migration.

Coastal wading birds are unlikely to come into contact with birds maintained at commercial poultry enterprises. Good biosecurity includes maintaining physical barriers, such as screens to prevent wild birds mingling with production birds, treating water for birds where it is drawn from dams and rivers, ensuring the integrity of feed supplies and good hygiene for people handling birds. (Murray 2006).

Despite the low probability, the Australian Quarantine Inspection Service has been trapping migrating shorebirds along Australia's northern coast to establish whether the populations are carrying avian influenza.

Table 12 – Risk assessment (exotic pests)

Risk event	Risk prior to implementation of controls		Possible control or remediation methods	Residual risk if controls implemented		Residual level of risk
	Likelihood	Consequence		Likelihood	Consequence	
Exotic marine pests	B	3	Ballast water provisions of Flinders Ports *Port Rules* Implement an educational campaign about marine pests, targeting recreational boat owners AQIS migratory bird trapping program	D	4	Low

8.1.5 Competition

Direct competition in the form of bait digging and brine shrimp poaching has a localised impact, in terms of the populations of the target & by-catch species. Most benthic invertebrates are widespread in appropriate habitat, reproduce rapidly and will move from populous into unpopulated areas. That said, bait digging also creates disturbance of shorebirds as it takes place at low tide when the birds are actively feeding. Protective zoning or activity restrictions are a relatively simple approach to controlling this impact.

Poaching swimming invertebrates such as brine & fairy shrimp can occur during the day-time or night-time. Swimming invertebrates are not distributed evenly through water bodies – they occur in patches. In the former case poachers look for 'boils' of the target species and net these areas. This is the same technique used by the birds, who harvest 'boils' because the energy required per prey

species caught is smaller than it would be if the prey were wider spread. At night, poachers use lights to attract the target species to the nets. In both cases the numbers of invertebrates remaining can fall below the numbers required to allow shorebirds to hunt efficiently. Improved fencing of the salinas may reduce poaching.

Table 13 – Risk assessment (competition)

Risk event	Risk prior to implementation of controls		Possible control or remediation methods	Residual risk if controls implemented		Residual level of risk
	Likelihood	Consequence		Likelihood	Consequence	
Direct competition	B	4	Protective zoning of northern feeding & roosting areas under Marine Parks Act Bait digging restrictions in Aquatic Reserves Improved access control to the salinas	C	5	Low

8.1.6 Disturbance

Disturbed shorebirds do not manage to consume the same quantity of food per hour as undisturbed birds. Birds that are poorly fed and rested are more likely to die during migration, or to arrive at the breeding grounds in poor condition and not attract a mate, or to have poor mating outcomes.

Disturbance comes in an incredible variety of guises and as such no one approach will address all forms. Activity-based disturbance (eg bait digging, off-road vehicle use, horse riding, walking & dog exercising on tidal flats and beaches) may be addressed by activity and zoning restrictions in Marine Parks and Aquatic Reserves. Outside protected areas, disturbance may be minimised by considering the approach taken in other states, where vehicles are banned on all state beaches with exceptions. This is a reversal of the current South Australian approach which permits vehicles on all beaches, with exceptions. Public education regarding shorebird disturbance may pave the way for such a policy change.

Development occurring in close proximity to shorebird feeding and roosting grounds may increase noise levels and trigger more 'peripheral vision' movement alarms in groups of shorebirds. Additionally, even though a development may not occur on the actual site used by shorebirds, occupiers of the developments will utilise areas outside the development, increasing direct disturbance in nearby shorebirds areas. Such 'spill over' increases in disturbance may be prevented by only approving appropriate developments, careful siting of new developments, incorporating habitat buffer zones, restricting coastal access to a few nodes, and designing open space landscaping to 'deflect' people away from areas of use to shorebirds.

Lower level disturbance (and some predation) results from high feral fox numbers. This disturbance can be reduced by control of foxes on land adjacent to shorebird high tide roosting sites. However there have been issues for agencies due to an inability to obtain indemnity for baiting programs from some land managers, and baiting for foxes is problematic in urban areas.

It is not possible, in an area as extensive as the study area with multiple landowners to completely remove the risk of disturbing events. However, it would appear possible to reduce the risk (and consequent impacts) to a lower level than currently.

Table 14 – Risk assessment (disturbance)

Risk event	Risk prior to implementation of controls		Possible control or remediation methods	Residual risk if controls implemented		Residual level of risk
	Likelihood	Consequence		Likelihood	Consequence	
Disturbance	A	3	Educational program to raise public consciousness Protective zoning of northern feeding & roosting areas under MP Act Activity restrictions in Aquatic Reserves Change vehicles on beach policy from permitted with exception to banned with exception Planning Strategy & development plans could incorporate habitat buffers between feeding/roosting areas and new developments Implement fox control Dog and Cat Management Act 1995	C	4	Mod

8.1.7 Habitat loss

Habitat loss may occur in the two main areas of shorebird habitat – low-tide habitat and high-tide habitat.

Within the study area high tide habitats appear the most subject to immediate threats from development pressure, although longer term threats from sea-level change may also impact these habitats. Besides the impacts of the loss of high tide habitat per se, a reduction in roosting areas will reduce the number of birds able to utilise the low-tide habitats – essentially wasting this remaining resource by making it inaccessible.

Appropriate zoning of coastal wetland habitats to prevent habitat loss through development could be addressed through the new state planning strategies and development plan for Greater Adelaide.

The southernmost portion of the study area, within the Cities of Port Adelaide Enfield and Salisbury, is exempt from the operation of the *Native Vegetation Act*. The native vegetation of the remainder of the study area is protected under the Act. Developments assessed in these areas must be referred to the Native Vegetation Council. If approval for clearance is given, habitat offsets are required.

Table 15 – Risk assessment (habitat loss)

Risk event	Risk prior to implementation of controls		Possible control or remediation methods	Residual risk if controls implemented		Residual level of risk
	Likelihood	Consequence		Likelihood	Consequence	
Continued high-tide habitat loss as a result of development pressure &/or sea-level change	A	3	Native Vegetation Act EPBC Act Planning Strategy & development plans Development of salt marsh retreat zones to provide mitigation	D	4	Low
Loss of low-tide habitat as a result of sea-level change	A	2	Development of significant salt marsh retreat zones to provide mitigation Implementation of Estuary Strategy to prevent hydrological changes to coastal wetland habitats Implementation of Coast Protection Board Policy on Coastal Acid Sulfate Soils Creation of salina and stormwater treatment wetland habitats Controlled reflooding of stranded salt marshes	C	4	Mod

Those parts of the study area with shorebird values of international and national value would trigger the EPBC Act in the event of development proposals. Similarly some parts of the study area that are not recognised for their international or national shorebird values, but that have some value for shorebirds, may support other species of national importance (for example the fan samphire, *Tecticornia flabelliformis*).

Very limited areas of low-tide could be impacted by the development of marina access channels in the study area. While there is always potential for land reclamation, policies including the CPB's *Coastal Acid Sulfate Soils Policy* and the draft *Estuary Strategy* should make these unlikely. Over the longer term,

loss of low-tide habitat is a possible result of sea-level change, although the extent and time frame are unknown. For risk assessment, this lack of knowledge means the likelihood has to be assessed as high.

Mitigation for sea-level rise could include allocating areas for salt marsh retreat and the controlled reflooding of stranded areas of salt marsh such as those at Gillman.

8.2 Risk summary

With no mitigation or risk controls the following present an extreme level of risk to the shorebird use of the study area - disturbance, loss of high tide habitat to development and potential loss of low-tide habitat to sea level change.

If all possible mitigation approaches are implemented, disturbance remains a moderate risk in the immediate term while loss of low-tide habitat remains a moderate risk in the longer term.

9. Legislative and management background

9.1 Who is responsible?

Management and conservation of shorebirds and shorebird sites in Australia occurs at international, national, state and local scales.

9.1.1 International agreements

Australia has signed agreements to protect shorebird habitat with China, Japan and the Republic of Korea. The Commonwealth is also a signatory to the *Convention on Migratory Species* (Bonn) and the *Convention on Wetlands* (Ramsar). In partnership with countries along the East Asian Flyway and a private conservation organisation (Wetlands International), Australia played a part in developing the East Asian-Australasian Shorebird Site Network. This was a network of sites of international importance to shorebirds. In nominating a site the owner/manager undertook to maintain the shorebird values as part of the integrated management of the site, however the Network listing had no legal implications on land tenure or management. Only 16 Australian sites were listed in the Network up to 2006.

Since that time, extensive population and site studies by Bamford *et al* (2008) have identified 397 sites of international importance to shorebirds along the East Asian-Australasian Flyway, of which 118 sites are within Australia. This approach is more robust, from a wildlife conservation perspective, than self-

nomination. However it does not address the management needs of the identified sites, which are addressed at a National, State and local level.

9.1.2 National legislation and other instruments

The EPBC Act and its dependent Wildlife Conservation Plans (WCP) are the statutory instruments by which the Commonwealth ensures Australia's international obligations are met. The Commonwealth must take all reasonable steps to implement actions detailed in the WCP for Migratory Shorebirds.

The Commonwealth, through its agencies, is implementing WCP actions that meet Objective 1 (increase international co-operation). The provision of funding through Caring for Country to a consortium made up of Birds Australia, the Wader Studies Group and the World Wildlife Fund has enabled the establishment of the Shorebirds 2020 program that is undertaking some of the actions to meet Objective 2 (identify, protect and manage habitat), Objective 3 (Increase biological knowledge of shorebird ecology) and Objective 4 (raise awareness of migratory shorebirds). Additional funding support from the AMLRNRM Board is allowing regional survey, community outreach and management investigation components of the Shorebirds 2020 project to be undertaken in more detail. Further funding may be available to assist State agencies, local government and community groups to undertake region-specific actions derived from the plan.

9.1.3 State measures

Under the *Heads of Agreement on Commonwealth and State Roles and Responsibilities for the Environment* (COAG 1997) those species listed under the EPBC Act are protected co-operatively under State legislation. In South Australia the legislation providing specific protection is the *National Parks and Wildlife Act 1972*. In South Australia, state agencies (including NRM Boards) are the lead agencies in undertaking on-ground management of shorebirds in their jurisdiction and in providing community education programs and incentives for sustainable natural resources management on private land.

In order to manage habitat more effectively, State governments list all nationally important wetlands in the Directory of Important Wetlands (Environment Australia 2001). This national directory provides a database of wetland values that agencies and planning authorities may refer to when developing State and regional planning strategies, assessing development applications, or when developing management plans for specific wetland sites.

9.1.4 Site protection at a local level

Local Government has a key land management role through its planning powers and its involvement in on-ground projects. As well as regulating land use, local government may also influence community behaviour through the development and implementation of biodiversity planning and management activities. These

latter activities may be conducted in cooperation with NRM Boards through the NRM Coast, Estuary and Marine Officers that are hosted by local governments.

Local communities, including private landholders and community organisations protect important migratory shorebird habitat by undertaking on-ground works, developing site-specific management plans and utilising protective covenants.

The Regional NRM Plan identifies and resources a range of actions relevant to local implementation of the WCP for Migratory Shorebirds and local actions to conserve and protect beach-nesting birds.

9.2 Development

Management of development in the study area is a joint responsibility between Local, State and Commonwealth authorities. Smaller development (90%) is approved by the local planning authority (local Council), while larger or more complex developments are assessed by the State, and matters of national importance or development on Commonwealth land may be assessed by State planning authorities with input from the Commonwealth, or by the Commonwealth respectively.

Should a development be considered to comply with the current zoning of the area, or be a minor development, it would be assessed by the local Council. Such developments will normally require Provisional Development Plan consent, and if building is involved, Provisional Building Rules consent. The Council may refer applications to certain State bodies that have the right to provide advice, to direct development conditions, or in some cases direct refusal of the application. Within the study area, the bodies most likely to receive referrals include the Environment Protection Authority, the Adelaide Dolphin Sanctuary, the Coast Protection Board and the Native Vegetation Council.

Water affecting activities (including certain activities on floodplains and levees) may require a permit under the *Natural Resources Management Act 2004* through the NRM Board.

Proposed developments that do not comply with current zoning are considered to be ‘merit’ applications and will need the approval of both the Local Council the State’s Development Assessment Commission.

While the process above may trigger some protective actions for shorebird habitat directly impacted by a proposed development, the approvals process has little scope for assessing issues such as complying or merit applications that may increase disturbance levels to neighbouring shorebird areas. Or that reduce access to freshwater sources, thus reducing the value of neighbouring low-tide feeding habitat. Such concerns may really only be addressed through the Major Developments process.

Complex or economically significant developments may fall under the State planning processes (Planning SA, 1999). If a development is deemed to be a Major Development by the Minister it would require an Environmental Impact Study (for complex issues), a Public Environment Report (for single or less

complex issues) or a Development Report (when only planning related issues such as zoning are to be addressed). What constitutes a Major Development is determined by the Minister.

The decision on what level of study or reporting is necessary is made by the Development Assessment Commission (DAC) after circulating an Issues Paper to a wide range of State agencies. This process brings potential issues to the fore and the DAC then issues the developer with Guidelines that outline the questions to be answered and the level of report/study that is required. Major Developments are assessed by the Development Assessment Commission.

Where development is proposed for areas of significant shorebird habitat value (at a national or international level) the provisions of the Commonwealth EPBC Act should be triggered. In this case the developers will usually be required to conduct an Environmental Impact Study (EIS) under Commonwealth guidelines that will assess the magnitude of any impacts and propose measures to address those impacts.

It is probable that such a level of development oversight would only be afforded to the two sites of international importance listed by Bamford *et al* (2008). These two sites are the Cheetham Dry Creek Saltfields and an area from Port Wakefield to Webb Beach. The extent of these two sites was not available for this discussion paper.

It is less likely, but still possible, that Watkins' (1993) four sites of national importance could trigger the provisions of the EPBC Act. In this case the area subject to the more stringent oversight provided by an EIS would include the two sites listed by Bamford *et al* (2008), any remaining area of the Cheetham Dry Creek Saltfields not captured in Bamford's definition of the site, as well as an area in the north between Great Sandy Point & Port Parham, an area in the south at the Port River Mouth and an area around Port Prime. As with the internationally important sites, the exact extent of these sites is unknown.

Regardless of its utility to shorebirds, all land owned by the Commonwealth within the study area is subject to the provisions of the EPBC Act and development of any Commonwealth-owned sites requires an EIS and Commonwealth approval.

The benefits of undertaking a comprehensive EIS for developments that directly affect shorebird habitat, or that occur directly adjacent to shorebird habitat in the study area, include the ability to examine indirect impacts such as

- loss of high-tide roosting habitat impacting on the usability of the low-tide feeding habitats
- loss of usable freshwater sources impacting on the usability of the low-tide feeding habitats
- disturbance effects

10. Possible conservation and management actions

Australia has played an important role in international cooperation to conserve migratory birds in the East Asian – Australasian Flyway, with a significant achievement being the Shorebird Site Network, developed in collaboration with Wetlands International and other countries in the Flyway. The research and volunteer programs that have been carried out have provided a strong baseline of information on migratory shorebirds throughout Australia and the Flyway.

The aim of this section is to identify a range of possible actions that would contribute to the long term conservation and management of significant shorebird habitat within the study area.

In order to meet Australia's obligations under the international arrangements and provide for conservation of migratory shorebirds, migratory shorebirds are afforded protection by Commonwealth, State/Territory and Local Governments.

The EPBC Act provides protection for migratory birds through two main vehicles;

- Proclaiming that migratory species are a matter of national environmental significance, and
- Providing for the development and implementation of a Wildlife Conservation Plan for Migratory Shorebirds, which is a statutory instrument.

The National Heritage Trust (NHT) invested $2.5 million in Migratory Shorebird Conservation over the past eight years. Projects included population count and colour flagging programs over several decades and the Shorebird Conservation Project, currently being undertaken by a consortium of non-government organisations across Australia and coordinated by WWF Australia. This latter project is engaging communities in conservation activities at priority sites for migratory shorebirds.

Recent changes have seen the NHT replaced by the Caring for our Country program. Actions need to be inline with the Caring for Our Country targets to obtain funding through this program.

10.1 Getting involved in existing action plans

The simplest method for protecting shorebird habitat, with the lowest overhead cost is to get involved in implementation of existing action plans. Unfortunately existing plans and programs rarely address area-specific threats, so participating in existing state or national plans is best combined with area specific works.

10.1.1 Wildlife Conservation Plan for Migratory Shorebirds

Actions identified in the Wildlife Conservation Plan for Migratory Shorebirds (under the EPBC Act) that are appropriate to be undertaken at a local level, or with assistance from local and regional bodies include;

- Action 2.5: Identify threats to important habitat and develop conservation measures for managing them.
- Action 2.7 [Part]: Develop appropriate management arrangements for important sites.
- Actions 2.10 & 2.11 [Part]: Nominate critical areas of shorebird habitat within the region as wetlands of international importance to migratory waterbirds, Ramsar sites, in the Directory of Important Wetlands in Australia, or for inclusion in Protected Areas, where appropriate.
- Action 2.12 [Part]: Include migratory shorebirds and their habitat in environment protection arrangements at Local and State levels to avoid significant impacts on migratory shorebird populations.
- Action 4.1: Promote public and community education and conservation awareness, through strategic programs and education products.

These actions may benefit significantly from State, Regional or Local participation or leadership, as it is difficult to undertake value and threat assessment without extensive on-site assessment. State, Regional and Local governments also have a range of management tools that are not available at a National level.

Provision of this document to Commonwealth agencies may encourage joint participation and feedback into many of the higher level nation-wide actions documented within the Wildlife Conservation Plan.

10.1.2 Caring for Our Country program

Actions to conserve shorebirds suggested within this discussion paper are more likely to obtain funding from the Caring for Our Country program if they relate to the program targets. Targets of interest to shorebird protection include;

- To increase by at least 400 000 hectares, over the next two years, the area of native habitat and vegetation that is managed to reduce critical threats to biodiversity and enhance the condition, connectivity and resilience of habitats and landscapes in priority regions.
- To address the threats posed by invasive plant and animal species to the environmental values of high priority non-Ramsar high conservation value aquatic ecosystems, over the next two years.
- To address the threats affecting the environmental values of coastal hotspots over the next two years, such as declining or poor water quality,

disturbance of acid sulfate soils or ecosystem disturbance leading to habitat loss and biodiversity decline.

- To engage at least 500 community organisations in coastal rehabilitation, restoration and conservation projects over the next two years.

10.2 Key conservation & remedial needs

A range of key conservation and remedial actions are required if the identified risks to shorebirds and their habitat are to be reduced. The greatest risks are the ongoing and increasing disturbances to habitat that reduce the feeding benefits offered to shorebirds from feeding habitat within the study area, along with incremental, continued habitat loss that will reduce high tide feeding and refuge areas and may thereby reduce the accessibility of the low-tide feeding grounds.

To assist discussion within the NRM Board, between government agencies, with key landholders and in the public arena, the following dot-points highlight a range of actions that could be undertaken to enhance current or future shorebird use of moderate to high value shorebird habitats in the Adelaide & Mt Lofty Ranges NRM Board's northern region.

The actions provided here for discussion are divided into sub-sections and are cross-referenced, where possible, to actions within the Wildlife Conservation Plan for Migratory Shorebirds (see Appendix 6).

10.2.1 Legislative and policy changes

- Implement protective covenants for shorebird habitat on government land within the study area (Action 2.7, 2.12)

- Create decisive policy on redistribution of state lands when leases are relinquished within shorebird habitat areas (Action 2.7).

- Prepare a regional shorebird habitat management plan, following the *Guidelines for Management Planning*, and *Community-based Management Planning Brief* developed by the Shorebirds 2020 program, which documents threats and tabulates agreed conservation measures (Action 2.7).

- Develop appropriate management arrangements for shorebird habitats of medium or higher habitat value (Action 2.7).

- Nominate medium to very high value shorebird habitat for recognition or protection under international, national, state and regional policies or plans, where appropriate (Action 2.12).

- Encourage Local Councils and Planning Authorities to regulate land use where shorebird habitat exists (Action 2.5, 2.7).

- Include maximization of shorebird habitat value as an approval condition for all major developments within the study area (Action 2.7).

- Liaise with Local and State government bodies to identify and implement other protection measures to avoid significant impacts on migratory shorebird populations. Some of the existing strategies and plans where implementation may have positive impacts for shorebirds include the *Port Waterways Water Quality improvement Plan*, Flinders Ports' *Port Rules*, the *Adelaide Dolphin Sanctuary Management Plan*, the draft *Estuary Strategy*, the CPB's *Coastal Acid Sulfate Soils Policy* and the District Council of Mallala draft *Samphire Coast Strategy*. Plans currently under development that could provide further avenues for protecting shorebirds and their habitats include the planning process for the Upper Gulf St Vincent Marine Park boundaries and zones, the new 30-year *Plan for Greater Adelaide* and the *City of Salisbury Biodiversity Corridors Management Plan*. Additional areas for discussion could include the need to review the 'vehicles on beaches' policy (Action 2.5, 2.7).

- Seek listing of moderate to very high value shorebird habitat within the study area as Caring for Our Country High Conservation Value Aquatic Ecosystems (HCVAE), Wetlands of International Importance under the Ramsar Convention on Wetlands, Flyway Partnership sites, or for inclusion in protected areas such as conservation reserves or protected zones within marine parks (Action 2.10, 2.11).

10.2.2 Community education and capacity building

- Increase landholder awareness of shorebird habitat issues with a regular newsletter, educational flyers and media releases (Action 4.1).

- Assist landholders identify, protect (by covenant or otherwise) and enhance shorebird habitat on their properties (Action 2.5, 2.7, 2.12)

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10.2.3 On-ground works

- Coordinate fox control measures within a buffer zone around areas of moderate to very high shorebird habitat value (Action 2.7).

- Limit disturbance in areas of moderate to very high shorebird habitat, potentially by restricting visitors or controlling noise during the months that shorebirds are present (Action 2.7).

- Restrict harvesting of shorebird food sources within areas of shorebird habitat value (Action 2.7).

- Develop extensive storm water treatment wetlands in the near-coastal zone for the catchments of the Helps Road drain, Smith & Adams Creeks, and Gawler River and in the Gillman area (Action 2.7).

- Assist in the development of access controls to areas of high-tide feeding and roosting habitat

10.2.4 Climate change precautions

- Protect existing samphire retreat zones using planning or other measures and provide additional, adequate, area for samphire retreat (Action 2.5, 2.7)

- Open or partially-open tidal crossings restricting tidal flows in stranded salt marshes (Action 2.7).

- Where development is approved in near coastal areas and allowance for floodwater escape to the sea is required, allow additional width for the flood escape routes, over that required to handle the 1:100 year ARI flood event, to provide area for shorebird habitat and a path for landward migration of salt marshes (Action 2.7).

11. References

All documents used in the discussion paper are included here. They include, but are not limited to, published reference works, published and unpublished flora and fauna observation datasets, development strategies, development plan amendments, major development concept plans and wildlife management plans and strategies.

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12. Appendices

A1 - Consultation

Name	Organisation	Interest
George Levay	City of Port Adelaide Enfield	Local government
Verity Sanders	City of Port Adelaide Enfield	Local government
Phil Jones	Land Management Corporation	Landholder
Jason Rollison	Land Management Corporation	Landholder
Harry Pitrans	City of Salisbury	Local government
Dameon Roy	City of Salisbury	Local government
Frank Kurylowicz	City of Salisbury	Local government
Peter Gatsios	Delfin	Developer
John Petrov	Cheetham Salt Limited	Mining/Landholder
Chris Purnell	Birds Australia, The Australasian Wader Studies Group (AWSG), WWF-Australia & the Natural Heritage Trust	Shorebird 2020 project
Sharon Mitchell	Defense Support Unit	Landholder
Heather Campbell	Cheetham Salt Limited	Mining/Landholder
Stephen Butler	Ridley Corporation	Mining/Landholder
John Tillack	District Council of Mallala	Local government
Henri Mueller	District Council of Mallala	Local government
Mac Crabb	Camberwarra Pty Ltd	Mining
Karen Rouse	SA Water	Landholder
Harry Roberts	SA Water	Landholder
Lisa Porrovecchio	Clay & Mineral Sales Pty Ltd	Mining
Rychard Oleszczyk	AGL Torrens Is Power Station	Landholder
Leanne Burch	DEH	Natural and cultural heritage policy
Doug Fotheringham	DEH	Coastal management
Wendy Stubbs	DEH	Biodiversity conservation
David Turner	DEH	Regional conservator
Rob Laver	DEH	Adelaide Dolphin Sanctuary
Andrew Grear	Planning SA	Strategic planning
Matthew Lang	Planning SA	Open space planning
Paul Johnson	City of Playford	Local government

Invitations to meet or correspond were provided to all of the above stakeholders.

A2 - Summary of stakeholder discussions

Not all stakeholders responded to the invitation to meet or correspond. Summaries of discussions or correspondence were provided to respondents for approval prior to being incorporated into the following appendix.

City of Port Adelaide Enfield

The City has relatively small areas of shorebird habitat within its boundaries, much of that being undeveloped land belonging to the Land Management Corporation (LMC). The Council has care and control of several stormwater treatment wetlands that are formally owned as freehold by the LMC. There are large areas of valuable shorebird habitat just outside the City boundaries, on Torrens Island and Section Bank.

Stormwater treatment wetlands envisaged in the Northern LeFevre Peninsula Industry and Open Space Development Plan Amendment (Minister for Urban Development and Planning, 2008) were mentioned as providing some useful, if small, habitat areas. The stormwater treatment wetlands at Barker Inlet are likely to undergo some alterations as a result of the construction of the Northern Expressway, but the City is unaware of the final alignment of this road.

Flood studies (King & Jacobi 2008, Ruan Consulting 2006) have been undertaken for much of the City and it is envisaged that wetland systems may be incorporated to manage the interface between tidal and storm waters.

SA Water

The treatment plant at Bolivar is frequented more by waterbirds than by shorebirds, however it does provide a useful fresh water resource in summer, particularly for small shorebirds using the shallow hypersaline salt ponds to the west of the treatment plant. Agency staff provided bird counts, counts of invertebrates in their treatment ponds and a consultant's report (Paton, 2001), to demonstrate the biodiversity value of the ponds. Paton noted that most shorebirds tend to use the drains and adjacent swampy areas surrounding the sewage treatment ponds themselves. It is likely that birds that harvest swimming invertebrates in deeper waters, including banded stilts, use the shallower treatment ponds as a food source.

While the agency sees no likelihood of any change in the location of their operations for the foreseeable future, they are concerned that development is gradually moving closer towards their operations. It is possible that if development encroached too close, they may eventually be forced to relocate.

Land Management Corporation (LMC)

The LMC is responsible for managing government land assets including, where appropriate, the development or redevelopment of underutilised or vacant land including Gillman/Dry Creek. They have prepared a draft structure plan for this area (see mapping attached in Appendix 3) which includes a large area of open space to be managed for stormwater or intertidal wetlands, as the site receives

runoff from extensive areas of Adelaide (Ruan Consulting, 2006). While the area of habitat involved is relatively small, it includes habitat that is used for high tide feeding when the tidal flats are submerged, and maintaining these areas in a form of habitat suitable for shorebird use will be beneficial.

Cheetham Salt Limited

Discussion centred on possible changes to the current usage of Cheetham's mining lease land. Cheetham indicated that it was investigating the possibility of expanding the capacity of the operation from around 650,000 tonnes to 900,000 tonnes per annum. This could be achieved by constructing additional crystalliser area at Dry Creek and establishing additional ponds further north. Cheetham is also in discussion with DTEI regarding possible impact of Northern Connector on the harvesting operation. If DTEI reclaim a portion of the Dry Creek harvesting operation land then expansion of the field to 900,000 tonnes annual production would require crystallisers to be built near Light Beach. The company discussed the options of leaving things as they are, or relocating their operational footprint as a result of pressures on the southern portion their operations. This could involve selling the land south of Dry Creek for housing and road/rail infrastructure, while extending northward into their undeveloped leases. The have provided a concept plan (see Appendix 3) for the latter option. They are aware of habitat values that prevent them utilising some of their leases in the River Light's delta. They were interested in the habitat values mapping and have said that they would be willing to discuss the design and management of any new or rearranged ponds to maintain habitat values for shorebird use.

City of Salisbury (CoS)

CoS are currently undertaking a strategic planning exercise that covers land west of Port Wakefield Road. They have recognised that there are matters of biodiversity conservation in these areas, particularly in regards to shorebirds, shorebird habitat and the possible impacts of relative sea-level rise. The planning exercise is in its very early stages at present. As a result the City would expect that references to this area, in the Shorebird Discussion Paper, would be necessarily very 'broad-brush'.

The City is looking at developing a digital elevation model of sufficient resolution to assist them in understanding possible habitat migration. They feel further work in relation to climate change and sea-level rise is required and would be interested in a joint approach (with neighbouring councils, the NRM Board and state agencies) to funding a graduate research position to research this matter further and inform future land use policy.

Other strategic work the City has undertaken includes the Salisbury Sustainable Futures: Salisbury City Plan 2020 and its dependent Salisbury Environmental and Climate Change Strategy: Sustaining Our Environment. One of the strategy's objectives is to conserve and promote biodiversity, natural habitats and open spaces within the City. As a result the Council has developed a draft City of Salisbury Biodiversity Corridors Management Plan (CoS, 2009) that aims to provide connected habitat through the City and to restore habitat for specific faunal requirements. Many of the habitats favoured by shorebirds are included in four of the CoS 'corridors' – the Mangroves Corridor and the estuarine ends of each of the Dry Creek, Helps Road Drain and Little Para corridors.

District Council of Mallala (DCM)

DCM identified management problems in the shorebird habitat areas of their Council area. The immediate threats they identified were off-road vehicle use in the sabkhas and beach nesting areas, and feral animal control (foxes). They suggested the ongoing management of these issues is a large imposition on a small Council. Currently the Council has several roads temporarily blocked to prevent inappropriate activities. Light Beach Road is one of these and the temporary blocking will be reviewed by Council in December 2010. Prior to that time the Council will be looking for feedback from ornithologists and others as to whether the blockage of the road had any beneficial effects.

The Council has requested that Department for Environment and Heritage extend the proposed outer boundary of the Upper Gulf St Vincent Marine Park (Baker 2004, DEH 2004, 2008, 2009) to include all the coast of the DCM and would prefer that the Park's landward boundary include near-coastal Crown Lands.

Starting with Priest's (2002) work, the Council has supported biodiversity studies and subsequent biodiversity planning for the near-coastal area, and has produced a draft Samphire Coast Conservation Strategy (DCM, 2003) that has a strong shorebird habitat focus. They have also developed management plans for coastal reserves under their control (Coleman & Eden 2005, Jensen 2003). The Council will be hosting a Coastal, Estuary and Marine officer jointly with the Cities of Playford and Salisbury and the Adelaide and Mt Lofty Ranges NRM Board.

DCM has no plans for major developments on the coast, preferring to maintain the existing nodal approach to developments. However there is some speculation regarding the development of a marina, either at Middle Beach or at Port Gawler. Council has noted (through newspapers) that the Cheetham Dry Creek Saltfields may be relocating some of its salinas. Cheetham has extensive leases in the near-coastal portions of the district and Council raised the need for habitat retreat zones for salt marsh communities, adequacy of flood 'gaps' to allow the River Light to reach the sea, and concerns relating to offset requirements for areas of habitat alienated by salina development.

Department for Environment and Heritage (DEH)

DEH manage the Crown Lands in the study area and conservation reserves including Port Gawler and Torrens Island. The agency also recently approached DTEI about placing land newly emerged from the sea (Section Bank) under DEH's care. Although DTEI responded favourably to this proposal they advised contacting Flinders Ports as some of the land is within the Port Agreement zone. Flinders Ports when approached indicated that they could not support formal conservation protection. DEH have yet to approach them about their support for informal management of the area. The matter is still being considered. Currently the land does not have a cadastral boundary, although this is not strictly necessary for a conservation reserve as a tidal boundary around a central polygon can be accommodated. This would allow the boundary to 'migrate' with the island. Section Bank is an important shorebird and waterbird feeding, roosting and nesting area, and current threats include foxes and people accessing the island with their dogs.

After reviewing the habitat mapping, agency representatives discussed the fate of Crown Lands currently under mining lease, in the event that any leases were ever to be relinquished. They identified that there are no existing policies that could determine whether developed mining areas having a specific habitat value would be considered to be of more value to the State as habitat or as potential development sites.

DEH have several management plans for reserves and sanctuaries within the boundary of this discussion paper (Cook & Coleman 2003, NPWS 1983, DEH 2008a). They have developed strategies to manage near-coastal habitat including a wetland strategy (DEH 2003) and a draft estuary policy with supporting information packages (DEH 2005, 2007, 2007a). The department is currently developing a representative system of marine protected areas, including one that is located in the northern portion of the study area (Baker 2004, DEH 2009, 2008, 2004).

City of Playford (CoP)

CoP has no master plan covering the study area. The Council has stated that as the Department of Planning and Local Government's Planning Strategy is currently being revised through the production of a 30 year plan for Adelaide, they are unclear what changes this may include and will need to look at their own strategies when the State Plan is finalised.

Planning SA

Planning SA is currently undertaking the Better Development Plans process but does not believe there will be any major changes to zoning in the coastal regions of the State, including those within the study area.

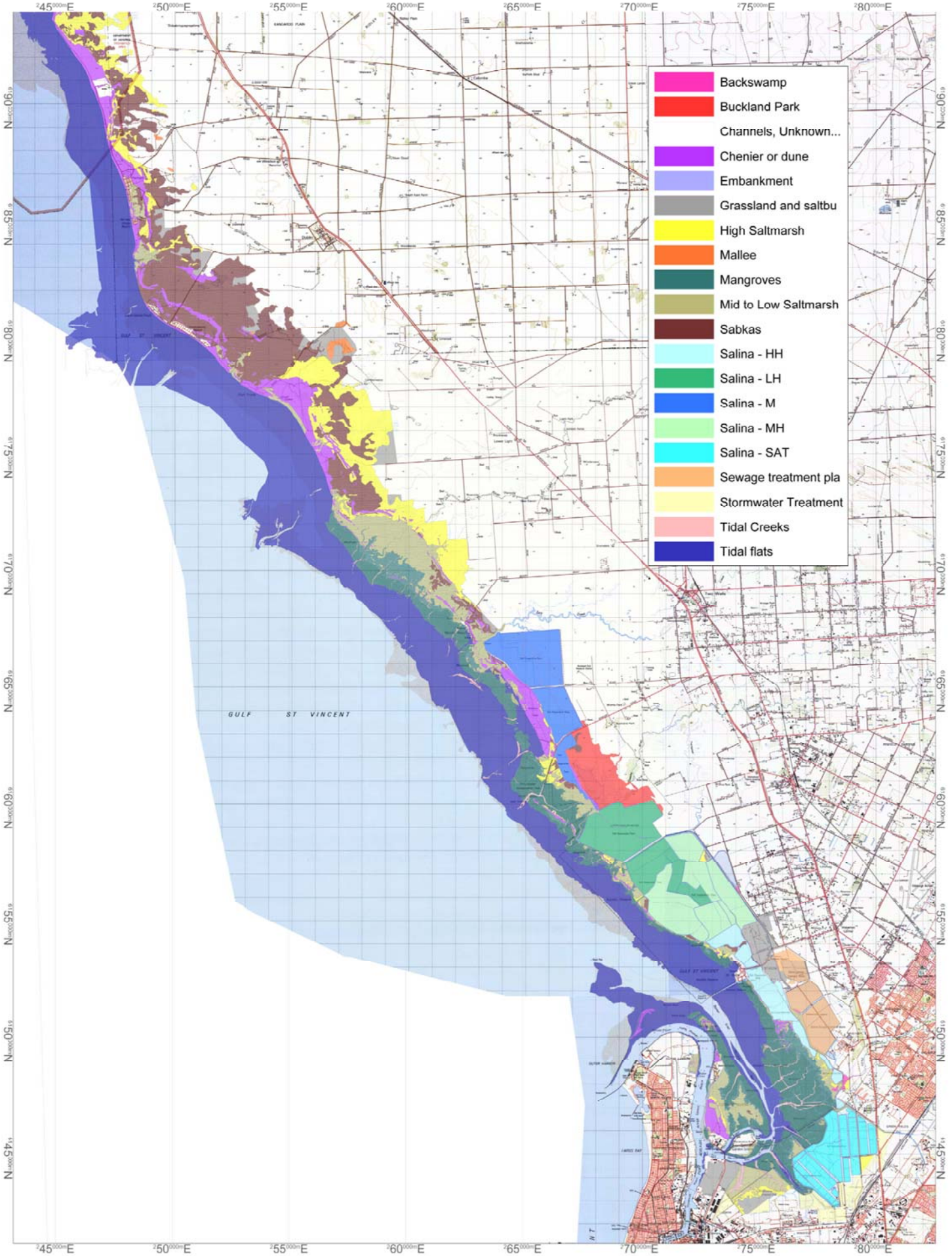
They are aware of high habitat values throughout the near-coastal zone and have explored whether some additional freehold land may be purchased by the Department for Environment and Heritage to increase open space adjacent to the proposed Buckland Park township.

They have heard speculation that the Coast Park project could be extended around Barker Inlet to connect to a linear track along the Gawler River. However they have not seen any formal proposals. At present they are aware that such a proposal would not be consistent with the mining tenure of much of the land such a route would traverse. Should the Crown Land currently under mining tenure ever be relinquished, they would support a northern extension to the Coast Park, albeit in a style more consistent with the undeveloped nature of these semi-wilderness habitats.

Delfin

Email correspondence was received from Delfin describing their proposed residential development at Dry Creek on land currently used for salt production. They suggested that development of the area would result in 80Ha of new wetlands, 98Ha of land returned to samphire/mangroves, 120Ha of internal water body and 17Ha of district open space. The remaining land would comprise roads and developed areas.

A3 - Maps



Habitat types, Barker Inlet to Middle Spit
AMLR NRM Board Shorebird Discussion Paper

Drawing: AML-SDC-001
Author: Delta Environmental Consulting (ABN 59 167 105 261). Generated from a variety of source materials.
Datum: The map datum is GDA94. Positional accuracy of this map is +/ 20m to +/ 50m. Spatial resolution is 0.05 1ha.
Data: The "habitat" classifications presented here represent combined vegetative/geomorphic classes, rather than purely vegetation associations. Tables containing flora and fauna records for each habitat accompany this map.

Delta Environmental Consulting

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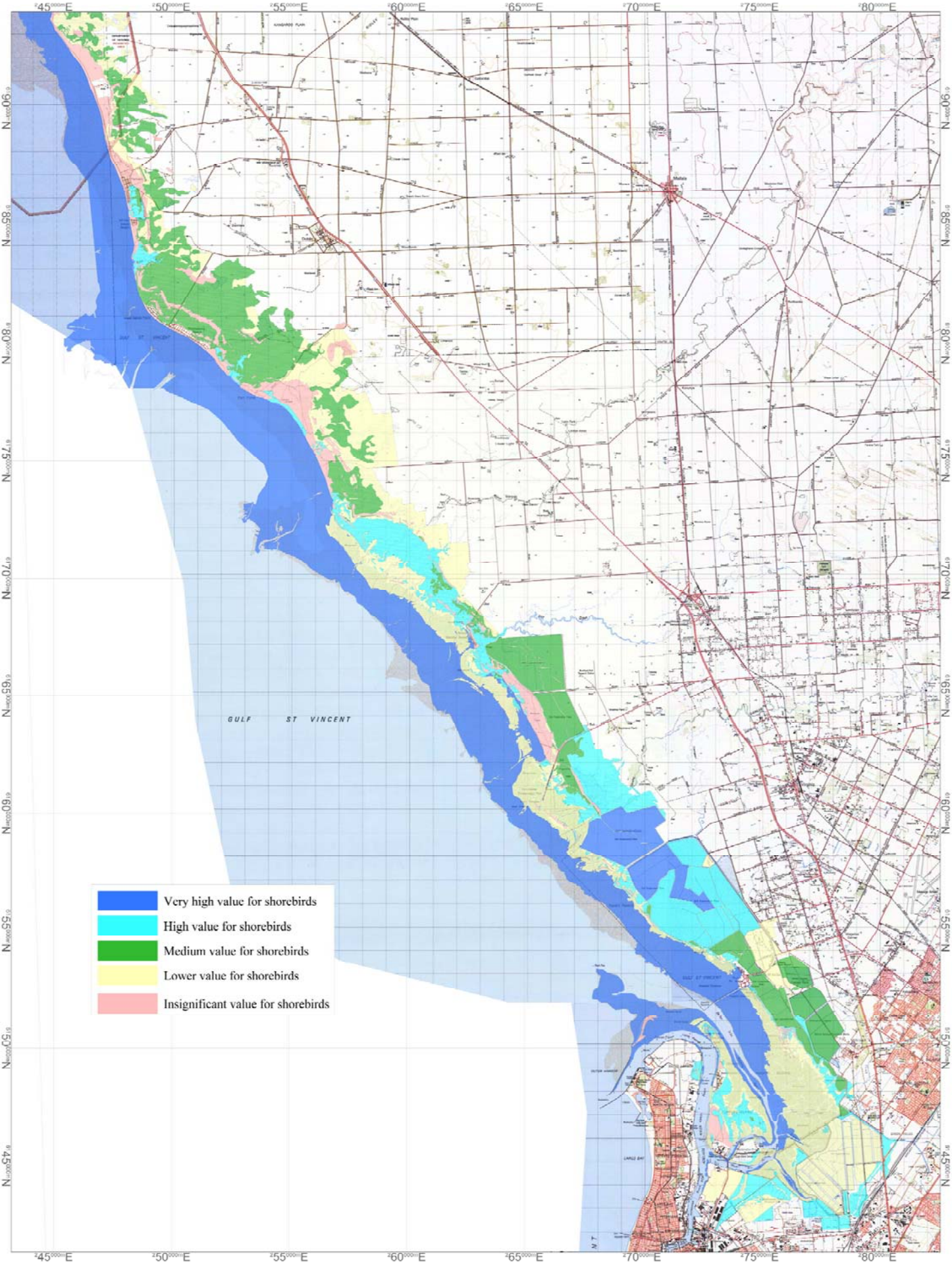


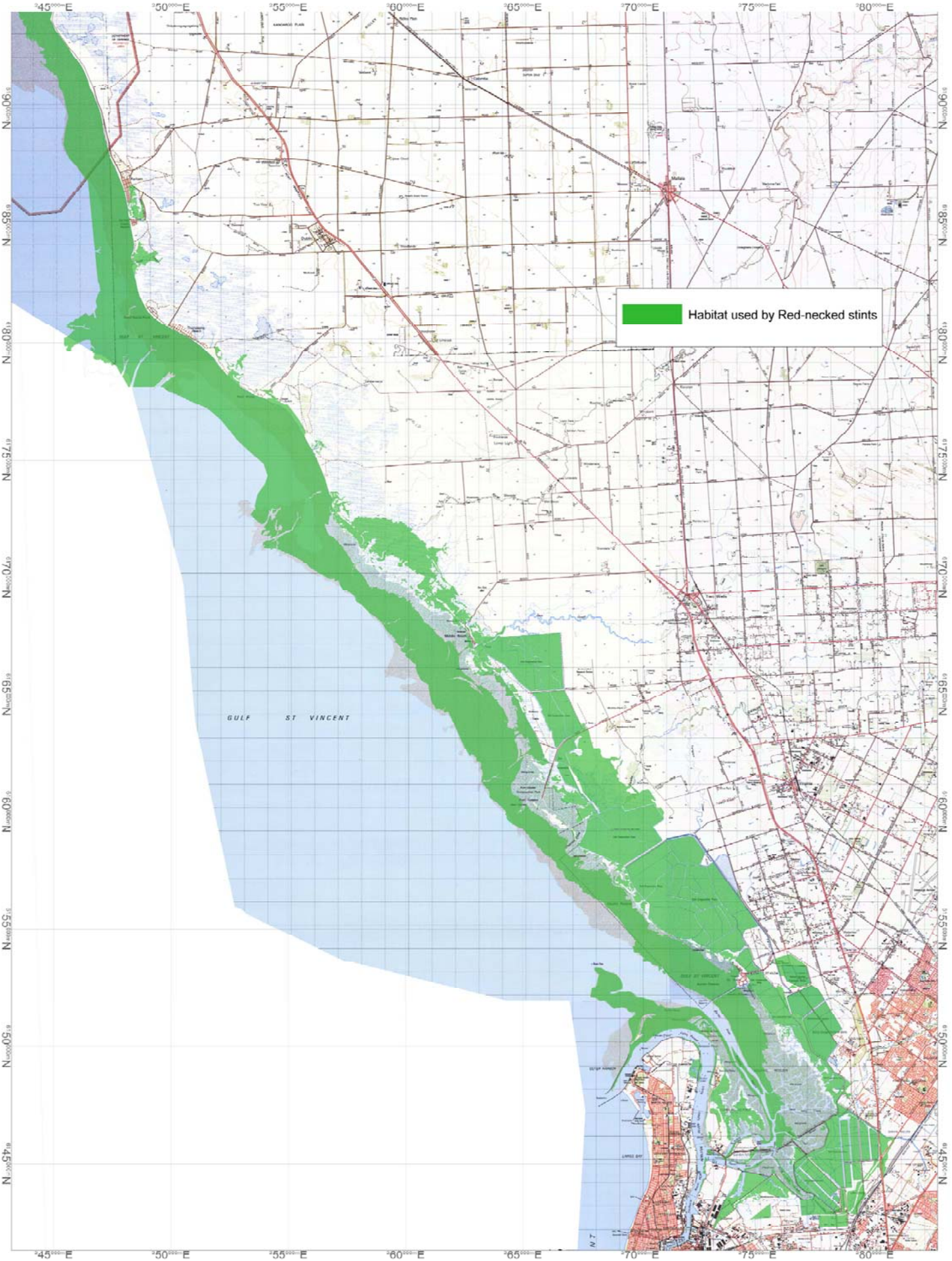
Habitat of Value to Shorebirds, Barker Inlet to Middle Spit
AMLR NRM Board Shorebird Discussion Paper

Drawing: AML-SDC-002
Author: Delta Environmental Consulting (ABN 59 167 105 261). Generated from a variety of source materials
Datum: The map datum is GDA94. Positional accuracy of this map is +/-20m to +/-50m. Spatial resolution is 0.05-1ha
Data: The "value" classifications are diversity values based on the number of different shorebird species displaying a preference for each habitat.

Delta Environmental Consulting

Sites of International Importance for Shorebirds (Bamford et al, 2008)

Drawing AML-SDC-003



Red-necked stint habitats, Barker Inlet to Middle Spit
AMLR NRM Board Shorebird Discussion Paper

Drawing: AML-SDC-004
Author: Delta Environmental Consulting (ABN 59 167 105 261). Generated from a variety of source materials
Datum: The map datum is GDA94. Positional accuracy of this map is +/-20m to +/-50m. Spatial resolution is 0.05-1ha.
Data: The "habitat" classifications presented here represent combined vegetative/geomorphic classes, rather than purely vegetation associations. Tables containing flora and fauna records for each habitat accompany this map.
The data and map are owned by Delta Environmental Consulting.

Delta Environmental Consulting

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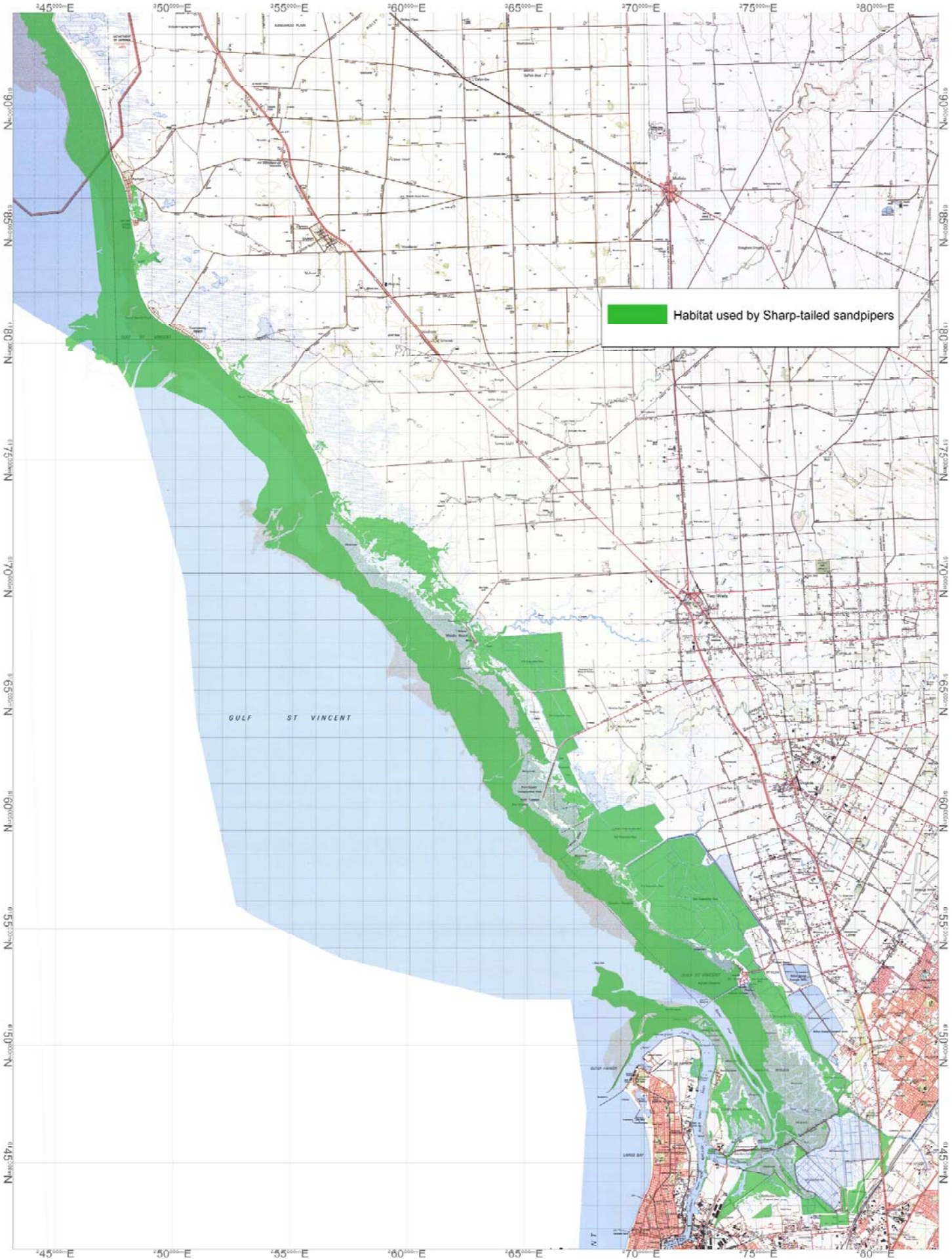


Sharp-tailed sandpiper habitats, Barker Inlet to Middle Spit
AMLR NRM Board Shorebird Discussion Paper

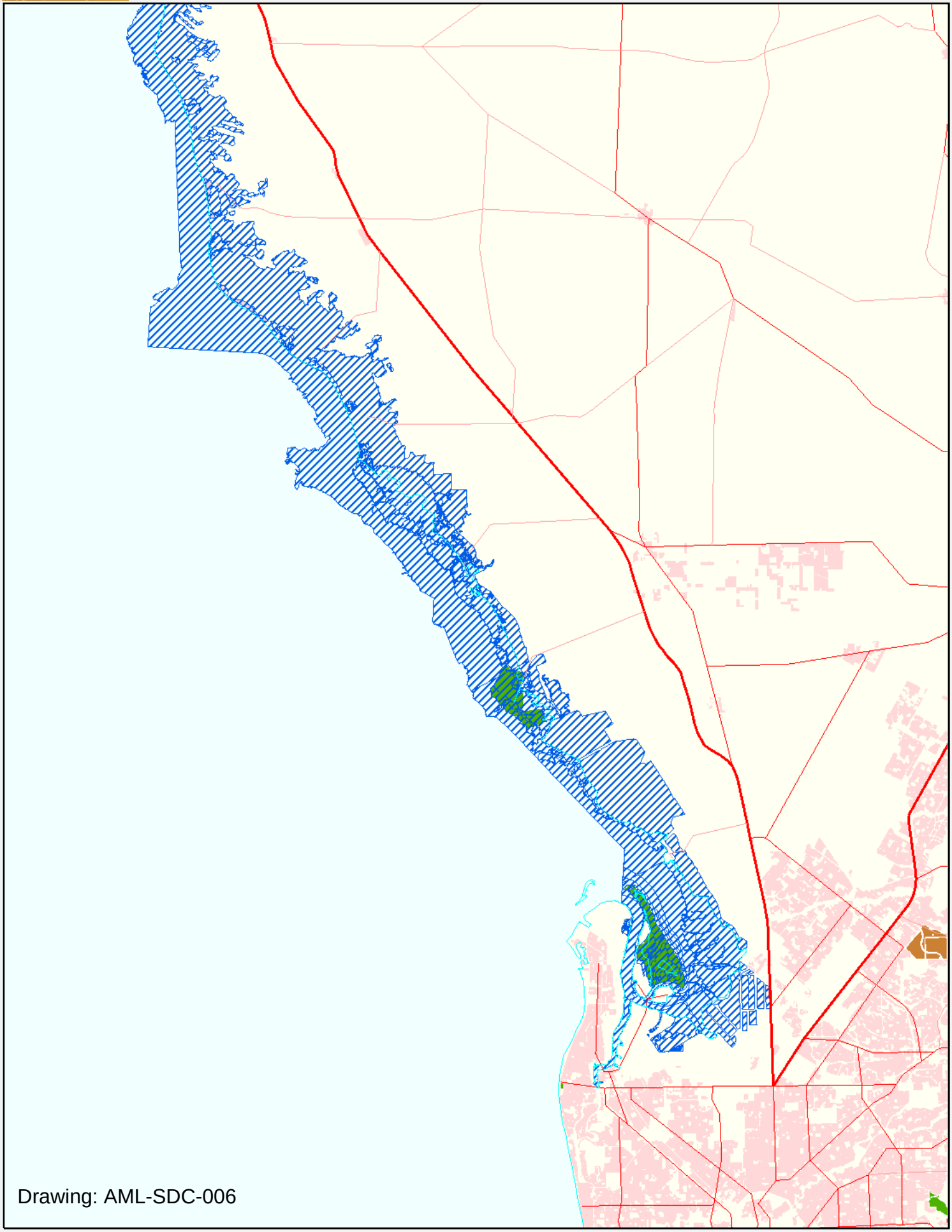
Drawing: AML-SDC-005
Author: Delta Environmental Consulting (ABN 59 167 105 261). Generated from a variety of source materials
Datum: The map datum is GDA94. Positional accuracy of this map is +/-20m to +/-50m. Spatial resolution is 0.05-1ha.
Data: The "habitat" classifications presented here represent combined vegetative/geomorphic classes, rather than purely vegetation associations. Tables containing flora and fauna records for each habitat accompany this map.
The data and map are owned by Delta Environmental Consulting.

Delta Environmental Consulting

NatureMaps

Wetlands of National Importance

Produced: 11 May 2009



Drawing: AML-SDC-006

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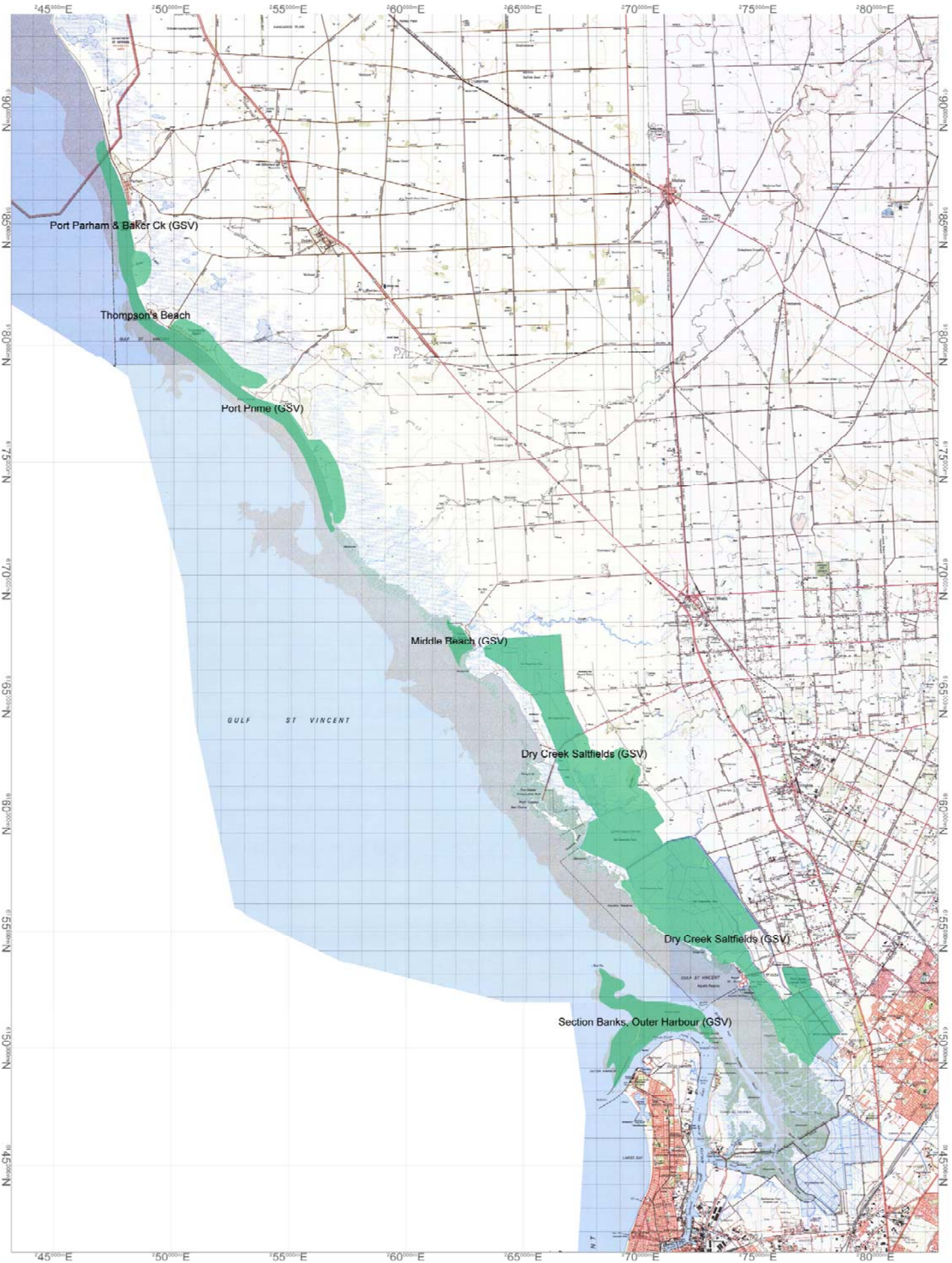
Projection: Lambert Conformal Conic
Datum: Geocentric Datum of Australia, 1994

Government of South Australia
Department for Environment and Heritage



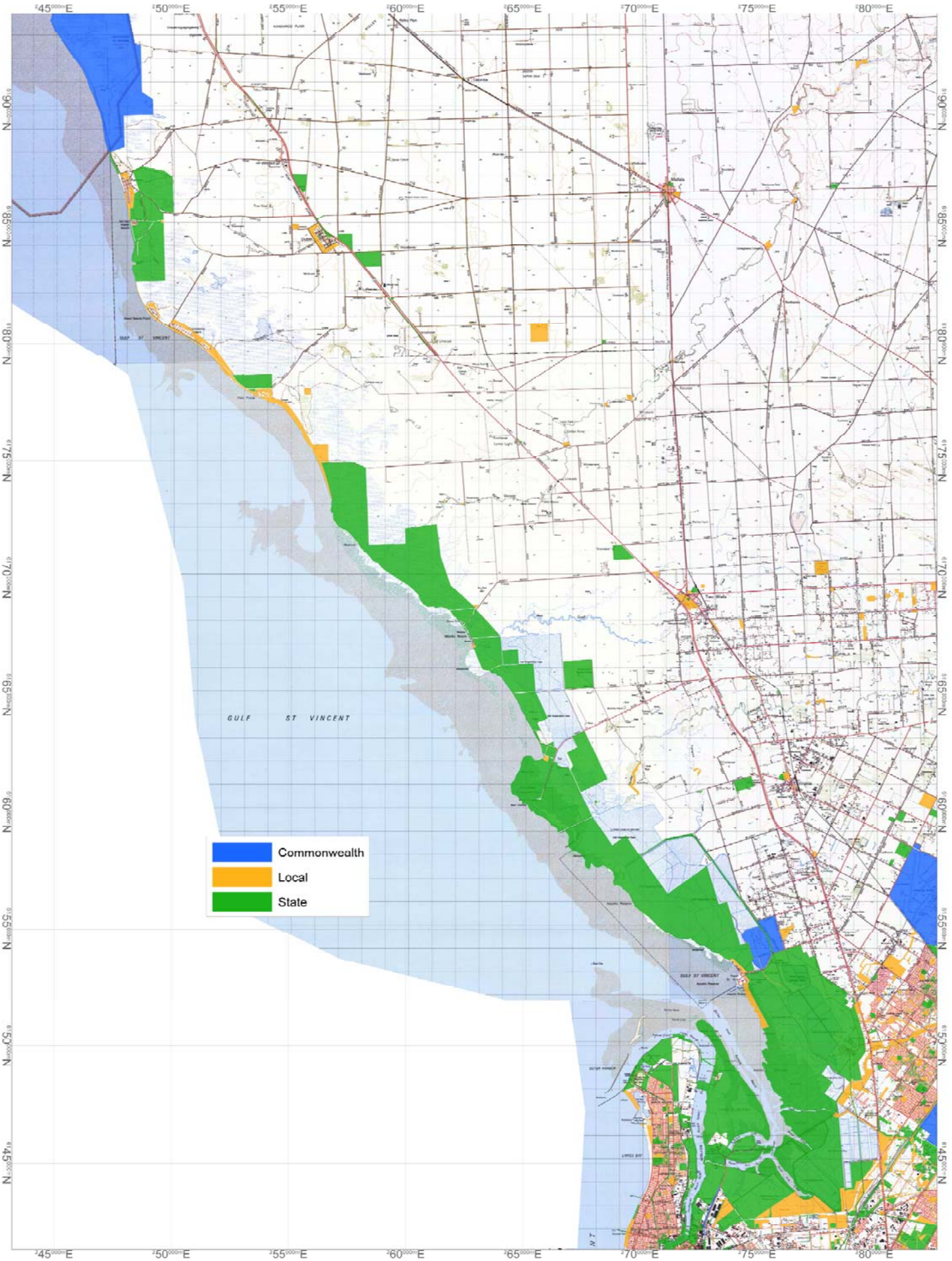
Shorebird 2020 count areas, Barker Inlet to Middle Spit
AMLR NRM Board Shorebird Discussion Paper

Drawing: AML-SDC-007
Author: Delta Environmental Consulting (ABN 59 167 105 261). Generated from a variety of source materials, including Birds Australia & GeoScience Australia.
Datum: The map datum is GDA94. Positional accuracy of this map is +/-20m to +/-50m. Spatial resolution is 0.05-1ha.
Data: The map was produced by Delta Environmental Consulting.

Delta Environmental Consulting

Shorebird 2020 feed & roost areas, Barker Inlet to Middle Spit
AMLR NRM Board Shorebird Discussion Paper

Drawing: AML-SDC-008
Author: Delta Environmental Consulting (ABN 59 167 105 261). Generated from a variety of source materials, including GeoScience Australia and Birds Australia.
Datum: The map datum is GDA94. Positional accuracy of this map is +/-20m to +/-50m. Spatial resolution is 0.05-1ha.
Data: The map was produced by Delta Environmental Consulting and free use is permitted with acknowlegement



Government owned lands, Barker Inlet to Middle Spit
AMLR NRM Board Shorebird Discussion Paper

Drawing: AML-SDC-009
Author: Delta Environmental Consulting (ABN 59 167 105 261). Generated from a variety of source materials
Datum: The map datum is GDA94. Positional accuracy of this map is +/-20m to +/-50m. Spatial resolution is 0.05-1ha
Data: Data sources include GeoScience Australia and Planning SA. The map was produced by Delta Environmental Consulting. Free use is permitted, with appropriate acknowledgement.

Delta Environmental Consulting

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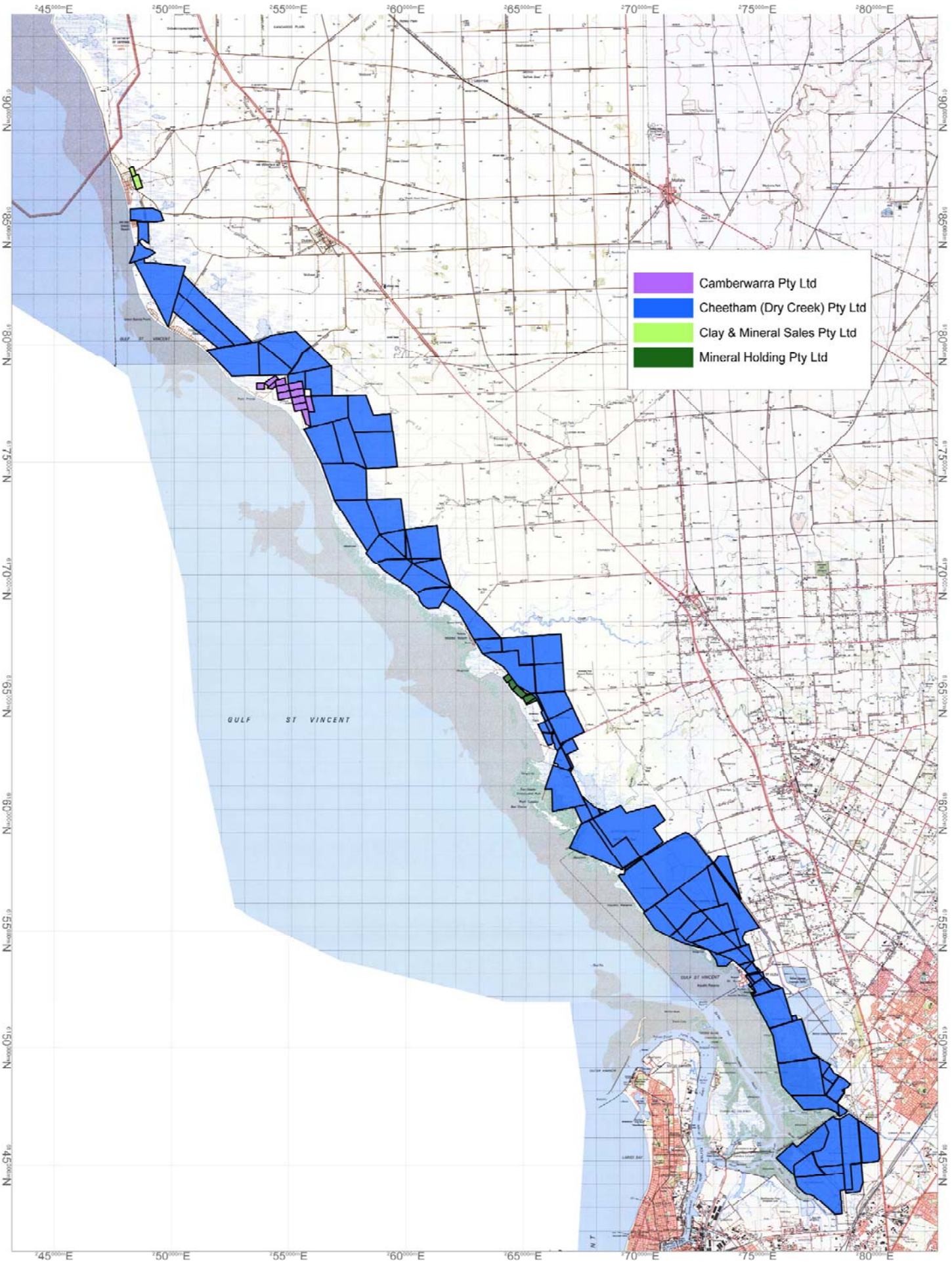
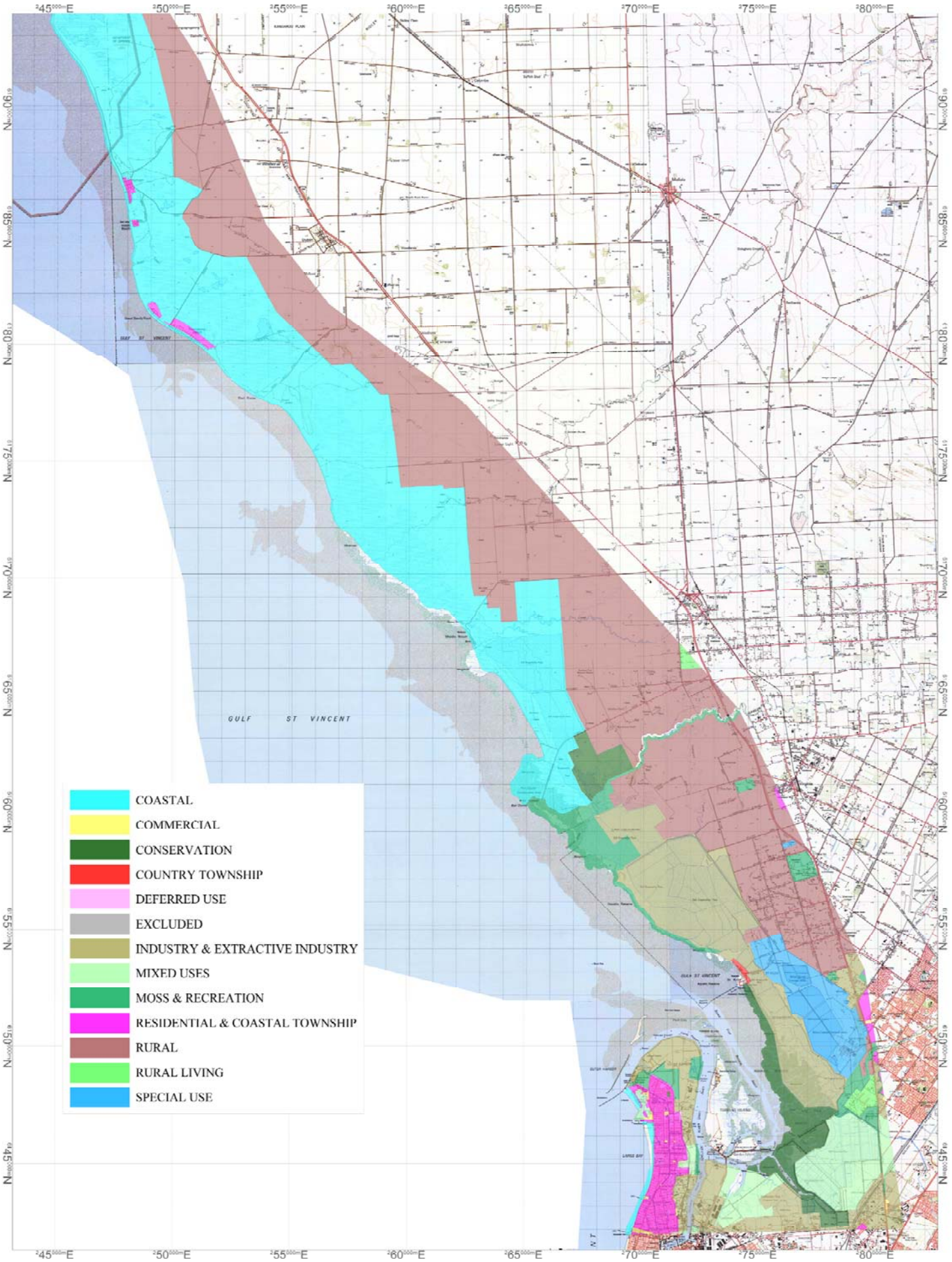


Mining Leases, Barker Inlet to Middle Spit
AMLR NRM Board Shorebird Discussion Paper

Drawing: AML-SDC-010
Author: Delta Environmental Consulting (ABN 59 167 105 261). Generated from a variety of source materials
Datum: The map datum is GDA94. Positional accuracy of this map is +/-20m to +/-50m. Spatial resolution is 0.05-1ha.
Data: The "habitat" classifications presented here represent combined vegetative/geomorphic classes, rather than purely vegetation associations. Tables containing flora and fauna records for each habitat accompany this map. The data and map are owned by Delta Environmental Consulting.

Delta Environmental Consulting



Generalised near-coastal planning zones, Barker Inlet to Middle Spit
AMLR NRM Board Shorebird Discussion Paper

Drawing: AML-SDC-011
Author: Delta Environmental Consulting (ABN 59 167 105 261). Generated from a variety of source materials
Datum: The map datum is GDA94. Positional accuracy of this map is +/-20m to +/-50m. Spatial resolution is 0.05-1ha.
Data: Data sources include GeoScience Australia and Planning SA. The map was produced by Delta Environmental Consulting. Free use is permitted, with appropriate acknowledgement.

Delta Environmental Consulting

Northern Lefevre Peninsula Masterplan

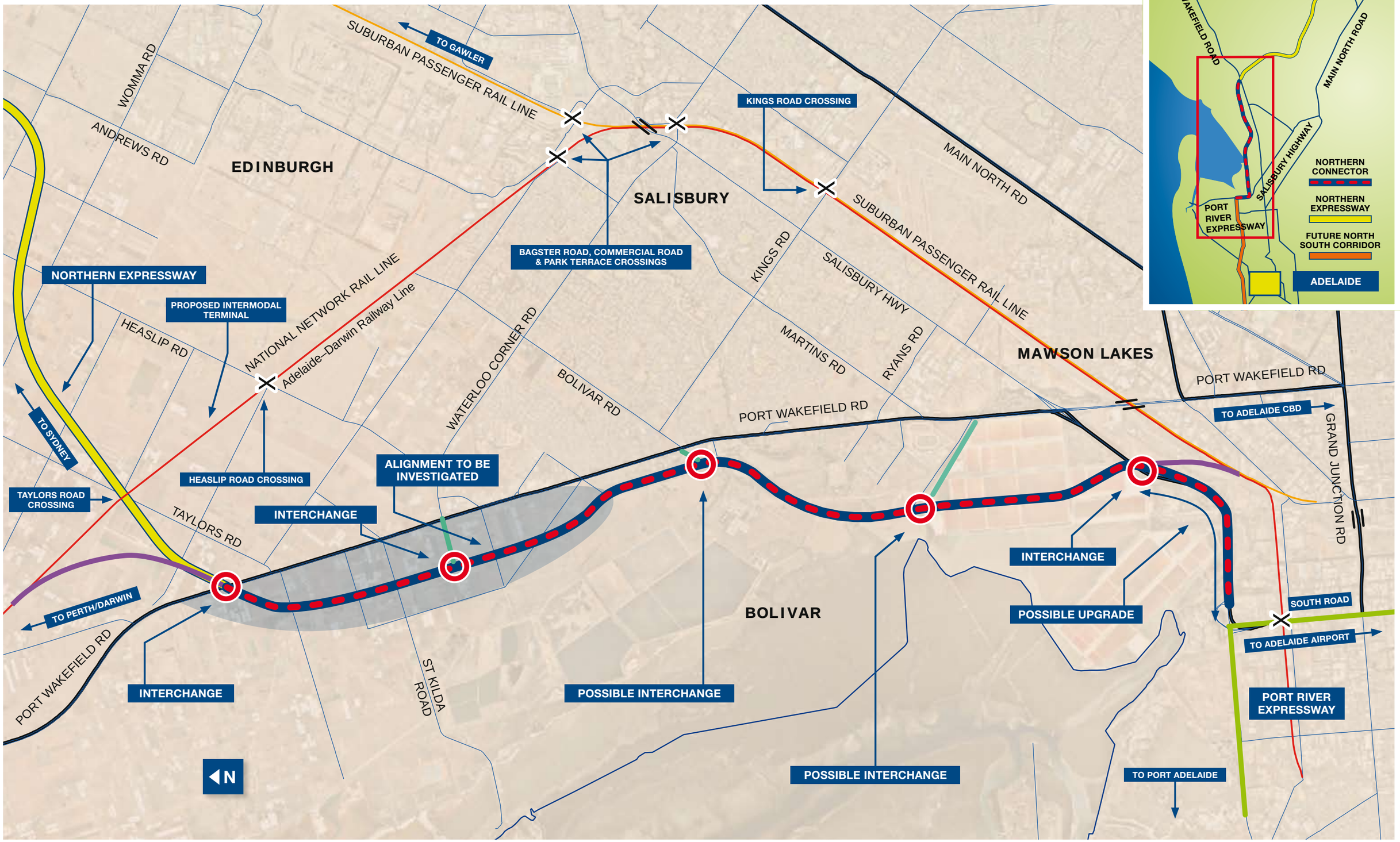
Drawing AMP-SDC-012

Pink - Area to be developed
Green - Existing stormwater treatment wetlands
Blue - Future stormwater

Proposed commercial/industrial developments at Gillman

Drawing AML-SDC-013

NEW NORTHERN CONNECTOR PROPOSED ROUTE



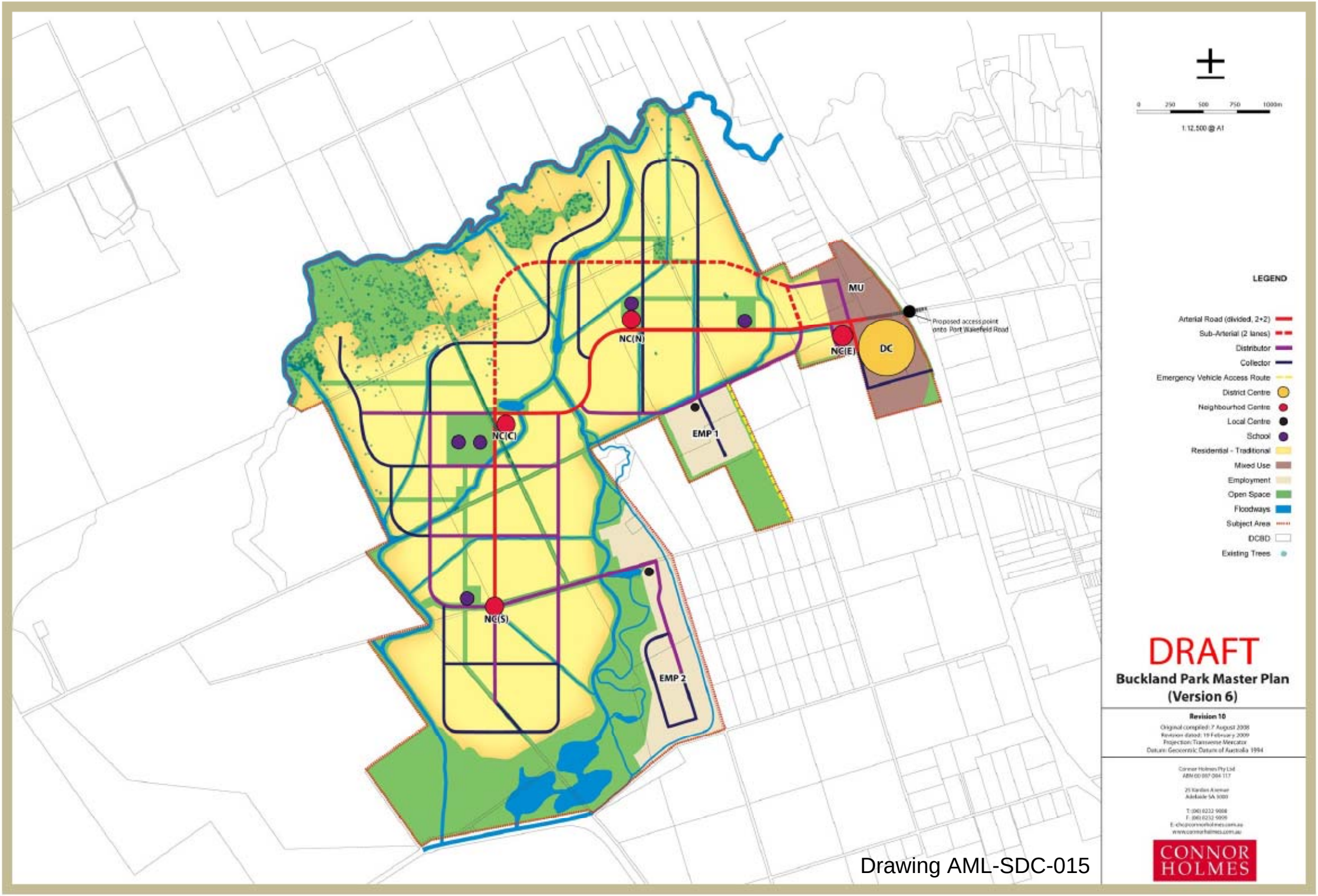
LEGEND

- PROPOSED NEW NORTHERN ACCESS ROAD/RAIL LINK
- NORTHERN EXPRESSWAY
- PROPOSED INTERCHANGE
- NATIONAL NETWORK ROAD
- SUBURBAN PASSENGER RAIL
- PROPOSED NATIONAL NETWORK RAIL
- NATIONAL NETWORK RAIL
- POSSIBLE CONNECTOR ROADS
- EXISTING LEVEL CROSSING
- EXISTING UNDERPASS/ OVERPASS

0 500 1,000 2,000 Metres

1:50,000

Drawing AML-SDC-014



Drawing AML-SDC-015

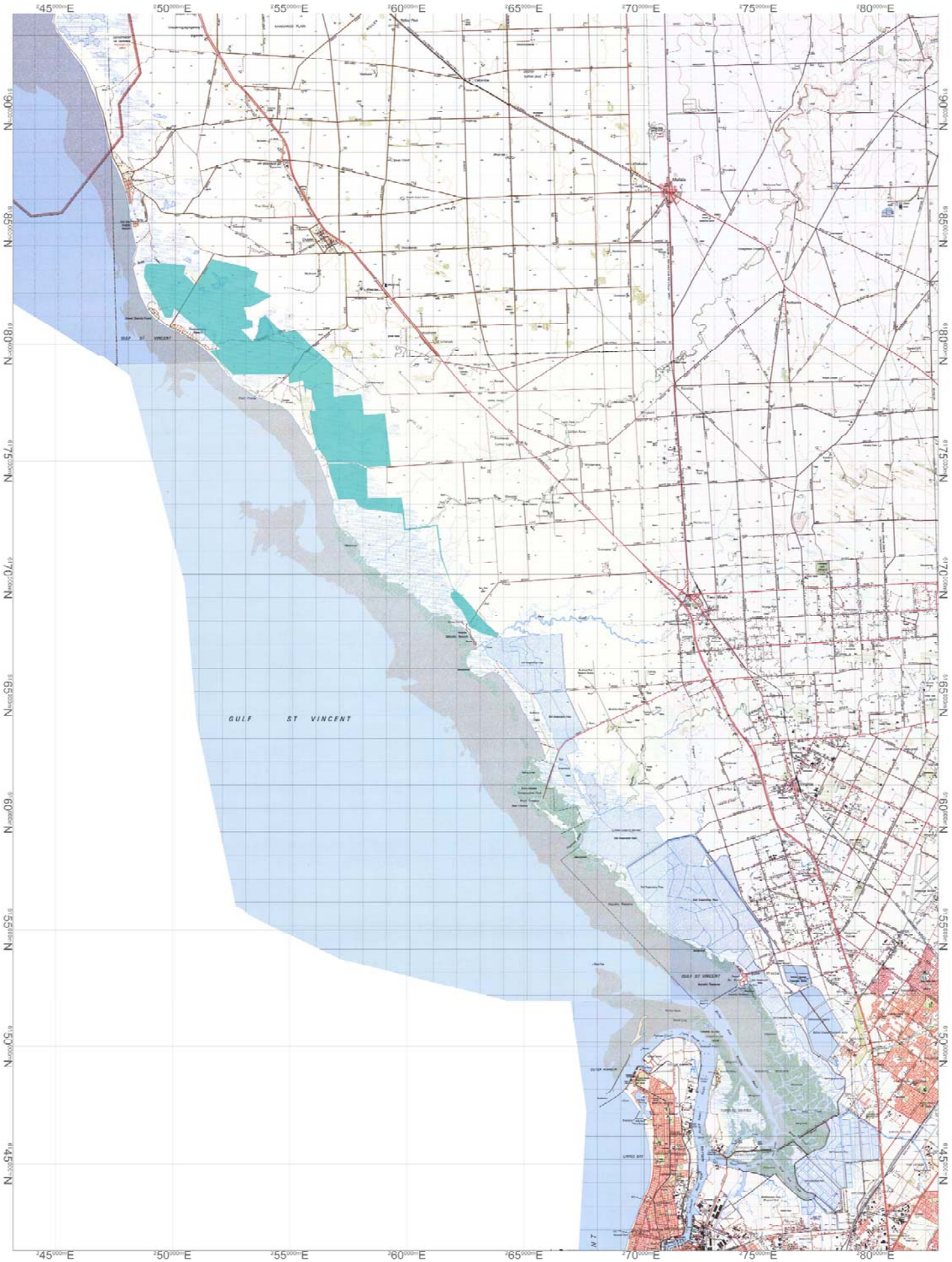
Proposed residential developments at Dry Creek (based on Delfin concept drawing) AML-SDC-016

Green - wetlands

Grey - area returned for mangrove/samphire retreat

Blue - internal waterways

Cream - developed areas & infrastructure



Proposed nothern expasion of the Dry Creek Saltfield.
AMLR NRM Board Shorebird Discussion Paper

Drawing: AML-5DC-017
Author: Delta Environmental Consulting (ABN 59 167 105 261). Generated from a variety of source materials
Datum: The map datum is GDA94. Positional accuracy of this map is +/-20m to +/-50m. Spatial resolution is 0.05- 1ha.
Data: The data and map are owned by Delta Environmental Consulting, unless otehrwise stated.
Free use is permitted, with appropriate acknowledgement.

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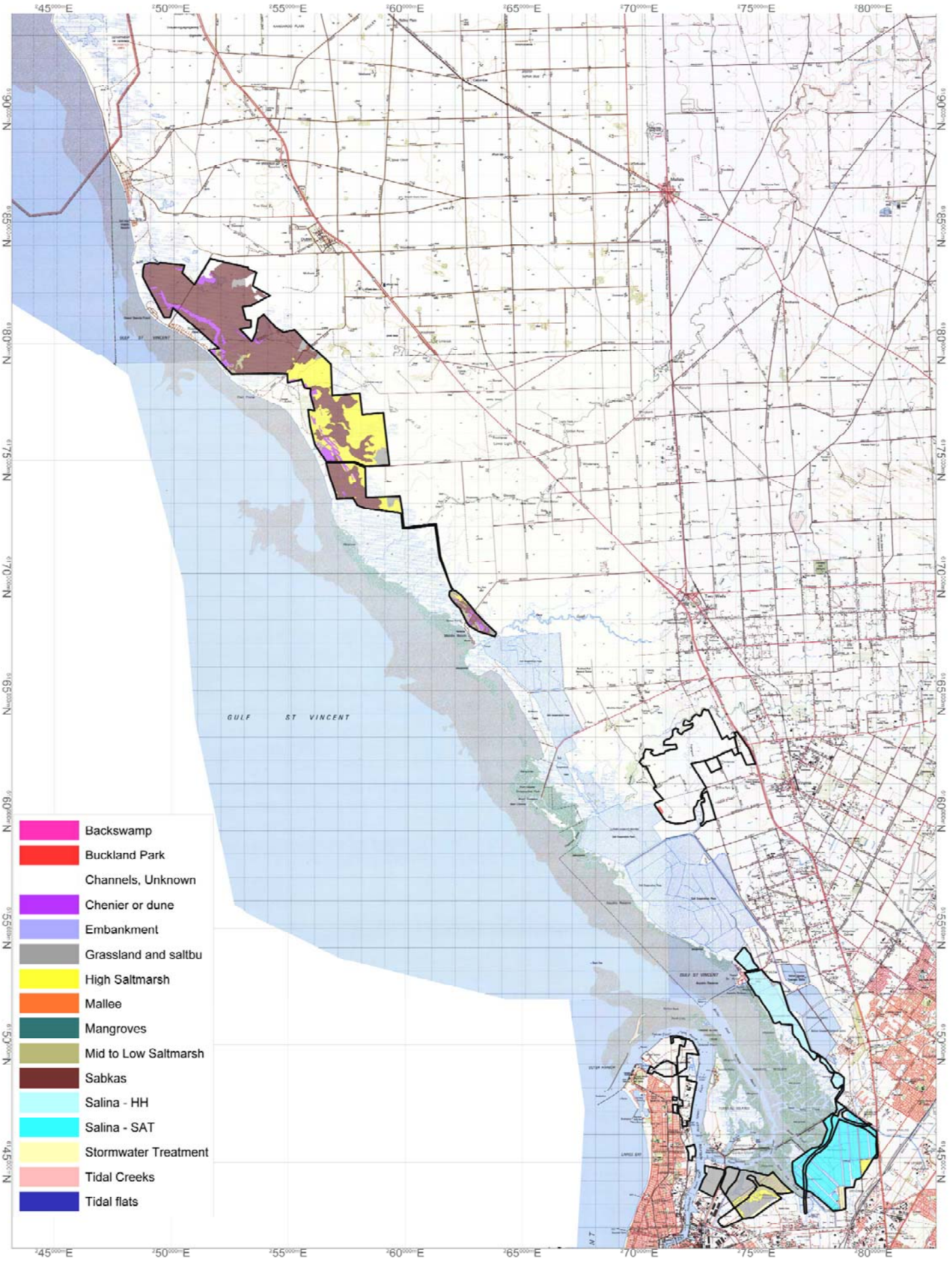

Areas of shorebird habitat impacted by proposed developments.
AMLR NRM Board Shorebird Discussion Paper

Drawing: AML-SDC-018
Author: Delta Environmental Consulting (ABN 59 167 105 261). Generated from a variety of sources including GeoScience Australia
Datum: The map datum is GDA94. Positional accuracy of this map is +/-20m to +/-50m. Spatial resolution is 0.05-1ha.
Data: The data and map are owned by Delta Environmental Consulting, unless otehrwise stated.
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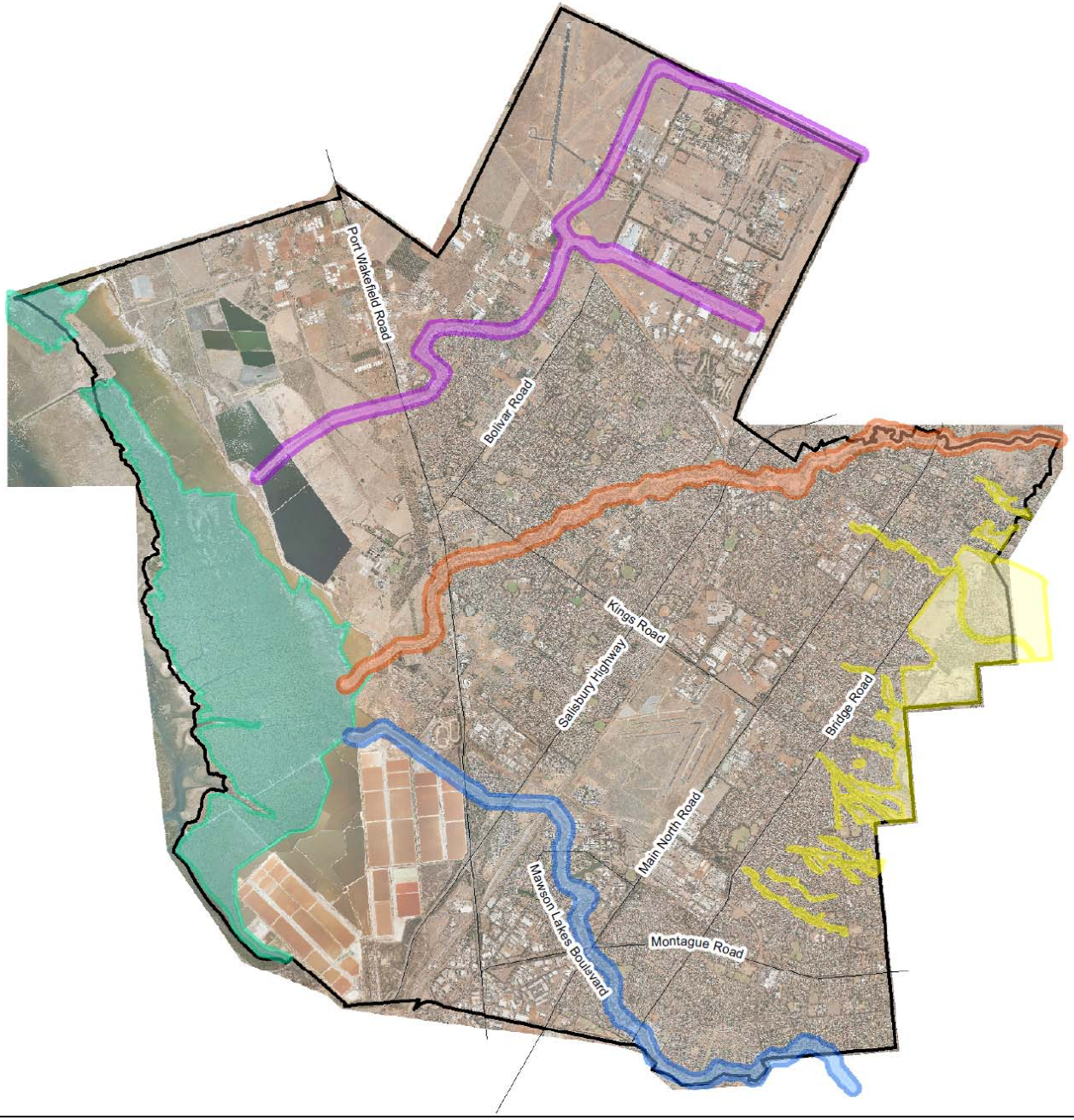
Delta Environmental Consulting



Dry Creek Corridor
Helps Road Drain Corridor
Little Para River Corridor
Mangroves Corridor
Para Escarpment Corridor
City of Salisbury Boundary

0 1.25 2.5 5
Kilometers

Drawing AML-SDC-019

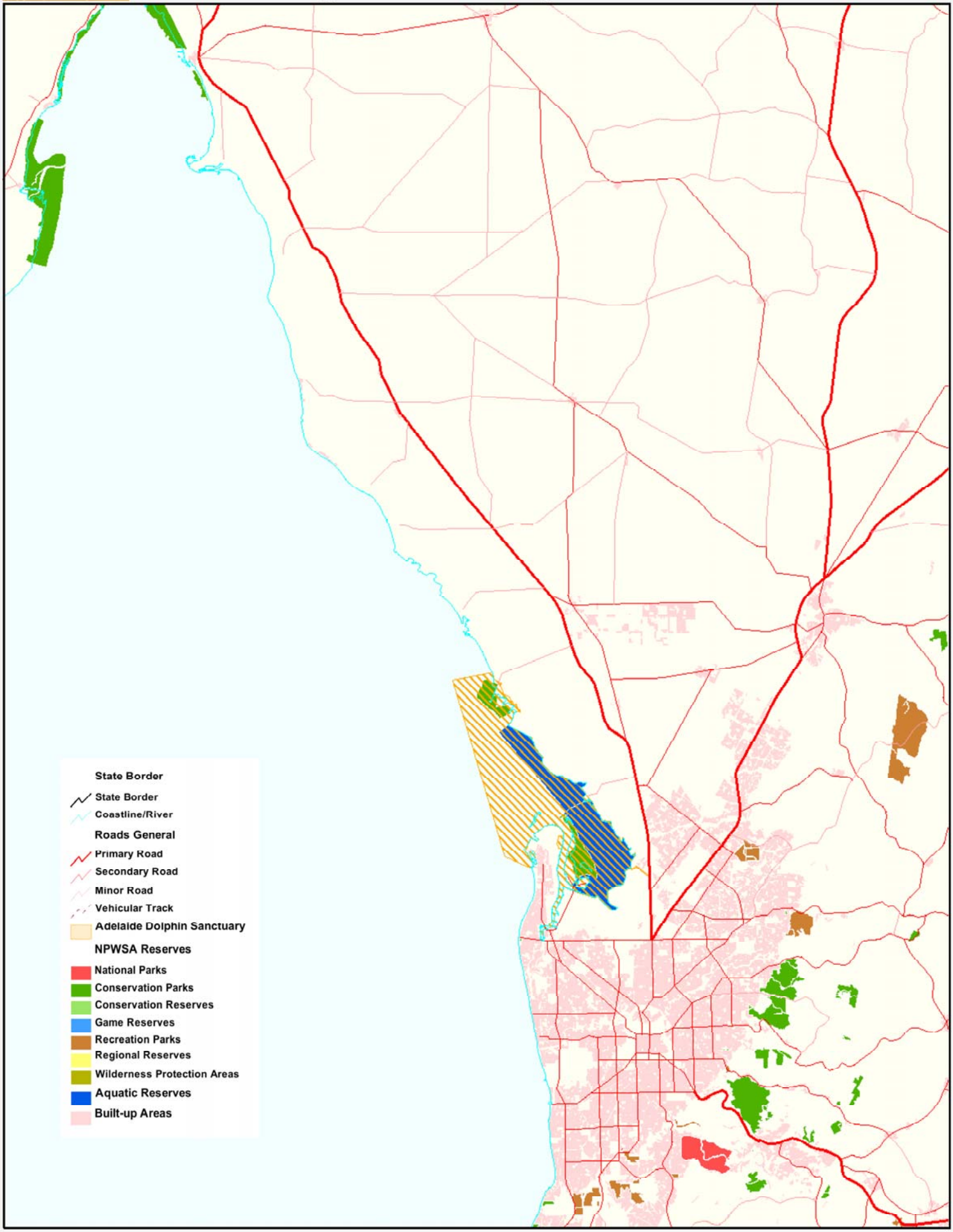
Biodiversity Corridors within the City of Salisbury

N

NatureMaps

Existing conservation & aquatic reserves

Produced: 22 May 2009



Map data is compiled from a variety of sources and hence its accuracy is variable.
Generated at www.naturemaps.sa.gov.au

N

1:409,035

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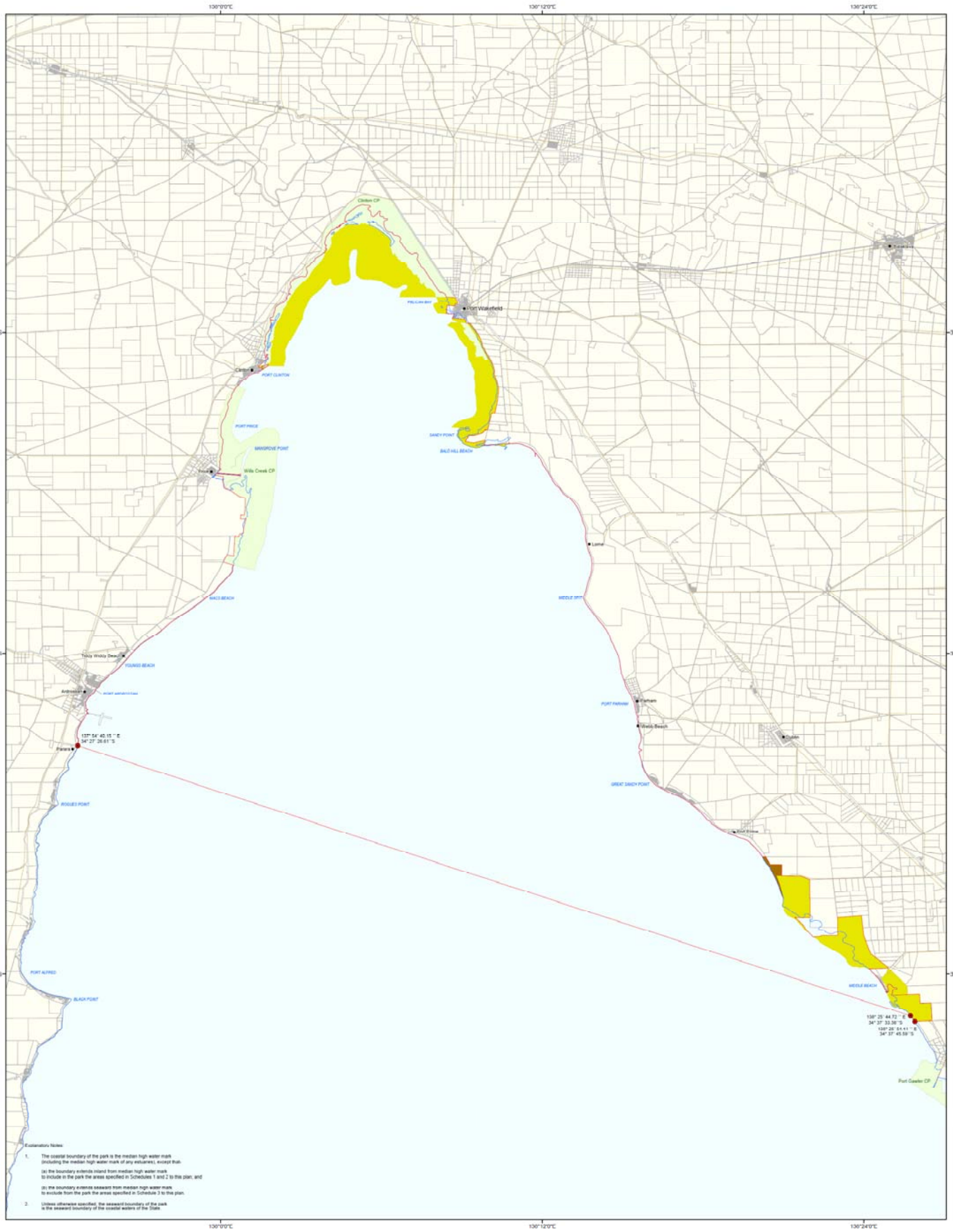
Projection: Lambert Conformal Conic
Datum: Geocentric Datum of Australia, 1994

Government of South Australia
Department for Environment and Heritage

Drawing AML-SDC-020

Rack Plan 1926

Upper Gulf St Vincent Marine Park



Marine Park Boundaries
Parks and Reserves
Coastal CrownLand Act Reserves
Coastal CrownLand Unallotted
DCDB Parcels
Coastline (median high water)
Roads

N

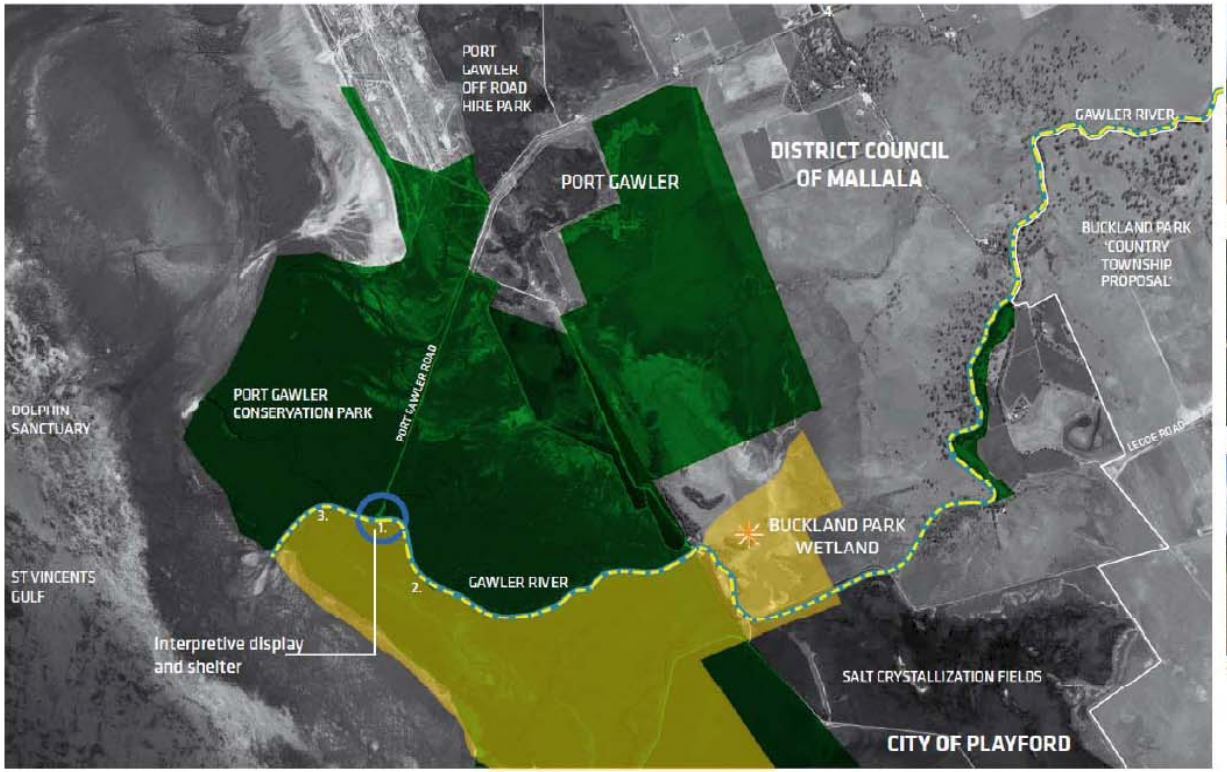
0 10
Kms

Produced by: Coast and Marine Conservation Branch, Department for Environment and Heritage, GPO BOX 1047 Adelaide SA 5001, www.environment.sa.gov.au/coasts
Data Source: Marine Parks, NPWSA, topographic Data - DLH, DCDB - DTEI, Crownland Parcels - DEH, DTEI
Compiled: 19 January 2009
Projection: Cassignatfori
Datum: Geocentric Datum of Australia, 1994

Drawing AML-SDC-021

Government of South Australia, Department for Environment and Heritage

DEH MapID: 2008-771



0 1km 2km 3km 4km

Scale

Key Plan

1.Interpretive signs at Port Gawler

2.Salt marshes, Port Gawler

3.Mouth of Gawler River

4.Gates to Salt Fields

Issues & Opportunities

- New interpretive shelter at end of Port Gawler Road showing signs of vandalism
- Activity node provides more opportunities for recreation and tourism. eg: Bird hides, boardwalks, formalised small craft access ramp (kayak)
- Possible tours of Buckland Park Wetland
- Access to Buckland Park Wetland involves crossing private land
- There is evidence of rubbish and vandalism at Port Gawler
- The Buckland Park 'Country Township' Major Project may have environmental implications associated with Gawler River and existing vegetation. It also provides an opportunity to establish a linear park with recreational facilities.

LEGEND

- Activity Node
- Site of Environmental or Cultural Significance
- Existing trail
- River Alignment
- Council Boundary
- Public Land
- MOSS

Analysis Map A

URPS

DRAFT

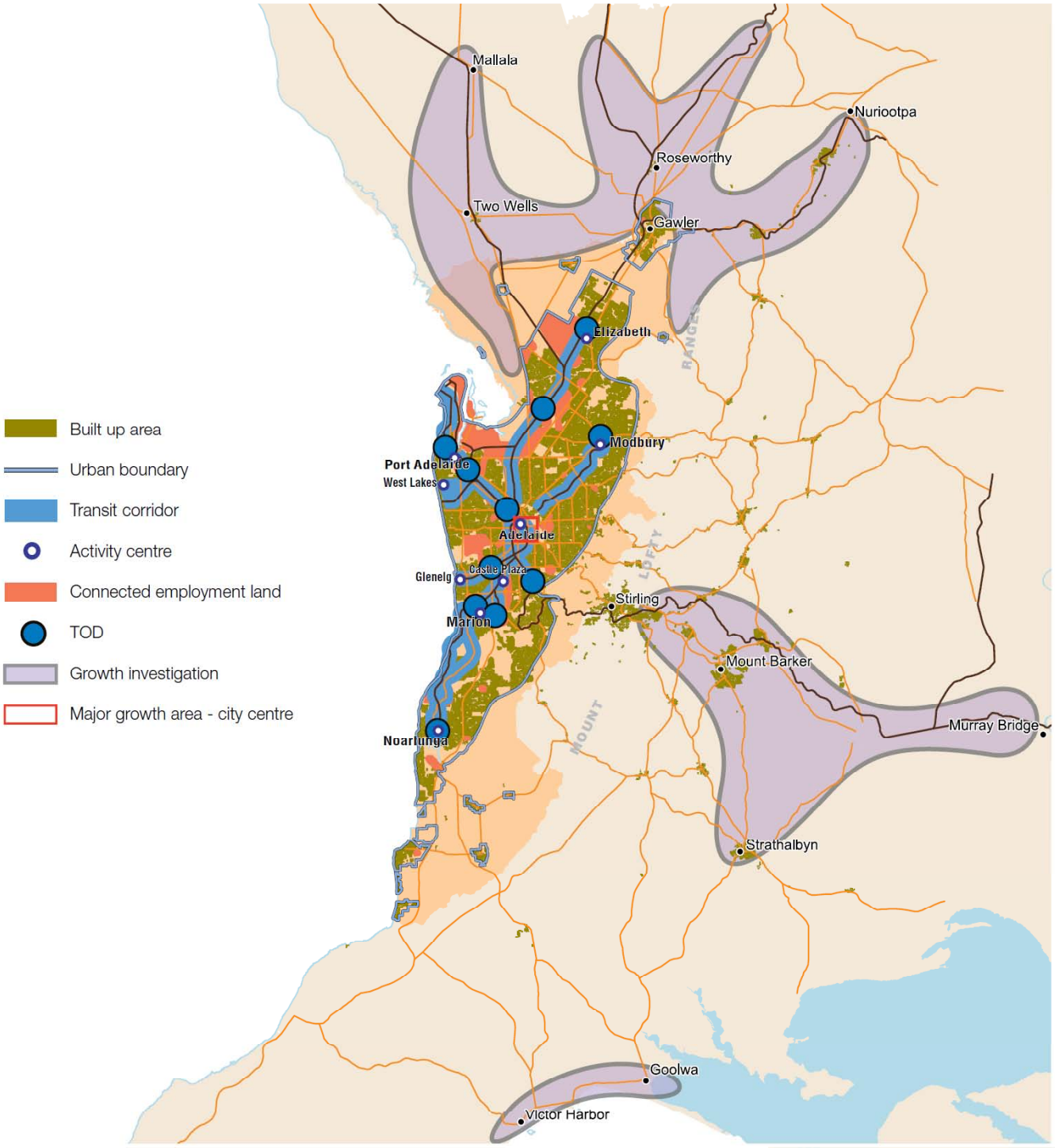
Drawing AML-SDC-022

November 2008

Pg 9

Job no. 07043

Map 2 Ideas for Adelaide - Key growth strategies



Drawing AML-SDC-023 (MUDP 2008a) NOVEMBER 2008

A4 - Habitat photographs

Tidal habitats

Tidal flats

Mangroves & tidal creeks

Mid to low saltmarsh

High saltmarsh

Swamplands and constructed wetlands

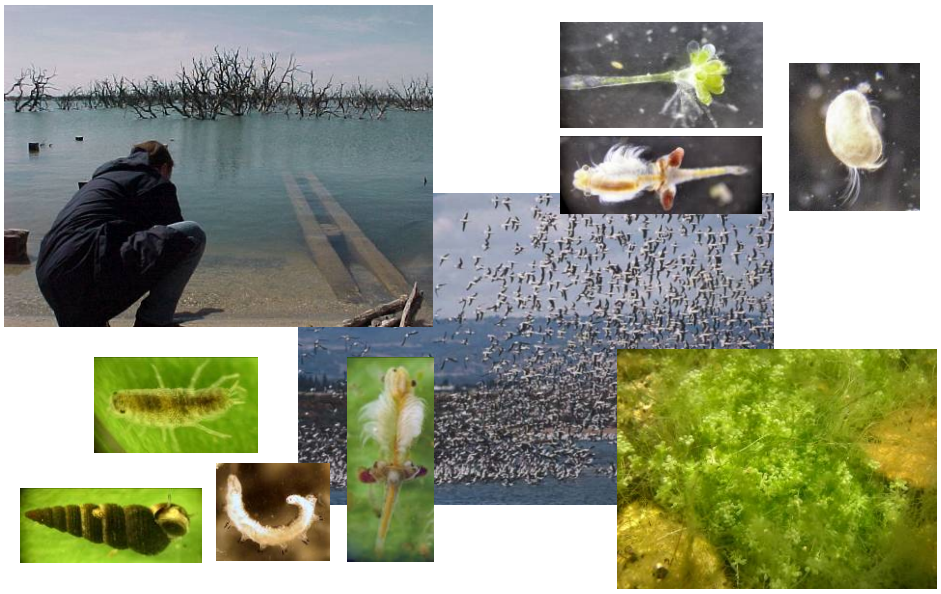
Buckland Park Lake & surrounds

Backswamps & freshwater tidal swamps

Stormwater wetlands

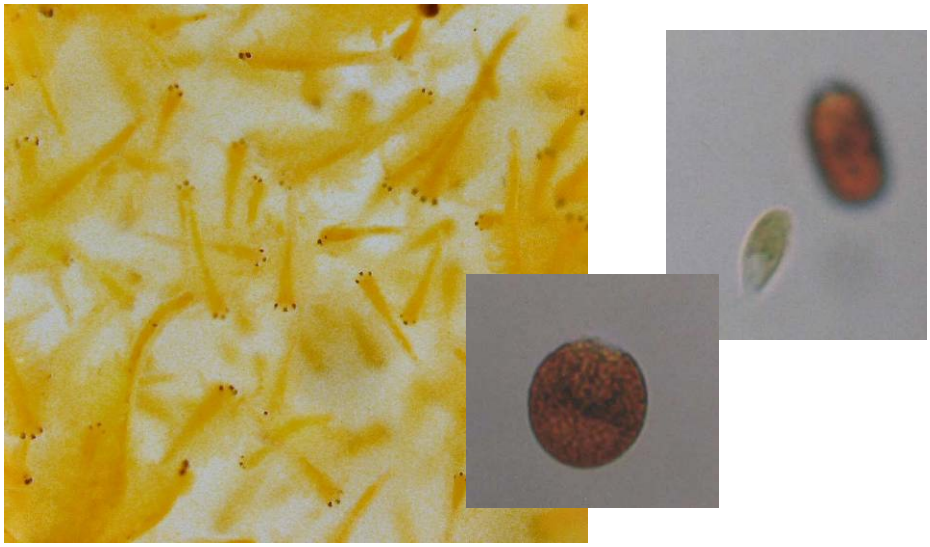
Salinas - marine

Salinas - low & medium hypersalinity



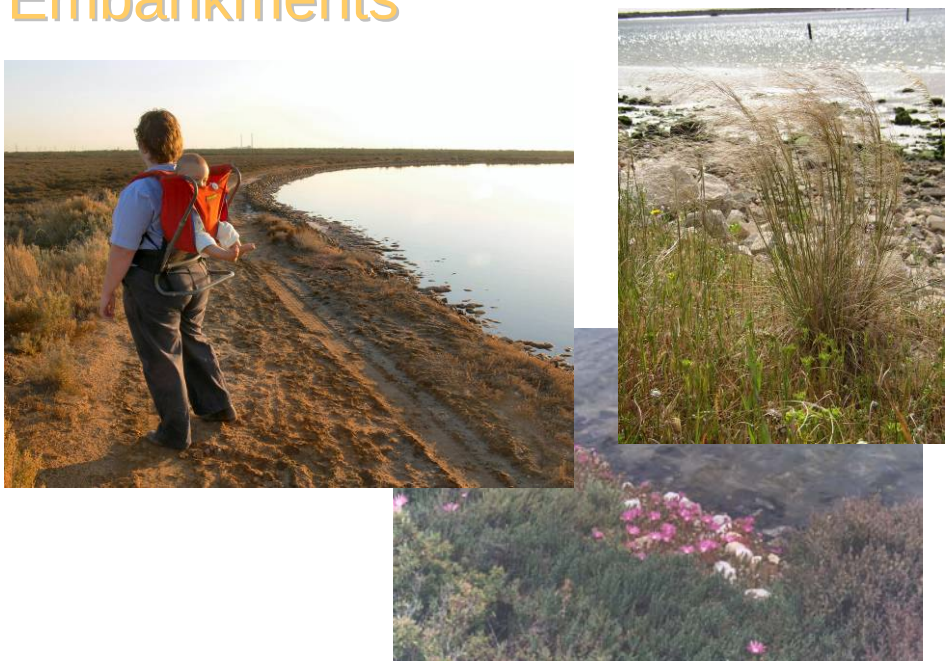
Salinas – highly hypersaline

Salinas - Saturated



Higher land

Embankments



Cheniers, beach berms and dunes

Sabkhas

Mallee & grasslands

A5 - Count data

Count Area	Dry Creek Saltfields							Light Beach			Middle Beach (GSV)			Port Gawler			Port Parham & Baker Cl			Saint Kilda			Section Banks, Outer Ha			Thompson's Beach (GS			Webb Beach (GSV)		
Observer	S2020, 2008-9			Cox, 1984-94		Day, 1976-96		S2020, 2008-9			S2020, 2008-9			S2020, 2008-9			S2020, 2008-9			S2020, 2008-9			S2020, 2008-9			S2020, 2008-9			S2020, 2008-9		
	Min	Max	Mean	Max	Mean	SF	Y/21	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Australian Pratincole				4		2%	11																							
Baird's Sandpiper				1		<1%	3																							
Banded Lapwing				116		7%	19	0	90	30							0	76	13											
Banded Stilt	0	10060	3758	150000	55000	76%	21	0	2	1							0	0	0											
Bar-tailed Godwit	0	1	0	25	5	6%	13	0	4	1							0	155	34							0	200	38			
Black-fronted Dotterel	0	22	3	27		19%	21										0	0	0											
Black-tailed Godwit	0	41	5	231	105	23%	20	0	25	8							0	210	35							0	2	0	0	7	2
Black-winged Stilt	10	141	69	620		91%	21							0	2	1				0	5	3				0	5	0			
Broad-billed Sandpiper				3	1	1%	6																							
Buff-breasted Sandpiper				1		<1%	1																							
Common Redshank				1		<1%	1																							
Common Sandpiper	0	1	0	15	6	39%	21							0	2	1														
Curlew Sandpiper	0	300	82		2700	78%	21	0	74	31				0	62	31	0	10	3	0	49	16	4	350	177	0	13	3	0	39	13
Double-banded Plover	0	1	0		27	8%	18							0	4	2														
Far Eastern Curlew	0	36	6	80	50	40%	21	0	27	13				0	4	2							0	21	11	0	5	0			
Great Knot	0	0	0	6	2	2%	7	0	70	33							0	4	1							0	80	15	0	1	0
Greater Sandplover	0	0	0	1																						0	8	1	0	7	3
Greenshank	0	500	102		450	97%	21	6	80	31	7	10	9	5	28	17	0	16	6	0	44	19	0	4	2	0	85	27	0	50	17
Grey Plover	0	52	24	234	125	18%	18	2	50	34				8	47	28	0	10	4				1	1	1	0	50	12	0	13	4
Grey-tailed Tattler	0	5	1	2		<1%	5				0	1	0																	
Hudsonian Godwit				1		<1%	2																							
Latham's Snipe				3		<1%	2																							
Lesser Sandplover						<1%	2							0	3	2	0	3	1							0	4	1	0	6	2
Lesser Yellowlegs				1		<1%	2																							
Little Curlew				2		<1%	3																							
Little Ringed Plover				1		<1%	2																							
Little Stint				2		<1%	5																							
Long-toed Stint				30	6	4%	13																							
Marsh Sandpiper	0	7	1	210	142	49%	20				0	1	0	1	6	4	0	15	3							0	1	0	0	2	1
Masked Lapwing	0	56	21		140	93%	21	0	9	4	0	2	1	2	9	6	0	12	4	1	6	3	5	7	6	0	7	1	0	3	1
Oriental Plover				2		<1%	2																							
Oriental Pratincole				1		<1%	1																							
Pacific Golden Plover	0	2	0	36	8	6%	18										0	5	1											
Painted Snipe				2		<1%	1																							
Pectoral Sandpiper	0	1	0	6	3	3%	12																							
Pied Oystercatcher	0	5	1	47		10%	17	12	14	13	0	3	1	0	3	2	0	2	1				25	120	73	0	2	0			
Red Knot	0	0	0	150	140	9%	16	0	2500	1000				0	1	1	0	750	234							0	1300	180			
Red-capped Plover	0	567	124		1900	90%	21	4	1000	341	0	14	5	414	540	477	0	100	36	0	306	102	405	1140	773	12	353	110	0	76	34
Red-kneed Dotterel	0	120	26	560	180	52%	21				0	7	2	0	9	5														
Red-necked Avocet	0	150	30		2200	79%	21																							
Red-necked Phalarope				2	1	1%	6																							
Red-necked Stint	0	7000	1682		23000	87%	21	0	1200	587	0	24	8	0	770	385	20	600	174	0	782	447	2857	4700	3779	0	3000	478	0	220	123
Ruddy Turnstone	0	3	0	42	17	17%	18							0	8	4	0	9	2							0	50	13	0	14	5
Ruff				4	1	2%	11																							
Sanderling				2		<1%	1																							
Sharp-tailed Sandpiper	0	3000	728		9800	67%	21	0	3	1	0	31	14	29	155	92	0	33	13	0	481	311	55	800	428	0	150	30	0	61	25
Sooty Oystercatcher	0	0	0	79		<1%	2																79	206	143						
Terek Sandpiper	0	7	1	5	2	6%	13																0	1	1						
Whimbrel	0	1	0	28	14	12%	18																							
White-rumped Sandpiper				1		<1%	1																							
Wood Sandpiper				40	15	19%	20																							
Total of means			**6714**		**96040**					**2249**			**40**			**1066**			**570**			**903**			**5451**			**911**			**233**

SF (Sighting frequency) = number of visits in which the species was recorded / total number of visits (in this case 833) x 100
Y/21 = number of years out of the 21 years of records where the species was recorded at least once

A6 - Actions from the WCP for Migratory Shorebirds

The **Objectives** of the Wildlife Conservation Plan for Migratory Shorebirds are to:

1. Increase international cooperation for migratory shorebirds and ensure that countries of the East Asian - Australasian Flyway work together to conserve migratory shorebirds and their habitat.

2. Identify, protect and sustainably manage a network of important habitat for migratory shorebirds across Australia to ensure that healthy populations remain viable into the future.

3. Increase biological and ecological knowledge of migratory shorebirds, their populations, habitats and threats in Australia to better inform management and support the long term survival of these species.

4. Raise awareness of migratory shorebirds and the importance of conserving them, and increase engagement of decision makers and the community in Australia in activities to conserve and protect migratory shorebirds and their habitat

Actions identified to achieve the Objectives (287(2)(c))

Objective 1.

Action 1.1. Through leadership, encourage participation by countries throughout East Asia, South East Asia and Australasia, and particularly those countries with sites of international importance for migratory shorebirds, in activities to conserve migratory shorebirds.

Action 1.2. Lead the development and implementation of an action plan for migratory shorebird conservation in the East Asian -Australasian Flyway.

Action 1.3. Include at least 25% of the known sites of international importance for migratory shorebirds in Australia in the Flyway site network.

Action 1.4. Through example, encourage information sharing on migratory shorebird conservation activities across the Flyway.

Action 1.5. Develop and support training programs in population monitoring and habitat management for site managers in Australia and throughout the Flyway.

Action 1.6. Encourage shorebird migration and population dynamic research across the Flyway.

Objective 2.

Action 2.1. Agree and adopt criteria for identification of sites of national and regional importance.

Action 2.2. Review the boundary of large sites to ensure that they are appropriate.

Action 2.3. Using agreed criteria and reviewed boundaries assess the importance of sites.

Action 2.4. Encourage the production and dissemination of maps for important sites to assist with their management.

Action 2.5. Identify threats to important habitat and develop conservation measures for managing them.

Action 2.6. Identify priority sites for conservation action based on their importance to migratory shorebirds, the level of threat and adequacy of existing management arrangements.

Action 2.7. Encourage and support the development of appropriate management arrangements for important sites, particularly those identified as priority sites.

Action 2.8. Develop a directory of organisations and people responsible for managing important sites throughout Australia.

Action 2.9. Develop and support training programs in population monitoring and habitat management for site managers in Australia.

Action 2.10. Support the Flyway Partnership on migratory waterbirds, through encouraging and supporting nomination of wetlands of international importance to the migratory waterbird site network.

Action 2.11. Encourage nomination of wetlands of international and national importance for inclusion as Wetlands of International Importance under the Ramsar Convention on Wetlands and/or A Directory of Important Wetlands in Australia and inclusion in Protected Areas.

Action 2.12. Include migratory shorebirds and their habitat in environment protection arrangements at Local, State and National level to avoid significant impacts on migratory shorebird populations.

Objective 3.

Action 3.1. Identify gaps in knowledge required for management of migratory shorebirds, their habitats and threats in Australia.

Action 3.2. Prioritise and support research on migratory shorebirds, their population and conservation status, habitats and threats to address knowledge gaps.

Action 3.3. Identify and implement ways to integrate research and enhance collaboration.

Action 3.4. Encourage shorebird movement and migration research within Australia and across the Flyway.

Action 3.5. Develop and implement a consistent national method to monitor migratory shorebird populations.

Action 3.6. Encourage ongoing population monitoring programs for species covered by this plan.

Action 3.7. Encourage research on reproduction and survival rates of migratory shorebirds and trends of these over time.

Action 3.8. Collect and make available information resulting from research projects.

Objective 4.

Action 4.1. Promote public and community education and conservation awareness, through strategic programs and educational products.

Action 4.2. Identify existing migratory shorebird and wetland communication networks and where possible use these networks to promote conservation of migratory shorebirds.

Action 4.3. Develop and implement a communication strategy to promote the exchange of information on shorebird conservation and habitat management, between all levels of Government, non-government organisations, Natural Resource Management regional bodies, Industry and Communities.

Action 4.4. Distribute demonstration materials and models for community engagement in shorebird conservation activities.

Action 4.5. Prepare supplementary administrative guidelines on significance for migratory shorebirds to assist with EPBC Act referrals and determining whether an action has, will have, or is likely to have a significant impact on migratory shorebirds.