Data Collation, Review and Preliminary Ecological Assessment
Coorong Temporary Saline Water Discharge
SA Murray Darling Basin NRM Board

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1. Introduction

The ecological viability of the Coorong has been threatened by the prolonged drought and lack of flow in the Murray-Darling River system. To alleviate the potential damage to the Coorong ecosystem the South Australian Murray-Darling Basin Natural Resource Management Board (SA MDB NRM) propose to reduce the excessive salt load of the Coorong south lagoon by installing a pumping system that would discharge high salinity water from the Southern Lagoon of the Coorong to the adjacent ocean via a pipeline discharge system.

It is proposed to establish a "temporary" pumping system to discharge hypersaline water (with a starting salinity of 120 - 150 ppt) from the Coorong at a location near Policeman Point/Woods Well via a pipeline from the Coorong inlet to an outlet on the adjacent ocean beach.

To date, investigations have focused on identifying options that would benefit the Coorong lagoons and have identified the pumping option as the preferred solution. The possible impact of the hypersaline discharge on Southern Ocean receiving waters, however, also requires assessment. Salinity within the Southern Ocean adjacent to the lagoons is usually within the range of 35 to 36ppt - a factor of 4 less than the proposed discharge.

This document reviews the environmental impact issues with an emphasis on the ecological aspects associated with discharging hypersaline Coorong Southern Lagoon waters to the Southern Ocean. Hydrodynamic modelling of the potential saline plume (if discharged) is discussed elsewhere and it is recommended that this report be read in conjunction with the modelling report (Aurecon 2009).

The consideration of ecological benefits to the Coorong lagoons for the pumping of hypersaline waters to the Southern Ocean has not been considered here as it has been considered elsewhere (Lester *et al.* 2009). This study demonstrated that the reduction of salinity levels within the Southern lagoon would help alleviate the stress under which the ecological system now finds itself in the light of reduced freshwater flows

Preliminary discussion with the Department of Environment, Water, Heritage and Arts (DEWHA) suggested that the proposal will require referral to the department under the federal Environment Protection and Biodiversity Conservation Act 1999 (EPBC). To support this referral it has been considered necessary to include hydrodynamic modelling of the proposed discharge to the marine environment to provide a more detailed understanding of the likely footprint of the discharging plume. In addition to the preliminary “desktop” review Aurecon were also commissioned to commence this preliminary hydrodynamic modelling exercise.

Table 1 below outlines a number of key factors that will require consideration during the preliminary works. Each will require information to inform the process and to adequately satisfy regulatory requirements.

Table 1 Key factors during preliminary works

Consideration	Aspect	Where considered?
Pipeline	Pump connection to shore	Hydrodynamic modelling report
	Type of connection	To be considered during detailed design
	Route through sand dune	Flora / Fauna assessment to be undertaken to inform
Discharge plume dispersion	Dispersion of saline concentrate	Hydrodynamic modelling report
	Hydrodynamics of nearshore surf zone	Hydrodynamic modelling report
	Shelf waves	Hydrodynamic modelling report
	Type of outlet/diffuser	To be considered during detailed design

Consideration	Aspect	Where considered?
	location on beach (top of beach or below MWL)	To be considered during detailed design
	beach stability/erosion	To be considered during detailed design
	Seasonal water level variability	To be considered during detailed design
	Tide patterns	Hydrodynamic modelling report
	Prevailing winds and wave climate	Hydrodynamic modelling report
	Dodge tides	Hydrodynamic modelling report
	Bathymetry	Hydrodynamic modelling report
Marine and coastal communities	Marine and coastal species – rare, scarce, feral, iconic, recreational and commercial fishery species	Review contained within Section 3
	Habitats – marine and sand dune	Flora / Fauna assessment/s to be undertaken to inform pipeline route
	Ecotoxicology of saline concentrate	Review contained within Section 5
	Water quality (origin and receiving waters)	Coorong Lagoons water quality not considered. Water quality assessment required for Southern Ocean.
Cultural impacts	Aboriginal heritage	Aboriginal heritage assessment to be undertaken to inform pipeline route
	Recreational fisheries	Review undertaken in Section 3
	Commercial fisheries	Review undertaken in Section 3
Site selection	Pump facility footprint	To be considered during detailed design
	Maintenance requirements (especially access)	To be considered during detailed design
	Energy and ETSA connection	To be considered during detailed design

1.1 Scope of Works

1.1.1 Preliminary Desktop Review

The scope of works for the present study was developed in consultation with the client. It was recognised early on in the process that the scope of works would need to evolve as the issues developed. The initial phase of issues identification and scoping for further investigations involved the following components:

- Initiation meeting to confirm the objectives and deliverables
- Information review, gap analysis and issues identification
- Outline concept design (refer Aurecon modelling report)
- Desktop dispersion assessment (refer Aurecon modelling report)
- Consultation and liaison with Regulators
- Preliminary Impact Assessment and sensitivity testing
- Reporting

This report presents the environmental data collation, review and preliminary assessment. Relevant and readily available information including publications and reports of previous studies on the Coorong and adjacent marine areas were reviewed to develop an understanding of the existing system, and to identify information gaps and issues that may affect the project moving forward. Outcomes of this initial phase have included development

of conceptual diagrams describing the key processes affecting dispersion of the hypersaline discharge and the habitat scales and ecosystem processes that may be affected by the discharge.

To facilitate a preliminary impact assessment two options were developed further for the configuration of the discharge infrastructure comprising

- an outlet above higher high water at the back of the beach and;
- a submerged outlet in the surf zone below mean sea level.

The general engineering constraints for these two concepts are described in the Aurecon Preliminary Hydrodynamic Modelling Report (Aurecon 2009) in terms of the likely pumping requirements (pipe size, head, flow), possible energy supply issues, discharge location, and possible construction methods/issues.

The likely footprint of the dense hypersaline saline discharge within the marine waters was assessed initially through application of simple scaling and dimensional analysis to inform the hydrodynamic modelling and is presented elsewhere in the Aurecon Preliminary Hydrodynamic Modelling Report (Aurecon 2009). This report presents a preliminary high level impact assessment undertaken in order to give an indication of the potential environment impacts of the proposed development. Hydrodynamic modelling undertaken for other recent projects in South Australia (including the Adelaide Desalination Project) was also reviewed and where appropriate the results utilised to inform this assessment.

2. Regional Setting

2.1 The Murray-Darling Basin

The Murray-Darling Basin is the largest freshwater catchment in Australia, spanning an area of about 1,060,000 km^2 and extending into Queensland, New South Wales, Victoria, South Australia and the Australian Capital Territory. The entire system has evolved in an environment of extremes, characterised by periodic flooding and extended periods of drought (Crabb, 1997). Because of its critical importance to human survival and industrial development within the basin, the entire system has been dramatically modified since European settlement that commenced in earnest over 150 years ago in the mid 1800's. The introduction of various flow management and water diversion systems, the associated barriers to fish migration, the proliferation of many exotic fish and plant species and pollution from agricultural run-off have collectively had a significant negative impact on the overall environmental health of the entire riverine and estuarine environment.

There are six broad ecosystem components that can be identified within the South Australian section of the River Murray. These include the River Murray Mouth, the Lower Lakes (Lake Albert and Lake Alexandrina), the Coorong (of which this report is concerned), the River channel, the wetlands and the floodplain.

In the wider context of the Murray-Darling Basin, the River Murray Mouth, Lower Lakes and Coorong form what was historically the River Murray estuary. Important interrelated wetland habitats exist, including the hyper-saline waters of the southern Coorong lagoon, a narrow lagoon that extends about 100km south east from the Murray Mouth adjacent to the coastline, the freshwater Lower Lakes, the estuarine waters of the northern lagoon and the coastal marine waters adjacent to the ocean beaches and dune system.

The River Murray enters Lake Alexandrina and Lake Albert at Wellington in South Australia and then separates into five channels that lead to the Murray Mouth. Historically, these channels allowed River Murray water to either mix with the saline waters of the Coorong or enter the Southern Ocean through the Murray Mouth. However, natural flows have been controlled since the early 1940s when a network of five barrages (Goolwa, Boundary Creek, Mundoo, Ewe Island and Tauwitchere) were constructed across each of the five channels to reduce salinity levels in the lower Murray River and Lakes and stabilise the river level to provide for irrigation and human consumption (MDBC, 2005).

2.2 Coorong Bioregion

The Coorong bioregion is made up of a large barrier coast with a series of wetlands, lagoons and lakes on the landward side of the Younghusband Peninsula and the Southern Ocean on the other. The bioregion comprises 29,830 km^2, of which 2,048 km^2 is within South Australian state waters (Edyvane 1999). Approximately 1% of the 2,048 km^2 area is designated as National Parks and Wildlife Reserves (Baker 1998).

The Coorong National Park and lower lakes contain some of Australia's most internationally important and biologically significant Lower Lakes. The area is home to several rare and endangered species, and the inshore and coastal parts have been the focus of a number of studies. The nearshore marine habitats, however, have comparatively little data available and as such the nearshore ecosystems are not well understood.

The southern ocean-side of the Younghusband Peninsula varies from warm in summer to cold in winter, and contains species typical of such variations. In areas where data is available, the marine habitats appear to be variable with complex near-shore reef systems supporting a diversity of habitats and marine organisms. Wave energy is high between the Murray Mouth and the Granites (a geological feature about 45 km north of Cape Jaffa), but lower in the shelter of Cape Jaffa (Haig *et al.*, 2006).

2.3 Coorong and Lakes Alexandrina and Albert Ramsar Site

The project area is within the boundaries of the Coorong and Lakes Alexandrina and Albert Ramsar site. The unique ecological character of the Lakes and Coorong wetlands are recognised both internationally and nationally for their significance to waterbirds. High

conservation status is afforded to the area as a South Australian National Park and as a wetland area listed under the international Ramsar convention. The Murray-Darling Basin Commission has recognised the importance of the Murray Mouth, by identifying it as one of six 'significant ecological assets' in the Basin (MDBC, 2005).

The waterbird habitats of the Lower Murray Lakes and Coorong region were designated as wetland of international importance under the Ramsar Convention in 1985. These wetlands provide habitat for many local species as well as migratory wading birds. A Ramsar Management Plan for the Lower Lakes and Coorong was prepared in 2006 to fulfil the Australian Government obligations under the Convention agreement. The Coorong and Lakes Alexandrina and Albert Ramsar Management Plan aims to provide an integrated management framework to promote wise use and conserve the ecological character in the Lakes and Coorong wetlands, while taking into account the social, cultural and economic values attached to the area (DEH 2000).

The Coorong lakes and wetlands are separated for the Southern Ocean by Younghusband Peninsula, a long narrow (1-2 km wide) isthmus of sand dunes facing the full brunt of the Southern Ocean winds and waves. A continuous sandy beach stretches from Lacepede Bay in the south east to Encounter Bay at Victor Harbour, a distance of nearly 200km and broken only by the Murray Mouth.

The reduction of both Murray inflows and tidal exchange are thought to be the main factors causing habitat decline in this region. To this end, a number of studies have focused on examining options to keep the Murray Mouth open through either artificial means (dredging) and/or restoring the Murray River flows to the estuarine lakes and Coorong. Recent research has focused upon the estuarine areas and their associated flow related ecosystem issues including long term modelling of low flows and altered state scenarios as reported in Lester *et al*. (2009); Lester and Fairweather (2008) and Webster (2007).

The amount of water flowing into the Lower Lakes, then into the Coorong and through the Murray Mouth to the ocean, has decreased dramatically since water flow control measures were introduced throughout the Murray-Darling Basin and in the Lower Lakes. On average, the annual flow through the Murray Mouth is limited to about 27% of the natural median flow recorded before water flow regulation (MDBC, 2002). Prior to flow regulation, flows through the Murray Mouth ceased about every twenty years. This now occurs every two years on average (Jensen, *et al.,* 2000). Reduced river flows and less frequent flooding have changed the morphology of the Mouth, causing sand to build up in and around the Mouth. The Murray Mouth closed in 1981 during a period of extended drought and is now maintained through ongoing dredging.

The concerns over the deteriorating environmental health of the Coorong have lead to the proposal to pump hypersaline water from the Coorong lagoons to the Southern Ocean. This report examines the potential impacts associated with the construction and operation of the proposed works upon the coastal and marine environments.

3. Existing Environment

The Coorong is a long narrow estuarine and freshwater wetlands complex extending some 100 km south east of the Murray Mouth parallel to the coastal dunes of the Younghusband Peninsula that separate the system from the Southern Ocean. The Coorong consists of the north and south estuarine lagoons, saline marshes, freshwater soaks and hypersaline areas at the southern end. The area also contains a number of ephemeral salt lakes and examples of ephemeral carbonate lakes of national and international significance.

The proposed project site extends from the proposed inlet in the South Lagoon, across the sand dunes to the proposed ocean discharge area located on the seaward side of the Coorong opposite Policeman's Point south of Lake Alexandrina (Figure 1). It is proposed to pump saline water from the southern lagoon via a pipeline over sand dune system and discharge this water from an outlet to the Southern Ocean.

3.1 Sand dune and Coastal Habitat

The ocean shoreline adjacent to Policeman's Point is a gently sloping beach of fine to medium sand exposed to the high energy wave input from the Southern Ocean. The southern end of the beach consists of coarse shell gravel grading to finer sands toward the north. The beach is flat with high wave exposure and is backed by bare or partially vegetated dune systems. Adjacent to Policeman's Point, in the southern lagoon there are records of intact intertidal *Samphire* habitats between the sand dune systems with *Melaleuca* communities also having been recorded in the adjacent areas although no records are known in the Policeman Point area itself.

3.2 EPBC Protected Species

An Environment Protection and Biodiversity Conservation (EPBC) Act Protected Matters search was conducted for the Policeman Point location. The EPBC protected matters search tool is an online tool designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World Heritage and Register of National Estate properties, Wetlands of International Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities.

Not all species listed under the EPBC Act have been mapped and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms.

The EPBC report identified a large number of species listed on the EPBC Act Online Database. Many of the species are fully marine mobile species or migratory species (including birds and marine mammals). The migratory marine species are not considered likely to be impacted by the proposed works as the modelling has shown that the zone of influence of the saline water discharge is likely to be within the inshore shallow intertidal waters rather than the deeper offshore waters. Most of the bird species are found within the Coorong lagoons and the coastal habitats of the Younghusband Peninsula and the species will probably relocate to adjacent areas if disturbed by the pumping project. Although the database may highlight species which have not been recorded in South Australia (for example the Tristan Albatross) or are fully pelagic species which would very rarely enter nearshore waters, for completeness the full list of species generated by the database has been reproduced in its entirety.

A copy of the Protected Matters Report is presented in Appendix A. The following matters of national environmental significance were identified.

3.2.1 Wetlands of International Importance

Three Wetlands of International Importance were identified (Table 2). The Coorong, Lakes Alexandrina and Albert and Riverland are an interconnected Ramsar site. Bool and Hacks Lagoons are also Ramsar sites, however are geographically separated from the subject location.

Table 2 Wetlands of International Importance

Ramsar Site	Type of presence
Coorong and Lakes Alexandrina and Albert	Location within this Ramsar site
Bool and Hacks Lagoons	Ramsar site approximately 170km from location
Riverland	Ramsar site approximately 200km from location

3.2.2 Threatened Ecological Communities

One threatened ecological community was identified (Table 3). The Buloke Woodland is very unlikely to occur in the coastal sand dunes between the Coorong and the Southern Ocean.

Table 3 Threatened Ecological Communities

Community	Status	Type of presence
Buloke Woodlands of the Riverina and Murray-Darling Depression Bioregions	Endangered	Community may occur within area

3.2.3 Threatened Species

The threatened species identified included 21 birds, one frog, four mammals, two ray-finned fishes, one shark and six plants (Table 4). The majority of the bird species are transient species or their habitat is unlikely to occur in the sand dune and intertidal location of the project. Likewise, it is unlikely that the six plant species will have suitable habitat in the project location. The four marine mammals and one shark are considered possibly transient and largely unpredictable across the area however it is considered that these species will be unlikely to be present in the immediate location of works in the shallow subtidal and mid benthic areas adjacent to the discharge pipe/s.

Table 4 Threatened Species

Species Name	Common Name	Status	Likelihood of presence
Birds			
Diomedea epomophora epomophora	Southern Royal Albatross	Vulnerable	Possibly transient
Diomedea epomophora sanfordi	Northern Royal Albatross	Endangered	Possibly transient
Diomedea exulans (sensu lato)	Wandering Albatross	Endangered	Possibly transient
Diomedea exulans amsterdamensis	Amsterdam Albatross	Vulnerable	Possible transient
Diomedea exulans exulans	Tristan Albatross	Endangered	Possibly transient although no South Australian records
Diomedea exulans gibsoni	Gibson's Albatross	Vulnerable	Possibly transient
Halobaena caerulea	Blue Petrel	Vulnerable	Possibly transient
Lathamus discolor	Swift Parrot	Endangered	Possibly transient
Leipoa ocellata	Malleefowl	Vulnerable	Habitat unlikely in sand dune and intertidal area
Macronectes giganteus	Southern Giant-Petrel	Endangered	Possibly transient
Macronectes halli	Northern Giant-Petrel	Vulnerable	Possibly transient

Species Name	Common Name	Status	Likelihood of presence
Neophema chrysogaster	Orange-bellied Parrot	Critically Endangered	Habitat unlikely in sand dune and intertidal area
Psophodes nigrogularis leucogaster	Western Whipbird (eastern)	Vulnerable	Possibly resident
Pterodroma mollis	Soft-plumaged Petrel	Vulnerable	Possibly transient
Rostratula australis	Australian Painted Snipe	Vulnerable	Possibly transient
Thalassarche bulleri	Buller's Albatross	Vulnerable	Possibly transient
Thalassarche cauta cauta	Shy Albatross, Tasmanian Shy Albatross	Vulnerable	Possibly transient
Thalassarche cauta salvini	Salvin's Albatross	Vulnerable	Possibly transient
Thalassarche chrysostoma	Grey-headed Albatross	Vulnerable	Possibly transient
Thalassarche melanophris	Black-browed Albatross	Vulnerable	Possibly transient
Thalassarche melanophris impavida	Campbell Albatross	Vulnerable	Possibly transient
Frogs			
Litoria raniformis	Growling Grass Frog, Southern Bell Frog, Green and Golden Frog, Warty Swamp Frog	Vulnerable	Habitat unlikely in sand dune and intertidal area
Mammals			
Balaenoptera musculus	Blue Whale	Endangered	Possibly transient
Eubalaena australis	Southern Right Whale	Endangered	Possibly transient and recorded offshore of the project area coastline
Megaptera novaeangliae	Humpback Whale	Vulnerable	Possibly transient
Neophoca cinerea	Australian Sea-lion	Vulnerable	Possibly transient
Ray-finned fishes			
Craterocephalus fluviatilis	Murray Hardyhead	Vulnerable	Possibly resident
Maccullochella peelii peelii	Murray Cod, Cod, Goodoo	Vulnerable	Possibly resident
Sharks			
Carcharodon carcharias	Great White Shark	Vulnerable	Possibly transient
Plants			
Caladenia conferta	Coast Spider-orchid	Endangered	Habitat unlikely in sand dune and intertidal area
Cassinia tegulata	a shrub	Critically Endangered	Habitat unlikely in sand dune and intertidal area
Frankenia plicata		Endangered	Habitat unlikely in sand dune and intertidal area
Senecio macrocarpus	Large-fruit Fireweed, Large-fruit Groundsel	Vulnerable	Habitat unlikely in sand dune and intertidal area

Species Name	Common Name	Status	Likelihood of presence
Thelymitra epipactoides	Metallic Sun-orchid	Endangered	Habitat unlikely in sand dune and intertidal area
Thelymitra matthewsii	Spiral Sun-orchid	Vulnerable	Habitat unlikely in sand dune and intertidal area

3.2.4 Migratory Species

The 42 migratory species identified included five terrestrial birds, ten wetland birds, 19 marine birds, seven marine mammals and one sharks (Table 5). The majority of these species are considered possibly transient through the location. The two migratory marine mammals more likely to be possibly occurring: southern right whales and humpback whales; may pass through the region from time to time, but these occurrences are likely to be transitory, largely unpredictable, and occur seasonally.

Also it is considered highly unlikely that these species will be present within the shallow intertidal / subtidal guttering sands adjacent to the discharge pipe.

The Orange Bellied Parrot

Parnka Point is a known location utilised by the orange bellied parrot during their winter migration. Since 1984, five Recovery Plans have been prepared for the Orange-bellied Parrot; the first by Brown and Wilson (1984), followed by Stephenson (1991), Askey Doran (1995) and the two most recent by the Orange-bellied Parrot Recovery Team (1996, 2006).

The entire population of the critically endangered Orange-bellied Parrot (OBP) stands at around 150 individuals, making it one of Australia's rarest bird species. One of only three migratory parrots in the world, the OBP breeds in remote south-western Tasmania and winters in coastal south-eastern mainland Australia, usually between The Coorong, South Australia, and Jack Smith Lake in Gippsland, Victoria.

OBPs arrive on the mainland from as early as February, but usually during early April. Most 'early' records (February-April) are from Victoria, and birds are not usually detected in South Australia until later, usually from late April-May. However, it should be considered that much of the South Australian coast is remote and less frequently accessed and surveyed for OBPs. Over the course of winter, the dispersal patterns of the OBP are poorly understood. They remain for varying durations at different locations, largely dictated by the availability of food resources. The birds appear to be particularly erratic and highly-mobile in SA. By late September-October, OBPs commence their departure from the mainland. Some birds are still recorded in Victoria as late as early November but the return migration to Tasmania is rapid and most birds will have returned and be ready to commence breeding by mid-November.

Habitat

Whilst on the mainland, OBPs are found mostly within 3 km of the coast. In Victoria, they use sheltered coastal areas such as bays, estuaries and lagoons. Some of the known key OBP areas include sites along the western shores of Port Phillip Bay (e.g. Western Treatment Plant, Spit Nature Reserve), the Bellarine Peninsula (e.g. Lake Connewarre, Swan Island, Duck Island, fringe of Swan Bay) and south-west Victoria (e.g. near Rutledge's Cutting, Lake Yambuk). Other sites known to occasionally support OBPs include French Island, the fringes of Westernport, and the fringes of Corner Inlet and several islands within. At these sites, they rely on coastal saltmarsh vegetation as their primary foraging habitat. These communities support many of the known key food plants such as Beaded Glasswort *Sarcocornia quinqeflora*, Shrubby Glasswort *Sclerostegia arbuscula*, Sea-blite *Suaeda australis* and other low herbaceous plants. OBPs are also known to forage in nearby pastures on a range of weeds and grasses. For roosting, the parrots require taller dense vegetation such as Moonah *Melaleuca lanceolata*, Golden Wattle *Acacia pycnantha*, Coast Beard Heath *Leucopogon parviflora* and, in some cases, African Boxthorn *Lycium ferocissimum*.

In South Australia, dune frontages and hind dune systems, near coastal wetlands, saline depressions and sheltered beaches appear to be favoured. Here, they are known to feed on a variety of plants such as Bidgee-widgee *Acaena novaezelandiae* and Sea Rocket *Cakile maritima*. They also use Sarcocornia-dominated saltmarshes around low-lying saline drains, coastal lagoons and estuaries, as well as coastal heaths and open grassy pastures. OBPs are widely dispersed in SA but are most often found in the far south-east in the Port MacDonnell region, and the Coorong. Sites where the species has recently been recorded include the northern side of Lake Alexandrina, the Coorong National Park near Magrath Flat, and Piccaninnie Ponds in the far south-east.

Surveys for OBPs and population monitoring have been conducted on the mainland each winter since 1980. In recent years (since around 1990), patterns of habitat usage and dispersion appear to have changed, to the point where records have essentially 'lost track' of where most of the birds occur whilst they occur on the mainland. Compared to survey results from the 1980s, where an average of 43% (86 birds) of the known total population was accounted for, surveys since 2000 have recorded an average of just 10% (20 birds), despite increased volunteer numbers and greater survey site coverage. Without knowledge of the current winter distribution of the species, the capacity to plan adequate conservation measures to ensure its ongoing survival has been greatly reduced.

The shores of the Coorong lagoons and lakes represent one of the largest and most important environments for OBPs on the mainland. They comprise around a third of the species core non-breeding range (as predicted by the recently completed habitat models), and for years OBPs have been observed at sites like 29 Mile Crossing, Cantara, Parnka Point and the Younghusband Peninsula. In the more distant past, dozens of OBPs were trapped on islands near Salt Creek at the southern end of the South Lagoon for aviculture.

Orange bellied, Blue-winged, Elegant and Rock Parrots in the Coorong all feed largely on samphires and other saline vegetation. Birds Australia recently assessed OBP habitat at around 30 sites around the Coorong for the South Australian Department for Environment and Heritage and it emerged that potential habitat in the lower Coorong is in the worst condition, with salinity (and possibly acidity) levels well in excess of physiochemical tolerance of all known OBP target plants.

Table 5 Migratory Species

Species Name	Common Name	Status	Likelihood of presence
Migratory Terrestrial Species – Birds			
Haliaeetus leucogaster	White-bellied Sea-Eagle	Migratory	Possibly transient
Hirundapus caudacutus	White-throated Needletail	Migratory	Possibly transient
Leipoa ocellata	Malleefowl	Migratory	Habitat unlikely in sand dune and intertidal area
Merops ornatus	Rainbow Bee-eater	Migratory	Habitat unlikely in sand dune and intertidal area
Neophema chrysogaster	Orange-bellied Parrot	Migratory	Habitat unlikely in sand dune and intertidal area. Previously recorded at Parnka Point
Migratory Wetland Species - Birds			
Ardea alba	Great Egret, White Egret	Migratory	Possibly transient
Ardea ibis	Cattle Egret	Migratory	Possibly transient
Calidris acuminata	Sharp-tailed Sandpiper	Migratory	Possibly transient
Calidris alba	Sanderling	Migratory	Possibly transient
Calidris ferruginea	Curlew Sandpiper	Migratory	Possibly transient

Species Name	Common Name	Status	Likelihood of presence
Calidris ruficollis	Red-necked Stint	Migratory	Possibly transient
Gallinago hardwickii	Latham's Snipe, Japanese Snipe	Migratory	Possibly transient
Pluvialis fulva	Pacific Golden Plover	Migratory	Possibly transient
Rostratula benghalensis s. lat.	Painted Snipe	Migratory	Possibly transient
Tringa nebularia	Common Greenshank, Greenshank	Migratory	Possibly transient
Migratory Marine Birds			
Apus pacificus	Fork-tailed Swift	Migratory	Possibly transient
Ardea alba	Great Egret, White Egret	Migratory	Possibly transient
Ardea ibis	Cattle Egret	Migratory	Possibly transient
Diomedea exulans amsterdamensis	Amsterdam Albatross	Vulnerable	Possible transient
Diomedea exulans exulans	Tristan Albatross	Endangered	Possibly transient
Diomedea epomophora (sensu stricto)	Southern Royal Albatross	Migratory	Possibly transient
Diomedea exulans (sensu lato)	Wandering Albatross	Endangered	Possibly transient
Diomedea gibsoni	Gibson's Albatross	Migratory	Possibly transient
Diomedea sanfordi	Northern Royal Albatross	Migratory	Possibly transient
Macronectes giganteus	Southern Giant-Petrel	Migratory	Possibly transient
Macronectes halli	Northern Giant-Petrel	Migratory	Possibly transient
Sterna albifrons	Little Tern	Migratory	Possibly transient
Thalassarche bulleri	Buller's Albatross	Migratory	Possibly transient
Thalassarche cauta (sensu stricto)	Shy Albatross, Tasmanian Shy Albatross	Migratory	Possibly transient
Thalassarche chlororhynchos	Yellow-nosed Albatross, Atlantic Yellow-nosed Albatross	Migratory	Possibly transient
Thalassarche chrysostoma	Grey-headed Albatross	Vulnerable	Possibly transient
Thalassarche impavida	Campbell Albatross	Migratory	Possibly transient
Thalassarche melanophris	Black-browed Albatross	Vulnerable	Possibly transient
Thalassarche salvini	Salvin's Albatross	Migratory	Possibly transient
Migratory Marine Species – Mammals			
Balaenoptera edeni	Bryde's Whale	Migratory	Possibly transient
Balaenoptera musculus	Blue Whale	Migratory	Possibly transient
Caperea marginata	Pygmy Right Whale	Migratory	Possibly transient
Eubalaena australis	Southern Right Whale	Migratory	Possibly transient and recorded offshore of the project coastline
Lagenorhynchus obscurus	Dusky Dolphin	Migratory	Possibly transient

Species Name	Common Name	Status	Likelihood of presence
Megaptera novaeangliae	Humpback Whale	Migratory	Possibly transient
Orcinus orca	Killer Whale, Orca	Migratory	Unlikely to occur
Sharks			
Carcharodon carcharias	Great White Shark	Migratory	Possibly transient

3.2.5 Listed Marine Species

73 listed marine species were identified (Table 6). Eleven of these species also occurred on the threatened species list.

Hooded Plover

Of particular risk during construction activities on the site is the Hooded Plover. The hooded plover is known to inhabit the Younghusband Peninsula component of the Coorong beach area and as such there is restricted access during the key plover reproductive period. Vehicle use of the Younghusband Peninsula is closed to all but commercial fishers and permitted vehicles from the 25th October to the 25th December of each year. The reason for this vehicular restriction is that the hooded plover attempts to hide from disturbance in shallow depressions such as those formed by tire trucks in the sand. This behaviour increases the potential for the plovers to be injured or killed by vehicles. A draft Recovery Plan was prepared by Baker-Gabb and Weston (1999). Management documentation has been authored by Urquhart and Teoh (2001), Weston (2003) and Weston and Morrow (2000). A recovery plan for the South Australian population of the Hooded Plover (eastern) is in preparation. To protect the hooded plover, the ocean beach is closed to vehicles from 24 October to 24 December each year. This closure applied to the beach from the Tee Tree Crossing to the Murray Mouth.

Syngnathids

Twenty six syngnathids (pipefish) were identified to be possibly resident within the area. Syngnathids are generally favour particular habitats such as seagrasses and reef and/or broken (rubble) substrates (Browne *et al*., 2008). However, the level of habitat fidelity between species can differ, with some species occurring broadly across different habitats. Habitat mapping from Haig *et al.* (2006) identifies the subject location as bare sand, an unsuitable and unlikely habitat for syngnathids. No seagrasses have been recorded within the zone of saline influence from the discharge which also reduces the likelihood of syngnathids occurring.

Table 6 Listed Marine Species

Species Name	Common Name	Status	Likelihood of presence
Listed Marine Species			
Apus pacificus	Fork-tailed Swift	Listed –overfly marine area	Possibly transient
Ardea alba	Great Egret, White Egret	Listed –overfly marine area	Possibly transient
Ardea ibis	Cattle Egret	Listed –overfly marine area	Possibly transient
Calidris acuminata	Sharp-tailed Sandpiper	Listed	Possibly transient
Calidris alba	Sanderling	Listed	Possibly transient
Calidris ferruginea	Curlew Sandpiper	Listed –overfly marine area	Possibly transient

Species Name	Common Name	Status	Likelihood of presence
Calidris ruficollis	Red-necked Stint	Listed –overfly marine area	Possibly transient
Diomedea epomophora (sensu stricto)	Southern Royal Albatross	Listed	Possibly transient
Diomedea gibsoni	Gibson's Albatross	Listed	Possibly transient
Diomedea sanfordi	Northern Royal Albatross	Listed	Possibly transient
Gallinago hardwickii	Latham's Snipe, Japanese Snipe	Listed –overfly marine area	Possibly transient
Haliaeetus leucogaster	White-bellied Sea-Eagle	Listed	Possibly transient
Hirundapus caudacutus	White-throated Needletail	Listed –overfly marine area	Possibly transient
Larus novaehollandiae	Silver Gull	Listed	Possibly transient
Lathamus discolor	Swift Parrot	Listed –overfly marine area	Possibly transient
Limnodromus semipalmatus	Asian Dowitcher	Listed-overfly marine area	Possibly transient
Macronectes giganteus	Southern Giant-Petrel	Listed	Possibly transient
Macronectes halli	Northern Giant-Petrel	Listed	Possibly transient
Merops ornatus	Rainbow Bee-eater	Listed –overfly marine area	Possibly transient
Neophema chrysogaster	Orange-bellied Parrot	Listed –overfly marine area	Possibly transient
Pluvialis fulva	Pacific Golden Plover	Listed	
Rostratula benghalensis s. lat.	Painted Snipe	Listed –overfly marine area	Possibly transient
Sterna albifrons	Little Tern	Listed	Possibly transient
Sterna bergii	Crested Tern	Listed	Possibly transient
Sterna fuscata	Sooty Tern	Listed	Possibly transient
Sterna nereis	Fairy Tern	Listed	Possibly transient
Thalassarche bulleri	Buller's Albatross	Listed	Possibly transient
Thalassarche cauta (sensu stricto)	Shy Albatross, Tasmanian Shy Albatross	Listed	Possibly transient
Thalassarche impavida	Campbell Albatross	Listed	Possibly transient
Thalassarche salvini	Salvin's Albatross	Listed	Possibly transient
Thinornis rubricollis rubricollis	Hooded Plover (eastern)	Listed –overfly marine area	Likely transient
Tringa nebularia	Common Greenshank, Greenshank	Listed –overfly marine area	Likely transient
Mammals			
Arctocephalus forsteri	New Zealand Fur-seal	Listed	Possibly transient
Arctocephalus pussillus	Australian Fur-seal	Listed	Possibly transient
Neophoca cinerea	Australian Sea-lion	Listed	Possibly transient
Ray-finned fishes			

Species Name	Common Name	Status	Likelihood of presence
Acentronura australe	Southern Pygmy Pipehorse	Listed	Possibly resident
Campichthys tryoni	Tryon's Pipefish	Listed	Possibly resident
Heraldia nocturna	Upside-down Pipefish	Listed	Possibly resident
Hippocampus abdominalis	Eastern Potbelly Seahorse, New Zealand Potbelly, Seahorse, Bigbelly Seahorse	Listed	Possibly resident
Hippocampus breviceps	Short-head Seahorse, Short-snouted Seahorse	Listed	Possibly resident
Histiogamphelus cristatus	Rhino Pipefish, Macleay's Crested Pipefish	Listed	Possibly resident
Hypselognathus rostratus	Knife-snouted Pipefish	Listed	Possibly resident
Kaupus costatus	Deep-bodied Pipefish	Listed	Possibly resident
Leptoichthys fistularius	Brushtail Pipefish	Listed	Possibly resident
Lissocampus caudalis	Australian Smooth Pipefish, Smooth Pipefish	Listed	Possibly resident
Lissocampus runa	Javelin Pipefish	Listed	Possibly resident
Maroubra perserrata	Sawtooth Pipefish	Listed	Possibly resident
Notiocampus ruber	Red Pipefish	Listed	Possibly resident
Phycodurus eques	Leafy Seadragon	Listed	Possibly resident
Phyllopteryx taeniolatus	Weedy Seadragon, Common Seadragon	Listed	Possibly resident
Pugnaso curtirostris	Pug-nosed Pipefish	Listed	Possibly resident
Solegnathus robustus	Robust Spiny Pipehorse, Robust Pipehorse	Listed	Possibly resident
Solegnathus spinosissimus	Spiny Pipehorse, Australian Spiny Pipehorse	Listed	Possibly resident
Stigmatopora argus	Spotted Pipefish	Listed	Possibly resident
Stigmatopora nigra	Wide-bodied Pipefish, Black Pipefish	Listed	Possibly resident
Stipecampus cristatus	Ring-backed Pipefish	Listed	Possibly resident
Urocampus carinirostris	Hairy Pipefish	Listed	Possibly resident
Vanacampus margaritifer	Mother-of-pearl Pipefish	Listed	Possibly resident
Vanacampus phillipi	Port Phillip Pipefish	Listed	Possibly resident
Vanacampus poecilolaemus	Australian Long-snout Pipefish, Long-snouted Pipefish	Listed	Possibly resident
Vanacampus vercoi	Verco's Pipefish	Listed	Possibly resident
Whales and Other Cetaceans			
Balaenoptera acutorostrata	Minke Whale	Cetacean	Possibly transient

Species Name	Common Name	Status	Likelihood of presence
Balaenoptera edeni	Bryde's Whale	Cetacean	Possibly transient
Balaenoptera musculus	Blue Whale	Cetacean	Possibly transient
Caperea marginata	Pygmy Right Whale	Cetacean	Possibly transient
Delphinus delphis	Common Dolphin, Short-beaked Common Dolphin	Cetacean	Possibly transient
Eubalaena australis	Southern Right Whale	Cetacean	Likely transient
Grampus griseus	Risso's Dolphin, Grampus	Cetacean	Possibly transient
Lagenorhynchus obscurus	Dusky Dolphin	Cetacean	Possibly transient
Megaptera novaeangliae	Humpback Whale	Cetacean	Likely transient
Orcinus orca	Killer Whale, Orca	Cetacean	Possibly transient
Tursiops aduncus	Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin	Cetacean	Likely transient
Tursiops truncatus s. str.	Bottlenose Dolphin	Cetacean	Possibly transient

3.3 Marine habitats

The ecosystems of the inshore marine waters of this high energy area are difficult to access and hence there is little recorded information on these systems. A recent survey by Haig *et al.* (2006) showed that coarse sands overlying low platform limestone reef dominate the Coorong offshore marine areas although the area adjacent and offshore of the project site was classified by Haig *et. al*. (2006) as bare reef. The low platform reefs running parallel to shore are interspersed with more complex reef formations and algal beds. Little fauna was directly observed in these offshore regions during the Haig *et al.* (2006) surveys although the authors did indicate that poor conditions may have influenced the results.

Sandy habitats are formed by an accumulation of sediment deposited by waves and long shore currents. The energy of the wave action dictates the types and size of sediment grains deposited, and the profile of the sandy habitat, which will in turn facilitate the types of organisms capable of inhabiting the zone. For example, medium wave energy zones typical of southern Australian beaches generally consist of fine to medium grain sands, and create a diversity of habitats available to biota (Jones and Short 1995). It is likely that high wave energy and constant sand movements to the south of the Murray Mouth prevent the settlement of many sessile species (Edyvane, 1999); however, these areas are likely to provide habitat for an abundance of infaunal invertebrate biota. Dependent on sediment particle size, invertebrates in and on the sandy habitats of the marine areas offshore of the Coorong are likely to be dominated by worms (nematodes, polychaetes, flatworms and ribbon worms); crustaceans (crabs, amphipods and isopods) and molluscs (Jones and Short 1995). The Goolwa cockle (*Donax deltoids)*, is particularly abundant in inshore, mainly intertidal areas, and forms the basis of a commercial fishery (Murray-Jones and Johnston 2003).

A series of complex reefs and low platform limestone reefs provide hard substrates suitable for the settlement of sessile biota. Floral and faunal assemblages on these reef surfaces are shaped predominantly by wave exposure and light availability. In the deeper waters of the offshore marine areas of the Coorong, algal beds on rocky substrate are dominated by depth-tolerant red algae (Edyvane 1999; Pierce & Doonan 1999). Haig *et al*. (2006) recorded mainly red foliose algal assemblages on reefs at deep (> 20 m) offshore sites with the kelp *Ecklonia* in abundance at sites deeper than eight metres in areas north of Policeman's Point (West Island, Knight Beach, Pullen Island South).

In contrast to the offshore reefs, the shallower high-energy platform reefs of the Coorong offshore marine habitats are mostly dominated by robust brown branching algae such as *Cystophora* and *Seirococcus* genera, and *Ecklonia radiata* with an understorey of red foliose and red encrusting species (Haig *et al.*, 2006).

Much of the fauna identified from previous surveys (Edyvane, 1999; Haig *et al*., 2006) are considered reasonably common in southern Australian waters. However, it should be noted that (and particularly for South Australia) for many marine invertebrates, even common ones, there is little biological, taxonomic or distributional information available. Rowling *et al* (2009) surveyed 2km directly offshore from the proposed discharge location and also found no evidence of any EPBC listed species or habitats which have the potential to support these species.

It is considered that the communities most likely to be impacted by the proposed project are in the intertidal and inshore sandy infaunal assemblages as the modelling has shown that the salinity will be back to background levels within a short distance (within the bare sand zone) . These communities are typically dominated by worms and, within the Younghusband Peninsula, the Goolwa cockle and are typical of high energy sandy habitats. Information relating to these inshore habitat is scarce and little survey work has been carried out here although cockle biology in relation to the fishery has recently been the subject of a PhD due to be published (Coby Mathews, *per com*).

3.4 Cultural heritage

The MDB NRM are committed to informing and consulting with the Ngarrindjeri people and a formal position regarding this concept will be formulated prior to the projects implementation. Work order clearances and Heritage Approvals will also be mandatory and the pipeline contractor will be required to ensure these are in place.

3.5 Recreational fisheries and boat-users

There are two boat ramps in the vicinity of the project area on the Coorong lagoons side. The boat ramp at Policeman's Point is accessible by a rough track, although there is difficulty launching off the loose sandy beaches. Timber piles at this location mark the channel to deep water. The other local boat ramp is at Seagull Island to the south east of Policeman's Point.

Popular recreational fishing areas on the Coorong ocean side are located opposite Princes Soak approximately 2km from the project area. Also Salt Creek wreck in the ocean is also popular with recreational fishers. Key species fished within the area are mulloway, sharks, salmon, mullet, flathead and snapper.

3.6 Commercial fisheries

The lower Murray Lakes and Coorong region is situated at the tail end of the largest freshwater catchment in Australia, the Murray-Darling Basin, where the river system meets the Southern Ocean. The entire catchment spans across four state management jurisdictions and has been significantly modified since European settlement because of its importance in supporting human existence and industrial development. The introduction of various water flow management measures, water extraction systems, the associated barriers to fish migration and the proliferation of a number of exotic fish species have collectively served to modify the structure, productivity and function of the entire ecosystem and had a generally negative impact on fish habitat.

The lower River Murray and Coorong Lakes and coastal marine waters adjacent to the Younghusband Peninsulas are considered a significant part of the South Australian commercial fisheries industry (DEH 2005). Target species fished in these locations are shown in Table 7.

Table 7 – Target Fisheries Species in Lower River Murray and Coorong Lakes and Adjacent Marine Waters (adapted from DEH 2005)

Common Name	Scientific Name	Location found
Goolwa cockles (also known as pipi)	*Donax deltoides*	Younghusband Peninsula
Mulloway	*Argyrosomus japonicus*	Coorong lagoons and open ocean
Yellow-eye Mullet	*Aldrichetta forsteri*	Coorong lagoons
Black bream	*Acanthopagrus butcheri*	Coorong lagoons
Greenback flounder	*Rhombosolea taparina*	Coorong lagoons
Golden perch	*Macquaria ambigua*	Coorong lakes
European carp	*Cyrpinus carpio*	Coorong lakes

The regulations that govern the management of the Lakes and Coorong Fishery are the Fisheries (Scheme of Management - Lakes and Coorong Fishery) Regulations 1991 and the Fisheries (General) Regulations 2000. The South Australian Government has management jurisdiction for the full suite of species taken in the Lakes and Coorong Fishery. The one exception to this is school and gummy shark which is regulated by the Australian Fisheries Management Authority (AFMA) under an Offshore Constitutional Settlement (OCS) agreement between the South Australian and Commonwealth governments.

The Lakes and Coorong Fishery is a multi species, multi-method fishery. The primary species fished include mulloway (*Argyrosomus japonicus*), the Goolwa cockle (*Donax deltoides)*, yellow-eye mullet (*Aldrichetta forsteri*), golden perch (*Macquaria ambigua*), greenback flounder (*Rhombosolea tapirina*) and black bream (*Acanthopagrus butcheri*). Important exotic fish species also fished include European carp (*Cyprinus carpio*) and redfin (*Perca fluviatilis*) which are found within the Coorong lake.

The range of flow regulation measures introduced throughout the Murray-Darling Basin has caused the Murray Mouth to approach closure more frequently than would have occurred naturally. As a result, there are varied and acute pressures placed on the environment, many of which are exposed during periods of extended drought or reduced water flow. During periods of low River Murray flow or non-flow, suitable winds, tide and swell has previously resulted in closure of the Murray Mouth. The potential impacts of a long-term Murray Mouth closure on the fish stocks of the Lakes and Coorong are considered severe (Higham *et al*., 2002).

Recent studies have hypothesised that high freshwater flow through the Murray Mouth may be correlated with peaks in seasonal commercial catches of mulloway inside and outside the Coorong estuary (Ferguson and Ward, 2003). Freshwater outflows is also thought to enhance nutrient levels, which in turn elevate primary production and provides a more abundant food supply of phytoplankton for species such as the Goolwa cockle (King, 1976; Murray-Jones and Johnson, 2003).

3.6.1 The Goolwa (pipi) cockle fishery

The Goolwa and Coorong ocean beaches support a significant commercial and recreational fishery for the Goolwa cockle. Goolwa cockles are distributed on surf beaches from southern Queensland to Eyre Peninsula, South Australia and are found along high-energy coastlines within the surf zone. King (1976) considered that the South Australian cockle population found in the Coorong was likely to be the largest population in Australia and the species is a particular concern for this proposal as the populations occur within the likely zone of influence of the saline concentrate discharge.

Cockles in South Australia are typically in their greatest numbers just below the lowest tide levels with juveniles typically living at higher levels on the shore than adults. This is typical of

surf bivalves with tidal migration being a key activity. They can also bury themselves at up to approx 10cm in depth. The Coorong beach cockles have been shown by King (1976) to survive to a maximum of 3.5yrs. The maximum size reached by the species is >60mm at 3-3.5 years of age, and their maximum age is 4-5 years. Goolwa cockles mature at about 13 months of age (>36mm shell length) and spawn mainly during September and October in South Australia (Kailola *et al.*, 1993).

Like most bivalves, Goolwa cockles are filter feeders, and play an important role in the trophic structure of beaches they inhabit (McLachlan *et al*., 1996). Surf diatoms such as *Asterionella* in South Australian beaches are major food items for cockles. Cockle larvae are able to survive in the water column for up to several weeks prior to settlement which is thought to occur as a response to a variety of biological and chemical cues. King (1976) showed that the species spawn almost continuously but that recruitment actually tends to occur in pulses which may be related to favourable condition cues such as Murray flows and associated diatom and hence chlorophyll *a* levels.

Abundance of cockles from year to year is subject to enormous fluctuations and is affected by environmental variations such as reduced salinity. Freshwater flows in particular have been shown to cause mortality in the cockle fishery; however the results are double edged as freshwater outflows are also thought to enhance nutrient levels, which in turn elevate primary production and provide larger numbers of phytoplankton (Goolwa cockle) (King, 1976; Murray-Jones and Johnson, 2003). Very little work has been carried out on the effects increased salinities levels may have on the cockle populations, however Goolwa cockles have been shown to be able to tolerate salinities ranging from 20-45ppt (Nell and Gibbes 1986).

According to Murray-Jones and Johnson (2003), 37 license holders were operating in the Coorong and Lower Lakes with 29 having endorsements for cockle gear. Of these, in the 2000/2001 licensing year there were approximately 15 Lakes and Coorong (L&C) licensees and seven Marine Scale Fishery (MSF) licensees active in this fishery in. That being said, up till January 2001, only two to three fishers were active in the MSF sector and two MSF licensees endorsed to sell cockles.

Within SA the cockle fishery is focused on the intertidal zone where cockle aggregations are easier to access. Commercial effort is greater on the Younghusband Peninsula beach (east of the Murray mouth) rather than the Sir Richard Peninsula beach (west of the Murray Mouth) with recreational cockle fishing showing the opposite trend. The reasons for this are likely to be linked to the greater utilisation of the Sir Richard Peninsula by recreational vehicles and its perceived safety issues for commercial cockle fishermen. The harvest of cockles is currently limited to capture using solely the hand and/or feet, or capture with the aid of a manually operated cockle rake or net. Management measures are in place on the fishery including a minimum shell size of 35mm across its largest axis of the shell. A bag limit of 600 animals also exists for recreational fishers and taking of Goolwa cockles is prohibited between the 1st June and 31st October (inclusive) each year.

A new survey carried out in spring 2009 (Rowling et al. 2009) has confirmed that the cockle populations adjacent to the proposed discharge point were recorded as being approximately 5% catch compared to the commercial fishery area values with records at less than 500g per transect being recorded.

3.7 Physical Habitat

3.7.1 Environmental flows

As discussed previously, changes to Murray River flow rates can have significant impacts on the surrounding coastal areas. Recruitment of the species such as the Goolwa cockle is considered to be strongly linked to phytoplankton blooms, which are in turn triggered by flows from the Murray (Murray-Jones and Johnston 2003). Recent studies commissioned by

MDB NRM have examined different scenarios and methods for keeping the Murray Mouth open (BMT / WBM 2007)

3.7.2 Water Quality

Nitrogen and nutrient levels have been shown to decline in the southern ocean from south to north of the study area which has been attributed to the Bonney upwelling near Robe, which brings nutrient-rich waters from below the continental shelf to the surface waters of the southern Coorong. These higher levels of total nitrogen in the south do not appear to have a knock-on effect on plankton levels however, as chlorophyll a levels have been shown to remain similar within the area (Murray-Jones and Johnston, 2003).

The South Australian Departments of Environment and Heritage and of Water, Land and Biodiversity Conservation have been collecting data on water column chemistry at multiple stations in the Coorong since 1997 although not on the ocean side (Ford, 2007). For most of the study period, the study showed strong seasonal gradients of salinity increasing southward along both lagoons of the Coorong. These gradients vary seasonally and arise from the combination of low rainfall and high evaporation together with limited inputs of freshwater from the Lower Lakes. The concentration of chlorophyll a showed a pronounced spatial variation increasing from the northern end to the southern end where concentrations exceed 100 µgL-1 for most of the observations. The study also showed that the concentrations of dissolved organic carbon (DOC), dissolved organic nitrogen (DON), and dissolved organic phosphorus (DOP) all increase southwards along the Coorong faster than the salinity increases indicating that there are sources of these materials in the southern lagoon. This leads to the paradoxical situation of having a high phytoplankton biomass but low dissolved nutrient concentrations which appear insufficient to support the biomass production.

3.7.3 Offshore Salinity Temperature and Stratification

The CSIRO CARS database indicates the salinity and temperature in the ocean waters adjacent the Coorong vary from 35.7 ppt and 19 ℃ i n April to 35.6 ppt and 15 ℃ in September. Nearshore waters are likely to be influenced by the Murray River discharge that would lead to decrease in salinity during periods of high River flows. When compared to offshore water temperatures heating of near shore waters during summer is likely to lead to slightly higher temperatures at the shoreline and during winter colder water temperatures than offshore. For preliminary modelling purposes the ocean temperature and salinity have been assumed to be constant at 36 ppt and 20 ℃. Di spersion patterns will be predominantly driven by the salinity difference (density gradient) between the discharge and receiving water and as such any variation in these parameters (i.e. receiving water temp and salinity) are not likely to affect the relative dispersion patterns of the discharge.

3.7.4 Hydrodynamics

The likely footprint of the dense saline discharge within the marine waters is determined by the oceanographic dispersion processes within the receiving environment. The dispersion characteristics are in turn determined by the hydrodynamics or oceanographic processes. The dispersion processes in the nearshore zone are determined by a range of complex interactions between the dominant hydrodynamic forcing terms that include the wind, astronomical tides, surface waves and their interaction with the topography. The assessment of dispersion is detailed within the preliminary hydrodynamic modelling report (Aurecon 2009) and involved the collation of available data to gain an understanding of relative magnitudes of the key mixing processes in the receiving waters.

4. Conceptual Design of Discharge System

4.1 Engineering and Environmental Constraints

There a number engineering and environmental constraints affecting the development of this proposal. The general criteria for the design are that it be flexible, readily constructed and removed after about 3 years of use.

4.1.1 Issues

Issues to be considered in the preliminary design include:

- Constructability and removal
- Inlet Location selection
- Pipeline route selection
- Access to site
- Environmental and heritage issues in the lake, dunes and coastal areas
- On site work staging and storage areas
- Scour protection and armouring requirements
- Discharge configuration
- Dispersion in near shore and offshore zones
- Plume footprint to say 1 ppt salinity excess in the receiving waters
- Potential Acid Sulfate Soils

In terms of the discharge plume dispersion perspective worst case conditions are thought to comprise low winds and waves during neap tides when the natural turbulent mixing is low and hence the plume identity is retained over longer distances. Conversely, under strong shore parallel winds the plume may hug the shoreline for some distance thereby exposing inter-tidal habitats to the higher salinity waters. The worst case will depend upon the benthic habitat, flora and fauna that may be affected and its tolerance to high salinity water.

The engineering issues, constraints and design are considered within the Aurecon Preliminary Hydrodynamic Modelling Report (2009) and the Tonkin Consulting review of pumping options (2009). Readers are asked to refer to these report for further engineering details.

5. Preliminary Environmental Assessment

A preliminary high level impact assessment was undertaken in order to give an indication of the likely environment impacts of the proposed development. This assessment has been based upon consideration of the preliminary engineering and modelling options.

5.1 Planning framework

It is likely that an EPBC referral will be required in order to ascertain whether the project is of Controlled Action Status. However, the proposed works may be excluded from the Development Act by the State Government due to their emergency nature in ensuring that the Coorong is protected into the future. If this is the case baseline investigations will be required in order to establish baseline data against which to monitor during the temporary works.

In the event that approvals are required and the works are not exempt, then the likely level of assessment will be a Public Environment Report (PER) rather than a full Environmental Impact Assessment, given the emergency nature of the project and its overarching environmental significance.

5.2 Construction Impacts

There are a number of potential impacts that may occur during the construction period and these issues are detailed briefly below in Table 10 and in the following section. It should be noted that many of these potential impacts will be of a short duration and reversible. Good management and mitigation measures will further reduce the potential for significant issues relating to construction activities.

Table 10 Potential Construction Impacts

Issues	Potential concerns
Installation of outfall conduit in the coastal and marine environment	Removal, damage or disturbance of coastal and marine habitats or species Potential disturbance of cultural heritage artefacts. A full survey will be required prior to selection of the pipeline route. The contractor will be required to develop a heritage management plan and liaise with local indigenous liaison officer in order to ensure no impacts upon cultural heritage. Monitors may also be required onsite during the construction works. Visual impact during construction
Construction vehicles	Introduction of pest species Hydrocarbon and chemical spills. Localised damage of marine or coastal species
Excavation	Excavation and disposal of sediments impacting on marine biota and ecosystems Turbidity may become elevated due to excavation
Noise and vibration from construction activities	Impact on marine and coastal biota, particularly birds
Construction exclusion zone	Impacts on commercial fishing Impacts on recreational fishing

5.2.1 Sand dune disturbance and subsequent instability issues

There are a number of issues during construction which relate predominantly to the method of construction. Of particular concern are the sand dunes and coastal communities through which the pipeline from the Coorong to the ocean beach at Policemans Point will run. As detailed within Section 3, there are a number of communities which have the potential to be damaged or disturbed by the construction of the pipeline. There is also the Potential Acid Sulphate Soil (ASS) issue on the Coorong lakes side of the pipeline which is thought to be

present in the local area at a depth of 20-50cm below surface. Any construction method will be required to implement and develop an ASS management plan as well as a flora and fauna management plan in order to minimise impacts on any vulnerable species.

Construction of the proposed project will require removal and disturbance of a 1 km long x 10 m wide stretch of coastal habitat across the dunes and about 200 m across shore by 50 m alongshore (1 hectare) of sub-tidal and intertidal habitats in order to install the pipeline and pumping station. No rare or scarce species have been recorded as present in the proposed construction area. As discussed within section 3, communities within the Policemans Point area are broadly represented elsewhere along the 80 km stretch of coastline spanning from Goolwa to Cape Jaffa.

A flora and fauna assessment is required in order to identify the most suitable route for the pipeline with the least environmental impact. A flora and fauna management plan will also require development in order to remove, minimise or mitigate these impacts during construction and reinstate areas following removal of the system.

5.2.2 Marine and intertidal habitats and species

A minor amount of trenching and excavation may be required during the construction of the pipeline depending on the option taken forward. This is likely to cause sediment plumes and associated issues, result in the interruption of the sandy marine substrate and create an artificial reef structure in the form of either rock armoured pipeline within the subtidal beach zone, or a geotextile bag covered pipeline across the subtidal beach and into the intertidal surf zone.

There is also the risk that the construction of the pipeline has the potential to impact upon bird species such as the hooded plover which, due to its shoreline behaviour of sitting in low lying areas (including tire tracks), is at risk of having its nest and eggs destroyed or being injured by vehicles. Although the number of birds potentially impacted by the construction period is likely to be no more than 1 or 2 pairs, management plan should reduce this risk as far as possible and works should be avoided during the October to December months to avoid the plovers. Implementation of the Construction EMP may also bring beneficial impacts on the plover through reducing impacts of other beach traffic within the area.

The construction footprint would be minimised as far as practicable and excavation and entrenching methods that reduce impacts across all zones would be considered. Reef species may also colonise the rock armour protected pipeline. It is expected that the impacts of placing a hard structure within a soft sediment habitat will be balanced by the introduction of an artificial reef structure. This would result in a small change in the relative amount of hard versus soft substratum.

5.2.3 Sediment plumes during construction

For the surf zone discharge the impacts from excavation during construction are dependent on the type of trenching, excavation techniques and the nature of the sediments. The access bund to support the excavator and trench area is likely to impact area some 100 m long by 20 m wide from the shoreline into the intertidal surf zone. The impacts can also be considered to be direct and indirect with the direct impacts stemming from the physical removal of an area of seabed. The indirect impacts stem from the suspension of sediments during the excavation campaign and the associated issues related to dispersal and sedimentation of this plume.

The removal of material from the seabed results in the removal of the animals living on and in the sediments (sedentary and sessile benthic animals and plants / algae). With the exception of some deep burrowing animals or mobile surface animals that may survive a excavation event through avoidance, excavation will initially result in the complete removal of all animals and plants. In soft sediment environments recovery of communities generally occurs relatively quickly. Previous studies have shown that the rates of recovery of benthic communities following dredging in various habitats varies greatly between sites with recovery

ranging from a matter of weeks to many years (Nedwell and Elliot, 1998; Newell *et al*. 1998). Recovery rates are generally most rapid in highly disturbed sediments such as those found on dynamic beaches such as that on the Younghusband Peninsula.

Sediments dispersed during excavation and entrenching may resettle over the seabed and the animals and plants that live on and within it. Animals with delicate feeding or breathing apparatus, such as shellfish can be intolerant to increased siltation, resulting in reduced growth or fatality. This blanketing or smothering of benthic animals and plants may also cause stress, reduced rates of growth or reproduction and in the worse cases the effects may be fatal (Bray *et al*, 1997).

In general, small excavation campaigns often generate no more increased suspended sediments than those generated during severe storms, floods or large tides (Parr *et al*, 1998) and the likely impacts of the excavation activities will be localised and short-term. If excavation or entrenching is undertaken, the excavation contractor should utilise best practise to minimise the excavation footprint. A management plan should be compiled which defines operational protocols for the excavation contractors in order to ensure minimal harm to marine ecosystems.

5.2.4 Power connection and disturbance

If electric pumps are selected then the ability to connect into the power grid may constrain the location of the pumps and inlet system. It is assumed that this issue is considered elsewhere by MDBNRMB as part of the Coorong pumping options and connections. As such this document does not consider this aspect or draw any conclusions as to the construction corridor for the power supply. Should diesel pumps be selected then the supply and storage of diesel fuel at the site will need to be considered and appropriate management actions carried out.

5.2.5 Potential disturbance of cultural heritage artefacts.

A full survey will be required prior to selection of the pipeline route. The contractor will be required to develop a heritage management plan and liaise with local indigenous liaison officer in order to ensure no impacts upon cultural heritage. Monitors may also be required onsite during the construction works.

5.2.6 Noise and air quality issues

As detailed within Section 3, there are many important bird species which utilise the Coorong and Southern Beaches as part of their life cycle, whether it is as visitors or breeding within the area. During construction there is the potential to impact upon these species through direct impacts such as habitat disturbance and displacement from feeding areas, and indirect impacts such as noise disturbance. Due to the small duration of the works, and limited footprint this impact any noise impacts are considered likely to be minimal and short term. A flora and fauna management plan will require development in order to remove, minimise or mitigate these impacts during construction and reinstate areas following removal of the system.

No issues in relation to air quality are considered likely and as such are not considered further.

5.2.7 Pumping costs

The potential pumping costs have not been considered within this document as it is understood that the NDBNRMB have considered these as part of the Coorong side options assessment.

5.2.8 Visual impact

There will be some visual impact during the construction of the proposed pipeline. This will be of a temporary and short term impact and can be mitigated further by good construction

practise and maintenance of a tidy site. Construction works are likely to take longer than a week and hence a lay down area would be screened and maintained in a tidy manner to ensure minimal visual impacts. A CEMP will also be developed to detail how mitigation measures will reduce potential impact.

5.2.9 Recreational access

The marine beach access will be maintained throughout the project although there will be short term impacts during construction upon recreational users of the beach including fishers and recreational vehicles. The pipeline traversing down the beach would be designed in a manner to minimise impact on beach access.

5.2.10 Commercial fishing displacement

During the construction of the pipeline there will be a very small area of beach that will be inaccessible to beach users including the commercial fishers. This area is limited to about 1 hectare and represents only a small fraction of the beach. Potential safety issues related to the fishery 'runners' who run to and from the fishers and who may be at risk to vehicles such as the construction vehicles would need to managed during the construction process.

5.2.11 Potential for introduction / spread invasive species

There is the potential that, during construction, the contractor may introduce non native or pest species on construction vehicles and/or vessels. A pest management plan may be required as part of the CEMP and the Contractor will need to ensure that any vehicles and/or vessels coming in from other areas will be checked and cleaned to ensure no spread or movement to or from the site of pest species.

5.2.12 Potential for spillage during construction

During any construction activity there is the potential for spillage and leaks of chemicals and contaminants to the marine environment. This is particularly true when vehicles are working within the area as they often routinely utilise lubricants and mineral oils for machinery. A CEMP should be developed which will contain spill and chemical management measures.

5.3 Potential Operational Impacts

There are a number of potential issues that may arise from the discharge of the saline waters from the Coorong out to the Southern Ocean. These are outlined in Table 11 and are detailed further below:

Table 11 Potential operational effects of the Coorong saline waters being pumped out to the southern ocean

Issues	Potential Concerns
Installation of outfall conduit in the coastal and marine environment	Impacts upon recreational vehicle access on the beach. Visual impacts of the geotextile bags or rock on the natural beach view Noise and vibration potential Potential for interruption of beach processes (e.g. accretion, movement of sand to sand dunes) Introduction of a hard substrate within a sandy substrate environment

Issues	Potential Concerns
Salinity	The salt concentration of the discharge is potentially 3-4 times (on average), with a potential peak of 4.2 x seawater (150ppt) greater than source/receiving waters Elevated salinity concentrations may harm organisms near the outfall that cannot tolerate either high salinity levels or fluctuations in ambient concentrations. In particular there is the potential to impact upon the Goolwa cockle fishery. Localised elevated salinity concentrations may deter mobile organisms from remaining in the area of the discharge
Other potential impacts	Increased turbidity from Coorong lagoon water. Increase in localised nutrient levels. Decrease in dissolved oxygen levels due to 'pooling' of denser waters over seabed. Also water discharge will have decreased oxygen levels in the higher salinity waters.

5.3.1 Recreational access

There will be likely be operational impacts upon recreational users of the beach including fishers and recreational vehicles. The main potential impact is the geotextile bags covering the pipeline traversing down the beach from the sand dunes to the sea. The pipeline is likely to require some rock armour near the dunes. The pipeline however is not expected to stop beach vehicle movements and access would be maintained.

5.3.2 Visual disturbance

There is likely to be a negligible impact to the visual amenity value of the beach in the pipeline traversing down the beach from the sand dunes out to sea. The pipeline is likely to require some rock armour near the dunes at the back of the beach to protect the pipe and as such will be a noticeable difference to the previously unbroken sweeping swathe of sandy beach and dunes.

It is considered however that, with correct information signage, this would not necessarily be a negative impact and would indeed highlight the active works being carried out to protect the Coorong.

5.3.3 Interruption of beach processes

There is the potential that the interruption of the sandy beach with soft geotextile bags and hard rock structures covering the pipeline and the end-of-pipe discharge will interrupt the natural coastal processes. Impacts may include accretion or loss of beach in the vicinity of the pipeline or knock-on effects further down the coastline due to interruption to the littoral drift affecting coastal topography.

The effects of this project are likely to be short-term and no permanent impacts are envisaged once the pipeline is removed. There may be localised impacts from discharge scour in the vicinity of the outlet pipe but mitigation measures such as geotextile bag apron will be installed as required with regular maintenance ensuring any scour is reduced as far as practicable.

5.3.4 Noise and vibration impacts during operations

Noise impact studies undertaken elsewhere for the Adelaide Desalination Project (Aurecon 2009) indicated that noise from operations such as pumping works into marine zones are likely to be negligible and much lesser than the natural noise levels from breaking waves. As such, the main noise impacts are likely to result from maintenance activities. Due to the sub-marine location of the intake and outfall systems, access for inspection and maintenance will be highly restricted and therefore fairly minimal and infrequent in nature.

A noise and vibration impact assessment will further identify mitigation and management criteria for operational impact, however due to the large distance to sensitive receptors; these issues are unlikely to be of concern. Any potential operational noise of the outfall is likely to be within natural background levels within meters from the ports. Operational noise is likely to be exceeded by existing noise from localised wave motion at the site.

5.3.5 Effects of saline water to Southern Ocean

It should be noted that the following considerations on the likely impacts of the saline water pumping are based upon data collation and literature review along with discussion and consultation with a number of marine biological experts. A review of the potential for EPBC species to be impacted (refer Section 3) indicated that there are unlikely to be significant impacts upon Commonwealth or State protected species. Concerns however have been raised about the potential for impacts upon commercial species such as the Goolwa Cockle which are currently exploited from the Coorong ocean beaches. Recent studies (Rowling et al; 2009) have however confirmed that there are low numbers of cockles at the proposed discharge point and the hydrodynamic modelling has confirmed that the potential influence from the elevated salinity will be restricted to approx 500m from the discharge point at which point it will be indistinguishable form background salinity levels and within natural variability.

There may be localised effects in the vicinity of the discharge in relation to physical processes such as turbidity and water quality issues relating directly to the discharge and indirectly to the resuspension of sediments within the outfall area. Turbidity levels within the South Lagoon may result in discharge of fine suspended material to the southern ocean during wind stirring resuspension events over the South Lake. As the Southern Ocean is a higher energy stretch of coast and these levels are likely to be within the natural ocean variability, the discharge is not anticipated to significantly impact the local communities.

Potential effects on pelagic species.

It was long believed that the surf zone environment and bare sandy intertidal areas provided minimal benefit to marine species. However, a number of studies have shown that these habitats actually support significant populations of fish many of which are in their juvenile life stages (Crawley *et al.*, 2006; Harvey 1998).

There is the potential for pelagic species (particularly fish) which utilise the surf and intertidal / subtidal zones as feeding areas to be affected by the saline discharge both directly and indirectly. Concerns have been raised that pelagic species will be directly impacted in the event that low mixing of the saline discharge leads to a salinity ‘wedge’ being formed out from the point of discharge. Beyond the initial impact zone, the density of discharge is such that the discharge influence zone would move away from the surface into bottom water and mobile pelagic species will quickly move away from triggers such as salinity which they found unfavourable.

There is considered to be little direct risk to pelagic species from the saline discharge itself as, in the event that pelagic species travelled across the discharge influence zone, they will either quickly ‘drift’ through or swim away from negative environmental triggers (such as noise or salinity gradients) to areas more suitable. Also many of the fish found within the region are moderately tolerant of elevated salinities and indeed species such as Mulloway, Yellow-eye mullet and Black bream are recorded within the Upper Spencer Gulf which regularly records salinities in the range of 41 - 47.2ppt.

There is the potential for the saline discharge to impact upon food sources at, and adjacent, to the discharge point. This then has the potential to indirectly impact on pelagic species in the area. A possibility is that rather than a ‘dead zone’ around the discharge zone itself, organisms that are able to tolerate the higher salinity would persist and / or move into the area. The species are likely to be the environmental equivalents of native species which would likely result in a change in benthic composition in the area directly around the discharge point but would still effectively remain a feeding resource for pelagic species.

The impact on pelagic food sources in terms of surf species is considered to be minor directly within the zone of influence of the saline discharge and is likely to be negligible within 2-3km. There are also similar habitats both north and south of the proposed discharge point.

Potential effects from nutrient rich Coorong waters into Southern Ocean

There is the potential that nutrient rich waters from the Coorong could, upon pumping into the Southern ocean through the pipeline, increase nutrient levels within the ocean which could cause localised algal growth.

Water sampling in the Coorong over the past 10 years has indicated significant gradients along the Coorong lakes from near the Murray mouth to the south eastern extremity. Results from near Policemans Pt provide a reasonable representation of the likely water quality near the intake for the proposed pumping system and indicate a mean total nitrogen concentration of 6000 μg N/L and total phosphorus of 260 μg P/L near the intake. Chlorophyll-*a* concentrations are significantly higher in the south lake with a mean value around 80 μg Chl *a*/L. The conductivity indicates the strong saline gradient increasing from 50 mS/cm, a typical seawater concentration near the Murray mouth to a hypersaline value around 120 mS/cm at Policemans Pt in the south lake due the strong evaporative effects.

Soluble phosphorus, ammonia nitrogen and oxidised nitrogen concentrations are similar at both the north and south. Total phosphorus and total nitrogen concentrations however are considerably higher in the south lake than near the Murray mouth due to the high organic components associated with the high phytoplankton biomass at the Policemans Pt site. This is indicated by high chlorophyll-*a* concentration that also comprises nitrogen and phosphorus contributing to the total nutrient concentrations.

Primary production in the oceans is affected by a range of physical and chemical processes and in contrast to the Coorong Lakes is generally limited by the availability of nitrogen in its forms that can be readily assimilated by marine phytoplankton. The processes that lead to the conversion of nitrogen into bio-available forms are complex and the bio-available forms of nitrogen (NH4+ and NO3-) required to stimulate marine phytoplankton growth are produced by the decay of organic matter and nitrogen fixing bacteria or cyano-bacteria (blue-green algae).

At the Coorong ocean beaches the main sources of organic matter comprise phytoplankton, macro-algae and seagrass. Primary production in the marine waters adjacent the Coorong is stimulated by nutrient sources including the Murray outflow, upwelling of deep ocean nutrient-rich water onto the shelf and coastal areas and recycling from deposition and decay of organic matter in the coastal zone. The discharge of water from the Coorong will provide an additional source of nitrogen (both in the inorganic and organic forms) to the coastal waters that could lead to enhanced algal growth within some distance of the discharge. The secondary processes of biological uptake followed by mortality, sedimentation, decay and release back into the water column is another mechanism that may result in enhanced algal growth for some period following the initial discharge of nutrient rich water to the ocean.

Investigations of the marine ecosystem in the ocean waters offshore the Coorong were carried out in 2005 for the SA MDB NRM Board (Haig *et al*, 2006) to assist with providing information on the environmental assets of the Coorong Marine Bioregion. Samples were collected in 5 to 20 m water depth from waters offshore the Coorong between Cape Jaffa in the southeast and Victor Harbour. The results indicated a maxima in Chlorophyll-*a* near the Murray mouth of about 2.5 μg Chl-*a*/L decreasing both northward and southward of this location. Near the proposed discharge location typical values of between 0.7 and 1 μg Chl-*a*/L were found. Total nitrogen concentrations generally decreased towards the southeast from around 120 μg N/L near the Murray mouth to around 80 μg N/L near the proposed discharge site. Concentrations of ammonia and phosphate (1 μg N/L and 20 μg P/L, respectively) showed little variability with longshore distance.

The nutrient loads from the Murray Mouth to the ocean have been estimated recently by Brookes et al. (2009). They conducted an analysis of available data on nutrient inflows to the lower lakes, assimilation of nutrients within the lakes and export from the lower lakes

(Alexandrina and Albert) to the ocean and to the Coorong. The average annual discharge from the Murray to the ocean is around 25 000 ML/day with significant interannual variability related to wet/dry and drought cycles. Total nitrogen and total phosphorus export loads from the Murray to the ocean for low and high Murray River inflow years are estimated as:

172 – 3245 Tonnes N/year and

94 – 540 Tonnes P/year.

The load of nutrients associated with the proposed discharge may be estimated by multiplying the Coorong discharge, Q = 250 ML/day, by the median nutrient concentrations. Assuming the pumps and discharge operate for the full 365 days per year and applying the above formula yields the following maximal annual nutrient loads estimates from the Coorong via the proposed pipe discharge:

520 Tonnes N/year and
23 Tonnes P/year.

These estimates are the maximum that could be exported assuming the pumps operate for the full 365 days per year and in addition assume the median nutrient concentrations will continue to persist after pumping commences. Both of these assumptions are conservative in that pump maintenance and operational constraints will require some shutdown periods. Further, the aim of the pumping system is to ultimately reduce the salt concentrations and this process will also lead to reductions in the nutrient concentrations. Hence the above estimates are considered to be conservative and somewhat higher than would likely occur.

Dispersion modelling in relation to nutrients

Results of the dispersion modelling (Aurecon 2009a) may be used to estimate the dilution of the discharge water with ambient marine water as a function of distance from the discharge source. Saline discharge dispersion modelling indicates when considering the 'worst case' scenario a dilution of 100 fold (~3 ppt excess salinity) occurs within about 2km of the source and the 1 ppt excess salinity (38 fold dilution) occurs within some 200 m of the discharge.

Assuming the nutrients may be treated as a passive tracer (like salt) then the concentrations at some distance, x, from the discharge may be estimated by the dilution formula:

$$C_x = \frac{C_d + D_x C_b}{D_x + 1}$$

where C_x
, C_d and C_b are the nutrient concentrations at a distance x from the source, in the discharge (subscript d) and background (subscript b) ocean, D_x is the dilution at distance x from the source.

These estimates indicate that the nutrient concentrations will rapidly disperse into the environment such that the ANZECC and SA EPA guideline trigger values for nutrients will be met within 200 m of the source for the mean and maximum discharge concentrations

In conclusion, the proposed discharge will effectively redistribute a small proportion of the historical point source Murray River export load to a new point source some 70-80 km south at the proposed discharge location. The modelling indicates that the nutrient concentrations will rapidly disperse into the environment such that the ANZECC and SA EPA guideline trigger values for nutrients will be met within 200 m of the source for the mean and maximum discharge concentrations. As such, there is not considered to be a significant effect likely from the discharge as the nutrients will be quickly dispersed and the concentrations are well within ranges traditionally discharged from the Murray Mouth with no recorded algal concentration issues.

Potential ecotoxicology effects

Larvae and young individuals are particularly susceptible to elevated ambient salinity concentrations (Einav *et al*., 2002). Numerous studies examining the ecotoxicological effects of increased salinity levels upon larval development of marine organisms have concluded that there is a salinity threshold, which when exceeded significantly influences growth and survival (Blaszkoski and Moreira, 1986; Reynolds *et al*, 1976; Pillard *et al*, 1999).

Certain species such as echinoderms, squid and cuttlefish are osmo-conformers that are unable to regulate internal salinity concentrations and are therefore susceptible to changes in ambient conditions. Sea urchins, for example, possess a permeable body wall where the gonads in the coelomic cavity are not protected from osmotic change. As such salinity effects are likely to impact these species more than osmo-regulating species (such as fish). Fernández-Torquemada *et al.* (2005) demonstrated that echinoderms were one of the first species to disappear from a brine discharge point when salinity was greater than 39.4 ppt. Squid (*Sepioteuthis australis*) and cuttlefish (*Sepia apama*) eggs have also been shown to be sensitive to changes in ambient salinity concentrations with a salinity threshold of around 44 ppt (Flinders and Adelaide University), after which there is a significant increase in mortality.

Infauna such as polychaetes are known for the ability to adapt to environmental variation and are well suited as indicator organisms of environmental change, as the group contains both sensitive and tolerant species and can be utilised to show a gradient of sensitivity from pristine to heavily disturbed areas (Del Pilar Ruso *et al.* 2008). Del Pilar Ruso *et al.* (2007) examined the spatial and temporal effects of a brine discharge and concluded that the brine causes reduction in abundance and diversity of infauna species (including salinity sensitive polychaetes) within the discharge zone, with the immediate area of the diffuser characterised by a community of nematode worms where the salinity exceeded 39psu (background salinity in this case was usually 37.1-38.7psu).

Other infauna species such as bivalves are better able to tolerate increases in salinity as they have mechanisms by which to limit the saline effects. Cockles and mussels for example will stop feeding and close their shells if conditions are unfavourable and Goolwa cockles are thought to be able to tolerate salinities ranging from 20-45 ppt (Nell and Gibbes 1986). Tanner (in prep) showed that juvenile metamorphosis and D-larval development of the Goolwa cockle was affected at salinities greater than 40 ppt, with all development ceasing when salinity concentrations reached 50 ppt. Adult ascidians (*Pyura praeputialis)* and brittle stars (*Ophiuroidea sp.*) have shown some tolerance to increased salinity concentrations, with a salinity threshold of 44 ppt after which mortality rapidly increases (Beatie 2009).

There are very few studies that have examined the effects of salinity on marine plants. Most studies have focused on species such as seagrasses as these species are considered to be more sensitive to water quality changes. Ralph (1998); Kahn & Durako (2006) and Kerr & Strother (1985) demonstrated that some seagrass species such as *Halophila ovalis* are able to tolerate elevated salinities of 25-150% higher than background levels without significant changes to their photosynthetic response to light. The species tended to tolerate elevated salinity concentrations better than a reduction in ambient salinity. This has also been observed in other studies on both tropical (Lirman & Manzello 2009) and temperate (Westphalen *et al.* 2006) seagrass species.

A number of studies (Del Pilar Ruso, 2007,2009; Lirman & Manzello, 2009; Raventos *et al.* 2006; Ralph 1998; Kahn & Durako 2006) have examined the potential effects on marine species from both a reduction and an increase in ambient salinity concentrations, due to freshwater (e.g. waste water treatment plants and storm water) and saline concentrate discharges (desalination plants).

There is a potential for the saline discharge to have impacts on the water quality and marine environment if not dispersed rapidly. Previous toxicity testing for desalination plant discharges (Geotechnical Services, 2008; Hydrobiology, 2008) indicated that the elevated salinity itself is the primary driver of potential effects on marine ecosystems. Marine organisms exist in an osmotic balance with their marine environment. An increase in the

concentration of salts via discharge may result in the dehydration of cells, decreasing cell turgidity leading to death (mainly of larvae and young individuals) (Einav *et al*., 2002).

Work carried out for the SA Water Adelaide Desalination Project (SA Water 2009) utilised ecotoxicology testing in order to assess the potential biological impacts that saline concentrate may have upon marine organisms. Although conditions at Port Stanvac are different to those at proposed discharge site, the tests can be considered broadly applicable and appropriate to the Coorong marine area in that they utilise South Australian species which are likely to be found within the Coorong marine site. Also the Port Stanvac tests were conservative in that the site had to consider issues such as dodge tides and flushing times of Gulf St Vincent which this project does not have due to its full ocean location.

The Adelaide Desalination Plant (ADP) utilised where possible South Australian species and as such the results will be broadly applicable to the Coorong marine species. The ADP selection of species satisfied the requirements of the ANZECC and ARMCANZ 2000) guidelines for the assessment of toxicants in receiving waters, by having at least 5 species from four taxonomic levels as part of the testing suite. The ANZECC and ARMCANZ 2000) guidelines provide the accepted method for deriving ecological trigger values and safe dilutions for the disposal of waste streams in an aquatic environment. The guidelines recognise that the implementation of trigger values for discharges is not a simple pass or fail and should be also linked back to management action(s) agreed prior to the operation of the discharge stream.

The potential ecotoxicology effects are of particular concern when considering species such as the Goolwa cockle which predominately live and spawn within the surf zone. It is likely that the Goolwa cockle has large population fluxes as is typical of cockle populations (McLachlan *et al.*, 1996). The proposed outfall location is at the easterly extent of the known cockle grounds and is currently not part of the known cockle fishery. Recent works on the cockle population indicates that although cockles are located in the area they are not as densely aggregated in the area as they are to the north of Policeman's Point coastal location.

A recent survey by Rowling et al. (2009) demonstrated that smaller numbers of cockles are located at the proposed discharge location compared to the known fishery cockle beds with numbers equating to approx 5% of the fishery stock being recorded. Wiltshire et al (2009) also examined the ecotoxicology effects of saline concentrate of various salinities on Goolwa cockles. This work demonstrated that salinities up to and including 40psu were tolerated by all life stages. Juveniles seemed to be able to tolerate periods of exposure up to 50 psu with few negative effects, however earlier life stages were most affected by elevated salinities and negatively impacted at salinities above 45psu. Preliminary calculations from the Roberts based diffuser model have estimated that the salinity at the point where a dilution of 50:1 is met (if the Port Stanvac discharge is in the range of ~72ppt) would be approx 37.7ppt. Salinity in the range of 38-40ppt approaches the upper tolerance levels of many marine organisms. Goolwa cockles, for example, are thought to be able to tolerate salinities ranging from 20-45ppt (Nell and Gibbes 1986). Research such as Beatie (2009) demonstrated that adult ascidians (*Pyura praeputialis*) and brittle stars (*Ophiuroidea* sp.) have tolerance to increased salinity concentrations with a salinity threshold of 44ppt after which mortality rapidly increases.

The Adelaide Desalination Project preliminary ecotoxicology tests demonstrated that a dilution of 16:1 was required to protect 95% of typical marine species. However, SA Water stipulated that the diffuser design should still be required to meet a minimum dilution of 50:1 at the point where the discharged saline water meets the seabed. This requirement was in order to ensure that a significant 'buffer' or error margin was incorporated within the design in order to ensure protection of marine species. This 50:1 dilution which should protect 95% of the typical species equated to a 0.6ppt increase above ambient salinity.

Concerns have been raised in relation to the Coorong pumping project over the possibility that onshore winds coupled with long-shore currents will result in the saline water discharge being pushed parallel along the beach thereby impacting further upon intertidal species along a long length of coast. The modelling undertaken to inform this project (Aurecon 2009)

therefore used the scenarios of SE and NW shore parallel winds as the 'worst-case' scenarios in terms of the saline discharge footprint and potential effects.

In the case of the Coorong ocean discharge environment, a 0.6ppt increase in salinity above ambient background results in a likely footprint (for a pumping capacity of 250ML/day) approx 5km for the SE shore parallel winds scenario and 2km for the NW shore parallel winds scenario. However, the tolerance of different organisms varies quite markedly and a key factor controlling this variability appears to be the normal salinity in which the organisms dwell. The WHO (2007) state that a 10% increase above the ambient salinity is a conservative estimate of threshold for species. The salinity of the receiving waters in the Coorong marine environment is likely to be in the range of 35-36 ppt therefore creating an estimated upper salinity threshold of between 38.5 and 39.6ppt. As such, it is considered that adoption of a 2ppt increase in salinity above ambient is considered conservative and more likely than the 0.6ppt suggested by the Adelaide Desalination Project which incorporated an extremely conservative buffer margin and doubling of dilution requirement.

The saline discharge footprint if the 2ppt salinity increase above ambient is adopted as a 'likely effects' value equates to approximately 1km when considering the shore parallel SE wind scenario, and approximately 750m when considering the shore parallel NW wind scenario. It can be considered therefore that 5% of typical species within the 1km area of 2ppt salinity increase above ambient are likely to not be able to survive the increased salinity. This equates to less than 2% of the Coorong marine coastline receiving salinities 2ppt above ambient background during the 'worst case' scenario of the shore parallel SE winds. As such it is considered that the potential impacts from the saline concentrate are negligible.

The impacts of the saline water discharge are likely to be observed at a number of different scales. Directly adjacent to the outfall will likely result in a depauperate zone due to the high salinity levels (salinity exceeding 100 ppt within 20 metres of the discharge) being outside of the ranges of most marine species. Mobile species will move away to areas with more tolerable salinities, non-mobile species that cannot move will likely not be able to survive the elevated salinities. The effects of the elevated salinities will be reduced to less than 2 ppt excess value within about 1 km offshore of the discharge which as Wiltshire *et al* (2009) demonstrated for Goolwa cockles, is well within the salinity tolerance range of most species. As the discharge dilutes away from the outfall, species will once again be able to tolerate the salinity levels.

It is considered that the effects of the saline discharge will be temporary as once the discharge ceases being released, no permanent impact upon salinities will be observed and communities within the area are expected to recover. Given the salinity exposures predicted by the hydrodynamic modelling the worst case scenario of a shore parallel winds as discussed it would be highly unlikely for acute toxicity to result from exposure to the saline discharge occurring within the mixing zone.

5.4 Recommendations for baseline studies

A number of additional studies will be required in order to fully assess the potential impacts within the Coorong marine area. This should include Before-After/Control-Impact (BACI) monitoring. These investigations should include but not be limited to:

- Pipeline route
  - Detailed terrain survey
  - Identification of potential ASS areas
- Flora and fauna assessment
  - sand dune systems (flora/fauna)
  - terrestrial vegetation including native vegetation assessment
- Marine environment
  - infaunal assessment (particularly of those communities within the likely discharge zone of influence)
  - Water quality (both of the Coorong lagoons and the receiving environment)

  - Epifaunal assessment (directly offshore and north / south of the discharge point)
  - Pelagic assessment (this could utilise fish baits and should continue after discharge begins)
- Consultation and workshops
  - PIRSA
  - SARDI
  - DEWHA
  - DEH
  - Indigenous and European Heritage survey
  - This will be required to finalise the construction route through the dunes from the Coorong lagoons.

6. Summary of potential environmental issues

The following section summaries the potential environmental issues during the construction, operation and decommissioning of the temporary saline pumping project discussed within section 5. These tables do not represent an impact assessment in that the predictions are not based on quantitative data. The tables instead represent the predicted potential impacts based upon available data and relevant studies. It should be noted that these potential risks are likely to change once the baseline surveys and investigations are available to inform the assessment, however, it is considered that this initial preliminary assessment is sufficient to highlight critical issues related to the proposed project.

Each table identifies the issue and the potential impact upon the environment of the issue. The initial risk is assessed and then studies and mitigation measures are proposed which should mitigate the risk somewhat. The residual risk (i.e. the risk remaining once mitigation has been undertaken) is detailed within the last column.

6.1 Construction and decommissioning issues

Issues specifically relating to the construction of the pipeline are detailed in Table 12. The potential impacts related to the decommissioning has been included within this table as well as the issues are broadly similar in nature.

Table 12 Potential construction and decommissioning Impacts

Issues	Potential impact	Predicted risk	Study/s to inform	Mitigation Measure	Residual risk
Installation (and eventual removal) of outfall conduit in the coastal and marine environment	Removal, damage or disturbance of aquatic habitats or species	MEDIUM	• Intertidal and subtidal assessment • Infaunal assessment	• Reduction of footprint as far as practicable • Contractor CEMP required to ensure minimal disturbance outside of direct footprint	LOW
	Removal, damage or disturbance of coastal habitats or species	MEDIUM	• Sand dune systems (flora / fauna survey) • Terrestrial vegetation including native vegetation assessment • Utilise existing Birds Australia (Hooded Plover and Orange-bellied parrot) surveys	• Reinstatement of habitat post construction and decommissioning should be undertaken by a qualified party • Existing management plan for Hooded Plover, Orange-bellied parrot, and migratory waders to be incorporated into CEMP for works	LOW

Issues	Potential impact	Predicted risk	Study/s to inform	Mitigation Measure	Residual risk
	Potential disturbance of cultural heritage artefacts in coastal zone	MEDIUM	• Consultation to confirm chosen route not within any known heritage sites • Indigenous and European heritage survey prior to selection of the pipeline route.	• Heritage Management Plan • Liaise with local indigenous liaison officer • Monitors may also be required onsite during construction works.	LOW
	Visual impact during construction	LOW	-	• Screen and maintain lay down areas. • Ensure minimal visual impact • Contractor CEMP	LOW
Construction (and decommissioning vehicles)	Introduction of pest species	LOW	• Sand dune systems (flora / fauna survey) • Terrestrial vegetation including native vegetation assessment	• Pest Management Plan • Contractor ensure vehicles and vessels are cleaned and checked to ensure no spread of pest species and where possible vehicles to be sourced from areas not known to by *Phytophera* infested areas.	LOW
	Hydrocarbon and chemical spills.	LOW	-	• Spill and chemical management measures in CEMP and decommissioning EMP	LOW

Issues	Potential impact	Predicted risk	Study/s to inform	Mitigation Measure	Residual risk
	Localised damage of marine or coastal species (particularly the Orange-bellied parrot, migratory waders and the hooded plover)	MEDIUM	• Utilise and incorporate existing Hooded Plover Management plan • Utilise and incorporate existing Orange-bellied parrot management plan	• Reduction of footprint as far as practicable • Flora & Fauna Management Plan • Adopt existing management plan for Hooded Plover, Orange-bellied parrot, and migratory waders to be incorporated into CEMP for works including where possible construction/decommissioning during specified seasons/times (height of summer of migratory waders and hooded plover and winder for Orange-bellied parrot migratory period).	LOW
Excavation	Excavation and disposal of sediments impacting on marine biota and ecosystems. Turbidity may become elevated due to excavation	LOW	-	• Excavation contractor to use best practice to minimise timeframe and footprint • Dredge / Excavation Management Plan if dredging / excavation required	LOW

Issues	Potential impact	Predicted risk	Study/s to inform	Mitigation Measure	Residual risk
Noise and vibration from construction activities	Impact on marine and coastal biota, particularly birds	MEDIUM	• Flora and Fauna Survey • Utilise and incorporate existing Hooded Plover Management Plan • Utilise and incorporate existing Orange-bellied parrot management plan	• Limit Footprint • Flora & Fauna Management Plan • Adopt existing management plan for Hooded Plover, Orange-bellied parrot, and migratory waders to be incorporated into CEMP for works including where possible construction/decommissioning during specified seasons/times (height of summer of migratory waders and hooded plover and winder for Orange-bellied parrot migratory period).	LOW
Construction exclusion zone	Impacts on commercial fishing	LOW	-	• Liaise with commercial fisheries and pre-works consultation	LOW
	Impacts on recreational fishing	LOW	-	• Recreational user consultation	LOW

6.2 Operational issues

The following section outlines the potential impacts during the operational stage of the Coorong saline pumping project. As can be seen within the table the key issues during the operation of the proposed project are the discharge leading to localised hydrodynamic and physical changes to the system from the interruption f beach processes and the impact of the hypersaline waters upon the marine biological receiving environment. It should be noted that although the predicted risk at this point is medium in both cases, a precautionary principle approach has been utilised.

Table 13 Potential operational effects of the Coorong saline waters being pumped out to the southern ocean

Issues	Potential Concerns	Predicted Risk	Study/s to inform	Mitigation Measures	Residual Risk
Outfall pipeline in the coastal and marine environment	Impacts upon recreational vehicle access on the beach.	LOW	-	• Maintain access for beach vehicle movements following construction • Any armouring of the pipe should ensure that the beach as an access route is maintained	LOW
	Visual impacts of the geotextile bags or rock on the natural beach view	LOW	-	-	LOW
	Noise and vibration potential	LOW	-	-	LOW
	Potential for interruption of beach processes (e.g. accretion, movement of sand to sand dunes)	MEDIUM	• Detailed hydrodynamic modelling should be undertaken to predict sediment and water scour adjacent to pipeline	• Use of geotextile bags • Regular Maintenance • Detailed design should investigate potential for moving of the pipeline in the event of localised scour	LOW
	Introduction of a hard substrate within a sandy substrate environment	LOW		• Removal of hard structure at end of project leading to reinstatement of the sandy substrate	LOW
Increased nutrient levels due to discharge from Coorong into Southern Ocean	Increased nutrients levels in Southern Ocean potentially causing algal growth	LOW	-	• Retain ability to reduce or shut down flows if chlorophyll levels increase during pumping	LOW

Issues	Potential Concerns	Predicted Risk	Study/s to inform	Mitigation Measures	Residual Risk
Salinity	The salt concentration of the discharge is potentially 3-4 times (on average) greater than source/receiving waters. Elevated salinity concentrations may harm organisms near the outfall that cannot tolerate either high salinity levels or fluctuations in ambient concentrations.	EPBC listed - LOW			LOW
		NES matters - LOW			
		HIGH	• Hydrological Modelling • Ecotoxicological Assessment • Preliminary Goolwa cockle population surveys • Salt tolerance investigations of the Goolwa cockle	• Define timeframe of operation • Choose discharge habitat location which is widely represented elsewhere • Chose optimal outfall location to increase dilution • Adjust pump regime if required in response to environmental monitoring	
	Localised elevated salinity concentrations may deter mobile organisms from remaining in the area of the discharge	LOW	• Hydrological Modelling • Ecotoxicological Assessment	• Define timeframe of operation • Chose optimal outfall location to increase dilution	LOW

7. Conclusions

This report presents a preliminary ecological assessment of the proposed temporary saline discharge into the marine zone adjacent to the Coorong lagoons. The findings of the preliminary environmental assessment are an impact directly adjacent to the discharge point is likely and there is the possibility that a change in community composition may also occur within the zone of discharge influence. However, based on available data, it appears that the hydrodynamic regime (as examined in the Aurecon Preliminary Modelling Report, 2009) is such that the salinity of the mixing zone is likely to be within the salinity tolerances of most species within 1-2km and the communities within the discharge zone are broadly represented along the adjacent beach and coast.

It should be noted that no consideration of the ecological benefits to the Coorong lagoons of the pumping of the hypersaline waters to the Southern Ocean has been included within this report as these matters have been discussed elsewhere (Lester and Fairweather 2007; Lester and Fairweather 2008; Webster 2007). The previous studies demonstrated that the reduction of salinity levels within the Southern lagoon would help alleviate the stress under which the ecological system now finds itself in the light of reduced freshwater flows.

In order to provide confidence in this preliminary environmental review, further investigations are required to provide more detailed assessment and evaluation of the likely effects of the proposed saline discharge. In particular these assessments should include selection and surveys (terrain, flora, fauna, heritage and acid sulphate soil identification) of the inlet location and pipeline route across the sand dunes to the ocean, further assessment of issues relevant to the cockle fishery including preliminary population surveys along beach of the Younghusband Peninsula and possibly salt tolerance investigations of the different life stages of the cockle.

This preliminary ecological assessment has indicated that it is unlikely that Matters of NES are likely to be impacted by the proposed project. However, further studies are required for State Approvals and to inform further the impact assessment of the hypersaline discharge from the Coorong lagoons.

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Appendix A

EPBC Database Review

Australian Government
Department of the Environment, Water, Heritage and the Arts

Protected Matters Search Tool

You are here: Environment Home > EPBC Act > Search

23 June 2009 15:05

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected. Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

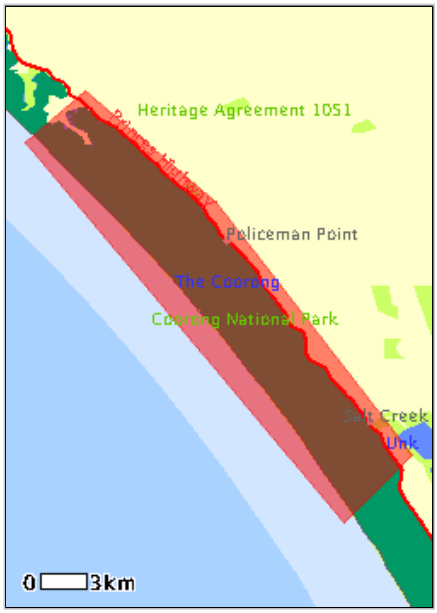
You may wish to print this report for reference before moving to other pages or websites.

The Australian Natural Resources Atlas at http://www.environment.gov.au/atlas may provide further environmental information relevant to your selected area. Information about the EPBC Act including significance guidelines, forms and application process details can be found at http://www.environment.gov.au/epbc/assessmentsapprovals/index.html

Search Type: Area

Buffer: 0 km

Coordinates: -35.8874,139.4428, -35.9682,139.5374, -36.1515,139.6793, -36.2007,139.6300, -35.9249,139.3994



Report Contents:

Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance - see http://www.environment.gov.au/epbc/assessmentsapprovals/guidelines/index.html.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Significance: (Ramsar Sites)	3
Commonwealth Marine Areas:	None
Threatened Ecological Communities:	1

Threatened Species:	36
Migratory Species:	42

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place and the heritage values of a place on the Register of the National Estate. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage/index.html.

Please note that the current dataset on Commonwealth land is not complete. Further information on Commonwealth land would need to be obtained from relevant sources including Commonwealth agencies, local agencies, and land tenure maps.

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species. Information on EPBC Act permit requirements and application forms can be found at http://www.environment.gov.au/epbc/permits/index.html.

Commonwealth Lands:	None
Commonwealth Heritage Places:	None
Places on the RNE:	2
Listed Marine Species:	70
Whales and Other Cetaceans:	12
Critical Habitats:	None
Commonwealth Reserves:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	1
Other Commonwealth Reserves:	None
Regional Forest Agreements:	None

Details

Matters of National Environmental Significance

Wetlands of International Significance [Dataset Information] (Ramsar Sites)		
BOOL AND HACKS LAGOONS		Within same catchment as Ramsar site
COORONG AND LAKES ALEXANDRINA AND ALBERT		
RIVERLAND		Within same catchment as Ramsar site
Threatened Ecological Communities [Dataset Information]	Status	Type of Presence
Buloke Woodlands of the Riverina and Murray-Darling Depression Bioregions	Endangered	Community may occur within area
Threatened Species [Dataset Information]	Status	Type of Presence
Birds		

Diomedea epomophora epomophora Southern Royal Albatross	Vulnerable	Species or species habitat may occur within area
Diomedea epomophora sanfordi Northern Royal Albatross	Endangered	Species or species habitat may occur within area
Diomedea exulans (sensu lato) Wandering Albatross	Vulnerable	Species or species habitat may occur within area
Diomedea exulans amsterdamensis Amsterdam Albatross	Endangered	Species or species habitat may occur within area
Diomedea exulans exulans Tristan Albatross	Endangered	Foraging, feeding or related behaviour may occur within area
Diomedea exulans gibsoni Gibson's Albatross	Vulnerable	Species or species habitat may occur within area
Halobaena caerulea Blue Petrel	Vulnerable	Species or species habitat may occur within area
Lathamus discolor Swift Parrot	Endangered	Species or species habitat may occur within area
Leipoa ocellata Malleefowl	Vulnerable	Species or species habitat likely to occur within area
Macronectes giganteus Southern Giant-Petrel	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant-Petrel	Vulnerable	Species or species habitat may occur within area
Neophema chrysogaster Orange-bellied Parrot	Critically Endangered	Species or species habitat known to occur within area
Psophodes nigrogularis leucogaster Western Whipbird (eastern)	Vulnerable	Species or species habitat likely to occur within area
Pterodroma mollis Soft-plumaged Petrel	Vulnerable	Species or species habitat may occur within area
Rostratula australis Australian Painted Snipe	Vulnerable	Species or species habitat may occur within area
Thalassarche bulleri Buller's Albatross	Vulnerable	Species or species habitat may occur within area
Thalassarche cauta cauta Shy Albatross, Tasmanian Shy Albatross	Vulnerable	Species or species habitat may occur within area
Thalassarche cauta salvini Salvin's Albatross	Vulnerable	Species or species habitat may occur within area
Thalassarche chrysostoma Grey-headed Albatross	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris impavida Campbell Albatross	Vulnerable	Species or species habitat may occur within area
Frogs		
Litoria raniformis Growling Grass Frog, Southern Bell Frog, Green and Golden Frog, Warty Swamp Frog	Vulnerable	Species or species habitat may occur within area
Mammals		
Balaenoptera musculus Blue Whale	Endangered	Species or species habitat may occur within area
Eubalaena australis Southern Right Whale	Endangered	Species or species habitat known to occur within area
Megaptera novaeangliae Humpback Whale	Vulnerable	Species or species habitat likely to occur within area
Neophoca cinerea Australian Sea-lion	Vulnerable	Species or species habitat may occur within area
Ray-finned fishes		

Craterocephalus fluviatilis Murray Hardyhead	Vulnerable	Species or species habitat may occur within area
Maccullochella peelii peelii Murray Cod, Cod, Goodoo	Vulnerable	Species or species habitat may occur within area
Sharks		
Carcharodon carcharias Great White Shark	Vulnerable	Species or species habitat may occur within area
Plants		
Caladenia conferta Coast Spider-orchid	Endangered	Species or species habitat may occur within area
Caladenia tensa Greencomb Spider-orchid, Rigid Spider-orchid	Endangered	Species or species habitat likely to occur within area
Cassinia tegulata a shrub	Critically Endangered	Species or species habitat may occur within area
Frankenia plicata	Endangered	Species or species habitat likely to occur within area
Senecio macrocarpus Large-fruit Fireweed, Large-fruit Groundsel	Vulnerable	Species or species habitat likely to occur within area
Thelymitra epipactoides Metallic Sun-orchid	Endangered	Species or species habitat likely to occur within area
Thelymitra matthewsii Spiral Sun-orchid	Vulnerable	Species or species habitat likely to occur within area
Migratory Species [Dataset Information]	Status	Type of Presence
Migratory Terrestrial Species		
Birds		
Haliaeetus leucogaster White-bellied Sea-Eagle	Migratory	Species or species habitat likely to occur within area
Hirundapus caudacutus White-throated Needletail	Migratory	Species or species habitat may occur within area
Leipoa ocellata Malleefowl	Migratory	Species or species habitat likely to occur within area
Merops ornatus Rainbow Bee-eater	Migratory	Species or species habitat may occur within area
Neophema chrysogaster Orange-bellied Parrot	Migratory	Species or species habitat known to occur within area
Migratory Wetland Species		
Birds		
Ardea alba Great Egret, White Egret	Migratory	Species or species habitat may occur within area
Ardea ibis Cattle Egret	Migratory	Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper	Migratory	Species or species habitat likely to occur within area
Calidris alba Sanderling	Migratory	Species or species habitat likely to occur within area
Calidris ferruginea Curlew Sandpiper	Migratory	Species or species habitat likely to occur within area
Calidris ruficollis Red-necked Stint	Migratory	Species or species habitat likely to occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe	Migratory	Species or species habitat may occur within area
Pluvialis fulva Pacific Golden Plover	Migratory	Species or species habitat likely to occur within area
Rostratula benghalensis s. lat. Painted Snipe	Migratory	Species or species habitat may occur within area

Tringa nebularia Common Greenshank, Greenshank	Migratory	Species or species habitat likely to occur within area
Migratory Marine Birds		
Apus pacificus Fork-tailed Swift	Migratory	Species or species habitat may occur within area
Ardea alba Great Egret, White Egret	Migratory	Species or species habitat may occur within area
Ardea ibis Cattle Egret	Migratory	Species or species habitat may occur within area
Diomedea amsterdamensis Amsterdam Albatross	Migratory	Species or species habitat may occur within area
Diomedea dabbenena Tristan Albatross	Migratory	Foraging, feeding or related behaviour may occur within area
Diomedea epomophora (sensu stricto) Southern Royal Albatross	Migratory	Species or species habitat may occur within area
Diomedea exulans (sensu lato) Wandering Albatross	Migratory	Species or species habitat may occur within area
Diomedea gibsoni Gibson's Albatross	Migratory	Species or species habitat may occur within area
Diomedea sanfordi Northern Royal Albatross	Migratory	Species or species habitat may occur within area
Macronectes giganteus Southern Giant-Petrel	Migratory	Species or species habitat may occur within area
Macronectes halli Northern Giant-Petrel	Migratory	Species or species habitat may occur within area
Sterna albifrons Little Tern	Migratory	Species or species habitat may occur within area
Thalassarche bulleri Buller's Albatross	Migratory	Species or species habitat may occur within area
Thalassarche cauta (sensu stricto) Shy Albatross, Tasmanian Shy Albatross	Migratory	Species or species habitat may occur within area
Thalassarche chlororhynchos Yellow-nosed Albatross, Atlantic Yellow-nosed Albatross	Migratory	Species or species habitat may occur within area
Thalassarche chrysostoma Grey-headed Albatross	Migratory	Species or species habitat may occur within area
Thalassarche impavida Campbell Albatross	Migratory	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross	Migratory	Species or species habitat may occur within area
Thalassarche salvini Salvin's Albatross	Migratory	Species or species habitat may occur within area
Migratory Marine Species		
Mammals		
Balaenoptera edeni Bryde's Whale	Migratory	Species or species habitat may occur within area
Balaenoptera musculus Blue Whale	Migratory	Species or species habitat may occur within area
Caperea marginata Pygmy Right Whale	Migratory	Species or species habitat may occur within area
Eubalaena australis Southern Right Whale	Migratory	Species or species habitat known to occur within area
Lagenorhynchus obscurus Dusky Dolphin	Migratory	Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale	Migratory	Species or species habitat likely to occur within area

Orcinus orca Killer Whale, Orca	Migratory	Species or species habitat may occur within area
Sharks		
Carcharodon carcharias Great White Shark	Migratory	Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species [Dataset Information]	Status	Type of Presence
Birds		
Apus pacificus Fork-tailed Swift	Listed - overfly marine area	Species or species habitat may occur within area
Ardea alba Great Egret, White Egret	Listed - overfly marine area	Species or species habitat may occur within area
Ardea ibis Cattle Egret	Listed - overfly marine area	Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper	Listed	Species or species habitat likely to occur within area
Calidris alba Sanderling	Listed	Species or species habitat likely to occur within area
Calidris ferruginea Curlew Sandpiper	Listed - overfly marine area	Species or species habitat likely to occur within area
Calidris ruficollis Red-necked Stint	Listed - overfly marine area	Species or species habitat likely to occur within area
Catharacta skua Great Skua	Listed	Species or species habitat may occur within area
Diomedea amsterdamensis Amsterdam Albatross	Listed	Species or species habitat may occur within area
Diomedea dabbenena Tristan Albatross	Listed	Foraging, feeding or related behaviour may occur within area
Diomedea epomophora (sensu stricto) Southern Royal Albatross	Listed	Species or species habitat may occur within area
Diomedea exulans (sensu lato) Wandering Albatross	Listed	Species or species habitat may occur within area
Diomedea gibsoni Gibson's Albatross	Listed	Species or species habitat may occur within area
Diomedea sanfordi Northern Royal Albatross	Listed	Species or species habitat may occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe	Listed - overfly marine area	Species or species habitat may occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle	Listed	Species or species habitat likely to occur within area
Halobaena caerulea Blue Petrel	Listed	Species or species habitat may occur within area
Hirundapus caudacutus White-throated Needletail	Listed - overfly marine area	Species or species habitat may occur within area

Larus novaehollandiae Silver Gull	Listed	Breeding known to occur within area
Lathamus discolor Swift Parrot	Listed - overfly marine area	Species or species habitat may occur within area
Limnodromus semipalmatus Asian Dowitcher	Listed - overfly marine area	Foraging, feeding or related behaviour likely to occur within area
Macronectes giganteus Southern Giant-Petrel	Listed	Species or species habitat may occur within area
Macronectes halli Northern Giant-Petrel	Listed	Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater	Listed - overfly marine area	Species or species habitat may occur within area
Neophema chrysogaster Orange-bellied Parrot	Listed - overfly marine area	Species or species habitat known to occur within area
Pluvialis fulva Pacific Golden Plover	Listed	Species or species habitat likely to occur within area
Pterodroma mollis Soft-plumaged Petrel	Listed	Species or species habitat may occur within area
Rostratula benghalensis s. lat. Painted Snipe	Listed - overfly marine area	Species or species habitat may occur within area
Sterna albifrons Little Tern	Listed	Species or species habitat may occur within area
Sterna bergii Crested Tern	Listed	Breeding known to occur within area
Sterna fuscata Sooty Tern	Listed	Breeding known to occur within area
Sterna nereis Fairy Tern	Listed	Breeding known to occur within area
Thalassarche bulleri Buller's Albatross	Listed	Species or species habitat may occur within area
Thalassarche cauta (sensu stricto) Shy Albatross, Tasmanian Shy Albatross	Listed	Species or species habitat may occur within area
Thalassarche chlororhynchos Yellow-nosed Albatross, Atlantic Yellow-nosed Albatross	Listed	Species or species habitat may occur within area
Thalassarche chrysostoma Grey-headed Albatross	Listed	Species or species habitat may occur within area
Thalassarche impavida Campbell Albatross	Listed	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross	Listed	Species or species habitat may occur within area
Thalassarche salvini Salvin's Albatross	Listed	Species or species habitat may occur within area
Thinornis rubricollis rubricollis Hooded Plover (eastern)	Listed - overfly marine area	Species or species habitat likely to occur within area
Tringa nebularia Common Greenshank, Greenshank	Listed - overfly marine	Species or species habitat likely to occur within area

	area	
Mammals		
Arctocephalus forsteri New Zealand Fur-seal	Listed	Species or species habitat may occur within area
Arctocephalus pusillus Australian Fur-seal, Australo-African Fur-seal	Listed	Species or species habitat may occur within area
Neophoca cinerea Australian Sea-lion	Listed	Species or species habitat may occur within area
Ray-finned fishes		
Acentronura australe Southern Pygmy Pipehorse	Listed	Species or species habitat may occur within area
Campichthys tryoni Tryon's Pipefish	Listed	Species or species habitat may occur within area
Heraldia nocturna Upside-down Pipefish	Listed	Species or species habitat may occur within area
Hippocampus abdominalis Eastern Potbelly Seahorse, New Zealand Potbelly, Seahorse, Bigbelly Seahorse	Listed	Species or species habitat may occur within area
Hippocampus breviceps Short-head Seahorse, Short-snouted Seahorse	Listed	Species or species habitat may occur within area
Histiogamphelus cristatus Rhino Pipefish, Macleay's Crested Pipefish	Listed	Species or species habitat may occur within area
Hypselognathus rostratus Knife-snouted Pipefish	Listed	Species or species habitat may occur within area
Kaupus costatus Deep-bodied Pipefish	Listed	Species or species habitat may occur within area
Leptoichthys fistularius Brushtail Pipefish	Listed	Species or species habitat may occur within area
Lissocampus caudalis Australian Smooth Pipefish, Smooth Pipefish	Listed	Species or species habitat may occur within area
Lissocampus runa Javelin Pipefish	Listed	Species or species habitat may occur within area
Maroubra perserrata Sawtooth Pipefish	Listed	Species or species habitat may occur within area
Notiocampus ruber Red Pipefish	Listed	Species or species habitat may occur within area
Phycodurus eques Leafy Seadragon	Listed	Species or species habitat may occur within area
Phyllopteryx taeniolatus Weedy Seadragon, Common Seadragon	Listed	Species or species habitat may occur within area
Pugnaso curtirostris Pug-nosed Pipefish	Listed	Species or species habitat may occur within area
Solegnathus robustus Robust Spiny Pipehorse, Robust Pipehorse	Listed	Species or species habitat may occur within area
Solegnathus spinosissimus Spiny Pipehorse, Australian Spiny Pipehorse	Listed	Species or species habitat may occur within area
Stigmatopora argus Spotted Pipefish	Listed	Species or species habitat may occur within area
Stigmatopora nigra Wide-bodied Pipefish, Black Pipefish	Listed	Species or species habitat may occur within area
Stipecampus cristatus Ring-backed Pipefish	Listed	Species or species habitat may occur within area
Urocampus carinirostris Hairy Pipefish	Listed	Species or species habitat may occur within area
Vanacampus margaritifer Mother-of-pearl Pipefish	Listed	Species or species habitat may occur within area

Vanacampus phillipi Port Phillip Pipefish	Listed	Species or species habitat may occur within area
Vanacampus poecilolaemus Australian Long-snout Pipefish, Long-snouted Pipefish	Listed	Species or species habitat may occur within area
Vanacampus vercoi Verco's Pipefish	Listed	Species or species habitat may occur within area
Whales and Other Cetaceans [Dataset Information]	Status	Type of Presence
Balaenoptera acutorostrata Minke Whale	Cetacean	Species or species habitat may occur within area
Balaenoptera edeni Bryde's Whale	Cetacean	Species or species habitat may occur within area
Balaenoptera musculus Blue Whale	Cetacean	Species or species habitat may occur within area
Caperea marginata Pygmy Right Whale	Cetacean	Species or species habitat may occur within area
Delphinus delphis Common Dophin, Short-beaked Common Dolphin	Cetacean	Species or species habitat may occur within area
Eubalaena australis Southern Right Whale	Cetacean	Species or species habitat known to occur within area
Grampus griseus Risso's Dolphin, Grampus	Cetacean	Species or species habitat may occur within area
Lagenorhynchus obscurus Dusky Dolphin	Cetacean	Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale	Cetacean	Species or species habitat likely to occur within area
Orcinus orca Killer Whale, Orca	Cetacean	Species or species habitat may occur within area
Tursiops aduncus Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin	Cetacean	Species or species habitat likely to occur within area
Tursiops truncatus s. str. Bottlenose Dolphin	Cetacean	Species or species habitat may occur within area

Places on the RNE [Dataset Information]
Note that not all Indigenous sites may be listed.

Natural

Coorong Game Reserve SA

Coorong National Park SA

Extra Information

State and Territory Reserves [Dataset Information]

Coorong National Park, SA

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the *Environment Protection and Biodiversity Conservation Act 1999*. It holds mapped locations of World Heritage and Register of National Estate properties, Wetlands of International Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

For species where the distributions are well known, maps are digitised from sources such as recovery plans and detailed habitat studies. Where appropriate, core breeding, foraging and roosting areas are indicated under "type of presence". For species whose distributions are less well known, point locations are collated from government wildlife authorities, museums, and non-government organisations; bioclimatic distribution models are generated and these validated by experts. In some cases, the distribution maps are based solely on expert knowledge.

Only selected species covered by the migratory and marine provisions of the Act have been mapped.

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers.

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites;
- seals which have only been mapped for breeding sites near the Australian continent.

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Acknowledgments

This database has been compiled from a range of data sources. The Department acknowledges the following custodians who have contributed valuable data and advice:

- New South Wales National Parks and Wildlife Service
- Department of Sustainability and Environment, Victoria
- Department of Primary Industries, Water and Environment, Tasmania
- Department of Environment and Heritage, South Australia Planning SA
- Parks and Wildlife Commission of the Northern Territory
- Environmental Protection Agency, Queensland
- Birds Australia
- Australian Bird and Bat Banding Scheme
- Australian National Wildlife Collection
- Natural history museums of Australia
- Queensland Herbarium
- National Herbarium of NSW
- Royal Botanic Gardens and National Herbarium of Victoria
- Tasmanian Herbarium
- State Herbarium of South Australia
- Northern Territory Herbarium
- Western Australian Herbarium
- Australian National Herbarium, Atherton and Canberra
- University of New England
- Other groups and individuals

ANUCliM Version 1.8, Centre for Resource and Environmental Studies, Australian National University was used extensively for the production of draft maps of species distribution. Environment Australia is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

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