Vandeleur Environmental Pty Ltd

Preliminary identification of ecosystem services – Coorong and Lakes Alexandrina and Albert Ramsar site

Report to the Department of Environment, Water and Natural Resources

Executive summary

The Coorong and Lakes Alexandrina and Albert site was listed as a 'Wetland of International Importance' under the Ramsar Convention in 1985. The Ecological Character Description of The Coorong and Lakes Alexandrina and Albert Wetland of International Importance (Phillips & Muller, 2006) provided the baseline description of the wetland with the intention of it being used to assess changes in the ecological character of the sites.

Ecosystem services can be broadly defined as the benefits people obtain from ecosystems (Millennium Assessment, 2005). Phillips and Muller (2006) provided limited description and justification for ecosystem services supplied by the site, with limited evidence to demonstrate their occurrence or quantify their importance to the site. A subsequent technical review of the ECD undertaken by Water's Edge Consulting (Butcher 2011) identified and clarified the details necessary to describe the ecosystem services for the site based on those proposed by Phillips and Muller (2006) to comply with the DSEWPaC guidelines.

This paper seeks to summarise the information pertaining to the ecosystem services provided by the site and in doing so, identify those that are important to ecosystem functioning to assist with updating the ECD Report.

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Introduction

The Coorong and Lakes Alexandrina and Albert site was listed as a 'Wetland of International Importance' under the Ramsar Convention in 1985. As a signatory to the Ramsar Convention, the Australian and South Australian Governments are expected to manage their Ramsar sites so as to maintain the ecological character of each site, remain informed of any changes to the ecological character of Ramsar sites and notify the Ramsar Secretariat of any changes at the earliest opportunity (Ramsar Convention 1987, Article 3.2 and further clarified by the Parties in Resolution VIII.8, 2002; Ramsar Convention 2005, Resolution IX.1 Annex B).

Ecological character is the combination of the ecosystem components, processes, benefits and services that characterise the wetland at a given point in time (Ramsar Convention 2005a, Resolution IX.1 Annex A).

The Ecological Character Description of The Coorong and Lakes Alexandrina and Albert Wetland of International Importance (Phillips & Muller, 2006) provides the baseline description of the wetland and can be used to assess changes in the ecological character of these sites. Following a notification to the Ramsar Secretariat in 2006 of potential changes in the ecological character of the site, followed by an update to this in 2008 and the availability of additional information about the site's Ecological Character, in line with Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) guidelines (Department of the Environment, Water, Heritage and the Arts, 2008), the Ecological Character Description (ECD) Report will be updated to include this new information.

Phillips and Muller (2006) provided limited description and justification for ecosystem services supplied by the site, with limited evidence to demonstrate their occurrence or quantify their importance to the site. A subsequent technical review of the 2006 ECD, undertaken by Water's Edge Consulting (Butcher 2011), identified and clarified the additional details necessary to describe the site's ecosystem services in compliance with the DSEWPaC guidelines.

There is a need, therefore, for a more detailed identification and summary of ecosystem services and benefits within the context of updating the Ecological Character Description for the site. This paper seeks to summarise the information pertaining to the ecosystem services provided by the site and, in doing so, identify those that are important to ecosystem function to assist with updating the ECD Report.

The Coorong and Lakes Alexandrina and Albert Ramsar site

The Coorong and Lakes Ramsar site lies at the terminus of the Murray-Darling Basin. It incorporates the freshwater bodies of Lakes Alexandrina and Albert and the more saline lagoons of the Coorong.

It is the only estuary within the Murray-Darling Basin and the Murray Mouth is the only connection between this one million square kilometre inland basin and the sea.

Figure 1 Map of Coorong and Lakes Alexandrina and Albert Ramsar Site.

Figure from Australian Government Department of the Environment Australian Wetlands Database (http://www.environment.gov.au/cgi-bin/wetlands/ramsardetails.pl?refcode=25#)

Surface water flows are predominantly from the River Murray into the north of Lake Alexandrina near Wellington, with other inflows from the tributary streams draining the eastern Mount Lofty Ranges (EMLR) along the south-western edge of Lake Alexandrina.

Lake Albert lies to the south east of Lake Alexandrina connected via a narrow channel (Narrung Narrows) near Point Malcolm. Lake Alexandrina is the primary source of inflows into Lake Albert, with supplementation from local rainfall and groundwater discharge. As Lake Albert has no through-flow connection to the Coorong, it represents a local, inland terminus of the River Murray system.

The fresh waters of the River Murray and Lake Alexandrina are separated by a series of five barrages from the more saline water of the Murray Mouth Estuary and Coorong lagoons. In recent years, inflows from the South East of South Australia into the Coorong's South Lagoon have been re-established to a minor extent, although under regulated conditions via the Upper South East Drainage Scheme.

The Murray Mouth is the only site where silt, salt and other pollutants can exit the Murray-Darling Basin through the provision of flow. These flows or barrage releases are necessary to maintain an 'open' Murray Mouth to the Southern Ocean.

The Ramsar site covers an area of approximately 142,500 ha which incorporates 23 different wetland types existing as a mosaic of fresh to hypersaline habitats variously interconnected across time and space. Ramsar Criterion 1 seeks to recognise sites that contain

> *'… a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate bioregion'*
>
> (Ramsar Convention 2008)

The Coorong and Lakes qualify against this criterion in addition to seven of the other eight (see the 2013 Ramsar Information Sheet for the site for further details).To assist this description of ecological character, the Ramsar site has been sub-divided into six units as follows:

Freshwater system units:

- Lake Alexandrina
- Lake Albert
- Tributary wetlands (lower reaches of Finniss River, Currency Creek and Tookayerta Creek).

Estuarine-saline system units:

- Murray Mouth and Estuary
- North Lagoon
- South Lagoon.

A full description of the system units (freshwater and estuarine-saline) are contained within Section 4 of the Coorong and Lakes Alexandrina and Albert Ramsar Site Ecological Character Description (Phillips & Muller 2006). Generally, the 23 wetland types contained within the Ramsar site can be grouped within three types (Marine/coastal, inland and human-made wetlands) as described by the Ramsar Convention. Table 1 (as borrowed from Phillips & Muller 2006) lists the wetland types as described within ECD and their extent within the site.

Marine/Coastal Wetlands		**Area (ha)**
A	**Permanent shallow marine waters** in most cases less than six metres deep at low tide; includes sea bays and straits.	50
D	**Rocky marine shores**; includes rocky offshore islands, sea cliffs.	788*
E	**Sand, shingle or pebble shores**; includes sand bars, spits and sandy islets; includes dune systems and humid dune slacks.	1,020#
F	**Estuarine waters**; permanent water of estuaries and estuarine systems of deltas.	2,200
G	**Intertidal mud, sand or salt flats**.	3,142
H	**Intertidal marshes**; includes salt marshes, salt meadows, saltings, raised salt marshes; includes tidal brackish and freshwater marshes.	536
I	**Intertidal forested wetlands**; includes mangrove swamps, nipah swamps and tidal freshwater swamp forests.	4
J	**Coastal brackish/saline lagoons**; brackish to saline lagoons with at least one relatively narrow connection to the sea.	10,128
K	**Coastal freshwater lagoons**; includes freshwater delta lagoons.	41

Inland Wetlands		
M	**Permanent rivers/streams/creeks**; includes waterfalls.	221
N	**Seasonal/intermittent/irregular rivers/streams/creeks**.	200
O	**Permanent freshwater lakes** (over 8 ha); includes large oxbow lakes.	79,480
P	**Seasonal/intermittent freshwater lakes** (over 8 ha); includes floodplain lakes.	120
R	**Seasonal/intermittent saline/brackish/alkaline lakes and flats**.	1,729
Ss	**Seasonal/intermittent saline/brackish/alkaline marshes/pools**.	1,289
Tp	**Permanent freshwater marshes/pools**; ponds (below 8 ha), marshes and swamps on inorganic soils; with emergent vegetation water-logged for at least most of the growing season.	4,474
Ts	**Seasonal/intermittent freshwater marshes/pools** on inorganic soils; includes sloughs, potholes, seasonally flooded meadows, sedge marshes.	1,037
W	**Shrub-dominated wetlands**; shrub swamps, shrub-dominated freshwater marshes, shrub carr, alder thicket on inorganic soils.	4,875
Xf	**Freshwater, tree-dominated wetlands**; includes freshwater swamp forests, seasonally flooded forests, wooded swamps on inorganic soils.	1,470
Y	**Freshwater springs; oases**.	<10
Human-made wetlands		
4	**Seasonally flooded agricultural land** (including intensively managed or grazed wet meadow or pasture).	1,235
6	**Water storage areas**; reservoirs/barrages/dams/impoundments (generally over 8 ha).	1
9	**Canals and drainage channels, ditches**.	44

Notes:
Ramsar wetland types not found in the Coorong and Lakes system have not been included in the table.
* = includes 165 ha from Lake Alexandrina a freshwater part of the system.
# = includes 6 ha from Lake Alexandrina and 1 ha from Lake Albert; freshwater parts of the system
Shaded boxes indicate the dominant wetland types within each broad category; marine-coastal, inland and human-made.
The total area of wetland types is approximately 114,000 hectares. The balance of the land (approx 26,000 hectares) within the Ramsar site is terrestrial habitat, which is not unclassified under the Ramsar Convention (see Section 2.2 for a description of the site boundaries).

What are Ecosystem Services?

The origins of Ecosystem Services

Ecosystem services are essentially those services that an ecosystem provides to humans and has been defined within the Millennium Ecosystem Assessment (2005) as the benefits people obtain from ecosystems. The MEA (2005) derived its definition from two other commonly referenced definitions, Daily (1997):

> *Ecosystem services are the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfil human life. They maintain biodiversity and the production of ecosystem goods, such as seafood, forage timber, biomass fuels, natural fiber, and many pharmaceuticals, industrial products, and their precursors (*Daily *1997).*

and Constanza *et al.*(1997)

> *Ecosystem goods (such as food) and services (such as waste assimilation) represent the benefits human populations derive, directly or indirectly, from ecosystem functions (*Constanza *et al. 1997).*

The Millennium Ecosystem Assessment (MEA) classified ecosystem services into four categories: provisioning, regulating, cultural, and supporting services with an acknowledgement that some of the categories overlapped. The MEA (2005) demonstrated linkages between Ecosystem Services and Human Well-being as summarised in Figure 2.

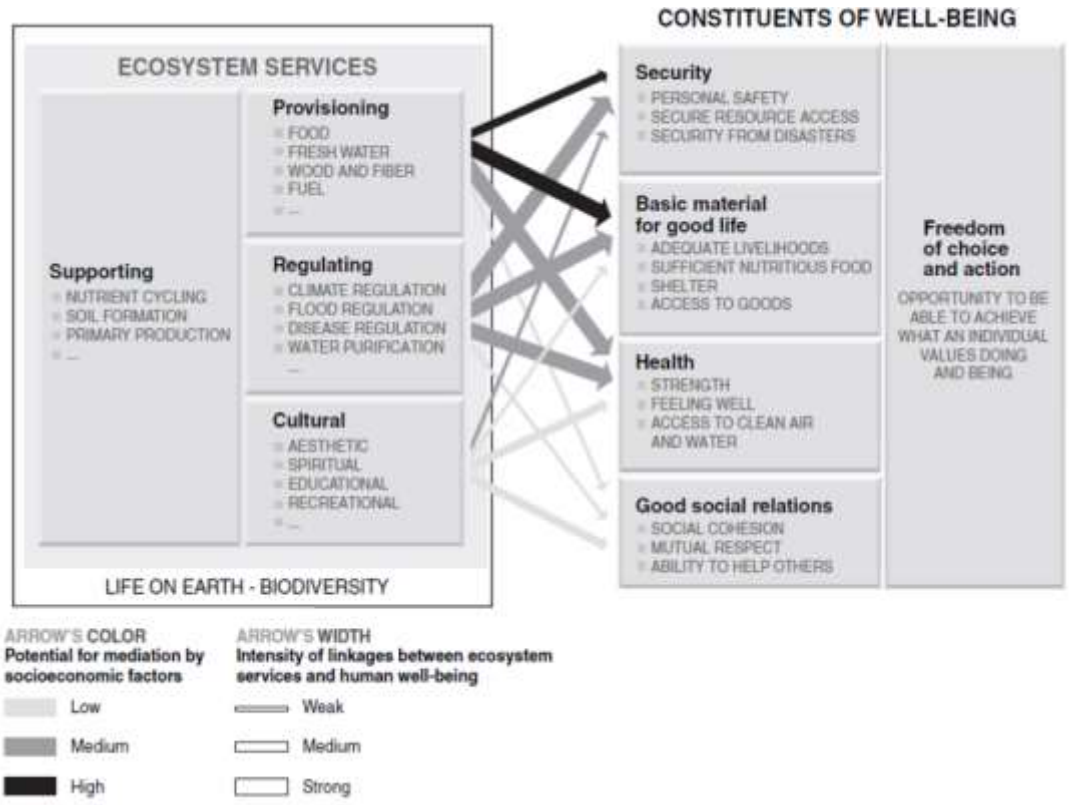

Figure 2 - Linkages between Ecosystem Services and Human Well-being (from Millennium Ecosystem Assessment 2005)

Provisioning Services

These provide the products available from ecosystems for use and consumption by people, including:

- *Food and fibre*. This includes the vast range of food products derived from plants, animals, and microbes, as well as materials such as wood, jute, hemp, silk, and many other products derived from ecosystems.
- *Fuel*. Wood, dung, and other biological materials serve as sources of energy.
- *Genetic resources.* This includes the genes and genetic information used for animal and plant breeding and biotechnology.
- *Biochemicals*, *natural medicines*, *and pharmaceuticals.* Many medicines, biocides, food additives such as alginates, and biological materials are derived from ecosystems.

- *Ornamental resources.* Animal products, such as skins and shells, and flowers are used as ornaments.
- *Fresh water.* Fresh water, used for domestic, irrigation, industrial and other purposes, and a good example of the overlap and linkages between categories (e.g. between provisioning, supporting and regulating services).

Regulating Services

These provide direct benefits to people by regulating and maintaining their natural and built environments, including:

- *Air quality maintenance.* Ecosystems both contribute chemicals to and extract chemicals from the atmosphere, influencing many aspects of air quality.
- *Climate regulation.* Ecosystems influence climate both locally and globally. For example, at a local scale, changes in land cover can affect both temperature and precipitation. At the global scale, ecosystems play an important role in climate by either sequestering or emitting greenhouse gases.
- *Water regulation.* The timing and magnitude of runoff, flooding, and aquifer recharge can be strongly influenced by changes in land cover, including, in particular, alterations that change the water storage potential of the system, such as the conversion of wetlands or the replacement of forests with croplands or croplands with urban areas.
- *Erosion control.* Vegetative cover plays an important role in soil retention and the prevention of landslides.
- *Water purification and waste treatment.* Ecosystems can be a source of impurities in fresh water but also can help to filter out and decompose organic wastes introduced into inland waters and coastal and marine ecosystems.
- *Regulation of human diseases.* Changes in ecosystems can directly change the abundance of human pathogens, such as cholera, and can alter the abundance of disease vectors, such as mosquitoes.
- *Biological control.* Ecosystem changes affect the prevalence of crop and livestock pests and diseases.
- *Pollination.* Ecosystem changes affect the distribution, abundance, and effectiveness of pollinators in terms of the success of crops.
- *Storm protection.* The presence of coastal ecosystems such as mangroves and coral reefs can dramatically reduce the damage caused by hurricanes or large waves.

Cultural Services

These provide the nonmaterial benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences, including:

- *Cultural diversity.* The diversity of ecosystems is one factor influencing the diversity of cultures.
- *Spiritual and religious values.* Many religions attach spiritual and religious values to ecosystems or their components.
- *Knowledge systems* (traditional and formal). Ecosystems influence the types of knowledge systems developed by different cultures.

- *Educational values.* Ecosystems and their components and processes provide the basis for both formal and informal education in many societies.
- *Inspiration.* Ecosystems provide a rich source of inspiration for art, folklore, national symbols, architecture, and advertising.
- *Aesthetic values.* Many people find beauty or aesthetic value in various aspects of ecosystems, as reflected in the support for parks, "scenic drives," and the selection of housing locations.
- *Social relations.* Ecosystems influence the types of social relations that are established in particular cultures. Fishing societies, for example, differ in many respects in their social relations from nomadic herding or agricultural societies.
- *Sense of place.* Many people value the "sense of place" that is associated with recognized features of their environment, including aspects of the ecosystem.
- *Cultural heritage values.* Many societies place high value on the maintenance of either historically important landscapes ("cultural landscapes") or culturally significant species.
- *Recreation and ecotourism.* People often choose where to spend their leisure time based in part on the characteristics of the natural or cultivated landscapes in a particular area.

Supporting Services

These provide only indirect benefits to people by supporting and maintaining all other ecosystem services. They differ from provisioning, regulating, and cultural services in that their impacts on people are generally indirect and may occur over a very long time, whereas changes in the other categories have relatively direct and short-term impacts on people. Some examples of supporting services are outlined below:

- *Soil formation and retention.* Because many provisioning services depend on soil fertility, the rate of soil formation influences human well-being in many ways e.g. through crop success.
- *Photosynthesis.* Photosynthesis produces oxygen necessary for most living organisms and therefore is fundamental for humans both through food production and oxygen availability.
- *Primary production*: The assimilation or accumulation of energy and nutrients by organisms. Benefot to humans is multi-faceted but includes food production, input to food webs etc.
- *Nutrient cycling:* Approximately 20 nutrients essential for life, including nitrogen and phosphorus, cycle through ecosystems and are maintained at different concentrations in different parts of ecosystems and are therefore available for uptake and is a primary building block of food webs.
- *Water cycling:* Water cycles through ecosystems and is essential for living organisms.
- *Provisioning of habitat:* The ecosystem provides habitat for migratory species eg wetlands provide vital feeding and resting areas for migratory bird species.

Three international classification systems are currently utilised for classification of ecosystem services: Millennium Ecosystem Assessment (MEA 2005); The Economics of Ecosystems and Biodiversity (TEEB 2010) and the Common International Classification of Ecosystem Services (CICES 2013). The three systems are similar and all include provisioning, regulatory and cultural services.

The current European Union guidance on mapping and assessment of ecosystems and their services (Maes *et al.* 2013) is based upon the Ecosystems Services Cascade Model (Haines-Young & Potschin 2010), the TEEB Framework (TEEB 2010) and the UK National Ecosystem Assessment (2011). The EU

guidance document aims to ensure consistency and allow for aggregation and comparison of results from across the EU and as such proposes common classifications and definitions in relation to ecosystem services.

Biodiversity and its relationship to ecosystem services

The necessity of understanding the underpinning processes of the system is fundamental to being able to map the ecosystem services a system provides. Clark *et al.* (2001) summarised this:

> 'The integrated approach of ecosystem services concept required the consideration of interacting ecosystem functions in any study assessing ecosystem services and goods. This necessitates a complete understanding of the system and thus a representation of the relevant biophysical processes in a realistic way.'

It is well established that biodiversity plays an important role in underpinning ecosystem services and that understanding the sensitivity of ecosystem processes and services to biodiversity changes is essential (Hooper 2005, EASAC 2009).There does however seem to be confusion within the academic literature as to how biodiversity fits within the ecosystem services concept. This confusion is demonstrated by the varied and differing approaches whereby biodiversity seems to be alternatively considered as both a regulator of ecosystem processes or final ecosystem service and as a good in its own right (Mace *et al.*2011).

The MEA (2005) demonstrated linkages between Ecosystem Services and Human Well-being (as summarised previously in Figure 1). The UKNEA also went on to further elicit and demonstrate these linkages. Within the MEA classification, biodiversity fits more within the regulating and cultural services (MEA, 2005) than the provisioning services. The UK National Ecosystems Assessment (NEA) was developed around a conceptual framework in a comparable way to the Millennium Assessment (MEA), whereby the assessment focuses on the output of final ES from a range of ecosystems types and the goods and values assessed with the services. The NEA works on the principal that final ES are underpinned by a range of ecosystem processes and recognises the functional role of biodiversity.

Other authors have argued that this is misrepresenting biodiversity in representing its importance as being only in underpinning final ES and that biodiversity can variously be a key ecosystem process, a final ES or a good (Norris 2012, Mace *et al.*2012). De Groot *et al.*(2006) includes biodiversity maintenance through habitat provision as an ecosystem service, asserting that biodiversity services underpin the provision of many other services.

A key issue is that often the data available in relation to biodiversity is restricted to species level research (often of larger charismatic or iconic species). The NEA examined the quality of the monitoring data on status and trends for a range of biodiversity groups in the UK and found data quality was correlated with cultural importance. This is in agreement with the data held for the Coorong and Lower Lakes (and the wider Murray Darling system,) in that key gaps in knowledge exist for elements that are less iconic or recognised by the community (such as micro-organisms and micro-invertebrates) and little is known of their role in other underpinning processes such as nutrient cycling and transformation.

Norris (2012) considered biodiversity in the context of ecosystem services and raised the interesting observation that most biodiversity science is largely retrospective (in that it usually attempts to understand how and why biodiversity has been lost and how to halt and reverse its decline). This is

very different from understanding how multiple, concurrent future changes in environment might impact on biodiversity and ecosystem services.

The relationship between species stability and diversity changes are poorly understood. Steudel *et al.*(2011) examined biomass production in aquatic plant assemblages of differing richness and found that richness did not explain variation in biomass in a stable environment. However, under changed environmental conditions (drought, increased salinity etc.), richness was important and species diverse assemblages were more productive.

Biodiversity can be considered to play a key role in the structural establishment of ecosystems which is essential in maintaining basic ecosystem processes and supporting ecosystem functions (with ecosystem functions being the potential to deliver ecosystem services). Biodiversity can be considered to be critical to ecosystem functioning through both direct and indirect means. Biodiversity directly delivers an ecosystem service (as well as supporting ecosystem functions) through aspects such as genetic diversity, species richness and taxonomic diversity, and through diversity of specific biotic interactions within a food web (e.g. predatory insects provide a regulatory service on pests on agricultural crops). Other more indirect ways in which biodiversity plays a role is through supporting ecosystem functions such as enhancing the efficiency of primary production and decomposition, structuring habitats and landscapes and providing functional diversity through variation in the degree of the expression of multiple functional traits (Maes *et al.* 2013).

Challenges of the ecosystem service approach

As discussed by Busch *et al.*(2012), politicians addressing clearly located subjects regularly prefer to justify political actions that are based on 'concrete' cost-benefit analyses rather than on projected trends of a qualitative assessment. However, undertaking quantitative assessment is usually expensive and time consuming in the absence of good physical or monetary assessment to build upon. The current 'trend' within regulatory agencies to adopt the ecosystem services concept can perhaps be attributed to this preference for definable (in monetary terms) contributions from ecosystems. That being said, attempting to define the services a system (such as a wetland system) provides in relation to humans may be a more effective way of achieving 'buy-in' from its users than previous approaches.

The Millennium Ecosystem Assessment (MEA 2005) has contributed to the use of the ecosystem services concept as a policy tool to achieve the sustainable use of natural resources. However, the MEA didn't propose a fully operational model to implement the concept and as such the term 'ecosystem services' has been redefined and used in many different ways achieving differing aims in a plethora of studies.

Seppelt *et al.* (2011) undertook a quantitative review of ecosystem services studies (using the Web of Science for search terms 'ecosystem service', 'ecosystem services' and 'ecosystem valuation') and located 460 studies in 20 years. However, review by this study has highlighted that there still appears to be some confusion in the academic literature between ecosystem functions and processes as opposed to ecosystem services (Moore & Hunt 2012, Thomsen *et al.*2012, Yang 2011).

Central to the concept of ecosystems services is the ability to define the services in a monetary basis. To quantify and value ecosystem services, The Economics of Ecosystems and Biodiversity (TEEB)

group (2010) suggested a hierarchical typology by separation of ecological processes from the actual benefits dependent upon these processes.

An important difference TEEB adopted was the omission of supporting services, which were seen in TEEB as a subset of ecological processes. Instead, habitat services were identified as a separate category to highlight the importance of ecosystems to provide habitat for migratory species (e.g. as nurseries) and gene-pool "protectors" (e.g. natural habitats allowing natural selection processes to maintain the vitality of the gene pool). The availability of the services was considered directly dependent on the status of the habitat (habitat requirements) providing the service. In cases such as commercial fish and shrimp species, which spawn within estuarine and coastal nursery areas but which also have adults being caught far away, the service has an economic (monetary) value in its own right. The importance of the gene-pool protection service of ecosystems was also recognised, both as "hot spots" for conservation and to maintain the original gene-pool of commercial species (European Commission 2013).

Another key issue that can occur when assigning ecosystem services is the issue of double accounting errors. This is particularly important when mapping the supporting services as distinct from the 'end' final ecosystem services, where there is the potential for double counting errors if an attempt is made to directly value those ecological processes (e.g. weathering, soil formation, nutrient cycling, etc.) support multiple ecosystem services. The concern is that, if both primary ecological processes (functions) and the final ecosystem services that directly generate wellbeing or directly contribute to the production of goods are counted, then we are liable to overestimate the total values generated (Bateman *et al.* 2011).

Among economists the application of monetary values to ecosystem services is debated; for while Constanza *et al.* (1997), Daily *et al.*(2009), TEEB (2010) and Bateman *et al.*(2011) suggest that monetisation is a major step towards ecosystem services preservation, other authors such as Norgaard (2010) and Vatn (2010) suggest it is more appropriate not to apply economic values to ecosystem services especially when related to some of the socio-cultural services (Smith *et al.*2011).

Smith *et al.*(2011) discuss the issues with relating values to ecosystem services, as for some socio-cultural services we may wish to give some aspects of the ecosystem infinite value (eg religious significance of a site precludes any change in the area). Bateman *et al.* (2011), however, argued for a strong economic perspective to ecosystem services underpinned by an ecological standard for the scenarios where a value cannot be established (similar to the widely-used concept of multi-criteria analysis).

Barbier (2011) cites good references of valuation studies for key ecosystem services and highlighted that there is an obvious bias to the literature with more valuation attempts for socio-cultural services such as tourism or easily-valued food services than the trickier less-quantifiable services. Tuvendal & Elmqvist (2011) highlighted that, where well-being in relation to wetlands is appreciated by a community, the ecosystem services approach is a useful framework for identifying and connecting stakeholders in the landscape.

Another issue central to the application of the ecosystem services approach is that of spatial scale, with spatial scale being an important determinant of whether an ecological process provides an ecosystem service or not. Generally, within the literature, spatial correlations between ecosystem

services are assumed rather than demonstrated. Syrbe & Walz (2012) examined the spatial characteristics of ecosystem services and argued that the term 'ecosystem services' should be enlarged to 'landscape services' justified by a strong reference to spatial characteristics and a more integrative approach which would take account of neighbouring processes.

One of the key issues with the use of Ecosystem Services to define a system are the potential problems of differences spatially and/or temporally in the same system over time (Lamarque *et al.* 2011; Holland *et al.* 2011). Holland *et al.* (2011) looked at the temporal variation on relationships between ecosystem services with their study highlighting issues of temporally disjunct datasets having the potential to influence conclusions about relationships between services.

Linked to the spatial scale aspect is the problem that most services are not delivered by the ecosystem as a whole, rather by distinct parts of the system. This led to the development of the concept of Service Providing Units (SPU) by authors such as Luck *et al.* (2003). These units represent populations of species that provide the service at a certain temporal or spatial scale. This concept therefore allows a direct link to be made between the service and the part of the ecosystem that provides it.

Ecosystem Services of Wetlands

Inland and coastal wetlands together are estimated to cover a minimum of 12.8 million km2 (Finlayson *et al.*1999). They deliver a range of ecosystem services, i.e. benefits that people obtain from ecosystems (Finlayson et al., 1999; MEA 2005) and the global decrease in estuarine and coastal ecosystems has been shown to affect at least three critical ecosystem services: number of viable fisheries; provision of nursery habitats; and filtering and detoxification services (Worm *et al*., 2006).

The ecosystem services concept has been utilised to show the true value of wetlands and other ecosystems so that they can be effectively included within development decisions (Barbier 2011). The desire to find the right balance between exploitation of services and their conservation has also led to the concept of 'wise use of wetlands', a more considerate and sustainable approach to living with wetland habitats (Maltby 1991, Ramsar Convention Bureau 2000).

Russi *et al.*(2013) as part of the TEEB works examined the economics of ecosystems and biodiversity for water and wetlands building on the previous TEEB work (2010) and outlined a scheme for describing the ecological character of wetlands in relation to their provision of ecosystem services (refer Table 2 reproduced from Russi *et al.* 2013).

Traditional water management has largely managed the 'blue' component of the water, where blue water is that component that exceeds the soils storage capacity and runs downstream to feed rivers, lakes and aquifers, and largely ignores the green component whereby green waters are defined as the rainfall infiltrated and stored in the soil root zone supporting primary productivity of natural and agricultural systems through evapotranspiration (Falkenmark, 2003). This focus of management on blue water has been termed by Willaarts *et al.*(2012) as 'green water blindness'.

Stratford *et al.*(2011) describes a method developed within a joint Ramsar – WWF led initiative (EU Asia Pro-Eco Programme) that developed an assessment of services provided by the greater

Himalaya wetlands. The work highlighted how remote wetlands are often undervalued and underappreciated as their ecosystem service is spatially removed far from the source.

This spatial dislocation of the service from its underlying processes can also lead to 'offsite effects' (Scharlemann & Laurance 2008), whereby processes underpinning ecosystem services are impacted by systems outside of the specific area (eg 'brown' waters flowing from upstream impacting upon the downstream habitats[1]). Tuvendal & Elmqvist (2011) demonstrated how ecosystem processes upstream of a wetland system can impact on ecosystem services downstream with brownification of waters impacting upon the ecosystem services of food (and the provisioning fishery) and hay (by impacting upon the farming).

The size of the wetland system in its own right also required consideration as to the ecosystem services it provides. Smaller wetlands are often overlooked in their contribution to ecosystem services; however Blackwell & Pilgrim (2011) demonstrated that small wetlands (<1 ha) are likely to be significant contributors to delivery of ecosystem services within a system when their cumulative impacts are considered. As such, it is likely many wetlands too small to have been designated for protection in their own right are contained within larger systems and are an over-looked but vital component of that system. Within the CLAMM system it is likely that the smaller wetlands, which appear of lesser value (such as the lagoons when compared to the two lakes), are still providing vital ecosystem services within the broader landscape.

A variety of papers have examined the role coastal habitats play in providing ecosystem services with authors such as Schmidt *et al.*(2011) demonstrating the essential ecosystem services that near-shore coastal plants play in providing habitat, refuges and carbon and/or nitrogen cycling and storage. Barbier *et al.*(2011) reviewed the value of estuarine and coastal ecosystem services for five different coastal ecosystems and highlighted the difficulty in generating dollar values in practise. This difficulty was attributed to the issue of examining a particular habitat's role in isolation for valuation purposes when, (especially in the coastal zone) most habitats and ecosystems have synergistic relationships in which the systems may actually provide 'more than the sum of their parts'.

This difficulty assessing the services was also a key conclusion of the recent Marsden Jacobs Associate (2013) report for the Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC), whereby the authors concluded that making generalisations and accurate valuations of ecosystem services is difficult due to the many influencing factors on the wetland-derived ecosystem service values.

Key to the identification of wetland ecosystem services is the perspective of the reviewer as different communities and individuals may have different expectations of the services a system provides. Holt *et al.*(2011) examined the implementation of the Ecosystem Approach in coastal environments and examined the views of the local residents as to the services they believed their local coastal area provided. The work demonstrated the apparent disagreement between the long-term philosophy of the Ecosystem Approach and the perceived needs of the stakeholder community

[1] In many areas in the northern hemisphere, freshwater systems, and particularly rivers, are deteriorating because of increased levels of dissolved organic carbon (DOC). A visible syndrome of increasing levels of DOC is brownification or browning of water colour. The difference in colour for different water bodies is assumed to be because of differences in vegetation, soils, and the strength of processes such as decomposition and sedimentation (Tuvendal & Elmqvist 2011).

who emphasised a requirement for more immediate benefits that were no longer related to extractive natural resources. Many of the benefits valued were recreational activities related to natural living and enjoyment of the natural environment. The study did note that many of the activities that were valued, however, were underpinned by wildlife and habitats being intact and free from pollution.

A growing body of work has focused on human health issues in a wetland setting. Horwitz & Finlayson (2011) assessed the service wetland ecosystems provide specifically in relation to human health and proposed that Health Impact Assessments should be developed specifically for use by wetland managers. The relationship between human health and provision of socio-cultural ecosystem services in wetlands is, however, outside the scope of this report and as such has not been discussed further.

CSIRO with funding from the SAMDB NRM and the EPA undertook a South Australian Murray-Darling Basin-wide Environmental Values Study (Cast *et al.* 2008). This study undertook extensive interviews with community policy advisors in order to answer the central questions: 'what do you value in the environment and why do you value it?'. As the study was undertaken in 2007/2008 in the middle of the Murray Darling Basin-wide drought, water was a key issue (and ecosystem service) with the overall findings showing that the respondents appeared to value water for how it enhanced their enjoyment of life and supported their continued existence. The report also found that the role of regulatory and supporting services was not highly valued and that there is a disconnect between the articulation of science and the investment process.

An interesting outcome of the study was that the respondents seem to have an easier time discussing natural resources from an ecosystem-service perspective than they did from an asset perspective. This leads to challenges in future examination of ecosystem services within the institutional framework of NRM policy management as they are traditionally grouped into asset categories as opposed to the services that collective assets provide (Cast *et al.* 2008).

Table 2. A global scheme for describing the ecological character of wetlands. Reproduced from Russi *et al*. (2013)

Ecological components	Ecological processes	Ecosystem services
Geomorphic setting: in the landscape, catchment, or river basin	Primary production (S)	Drinking water for humans or livestock (P)
Climate: overview of prevailing climate type, zone, and major features	Nutrient cycling (S)	Water for irrigated agriculture (P)
Habitat types	Carbon cycling	Water for industry (P)
Habitat connectivity	Animal reproductive productivity	Groundwater replenishment (R)
Area, boundary, and dimensions: site shape, boundaries, area, area of water or wet area, length, width, depth	Vegetational productivity, pollination, regeneration processes, succession, role of fire, etc.	Water purification,waste treatment or dilution (R)
Plant communities, vegetation zones, and structure	Notable species interactions, including grazing, predation, competition, diseases and pathogens	Food for humans (P)
Animal communities	Notable aspects concerning animal and plant dispersal	Food for livestock (P)
Main species present	Notable aspects concerning migration	Wood, reed, fiber, and peat (P)
Soil: geology, substrates, soil biology	Pressures, vulnerabilities, and trends concerning any of the above or concerning ecosystem integrity	Medicinal products (P)
Water regime: water source, inflow or outflow, evaporation, flooding frequency, seasonality and duration, magnitude of flow or tidal regime, links with groundwater		Biological control agents for pests or diseases (R)
Connectivity of surface waters and of groundwater		Other products and resources, including genetic material (P)
Stratification and mixing regime		Flood control, flood storage (R)
Sediment regime		Soil, sediment, and nutrient retention (R)
Water turbidity and color		Coastal shoreline and river bank stabilization and storm protection (R)
Light and attenuation in water		Other hydrological services (R)
Water temperature		Local climate regulation, buffering of change (R)
Water pH		Carbon storage or sequestration (R)
Water salinity		Recreational hunting and fishing (C)
Dissolved oxygen in water		Water sports (C)
Dissolved or suspended nutrients in water		Nature study pursuits (C)
Dissolved organic carbon		Other recreation and tourism (C)
Redox potential of water and sediments		Educational values (C)
Water conductivity		Cultural heritage (C)
		Contemporary cultural significance, including for arts and creative inspiration and including existence values (C)
		Aesthetic and "sense of place" values (C)
		Spiritual and religious values (C)
		Important knowledge systems, importance for research (C)

Source: Ramsar Convention 2008, with minor changes.
C, cultural ecosystem service; P, provisioning ecosystem service; R, regulating ecosystem service; S, supporting ecosystem service; categorized according to the Millennium Ecosystem Assessment (MA 2005a).

Potential Ecosystem Services of the Coorong and Lower Lakes

The Coorong and Lower Lakes Ramsar Site supports many species and habitats recognised under various National and International designations. Full details are contained with the Ecological Character Description (Phillips & Muller 2006) although a number of these listing are currently being updated. These include:

- Two ecological communities of note in the Coorong and Lakes Ramsar site:
  1. Swamps of the Fleurieu Peninsula which are classified as critically endangered
  2. Vegetation assemblage of *Gahnia filum* (type of sedgeland) – classified as threatened ecosystem
- Seven (7) nationally endangered and vulnerable plant species
- One amphibian (classified as vulnerable)
- Forty-nine (49) species of fish (of which 5 are classified as Nationally or Internationally vulnerable) with twenty (20) of these species utilising the site for critical stages of their life cycle
- Seventy-seven (77) bird species with: three (3) classified as Endangered or Critically Endangered globally or nationally; Five (5) classed as vulnerable in South Australia; forty-nine (49) spending their critical life stages in the site; forty-six (46) listed under the Australia migratory bird agreements (Japan or China) or the Convention on Migratory Species, and sixteen (16) that occur in numbers greater than or equal to 1% of the estimated population or sub-population.

The main driver within the Coorong and Lower Lakes system is hydrology and, as summarised within Phillips & Muller (2006), the habitat-scale water regime in the highly-regulated Coorong and Lakes environment has been simplified in many areas to be water-level dependent. Climate and geomorphology define the degree to which the wetlands exist, but the hydrology (and, in turn, the physicochemical environment including soils) determines what and how much biota, including vegetation is found in the wetland (Mitch & Gosselink 2007).

Within the Coorong and Lakes system, the regulated flows affect water levels and physico-chemical changes rather than inducing more natural system responses such as transitions from standing to flowing habitats as natural, dynamic flow regimes would typically exhibit on a seasonal basis. Phillips & Muller (2006) estimated that only 27% of the median natural flows for the Murray Darling System still discharge into the sea and barrage operation was, until recently, the primary level controlling the physico-chemical environment of the Murray Mouth and Coorong lagoons.

The Coorong and Lower Lakes Ramsar Site, although having degraded since designation (a trend that has likely been consistent since the change in land and water use of the MDB with the arrival of European settlers), still provides and underpins many essential ecosystem services both locally and to a wider audience. The Ecological Character Description (ECD) (Phillips & Muller 2006) presented a number of likely ecosystem services for the Coorong and Lower Lakes Ramsar Site. The Ecosystem Services as listed within the ECD appear reasonable however little scientific evidence was presented and there was some confusion between final and intermediate services (in the details section particularly). Butcher (2011) undertook a review of the ECD in light of updated thinking on the contents of an ECD and supplemented the detailed list of services provided by the Coorong and Lower Lakes system (refer Table 3 below).

Phillips & Muller (2006)		Butcher (2011)
Ecosystem Service	**Details**	**Ecosystem Service**
Provisioning Services		
Wetland Products	Water source for irrigators (horticulture, viticulture)	Irrigation
	Commercial and recreational fisheries	Provision of aquatic foods for human consumption
	Goolwa Cockle fishery	
	Drinking water supply	Drinking Water
Regulating Services		
Maintenance of hydrological stability	Flood mitigation	Maintenance and regulation of hydrological regimes
Water purification	Groundwater interactions	
	Removal and dilution of wastewaters from irrigation areas, urban areas and septic tanks	
Coastal shoreline and bank stabilisation	Reduce impact of wind and wave action and currents	
	Prevent erosion by holding sediments with plant roots	
Sediment and nutrient retention	Flood retardation and sediment and nutrient deposition	
Local climate regulation	Local climate stabilisation, particularly in relation to rainfall and temperature	
Climate change mitigation	Sequestering of carbon	
Biological control of pest and diseases	Support of predators of agricultural pests (e.g. ibis feeding on grasshoppers)	
Cultural Services		
Recreation and tourism	Boating and water-skiing	Recreation
	Bird watching and sightseeing	Tourism
	Swimming, picnicking and camping	
	Fishing	
Cultural values	Aesthetics, amenity	Cultural heritage and identity
	Cultural and spiritual significance for the Ngarrindjeri people	Spiritual and inspirational
	Educational and research site	
Supporting Services		
Food web support	Nutrient cycling	
	Primary ecosystem production	
Ecological values	Representative of a unique ecosystem (globally, nationally and regionally)	Ecological connectivity
	Supports a large variety of ecological communities	
	Supports a number of globally and nationally threatened species and communities	Supports threatened species (nationally/internationally listed – not necessarily all critical – southern bell frog, southern emu wren and orange-bellied parrot)
	Supports a high diversity of species and assemblages important for conserving biodiversity at the bioregional scale	Supports a diversity of wetland types (extent and diversity)
		Supports priority wetland species
		Supports distinct or unique wetland species (e.g. Ruppia)

		Biodiversity (includes state listed species, but not limited to these)
	Supports animal taxa at critical stages of their lifecycle and during drought	Special physical, ecological or geomorphic features (critical life stages and drought)
	Supports significant numbers and diversity of wetland-dependent birds, including migratory species listed under the JAMBA and CAMBA agreements	Provides physical habitat for waterbird and fish breeding and feeding
	Supports significant numbers and diversity of native fish, including migratory species	

Table 3: Ecosystem services as listed by Phillips & Muller (2006) compared with those listed by Butcher (2011)

Although Butcher (2011) refines the likely ecosystem services provided within the Ecological Character Description (Phillips & Muller 2006), all services were generally included within the ECD. As such, it is assumed that the ecosystem services listed by these authors are appropriate but require more definitive substantiation as well as careful defining for their specific unit to provide guidance as part of an updated ECD Report. For example defining wetland products within a Lake Alexandrina context as these may differ to those in the South Lagoon of the Coorong.

For ease, the Coorong and Lower Lakes have been broadly separated and discussed in relation to the areas defined by the Ramsar designation and ECD (Phillips & Muller 2006): the three freshwater areas Lake Alexandrina; Lake Albert and the Tributaries, and the 3 saline influenced areas; the Murray Mouth and Estuary; North Lagoon and South Lagoon. It is envisaged that any functional or process assessment will break down these units further (likely into hydrographical sub-units).

Table 4 presents the potential ecosystem services supported by each of the Coorong and Lakes Ramsar Site management unit (note, due to few differences in ecosystem services between Lake Alexandrina and Albert these are grouped together to avoid repetition). Appendix 1 builds upon Table 4 but also outlines the current status since Ramsar designation, the key underlying processes and the direct local evidence (where available) that the ecosystem process is operating within that system.

Table 4: Potential ecosystem services supported by each of the Coorong and Lakes Ramsar Site management units

Lake Alexandrina and Lake Albert		
Wetland type located within unit (as described in Phillips & Muller (2006)	**Ecosystem service**	**Details of Ecosystem Service at Ramsar designation (1985)**
• Rocky marine shores • Sand, shingle or pebble shores • Permanent rivers/streams/creeks • Seasonal/intermittent/irregular rivers/streams/creeks • Permanent freshwater lakes • Seasonal/intermittent freshwater lakes • Seasonal/intermittent saline/brackish/alkaline lakes and flats • Seasonal/intermittent saline/brackish/alkaline marshes/pools • Permanent freshwater marshes/pools • Seasonal/intermittent freshwater marshes/pools • Shrub-dominated wetlands • Freshwater, tree-dominated wetlands • Seasonally flooded agricultural land • Canals and drainage channels, ditches.	Wetland Products	Irrigation water
		Drinking Water (Lake Alexandrina only)
		Commercial and recreational fisheries
		Grazing
		Reeds and grasses for traditional crafts
		Traditional Ngarrindjeri food species (eggs, birds,fish, yabbies)
	Maintenance of hydrological stability	Flood mitigation
		Groundwater interactions
	Water purification	Removal and dilution of wastewaters form irrigation areas, urban areas and septic tanks
	Coastal shoreline and bank stabilisation	Reduce impacts of wind and wave action and currents
		Prevent erosion by holding sediments with plant roots
	Sediment and nutrient retention	Flood retardation and sediment and nutrient deposition
	Local climate regulation	Local climate stabilisation, particularly in relation to rainfall and temperature
	Climate change mitigation	Sequestering and cycling of carbon
	Biological control of pest and diseases	Support of predators of agricultural pests
	Recreation and tourism	Boating and water skiing
		Fishing
		Bird watching and sightseeing
		Swimming, picnicking and camping
		Wine & food related tourism
	Food web support	Nutrient cycling
		Primary ecosystem production
	Ecological values	Representative of a unique ecosystem (globally, national and regionally)
		Supports a large variety of ecological communities
		Supports a number of globally and nationally threatened species and communities
		Supports a high diversity of species and assemblages important for conserving biodiversity at the bioregional scale
		Supports animal taxa at critical stages of their lifecycle and during drought
		Supports significant numbers and diversity of wetland-dependent birds including migratory species listed under the JAMBA and CAMBA agreements
		Supports significant numbers and diversity of native fish, including migratory species.

	Cultural values[#]	Aesthetics, amenity
		Cultural and spiritual significance for the Ngarrindjeri people
		Educational and research site

Tributaries		
Wetland type located within unit (as described in Phillips & Muller (2006)	**Ecosystem service**	**Details of Ecosystem Service at Ramsar designation (1985)**
• Permanent rivers/streams/creeks • Permanent freshwater lakes • Seasonal/intermittent saline/brackish/alkaline marshes/pools • Permanent freshwater marshes/pools • Seasonal/intermittent freshwater marshes/pools • Freshwater, tree-dominated wetlands • Seasonally flooded agricultural land • Water storage areas • Canals and drainage channels, ditches.	Wetland Products	Irrigation water
		Drinking Water
		Commercial and recreational fisheries
		Grazing
		Reeds and grasses for traditional crafts
		Traditional Ngarrindjeri food species (eggs, birds,fish, yabbies)
	Maintenance of hydrological stability	Flood mitigation
		Groundwater interactions
	Water purification	Removal and dilution of wastewaters form irrigation areas, urban areas and septic tanks
	River bank stabilisation	Prevent erosion by holding sediments with plant roots
	Sediment and nutrient retention	Flood retardation and sediment and nutrient deposition
	Local climate regulation	Local climate stabilisation, particularly in relation to rainfall and temperature
	Climate change mitigation	Sequestering and cycling of carbon
	Biological control of pest and diseases	Support of predators of agricultural pests
	Recreation and tourism	Boating and water skiing
		Fishing
		Bird watching and sightseeing
		Swimming, picnicking and camping
		Wine and food tourism
	Food web support	Nutrient cycling
		Primary ecosystem production
	Ecological values	Representative of a unique ecosystem (globally, national and regionally)
		Supports a large variety of ecological communities
		Supports a number of globally and nationally threatened species and communities
		Supports a high diversity of species and assemblages important for conserving biodiversity at the bioregional scale
		Supports animal taxa at critical stages of their lifecycle and during drought
		Supports significant numbers and diversity of wetland-dependent birds including migratory species listed under the JAMBA and CAMBA agreements

[#] Cultural value ecosystem services have not been discussed further within this document as they are being considered elsewhere under a socio-cultural review currently in progress by CSIRO for the MDBA.

		Supports significant numbers and diversity of native fish, including migratory species.
	Cultural values[#]	Aesthetics, amenity
		Cultural and spiritual significance for the Ngarrindjeri people
		Educational and research site

Murray Mouth & Estuaries		
Wetland type located within unit (as described in Phillips & Muller (2006)	**Ecosystem service**	**Details of Ecosystem Service at Ramsar designation (1985)**
• Permanent shallow marine waters • Rocky marine shores • Sand, shingle or pebble shores • Estuarine waters • Intertidal mud, sand or salt flats • Intertidal marshes • Intertidal forested wetlands • Coastal brackish/saline lagoons • Coastal freshwater lagoons	Wetland Products	Commercial and recreational fisheries
		Commercial cockle industry
		Reeds and grasses for traditional crafts
		Traditional Ngarrindjeri food species (eggs, birds,fish, yabbies)
	Maintenance of hydrological stability	Flood mitigation
	Water purification	Removal and dilution of wastewaters form irrigation areas, urban areas and septic tanks
	Coastal shoreline and bank stabilisation	Reduce impacts of wind and wave action and currents
		Prevent erosion by holding sediments with plant roots
	Sediment and nutrient retention	Flood retardation and sediment and nutrient deposition
	Biological control of pest and diseases	Support of predators of agricultural pests
	Recreation and tourism	Boating and water skiing
		Fishing
		Bird watching and sightseeing
		Swimming, picnicking and camping
	Food web support	Nutrient cycling
		Primary ecosystem production
	Ecological values	Representative of a unique ecosystem (globally, national and regionally)
		Supports a large variety of ecological communities
		Supports a number of globally and nationally threatened species and communities
		Supports a high diversity of species and assemblages important for conserving biodiversity at the bioregional scale

[#] Cultural value ecosystem services have not been discussed further within this document as they are being considered elsewhere under a socio-cultural review currently in progress by CSIRO for the MDBA.

		Supports animal taxa at critical stages of their lifecycle and during drought
		Supports significant numbers and diversity of wetland-dependent birds including migratory species listed under the JAMBA and CAMBA agreements
		Supports significant numbers and diversity of native fish, including migratory species.
	Cultural values[#]	Aesthetics, amenity
		Cultural and spiritual significance for the Ngarrindjeri people
		Educational and research site

North Lagoon		
Wetland type located within unit (as described in Phillips & Muller (2006)	**Ecosystem service**	**Details of Ecosystem Service at Ramsar designation (1985)**
• Rocky marine shores • Sand, shingle or pebble shores • Intertidal mud, sand or salt flats • Intertidal marshes • Coastal brackish/saline lagoons • Coastal freshwater lagoons	Wetland Products	Drinking Water
		Commercial and recreational fisheries
		Grazing
		Reeds and grasses for traditional crafts
		Traditional Ngarrindjeri food species (eggs, birds,fish, yabbies)
	Maintenance of hydrological stability	Flood mitigation
		Groundwater interactions
	Water purification	Removal and dilution of wastewaters form irrigation areas, urban areas and septic tanks
	Coastal shoreline and bank stabilisation	Reduce impacts of wind and wave action and currents
		Prevent erosion by holding sediments with plant roots
	Sediment and nutrient retention	Flood retardation and sediment and nutrient deposition
	Local climate regulation	Local climate stabilisation, particularly in relation to rainfall and temperature
	Climate change mitigation	Sequestering and cycling of carbon
	Biological control of pest and diseases	Support of predators of agricultural pests
	Recreation and tourism	Boating and water skiing
		Fishing
		Bird watching and sightseeing
		Swimming, picnicking and camping

[#] Cultural value ecosystem services have not been discussed further within this document as they are being considered elsewhere under a socio-cultural review currently in progress by CSIRO for the MDBA.

	Food web support	Nutrient cycling
		Primary ecosystem production
	Ecological values	Representative of a unique ecosystem (globally, national and regionally)
		Supports a large variety of ecological communities
		Supports a number of globally and nationally threatened species and communities
		Supports a high diversity of species and assemblages important for conserving biodiversity at the bioregional scale
		Supports animal taxa at critical stages of their lifecycle and during drought
		Supports significant numbers and diversity of wetland-dependent birds including migratory species listed under the JAMBA and CAMBA agreements
		Supports significant numbers and diversity of native fish, including migratory species.
	Cultural values[#]	Aesthetics, amenity
		Cultural and spiritual significance for the Ngarrindjeripeople
		Educational and research site

South Lagoon		
Wetland type located within unit (as described in Phillips & Muller (2006)	**Ecosystem service**	**Details of Ecosystem Service at Ramsar designation (1985)**
• Rocky marine shores • Sand, shingle or pebble shores • Intertidal mud, sand or salt flats • Coastal brackish/saline lagoons • Permanent rivers/streams/creeks • Seasonal/intermittent saline/brackish/alkaline lakes and flats • Seasonal/intermittent saline/brackish/alkaline marshes/pools • Shrub-dominated wetlands • Freshwater, tree-dominated wetlands • Freshwater springs, oases	Wetland Products	Drinking Water
		Commercial and recreational fisheries
		Grazing
		Reeds and grasses for traditional crafts
		Traditional Ngarrindjeri food species (eggs, birds,fish, yabbies)
	Maintenance of hydrological stability	Flood mitigation
		Groundwater interactions
	Water purification	Removal and dilution of wastewaters form irrigation areas, urban areas and septic tanks
	Coastal shoreline and bank	Reduce impacts of wind and wave action and currents

[#] Cultural value ecosystem services have not been discussed further within this document as they are being considered elsewhere under a socio-cultural review currently in progress by CSIRO for the MDBA.

	stabilisation	Prevent erosion by holding sediments with plant roots
	Sediment and nutrient retention	Flood retardation and sediment and nutrient deposition
	Local climate regulation	Local climate stabilisation, particularly in relation to rainfall and temperature
	Climate change mitigation	Sequestering and cycling of carbon
	Biological control of pest and diseases	Support of predators of agricultural pests
	Recreation and tourism	Boating and water skiing
		Fishing
		Bird watching and sightseeing
		Swimming, picnicking and camping
	Food web support	Nutrient cycling
		Primary ecosystem production
	Ecological values	Representative of a unique ecosystem (globally, national and regionally)
		Supports a large variety of ecological communities
		Supports a number of globally and nationally threatened species and communities
		Supports a high diversity of species and assemblages important for conserving biodiversity at the bioregional scale
		Supports animal taxa at critical stages of their lifecycle and during drought
		Supports significant numbers and diversity of wetland-dependent birds including migratory species listed under the JAMBA and CAMBA agreements
		Supports significant numbers and diversity of native fish, including migratory species.
	Cultural values[#]	Aesthetics, amenity
		Cultural and spiritual significance for the Ngarrindjeri people
		Educational and research site

[#] Cultural value ecosystem services have not been discussed further within this document as they are being considered elsewhere under a socio-cultural review currently in progress by CSIRO for the MDBA.

Where to from here?

Lambert (2003) proposed a framework for assessment of ecosystem services in wetlands (simplified and adapted in Figure 2) which presents a transparent and clear way of evaluating wetland ecosystem services. This framework, if applied to the Coorong and Lower Lakes system, essentially comprises two distinct components of work for the future building upon the ecosystem services preliminarily identified within this report (which can be considered as 'wetland uses'):

1. Wetland Functioning: Identification and research into fundamental ecology components, and
2. Wetland Values: applying values to the direct, indirect and non-use aspects of the system.

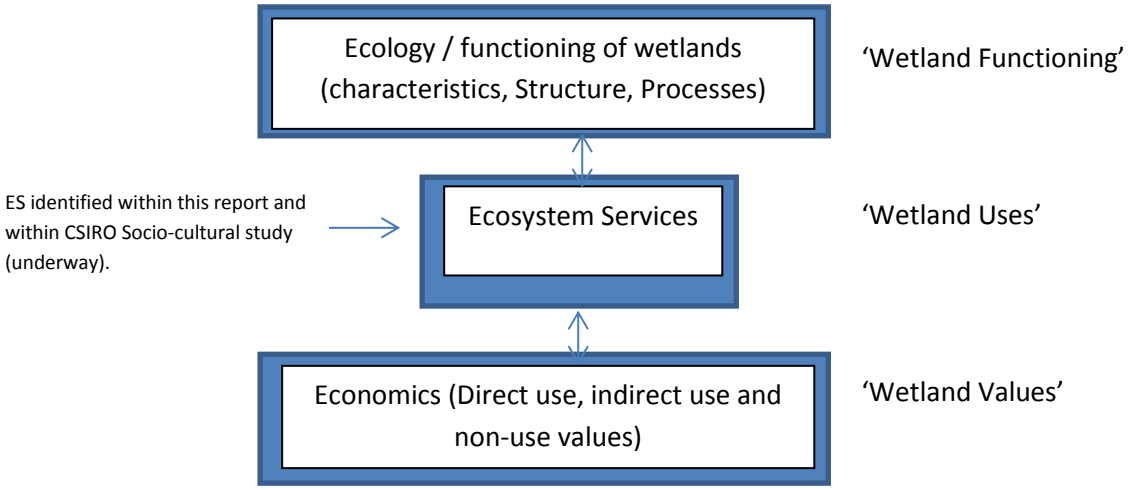

Figure 2 – Framework for assessment of Coorong and Lower Lakes Ramsar Site ecosystem services (building upon proposed ecosystem services)

Marsden Jacobs Associates (2013) undertook a limited qualitative assessment of the degree of confluence between Ramsar criteria and the degree to which wetlands meeting the specific Ramsar criteria might provide specific ecosystem services. This approach, whilst interesting, provides little relevant information and highlights the issue with retrospectively applying 'trend' concepts and theories. The designation of Ramsar status was not intended to be as a tool to support or protect ecosystem services and often, as its primary purpose is/was biodiversity conservation in relation to migratory birds and their supporting habitats, it can be at odds with those seeking to maintain or maximise ecosystem services.

Data Collation and Gap Analysis

This report has briefly examined the ecosystem services provided by the Coorong and Lakes Alexandrina and Albert Ramsar site provides and examined where information was available and some of the gaps within the currently held data. To give an accurate assessment of the 'wetland functioning' it will be essential to undertake a full data collation and review (which will, by default, provide the information for a gap analysis exercise). This will allow information requirements to be characterised and identified in key areas. Broadspread constraints on monitoring budgets mean that

baseline monitoring programs will need to be focussed. Whether this data collation and analysis can be undertaken as part of a larger Murray Darling Basin meta-data collation exercise should be considered in terms of potential cost savings, as it is likely all areas within the MDB will need to undertake a similar exercise.

Once the data collation and review has been completed, consideration will need to be given to how appropriate existing monitoring programs are in evaluating the ecosystem services (now and into the future. Geijzendorffer and Roche (2013) examined whether biodiversity monitoring schemes can provide indicators for ecosystem services. The authors concluded that generally well-designed biodiversity studies can be utilised but that there is a knowledge bias towards ecosystem services that have a direct link to ecological functions (as also demonstrated by Cardinale *et al.*2012). It is probable that those more well-established monitoring programs with many broad parameters will offer the most benefit to future monitoring programs but this will become more apparent through the gap analysis exercise.

To gain a complete understanding of 'wetland values', future works will need to build upon previous work undertaken within the Coorong and Lower Lakes. Hatton MacDonald *et al.*(2011) undertook a nonmarket valuation study utilising surveys to explore the values held by Australians for changes to a range of environmental attributes within the Murray River, including waterbird habitat in the Coorong. Although the paper will need revisiting (a key issue of the paper was that it undertaken during the period of drought), it does provide some indication of 'willingness to pay' (WTP) values for the system which will aid in applying 'wetland values'.

Functional Assessment Protocol for the Coorong and Lower Lakes

The Murray Darling Basin Authority (MDBA) and the South Australian Department of Environment, Water and Natural Resources (DEWNR) have recently held a workshop to begin to discuss an approach for undertaking a functional assessment protocol (FAP) of the Coorong and Lower Lakes Ramsar Site. It is anticipated that this will incorporate the research previously undertaken in the system (including the large amount of work undertaken for the CLLAMMecology projects). The FAP is likely to build upon existing work from the UK under the National Ecosystem Assessment on Hydrogeomorphic Management Unit (HGMU) assessment of wetlands. The FAP will need to be adapted to apply to Australian systems, but it offers a clear foundation on which to build a future assessment tool.

Conclusion

This report briefly discussed the ecosystem services concept and through application of the broad MEA (2005) classifications has provided an evidence-based list of ecosystem services for the Coorong and Lower Lakes Ramsar Site. These ecosystem services have been gleaned from a literature review and are expressed in terms of management units.

Many ecosystem services are provided by the Coorong and Lower Lakes Ramsar Site, such as the support of internationally and nationally important bird species through the provision of food and habitat. Outside of the traditionally-recognised services to wildlife though, it is also apparent that the services provided in terms of wetland products (such as drinking water, traditional food sources, irrigation waters and grazing areas) are also critical ecosystem services.

Future works will need to focus on collating and analysing the current available information as well as supplementing the information gaps. One proposed approach is through the application of a functional assessment protocol methodology as well as setting up a framework to monitor these processes into the future.

A future discussion is required as to whether the application of the ecosystem services concept to the Coorong and Lower Lakes Ramsar site is applicable to the wider Murray Darling Basin system. Although this approach could theoretically apply to any wetland site, it may be that the unique 'end of the line' nature of the Coorong and Lower Lakes (with predominantly one-directional influencing processes) and its plethora of different habitats render this system incomparable to that of the rest of the MDB.

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Appendix 1 - Potential ecosystem services supported by the Coorong and Lakes Ramsar Site management units (expanded tables)

Lake Alexandrina and Lake Albert						
Wetland type located within unit (as described in Phillips & Muller (2006)	**Ecosystem service**	**Details of Ecosystem Service at Ramsar designation (1985)**	**Current status**	**Evidence?**	**Supporting processes**	**Knowledge Gap**
• Rocky marine shores • Sand, shingle or pebble shores • Permanent rivers/streams/creeks • Seasonal/intermittent/irregular rivers/streams/creeks • Permanent freshwater lakes • Seasonal/intermittent freshwater lakes • Seasonal/intermittent saline/brackish/alkaline lakes and flats • Seasonal/intermittent saline/brackish/alkaline marshes/pools • Permanent freshwater marshes/pools • Seasonal/intermittent freshwater marshes/pools • Shrub-dominated wetlands • Freshwater, tree-dominated wetlands • Seasonally flooded agricultural land • Canals and drainage channels, ditches.	Wetland Products	Irrigation water	Pipelines were constructed to supply Murray Water from Tailem Bend in 2008/09. Irrigation water currently being utilised again from Lake Alexandrina and Lake Albert as quality (salinity levels) are restored The MDBA(2011) noted that a number of dairy and beef farmers on the Lakes had ceased irrigating (left industry or switched to dryland farming)	Yes - Pre-drought and currently dairy farmers and vineyards (Langhorne and Currency Creek) access/ed water from Lake Alexandrina. Also growers of Lucerne and horticulture[2]	- Salinity - Turbidity and sedimentation patterns - Water levels - Water regime (particularly flow patterns)	Consultation required with PIRSA on number of dairy and beef farmers remaining within industry and/or having transitioned to dryland farming Econsearch (2011) for PIRSA undertook an economic profile fo the River Murray Region of SA (utilising 2006/07 data). Consultation should be undertaken with PIRSA/Econsearch to ascertain whether this report can be broken down further to provide economic data on the Coorong, Alexandrina Coastal, Alexandrina Strathalbyn Distrcit Council and Murray Bridge Regional Council Statistical Local Areas only.

[2] Information sourced from 'Guide to the Proposed Basin Plan: Technical Background Part III: MDBA (2011)

		Drinking Water (Lake Alexandrina only)	No drinking water is utilised at present due to the elevated salinity levels	Yes – at time of designation a number of licenses were active and taken up	- Salinity - Turbidity and sedimentation patterns - Water levels - Water regime (particularly flow patterns) - Water quality	-

		Commercial and recreational fisheries	The sector in the Lakes and Coorong is a multi-species fishery including Coorong mullet, mulloway, bony bream, callop, European carp and Goolwa cockle (Pipi).	Yes - 36 fishing licences current in place[3] although only a small number are currently active. Fishery Stock Status Report for the Southern Australian Lakes and Coorong Fishery (Ferguson 2012) provided current data on the status of the fishery and showed the greatest contributions to total catch in 2010-1011was yellow-eye mullet (with 47% of the fishery catch) and pipi with the second greatest (38%).	- Salinity - Turbidity and sedimentation patterns - Keystone aquatic plant species and assemblages - Water levels - Habitat availability (particularly temporal and spatial connectivity) - Water regime (particularly flow patterns)	Request from SARDI / PIRSA whether a stock status assessment was carried out in 2011-2012 and update if applicable. Analysis could be undertaken on the fishery stock status reports from designation to present day in order to demonstrate how the composition and value of the fishery has changed since designation. Previous reports will require requesting from PIRSA. Suggest that consultation should be undertaken with Greg Ferguson of SARDI. Econsearch (2011) for PIRSA undertook an economic profile fo the River Murray Region of SA (utilising 2006/07 data). Consultation should be undertaken with PIRSA/Econsearch to ascertain whether this report can be broken down further to provide economic data on the Coorong, Alexandrina Coastal, Alexandrina Strathalbyn District Council and Murray Bridge Regional Council Statistical Local Areas only.

[3] http://www.environment.sa.gov.au/cllmm/pdfs/mhf-document.pdf

		Grazing	Dairy and beef farms surround the Lakes	Yes - Dairy and beef farms surrounding the Lakes	- Salinity - Water levels - Primary production - Vegetational productivity, pollination, regeneration processes, succession etc.	Consultation required with PIRSA on number of dairy and beef farmers remaining within industry and/or having transitioned to dryland farming.
		Reeds and grasses for traditional crafts	Area significant for location of spiny flat-sedge	Reduction in quantity and quality of reeds in recent years (Phillips and Muller 2006)	- Salinity - Water quality - Primary productivity - Vegetation productivity - Water levels - Farming (eg grazing pressures) - Competition with other reed species	Although reported through consultation undertaken by Philips and Muller (as part of the 2006 ECD), consultation should be undertaken with DAARD and local stakeholders in relation to use of the Coorong and Lower Lakes by traditional owners.

		Traditional Ngarrindjeri food species (eggs, birds,fish, yabbies)	Area locally important for items such as swan, duck, seagull and emu eggs, fish such as hardyhead and yabbies (Phillips and Muller 2006)	Yes – although there has been a loss, or severe decline of many of these species and their products, particularly in recent years	- Salinity - Turbidity and sedimentation patterns - Keystone aquatic plant species and assemblages - Water quality - Water levels - Habitat availability (particularly temporal and spatial connectivity) - Water regime (particularly flow patterns)	Although reported through consultation undertaken by Philips and Muller (as part of the 2006 ECD), consultation should be undertaken with DAARD And local stakeholders in relation to use of the Coorong and Lower Lakes by traditional owners.
	Maintenance of hydrological stability	Flood mitigation	-	Lakes are likely acting as flood mitigation to local residential communities (eg Goolwa)	- Water levels - Water regime (flow patterns and gradients) - Slope and bank stability - Connectivity between water bodies	Consultation could be undertaken with Alexandrina and Coorong Councilscoastal engineer to ascertain their understanding of the role the Coorong and Lower Lakes play in local flood prevention. Was modelling carried out as part of the CLLAMMecology work as to the retention of each part of the system?

		Groundwater interactions	-	Major processes such as groundwater recharge and discharge, drylandsalinisation, irrigation and groundwater/ surface water interaction identified within this region Barnett (1991), Barnett (1994), Cobb and Barnett (1994).	- Salinity - Water levels(particularly in the aquifers) - Water regime (particularly flow patterns and gradients) - Connectivity of surface water and groundwater	A number of boreholes exist within the Coorong and Lower Lakes catchment. In 2010 they were being monitored by the LAP for depth and salinity (as part of 200 BH's monitored). Current monitoring status and who currently undertaking should be identified DEWNR?). Also SA Obswell Network online has 33 BH's located within and directly adjacent to the Lower Lakes and Coorong. This data could be analysed for groundwater levels and salinity changes. Up-to-date irrigation details to be requested from PIRSA / MDBA.
	Water purification	Removal and dilution of wastewaters form irrigation areas, urban areas and septic tanks	-	Yes– although direct evidence unlikely to be available	- Salinity - Turbidity and sedimentation patterns - Keystone aquatic plant species and assemblages - Water levels - Water regime (particularly flow patterns) - Water retention times of Lakes	-

	Coastal shoreline and bank stabilisation	Reduce impacts of wind and wave action and currents	-	Yes – the coastal shoreline and vegetation plays a key role in prevention of wind erosion. This was particularly important during drought times when risk of ASS/PASS soils being exposed and mobilised through being blown around is higher.	- Keystone coastal plant species and assemblages - Dune and bank stability and slope gradients - Habitat availability (particularly temporal and spatial connectivity)	Establish whether any data on ASS/PASS exposure during and after the drought broke was collected (MDBA / DEWNR?)
		Prevent erosion by holding sediments with plant roots	-	Yes – as long as water levels are high enough the Lakes play a vital role in 'locking in' ASS/PASS. Lakes also act as a 'sink' in retaining sediments from upstream	- pH and salinity - Keystone aquatic plant species and assemblages - Turbidity and sedimentation patterns - Water levels - Habitat availability (particularly temporal and spatial connectivity) - Water regime (particularly flow patterns)	Establish whether any data on ASS/PASS exposure during and after the drought broke was collected (MDBA / DEWNR?) Were Lake sediment levels recorded as part of observational data during lake water level measurements? (DEWNR / MDBA)

	Sediment and nutrient retention	Flood retardation and sediment and nutrient deposition	-	Yes – Lakes act as a sediment sink for the fine sediments swept down the MBD	- Soil, geology, substrates, soil type - Turbidity and sedimentation patterns - Keystone aquatic plant species and assemblages - Water levels - Water regime (particularly flow patterns)	-
	Local climate regulation	Local climate stabilisation, particularly in relation to rainfall and temperature	-	No direct evidence although highly likely that Lagoons will be acting as climate regulators on a local level by absorbing heat during the day and expelling heat during the nights.	- Area, boundary and dimensions of lake - Temporal and spatial connectivity of Lake in conjunction to other water bodies - Water regime (particularly flow patterns) - Water levels - Temperature and stratification	Further research required to provide evidence that lagoons are acting as climate regulators on a local scale.

	Climate change mitigation	Sequestering and cycling of carbon	-	Yes – Brookes *et al.*(2009) demonstrated the Lower Lakes as a nutrient (and likely carbon) source for the downstream Coorong and Murray Mouth	- Carbon cycling - Nutrient cycling	Further research required – also the role that the Lower Lakes play (ie whether this role changes between drought and non-drought conditions?)
	Biological control of pest and diseases	Support of predators of agricultural pests		Yes – evidenced through support of bird populations (Patton *et al.*2009) and Rogers & Paton (2009)	- Salinity - Turbidity and sedimentation patterns - Keystone aquatic plant species and assemblages - Water levels - Habitat availability (particularly temporal and spatial connectivity) - Water regime (particularly flow patterns)	Current status of bird numbers and visits needed – Consultation with Dave Paton and other experts as well as local bird groups needed

	Recreation and tourism	Boating and water skiing	Diminished in recent years (particularly during the drought) due to low water levels and flows and barriers which were installed to aid Lakes salinity issues. Barriers have now been removed (last one at Currency Creek being removed at the moment) and locks are fully operational. Marina at Hindmarsh Island is increasing popularity in boating in local area.	Yes – area always has historically been a popular boating area. Also refer Cast *et al.* (2008)	- Access - Area, boundary and dimensions of Lakes - Temporal and spatial connectivity of Lakes in conjunction to other water bodies - Water regime (particularly flow patterns) - Water levels - Water quality - Visual aesthetics	Current recreation and tourism numbers should be sought (Tourism SA?) Econsearch (2011) for PIRSA undertook an economic profile of the River Murray Region of SA (utilising 2006/07 data). Consultation should be undertaken with PIRSA/Econsearch to ascertain whether this report can be broken down further to provide economic data on the Coorong, Alexandrina Coastal, Alexandrina Strathalbyn District Council and Murray Bridge Regional Council Statistical Local Areas only.

		Fishing	Diminished in recent years due to water quality issues (particularly salinity) and falling fish stocks	Yes – recreational fishing has historically been a popular pastime in the Lakes and adjacent areas. Also refer Cast *et al.* (2008)	- Salinity - Turbidity and sedimentation patterns - Keystone aquatic plant species and assemblages - Water levels - Habitat availability (particularly temporal and spatial connectivity) - Water regime (particularly flow patterns)	Consultation with SARFAC and local fishers should be undertaken for up-to-date numbers of rec fishers utilising the area.
		Bird watching and sightseeing		Yes - Site internationally renowned for birdwatching. Patton *et al.*(2009) and Rogers & Paton (2009) Also refer Cast *et al.* (2008)	- Salinity - Turbidity and sedimentation patterns - Keystone aquatic plant species and assemblages - Water levels - Habitat availability (particularly temporal and spatial connectivity) - Water regime (particularly flow patterns)	Current status of bird numbers and visits needed – Consultation with Dave Paton and other experts as well as local bird groups needed

		Swimming, picnicking and camping		Yes –area historically significant for swimming, picnicking and camping Also refer Cast *et al.* (2008)	- Access - Area, boundary and dimensions of Lakes - Temporal and spatial connectivity of Lakes in conjunction to other water bodies - Water regime (particularly flow patterns) - Water levels - Water quality - Visual aesthetics	Consultation should be undertaken with local tourism operators / caravan parks etc for current levels. Refer also comments on Econsearch (2011) report.

		Wine & food related tourism	Wine and food tourism has grown substantially since the Ramsar site designation (particularly since 2000).	Yes - Langhorne and Currency Creek wineries (over 20 branded vineyards and 10 wineries) draw tourism. Wine tourism at Langhorne Creek was highlighted within the SA Wine and Tourism Strategy2009-2014 as a key area[4]	- Salinity - Turbidity and sedimentation patterns - Water levels - Water regime (particularly flow patterns)	Consultation should be undertaken with the wineries and local tourism operators / for current visitor numbers / nights occupancy linked to winery visits etc Refer also comments on Econsearch (2011) report.

[4] South Australian Food and Wine Tourism Strategy 2009 – 2014: http://satic.com.au/images/uploads/industry_resources/foodwine_tourism_strategy.pdf

	Food web support	Nutrient cycling		Yes – Brookes *et al.* (2009) demonstrated the Lower Lakes as a food source for the downstream Coorong and Murray Mouth. Also refer CLLAMMecology reports: Cook *et al.* (2008), Fernandes& Tanner (2009), Grigg*et al.* (2009), Haese*et al.* (2009), Krull*et al.* (2008; 2009)	- Water levels - Salinity - Turbidity and sedimentation patterns - Keystone aquatic detritivores - Water regime (particularly flow patterns)	-
		Primary ecosystem production	-	Yes – refer CLLAMMecology reports - Aldridge *et al.* (2009) - Revill*et al.* (2009) - Cook *et al.* (2008) - Nayar& Loo (2009)	- Salinity - Turbidity and sedimentation patterns - Keystone aquatic plant species and assemblages - Water levels - Habitat availability (particularly temporal and spatial connectivity) - Water regime (particularly flow patterns) - Nutrient and organic cycling	-

	Ecological values	Representative of a unique ecosystem (globally, national and regionally) Supports a large variety of ecological communities Supports a number of globally and nationally threatened species and communities Supports a high diversity of species and assemblages important for conserving biodiversity at the bioregional scale Supports animal taxa at critical stages of their lifecycle and during drought Supports significant numbers and diversity of wetland-dependent birds including migratory species listed under the JAMBA and CAMBA agreements		Yes – As evidenced by inclusion within the Ramsar Site series. Refer Ramsar designation sheets. Also refer Phillips & Muller (2006) Ecological Character Description (ECD), Murray Darling Basin Plan (2013) and the following CLLAMMecology publications for data concerning underpinning processes: - Aldridge *et al.* (2009) - Deegan*et al.* (2009) - Ford (2007) - Gillanders& Munro (2009) - Lamontagn e*et al.*(2007) - Langley *et al.* (2009) - Lester *et al.* (2009) - Lester &Fairweathe	- Salinity - Turbidity and sedimentation patterns - Keystone aquatic plant species and assemblages - Water levels - Habitat availability (particularly temporal and spatial connectivity) - Water regime (particularly flow patterns) - Nutrient and organic cycling	A review of Ramsar status since designation should be undertaken. A focus could be made on bird numbers as a surrogate for overall ecological health. Will have to be in two parts: designation to drought and post drought

		Supports significant numbers and diversity of native fish, including migratory species.		r(2008, 2009) - Noell*et al.* (2009) - Rogers & Paton (2009) - Rolsten&Dittmann (2009) - Sharma *et al.* (2009) - Webster (2005; 2007)		
	Cultural values[5]	Aesthetics, amenity		Yes – refer Cast *et al.* (2008)		
		Cultural and spiritual significance for the Ngarrindjeri people		Yes – refer Phillips & Muller (2006) Ecological Character Description (ECD)		This will require updating through consultation in order to ascertain the ongoing cultural and spiritual significance (and whether this is/has been affected by the changing condition of the Coorong and Lower Lakes).
		Educational and research site		Yes		Consultation with local schools and Universities (as well as MBBA and DEWNR) should confirm the ongoing importance of the Coorong and Lower Lakes as educational and research sites.

Tributaries						
Wetland type located within unit (as described in Phillips & Muller (2006)	**Ecosystem service**	**Details of Ecosystem Service at Ramsar designation (1985)**	**Current status**	**Evidence?**	**Supporting processes**	**Knowledge Gaps**

[5] Cultural value ecosystem services have not been discussed further within this document as they are being considered elsewhere under a socio-cultural review currently in progress by CSIRO for the MDBA (reference).

• Permanent rivers/streams/creeks • Permanent freshwater lakes • Seasonal/intermittent saline/brackish/alkaline marshes/pools • Permanent freshwater marshes/pools • Seasonal/intermittent freshwater marshes/pools • Freshwater, tree-dominated wetlands • Seasonally flooded agricultural land • Water storage areas • Canals and drainage channels, ditches.	Wetland Products	Irrigation water	Unknown current status	Yes – Several dams rely on the flows from the Tributaries. Also as part of the MDB system generally at time of designation a number of licenses were active (and continue to remain so).	- Salinity - Turbidity and sedimentation patterns - Water levels - Water regime (particularly flow patterns)	Consultation should be undertaken to confirm the number of licences and water volumes still active
		Drinking Water	Unknown - Current status	Yes –as part of the MDB system generally at time of designation a number of licenses were active.	- Salinity - Turbidity and sedimentation patterns - Water levels - Water regime (particularly flow patterns) - Water quality	Consultation with MBDBA should confirm the number of active licences within the Tributaries

		Commercial and recreational fisheries			- Salinity - Turbidity and sedimentation patterns - Keystone aquatic plant species and assemblages - Water levels - Habitat availability (particularly temporal and spatial connectivity) - Water regime (particularly flow patterns)	Consultation with PIRSA should be undertaken to ascertain whether (and number of) existing fishing licenses extend up in to the Tributaries (and how far) SARFAC and local fishers should be consulted in order to ascertain the use of the Tributaries and how this has changed since designation Econsearch (2011) for PIRSA undertook an economic profile of the River Murray Region of SA (utilising 2006/07 data). Consultation should be undertaken with PIRSA/Econsearch to ascertain whether this report can be broken down further to provide economic data on the Coorong, Alexandrina Coastal, Alexandrina Strathalbyn District Council and Murray Bridge Regional Council Statistical Local Areas only.
		Grazing	Dairy and beef farms in areas surrounding and adjacent to the Tributaries	Yes - Dairy and beef farms surrounding and adjacent to the Tributaries	- Salinity - Water levels - Primary production - Vegetational productivity, pollination, regeneration processes, succession etc.	Consultation with PIRSA will confirm number of farms with grazing adjacent to the Tributaries (also whether they are utilising Tributary waters for livestock drinking water)

		Reeds and grasses for traditional crafts	Area significant for location of spiny flat-sedge	Reduction in quantity and quality of reeds in recent years (Phillips and Muller 2006)	- Salinity - Water quality - Primary productivity - Vegetation productivity - Water levels - Farming (eg grazing pressures) - Competition with other reed species	Consultation with local stakeholders and indigenous groups will be required to ascertain whether the reed quantity and quality is still poor.
		Traditional Ngarrindjeri food species (eggs, birds,fish, yabbies)	Area locally important for items such as swan, duck, seagull and emu eggs, fish such as hardyhead and yabbies (Phillips and Muller 2006)	Yes – although there has been a loss, or severe decline of many of these species and their products, particularly in recent years	- Salinity - Turbidity and sedimentation patterns - Keystone aquatic plant species and assemblages - Water quality - Water levels - Habitat availability (particularly temporal and spatial connectivity) - Water regime (particularly flow patterns)	Consultation with local stakeholders and indigenous groups should be undertaken to collate information of whether the traditional food species are still available and being utilised

	Maintenance of hydrological stability	Flood mitigation	-	Tributaries provide drainage and connection of different water bodies. Also provide water storage within the wetlands themselves.	- Water levels - Water regime (flow patterns and gradients) - Slope and bank stability - Connectivity between water bodies	Consultation could be undertaken local Council coastal engineers to ascertain their understanding of the role the Coorong and Lower Lakes play in local flood prevention. Was modelling carried out as part of the CLLAMMecology work as to the retention of each part of the system?
		Groundwater interactions	-	Groundwater inflows across the plains sustain flows over summer or initiate early autumn flows in dry years (Phillips & Muller 2006). Also refer Barnett (1991), Barnett (1994), Cobb and Barnett (1994) and Wedderburn and Hammer (2003)	- Salinity - Water levels (particularly in the aquifers) - Water regime (particularly flow patterns and gradients) - Connectivity of surface water and groundwater	-

	Water purification	Removal and dilution of wastewaters form irrigation areas, urban areas and septic tanks	-	Yes – although direct evidence unlikely to be available	- Salinity - Turbidity and sedimentation patterns - Keystone aquatic plant species and assemblages - Water levels - Water regime (particularly flow patterns) - Water retention times of Lakes	Further research required to establish how crucial a role the Tributaries play in removal and dilution of wastewaters from irrigation areas (particularly from the adjacent wineries and farming properties). Also likely holding times in wetland areas.
	River bank stabilisation	Prevent erosion by holding sediments with plant roots	-	Yes – within the wetland systems (as opposed to the rivers and streams which play a role in moving sediments downstream)	- Keystone aquatic plant species and assemblages - Habitat availability (particularly temporal and spatial connectivity)	Have surveys been undertaken of the current health of the trees lining the river/s? DEWNR/MDBA

	Sediment and nutrient retention	Flood retardation and sediment and nutrient deposition	-	Yes – within the wetland systems	- pH and salinity - Keystone aquatic plant species and assemblages - Turbidity and sedimentation patterns - Water levels - Habitat availability (particularly temporal and spatial connectivity) - Water regime (particularly flow patterns)	Research required to determine how the Tributaries influence flood retardation and sediment / nutrient deposition during drought and non-drought flows.
	Local climate regulation	Local climate stabilisation, particularly in relation to rainfall and temperature	-	Yes – no direct evidence although highly likely that Lagoons will be acting as climate regulators on a local level by absorbing heat during the day and expelling heat during the nights.	- Soil, geology, substrates, soil type - Turbidity and sedimentation patterns - Keystone aquatic plant species and assemblages - Water levels - Water regime (particularly flow patterns)	Further research required to ascertain whether systems such as the Tributaries play any role as climate regulators on a local scale.

	Climate change mitigation	Sequestering and cycling of carbon	-	Yes – Brookes *et al.*(2009) demonstrated the Lower Lakes as a nutrient (and likely carbon) source for the downstream Coorong and Murray Mouth	- Carbon cycling - Nutrient cycling	Further research required – also the role that the Tributaries play (ie whether this role changes between drought and non-drought conditions? Are they always linked to the rest of the system even in low flow scenarios?)
	Biological control of pest and diseases	Support of predators of agricultural pests	-	Yes – evidenced through support of bird populations (Patton *et al.*2009) and Rogers & Paton (2009)	- Salinity - Turbidity and sedimentation patterns - Keystone aquatic plant species and assemblages - Water levels - Habitat availability (particularly temporal and spatial connectivity) - Water regime (particularly flow patterns)	-

	Recreation and tourism	Boating and water skiing	Less popular that the Lakes. Also boating levels diminished in recent years (particularly during the drought) due to low water levels, flows and barriers which were installed to aid Lakes salinity issues. Barriers have now been removed (last one at Currency Creek being removed at the moment) and locks are fully operational.	Yes – continued use of the area by boaters	- Access - Area, boundary and dimensions of Lakes - Temporal and spatial connectivity of Lakes in conjunction to other water bodies - Water regime (particularly flow patterns) - Water levels - Water quality - Visual aesthetics	Current recreation and tourism numbers should be sought (Tourism SA?). Also refer previous comment regarding separation of Econsearch (2011) data into specific areas if possible.

		Fishing	Diminished in recent years due to water quality issues (particularly salinity) and falling fish stocks	Yes – recreational fishing has historically been a popular pastime in the Coorong, Lower Lakes and adjacent areas	- Salinity - Turbidity and sedimentation patterns - Keystone aquatic plant species and assemblages - Water levels - Habitat availability (particularly temporal and spatial connectivity) - Water regime (particularly flow patterns)	Consultation with SARFAC and local fishers should be undertaken for up-to-date numbers of rec fishers utilising the area.
		Bird watching and sightseeing	Current status of bird numbers and visits needed	Yes - Site internationally renowned for bird watching. Patton *et al.*(2009) and Rogers & Paton (2009)	- Salinity - Turbidity and sedimentation patterns - Keystone aquatic plant species and assemblages - Water levels - Habitat availability (particularly temporal and spatial connectivity) - Water regime (particularly flow patterns)	Current status of bird numbers and visits needed – Consultation with Dave Paton and other experts as well as local bird groups needed Will be difficult to separate data for the Tributaries alone.

		Swimming, picnicking and camping		Yes –area historically significant for swimming, picnicking and camping Also refer Cast *et al.* (2008)	- Access - Area, boundary and dimensions of Lakes - Temporal and spatial connectivity of Lakes in conjunction to other water bodies - Water regime (particularly flow patterns) - Water levels - Water quality - Visual aesthetics	Consultation should be undertaken with local tourism operators / caravan parks etc for current levels Will be difficult to separate data for the Tributaries alone.
		Wine and food tourism	Wine and food tourism has grown substantially since the Ramsar site designation (particularly since 2000).	Yes - Langhorne and Currency Creek wineries (over 20 branded vineyards and 10 wineries) draw tourism. Wine tourism at Langhorne Creek was highlighted within the SA Wine and Tourism Strategy2009-2014 as a key area[6]	-	Consultation should be undertaken with the wineries and tourism operators in order to estimate the importance of the Tributaries. Also refer previous comment regarding separation of Econsearch (2011) economic data into specific areas if possible

[6] South Australian Food and Wine Tourism Strategy 2009 – 2014: http://satic.com.au/images/uploads/industry_resources/foodwine_tourism_strategy.pdf

	Food web support	Nutrient cycling		Yes – Brookes *et al.* (2009)demonstrated the Lower Lakes as a food source for the downstream Coorong and Murray Mouth. Also refer CLLAMMecology reports: Cook *et al.* (2008), Fernandes& Tanner (2009), Grigg*et al.* (2009), Haese*et al.* (2009), Krull*et al.* (2008; 2009)	- Water levels - Salinity - Turbidity and sedimentation patterns - Keystone aquatic detritivores - Water regime (particularly flow patterns)	-
		Primary ecosystem production		Yes – refer CLLAMMecology reports - Aldridge *et al.* (2009) - Revill*et al.* (2009) - Cook *et al.* (2008) - Nayar& Loo (2009)	- Salinity - Turbidity and sedimentation patterns - Keystone aquatic plant species and assemblages - Water levels - Habitat availability (particularly temporal and spatial connectivity) - Water regime (particularly flow patterns) - Nutrient and organic cycling	-

	Ecological values	Representative of a unique ecosystem (globally, national and regionally) Supports a large variety of ecological communities Supports a number of globally and nationally threatened species and communities Supports a high diversity of species and assemblages important for conserving biodiversity at the bioregional scale Supports animal taxa at critical stages of their lifecycle and during drought Supports significant numbers and diversity of wetland-dependent birds including migratory species listed under the JAMBA and CAMBA agreements		Yes – As evidenced by inclusion within the Ramsar Site series. Refer Ramsar designation sheets. Also refer Phillips & Muller (2006) Ecological Character Description (ECD), Murray Darling Basin Plan (2013) and the following CLLAMMecology publications for data concerning underpinning processes: - Aldridge *et al.* (2009) - Deegan*et al.* (2009) - Ford (2007) - Gillanders& Munro (2009) - Lamontagn e*et al.*(2007) - Langley *et al.* (2009) - Lester *et al.* (2009) - Lester &Fairweathe	- Salinity - pH - Salinity - Turbidity and sedimentation patterns - Keystone aquatic plant species and assemblages - Water levels - Habitat availability (particularly temporal and spatial connectivity) - Water regime (particularly flow patterns) - Nutrient and organic cycling	A review of Ramsar status since designation should be undertaken. A focus could be made on bird numbers as a surrogate for overall ecological health. Will have to be in two parts: designation to drought and post drought

		Supports significant numbers and diversity of native fish, including migratory species.		r(2008, 2009) - Noelle*t al.* (2009) - Rogers & Paton (2009) - Rolsten&Dittmann(2009) - Sharma *et al.* (2009) - Webster (2005; 2007)		
	Cultural values	Aesthetics, amenity	Yes	Yes –refer Cast *et al.* (2008)		-
		Cultural and spiritual significance for the Ngarrindjeri people	Yes	Yes – refer Philips & Muller (2006)		This will require updating through consultation in order to ascertain the ongoing cultural and spiritual significance (and whether this is/has been affected by the changing condition of the Coorong and Lower Lakes).
		Educational and research site	Yes			Consultation with local schools and Universities (as well as MBBA and DEWNR) should confirm the ongoing importance of the Coorong and Lower Lakes as educational and research sites.

Murray Mouth & Estuaries						
Wetland type located within unit (as described in Phillips & Muller (2006)	**Ecosystem service**	**Details of Ecosystem Service at Ramsar designation (1985)**	**Current status**	**Evidence?**	**Supporting processes**	**Knowledge Gap**

• Permanent shallow marine waters • Rocky marine shores • Sand, shingle or pebble shores • Estuarine waters • Intertidal mud, sand or salt flats • Intertidal marshes • Intertidal forested wetlands • Coastal brackish/saline lagoons • Coastal freshwater lagoons	Wetland Products	Commercial and recreational fisheries	The sector in the Lakes and Coorong is a multi-species fishery including Coorong mullet, mulloway, bony bream, callop, European carp and Goolwa cockle (Pipi).	Yes - 36 fishing licences current in place[7] although only a small number are currently active Fishery Stock Status Report for the Southern Australian Lakes and Coorong Fishery (Ferguson 2012) provided current data on the status of the fishery and showed the greatest contributions to total catch in 2010-1011was yellow-eye mullet and pipi	- Salinity - Turbidity and sedimentation patterns - Keystone aquatic plant species and assemblages - Water levels - Habitat availability (particularly temporal and spatial connectivity) - Water regime (particularly flow patterns)	Econsearch (2011) for PIRSA undertook an economic profile of the River Murray Region of SA (utilising 2006/07 data). Consultation should be undertaken with PIRSA/Econsearch to ascertain whether this report can be broken down further to provide economic data on the Coorong, Alexandrina Coastal, Alexandrina Strathalbyn District Council and Murray Bridge Regional Council Statistical Local Areas only. Analysis could be undertaken on the fishery stock status reports from designation to present day in order to demonstrate how the composition and value of the fishery has changed since designation. Previous reports will require requesting from PIRSA. Suggest that consultation should be undertaken with Greg Ferguson of SARDI.

[7] http://www.environment.sa.gov.au/cllmm/pdfs/mhf-document.pdf

		Commercial cockle industry	Pipi was the second largest contributor to the total catch for the Lakes And Coorong fishery (at 38%) which is a 27% increase from the 2006-07 contribution. Catch has been constrained in recent years (2009-2010 and 2011-2012) recently by the TACC with approx. 10% TACC being withheld for winter fishing in 2010-2011 (Ferguson 2012).	Yes – Ferguson (2012) produced the sixth report (including the 2010-2011 data) on the status of seven species including the pipi fishery and built upon the stock status report for the South Australian Lakes and Coorong Fishery.	- Salinity - Turbidity and sedimentation patterns - Keystone aquatic plant species and assemblages - Water levels - Habitat availability (particularly temporal and spatial connectivity) - Water regime (particularly flow patterns through the Murray Mouth)	Request should be made to PIRSA whether the report has been updated with the 2011-2012 financial year data. Also whether there is any information on the individual areas within the fishery (eg the Coorong in regards to pipe and the individual lakes and Coorong in regards to yellow-eye mullet).
		Reeds and grasses for traditional crafts	Area significant for location of spiny flat-sedge and other reeds	Reduction in quantity and quality of reeds in recent years (Phillips and Muller 2006)	- Salinity - Water quality - Primary productivity - Vegetation productivity - Water levels - Farming (eg grazing pressures) - Competition with other reed species	Although reported through consultation undertaken by Philips and Muller (as part of the 2006 ECD), consultation should be undertaken with DAARD and local stakeholders in relation to use of the Coorong and Lower Lakes by traditional owners.

		Traditional Ngarrindjeri food species (eggs, birds,fish, yabbies)	Area locally important for items such as swan, duck, seagull and emu eggs, fish such as hardyhead and yabbies (Phillips and Muller 2006)	Yes – although there has been a loss, or severe decline of many of these species and their products, particularly in recent years	- Salinity - Turbidity and sedimentation patterns - Keystone aquatic plant species and assemblages - Water quality - Water levels - Habitat availability (particularly temporal and spatial connectivity) - Water regime (particularly flow patterns)	Although reported through consultation undertaken by Philips and Muller (as part of the 2006 ECD), consultation should be undertaken with DAARD and local stakeholders in relation to use of the Coorong and Lower Lakes by traditional owners.
	Maintenance of hydrological stability	Flood mitigation	-	Yes – Especially as this is the only natural exit for catchment waters and mobilised sediments and soils.	- Water levels - Water regime (flow patterns and gradients) - Slope and bank stability - Connectivity between water bodies	Consultation could be undertaken with Alexandrina and Coorong Councilscoastal engineer to ascertain their understanding of the role the Coorong and Lower Lakes play in local flood prevention. Was modelling carried out as part of the CLLAMMecology work as to the retention of each part of the system?

	Water purification	Removal and dilution of wastewaters form irrigation areas, urban areas and septic tanks	-	Yes as only natural exit for catchment waters and mobilised sediments and soils.	- pH and salinity - Keystone aquatic plant species and assemblages - Turbidity and sedimentation patterns - Water levels - Habitat availability (particularly temporal and spatial connectivity) - Water regime (particularly flow patterns)	-
	Coastal shoreline and bank stabilisation	Reduce impacts of wind and wave action and currents	-	The coastal shoreline and vegetation plays a key role in prevention of wind erosion. This was particularly important during drought times when risk of ASS/PASS soils being exposed and mobilised through being blown around is higher.	- Keystone coastal plant species and assemblages - Dune and bank stability and slope gradients - Habitat availability (particularly temporal and spatial connectivity)	Further research is needed into the current condition of the coastal dune systems when compared to designation conditions

		Prevent erosion by holding sediments with plant roots		Yes – dune plant species help in stabilising dune systems and thereby aid in sediment retention	- pH and salinity - Keystone aquatic plant species and assemblages - Turbidity and sedimentation patterns - Water levels - Habitat availability (particularly temporal and spatial connectivity) - Water regime (particularly flow patterns)	Further research is needed into the current condition of the coastal dune systems when compared to designation conditions
	Sediment and nutrient retention	Flood retardation and sediment and nutrient deposition	-	Yes – Murray Mouth is the only exit for the fine sediments swept down the MBD. In Murray Mouth closure and restriction times this area then acts as a depositional area.	- Soil, geology, substrates, soil type - Turbidity and sedimentation patterns - Keystone aquatic plant species and assemblages - Water levels - Water regime (particularly flow patterns)	-

	Biological control of pest and diseases	Support of predators of agricultural pests		Yes – evidenced through support of bird populations (Patton *et al.*2009) and Rogers & Paton (2009)	- Salinity - Turbidity and sedimentation patterns - Keystone aquatic plant species and assemblages - Water levels - Habitat availability (particularly temporal and spatial connectivity) - Water regime (particularly flow patterns)	-

	Recreation and tourism	Boating and water skiing	Less popular that the Lakes. Also boating levels diminished in recent years (particularly during the drought) due to low water levels, flows and barriers which were installed to aid Lakes salinity issues. Barriers have now been removed (last one at Currency Creek being removed at the moment) and locks are fully operational.	Yes – continued use of the area by boaters Also refer Cast *et al.* (2008)	- Access - Area, boundary and dimensions of Lakes - Temporal and spatial connectivity of Lakes in conjunction to other water bodies - Water regime (particularly flow patterns) - Water levels - Water quality - Visual aesthetics	Current recreation and tourism numbers should be sought (Tourism SA?)

		Fishing	Diminished in recent years due to water quality issues (particularly salinity) and falling fish stocks	Yes – recreational fishing has historically been a popular pastime on the beaches adjacent to the Murray Mouth and Coorong lagoons. Also refer Cast *et al.* (2008)	- Salinity - Turbidity and sedimentation patterns - Keystone aquatic plant species and assemblages - Water levels - Habitat availability (particularly temporal and spatial connectivity) - Water regime (particularly flow patterns)	Consultation with SARFAC and local fishers should be undertaken for up-to-date numbers of rec fishers utilising the area.
		Bird watching and sightseeing	Current status of bird numbers and visits needed	Yes - Site internationally renowned for birdwatching. Patton *et al.*(2009) and Rogers & Paton (2009) Also refer Cast *et al.* (2008)	- Salinity - Turbidity and sedimentation patterns - Keystone aquatic plant species and assemblages - Water levels - Habitat availability (particularly temporal and spatial connectivity) - Water regime (particularly flow patterns)	Current status of bird numbers and visits needed – Consultation with Dave Paton and other experts as well as local bird groups needed

		Swimming, picnicking and camping	-	Yes Large proportion of recreational activities occur in this region due to their relatively easy access and close proximity to Adelaide. Also refer Cast *et al.* (2008)	- Access - Area, boundary and dimensions of Lakes - Temporal and spatial connectivity of Lakes in conjunction to other water bodies - Water regime (particularly flow patterns) - Water levels - Water quality - Visual aesthetics	Consultation should be undertaken with local tourism operators / caravan parks etc for current levels
	Food web support	Nutrient cycling	-	Yes –refer CLLAMMecology reports: Cook *et al.* (2008), Fernandes& Tanner (2009), Grigg*et al.* (2009), Haese*et al.* (2009), Krull*et al.* (2008; 2009)	- Water levels - Salinity - Turbidity and sedimentation patterns - Keystone aquatic detritivores - Water regime (particularly flow patterns) - Connectivity between waterbodies and systems	-

		Primary ecosystem production	-	Yes – refer CLLAMMecology reports - Aldridge *et al.* (2009) - Revill*et al.* (2009) - Cook *et al.* (2008) - Nayar& Loo (2009)	- Salinity - Turbidity and sedimentation patterns - Keystone aquatic plant species and assemblages - Water levels - Habitat availability (particularly temporal and spatial connectivity) - Water regime (particularly flow patterns) - Nutrient and organic cycling	-
	Ecological values	Representative of a unique ecosystem (globally, national and regionally) Supports a large variety of ecological communities Supports a number of globally and nationally threatened species and communities		Yes – As evidenced by inclusion within the Ramsar Site series. Refer Ramsar designation sheets. Also refer Phillips & Muller (2006) Ecological Character Description (ECD), Murray Darling Basin	- Salinity - Turbidity and sedimentation patterns - Keystone aquatic plant species and assemblages - Water levels - Habitat availability (particularly temporal and spatial connectivity) - Water regime	A review of Ramsar status since designation should be undertaken. A focus could be made on bird numbers as a surrogate for overall ecological health. Will have to be in two parts: designation to drought and post drought

		Supports a high diversity of species and assemblages important for conserving biodiversity at the bioregional scale Supports animal taxa at critical stages of their lifecycle and during drought Supports significant numbers and diversity of wetland-dependent birds including migratory species listed under the JAMBA and CAMBA agreements Supports significant numbers and diversity of native fish, including migratory species.		Plan (2013) and the following CLLAMMecology publications for data concerning underpinning processes: - Aldridge *et al.* (2009) - Deegan*et al.* (2009) - Ford (2007) - Gillanders& Munro (2009) - Lamontagn ee*t al.*(2007) - Langley *et al.* (2009) - Lester *et al.* (2009) - Lester &Fairweathe r (2008, 2009) - Noell*et al.* (2009) - Rogers & Paton (2009) - Rolsten&Ditt mann (2009) - Sharma *et al.* (2009) - Webster (2005; 2007)	(particularly flow patterns) - Nutrient and organic cycling	

	Cultural values[8]	Aesthetics, amenity		Yes – refer Cast *et al.* (2008)		
		Cultural and spiritual significance for the Ngarrindjeri people		Yes – refer Philips & Muller (2006) ECD.		This will require updating through consultation in order to ascertain the ongoing cultural and spiritual significance (and whether this is/has been affected by the changing condition of the Coorong and Lower Lakes).
		Educational and research site		Yes		Consultation with local schools and Universities (as well as MBBA and DEWNR) should confirm the ongoing importance of the Coorong and Lower Lakes as educational and research sites.

North Lagoon						
Wetland type located within unit (as described in Phillips & Muller (2006)	**Ecosystem service**	**Details of Ecosystem Service at Ramsar designation (1985)**	**Current status**	**Evidence?**	**Supporting processes**	**Knowledge Gap**
• Rocky marine shores • Sand, shingle or pebble shores • Intertidal mud, sand or salt flats • Intertidal marshes • Coastal brackish/saline lagoons • Coastal freshwater lagoons	Wetland Products	Drinking Water	Number of freshwater soaks around the South and North Lagoons has diminished and those remaining are becoming more saline (as opposed to brackish)	The Ngarrindjeri community have told of the freshwater soaks around South and North Lagoons having once been vital for freshwater for humans and animals	- Salinity - Turbidity and sedimentation patterns - Water levels - Water regime (particularly flow patterns) - Water quality	Consultation with local users and stakeholders should establish whether the freshwater soaks are still usable.

[8] Cultural value ecosystem services have not been discussed further within this document as they are being considered elsewhere under a socio-cultural review currently in progress by CSIRO for the MDBA (reference).

		Commercial and recreational fisheries	The sector in the Lakes and Coorong is a multi-species fishery including Coorong mullet, mulloway, bony bream, callop, European carp and Goolwa cockle (Pipi). There is a small commercial fishery for mulloway, mostly restricted to the Coorong Lagoons where nets are used to take fish between about 46cm and 70cm in length[9].	Yes - 36 fishing licences current in place[10] although only a small number are currently active Fishery Stock Status Report for the Southern Australian Lakes and Coorong Fishery (Ferguson 2012) provided current data on the status of the fishery and showed the greatest contributions to total catch in 2010-1011was yellow-eye mullet (with 47% of the fishery catch) and pipi with the second greatest (38%).	- Salinity - Turbidity and sedimentation patterns - Keystone aquatic plant species and assemblages - Water levels - Habitat availability (particularly temporal and spatial connectivity) - Water regime (particularly flow patterns)	Econsearch (2011) for PIRSA undertook an economic profile of the River Murray Region of SA (utilising 2006/07 data). Consultation should be undertaken with PIRSA/Econsearch to ascertain whether this report can be broken down further to provide economic data on the Coorong, Alexandrina Coastal, Alexandrina Strathalbyn District Council and Murray Bridge Regional Council Statistical Local Areas only. Request from SARDI / PIRSA whether a stock status assessment was carried out in 2011-2012 and update if applicable.
		Grazing	Dairy and beef farms adjacent to North Lagoon. Grazing is managed around key wetland areas through	Yes - Dairy and beef farms adjacent to North Lagoon.	- Salinity - Water levels - Primary production - Vegetational productivity, pollination,	Consultation required with PIRSA on number of dairy and beef farmers remaining within industry and/or having transitioned to dryland farming

[9] http://www.pir.sa.gov.au/fisheries/recreational_fishing/target_species/mulloway
[10] http://www.environment.sa.gov.au/cllmm/pdfs/mhf-document.pdf

			partnership with the farmers and DEWNR.		regeneration processes, succession etc.	
		Reeds and grasses for traditional crafts	Area significant for location of spiny flat-sedge	Reduction in quantity and quality of reeds in recent years (Phillips and Muller 2006)	- Salinity - Water quality - Primary productivity - Vegetation productivity - Water levels - Farming (eg grazing pressures) - Competition with other reed species	Although reported through consultation undertaken by Philips and Muller (as part of the 2006 ECD), consultation should be undertaken with DAARD and local stakeholders in relation to use of the Coorong and Lower Lakes by traditional owners.
		Traditional Ngarrindjeri food species (eggs, birds,fish, yabbies)	Area locally important for items such as swan, duck, seagull and emu eggs, fish such as hardyhead and yabbies (Phillips and Muller 2006)	Yes – although there has been a loss, or severe decline of many of these species and their products, particularly in recent years	- Salinity - Turbidity and sedimentation patterns - Keystone aquatic plant species and assemblages - Water quality - Water levels - Habitat availability (particularly temporal and spatial connectivity) - Water regime (particularly flow patterns)	Although reported through consultation undertaken by Philips and Muller (as part of the 2006 ECD), consultation should be undertaken with DAARD and local stakeholders in relation to use of the Coorong and Lower Lakes by traditional owners.
	Maintenance of hydrological stability	Flood mitigation	-	North Lagoon is likely acting as flood mitigation to local residential	- Water levels - Water regime (flow patterns and gradients) - Slope and bank	Consultation could be undertaken with Alexandrina and Coorong Councils coastal engineer to ascertain their understanding of the role the Coorong and Lower Lakes

				communities (eg Goolwa)-	stability - Connectivity between water bodies	play in local flood prevention. Was modelling carried out as part of the CLLAMMecology work as to the retention of each part of the system?
		Groundwater interactions	-	Major processes such as groundwater recharge anddischarge, drylandsalinisation,irrigation and groundwater/surface water interaction identified within this region Barnett (1991), Barnett (1994), Cobb and Barnett (1994).	- Salinity - Water levels (particularly in the aquifers) - Water regime (particularly flow patterns and gradients) - Connectivity of surface water and groudwater	A number of boreholes exist within the Coorong and Lower Lakes catchment. In 2010 they were being monitored by the LAP for depth and salinity (as part of 200 BH's monitored). Current monitoring status and who currently undertaking should be identified DEWNR?). Also SA Obswell Network online has 33 BH's located within and directly adjacent to the Lower Lakes and Coorong. This data could be analysed for groundwater levels and salinity changes. Up-to-date irrigation details to be requested from PIRSA / MDBA.
	Water purification	Removal and dilution of wastewaters form irrigation areas, urban areas and septic tanks	-	Yes – although direct evidence unlikely to be available	- Salinity - Turbidity and sedimentation patterns - Keystone aquatic plant species and assemblages - Water levels - Water regime (particularly flow patterns) - Water retention times of Lakes	-
	Coastal shoreline and bank	Reduce impacts of wind and wave action and	-	Yes – the South and North lagoons play a	- Keystone coastal plant species and	-

	stabilisation	currents		key role in sheltering the habitats and communities behind them from wind and wave actions	assemblages - Dune and bank stability and slope gradients - Habitat availability (particularly temporal and spatial connectivity)	
		Prevent erosion by holding sediments with plant roots	-	Yes - the coastal shoreline and vegetation plays a key role in prevention of wind erosion. This was particularly important during drought times when risk of ASS/PASS soils being exposed and mobilised through being blown around is higher	- pH and salinity - Keystone aquatic plant species and assemblages - Turbidity and sedimentation patterns - Water levels - Habitat availability (particularly temporal and spatial connectivity) - Water regime (particularly flow patterns)	Establish whether any data on ASS/PASS exposure during and after the drought broke was collected (MDBA / DEWNR?) Were the North and South lagoon sediment levels recorded as part of observational data during lake water level measurements? (DEWNR / MDBA)
	Sediment and nutrient retention	Flood retardation and sediment and nutrient deposition	-	Yes	- Soil, geology, substrates, soil type - Turbidity and sedimentation patterns - Keystone aquatic plant species and assemblages - Water levels	-

					- Water regime (particularly flow patterns)	
	Local climate regulation	Local climate stabilisation, particularly in relation to rainfall and temperature	-	No direct evidence although highly likely that Lagoons will be acting as climate regulators on a local level by absorbing heat during the day and expelling heat during the nights.	- Area, boundary and dimensions of lake - Temporal and spatial connectivity of Lake in conjunction to other water bodies - Water regime (particularly flow patterns) - Water levels - Temperature and stratification	Further research required to provide evidence that lagoons are acting as climate regulators on a local scale.
	Climate change mitigation	Sequestering and cycling of carbon	-	Yes – Brookes *et al.* (2009) demonstrated the Lower Lakes as a nutrient (and likely carbon) source for the downstream Coorong and Murray Mouth	- Carbon cycling - Nutrient cycling	-
	Biological control of pest and diseases	Support of predators of agricultural pests		Yes – evidenced through support of bird populations refer Oborne (2003), Patton *et*	- Salinity - Turbidity and sedimentation patterns - Keystone aquatic plant	-

				al.(2009) and Rogers & Paton (2009)	species and assemblages - Water levels - Habitat availability (particularly temporal and spatial connectivity) - Water regime (particularly flow patterns)	
	Recreation and tourism	Boating and water skiing	Diminished in recent years (particularly during the drought) due to low water levels and flows and barriers which were installed to aid Lakes salinity issues. Barriers have now been removed (last one at Currency Creek being removed at the moment) and locks are fully operational. Marina at Hindmarsh Island is increasing popularity in boating in local area.	Yes – area always has historically been a popular boating area.	- Access - Area, boundary and dimensions of Lakes - Temporal and spatial connectivity of Lakes in conjunction to other water bodies - Water regime (particularly flow patterns) - Water levels - Water quality - Visual aesthetics	Current recreation and tourism numbers should be sought (Tourism SA?) Also refer Econsearch (2011) comments previously in relation to possible breakdown of economic data into smaller spatial units.
		Fishing	Diminished in recent years due to water quality issues (particularly	Yes – recreational fishing was historically been	- Salinity - Turbidity and sedimentation patterns	Consultation with SARFAC and local fishers should be undertaken for up-to-date numbers of rec fishers utilising the area.

			salinity) and falling /changing fish stocks	a popular pastime in the Lakes and adjacent areas	- Keystone aquatic plant species and assemblages - Water levels - Habitat availability (particularly temporal and spatial connectivity) - Water regime (particularly flow patterns)	
		Bird watching and sightseeing	Current status of bird numbers and visits needed Diminished in recent years due to elevated salinity levels within the North Lagoon	Yes - Site internationally renowned for bird watching. Patton *et al.* (2009) and Rogers & Paton (2009)	- Salinity - Turbidity and sedimentation patterns - Keystone aquatic plant species and assemblages - Water levels - Habitat availability (particularly temporal and spatial connectivity) - Water regime (particularly flow patterns)	Current status of bird numbers and visits needed – Consultation with Dave Paton and other experts as well as local bird groups needed
		Swimming, picnicking and camping		Yes - refer CSIRO report.	- Access - Area, boundary and dimensions of Lakes - Temporal and spatial connectivity of	Consultation should be undertaken with local tourism operators / caravan parks etc for current levels

					Lakes in conjunction to other water bodies - Water regime (particularly flow patterns) - Water levels - Water quality - Visual aesthetics	
	Food web support	Nutrient cycling		Yes – Brookes *et al.* (2009) demonstrated the Lower Lakes as a food source for the downstream Coorong and Murray Mouth. Also refer CLLAMMecology reports: Cook *et al.* (2008), Fernandes& Tanner (2009), Grigg*et al.* (2009), Haese*et al.* (2009), Krull*et al.* (2008; 2009)	- Water levels - Salinity - Turbidity and sedimentation patterns - Keystone aquatic detritivores - Water regime (particularly flow patterns)	-
		Primary ecosystem production	North Lagoon traditionally supported communities of *Ruppiamegacarpa* which is very important species in the food chain for waders and water birds. In	Yes – refer CLLAMMecology reports - Aldridge *et al.* (2009) - Revill*et al.* (2009) - Cook *et al.* (2008) - Nayar& Loo	- Salinity - Turbidity and sedimentation patterns - Keystone aquatic plant species and assemblages - Water levels - Habitat	Research needed into current status, extent and species composition of *Ruppiamegacarpa*communiites and whether theyare recovering now that the drought has ended.

			recent years, the beds of *R. megacarpa*have been lost and the more salt tolerant *R. tuberosa* is coloinising from South lagoon (Nichol, 2005).	(2009)	availability (particularly temporal and spatial connectivity) - Water regime (particularly flow patterns) - Nutrient and organic cycling	
	Ecological values	Representative of a unique ecosystem (globally, national and regionally) Supports a large variety of ecological communities Supports a number of globally and nationally threatened species and communities Supports a high diversity of species and assemblages important for conserving biodiversity at the bioregional scale Supports animal taxa at critical stages of their lifecycle and during drought Supports significant		Yes – As evidenced by inclusion within the Ramsar Site series. Refer Ramsar designation sheets. Also refer Phillips & Muller (2006) Ecological Character Description (ECD), Murray Darling Basin Plan (2013) and the following CLLAMMecology publications for data concerning underpinning processes: - Aldridge *et al.*(2009) - Deegan*et al.*(2009) - Ford (2007) - Gillanders&	- Salinity - Turbidity and sedimentation patterns - Keystone aquatic plant species and assemblages - Water levels - Habitat availability (particularly temporal and spatial connectivity) - Water regime (particularly flow patterns) - Nutrient and organic cycling	A review of Ramsar status since designation should be undertaken. A focus could be made on bird numbers as a surrogate for overall ecological health. Will have to be in two parts: designation to drought and post drought

		numbers and diversity of wetland-dependent birds including migratory species listed under the JAMBA and CAMBA agreements		Munro (2009) - Lamontagn e*et al.*(2007) - Langley *et al.*(2009) - Lester *et al.*(2009) - Lester &Fairweathe r (2008, 2009) - Noell*et al.*(2009) - Rogers & Paton (2009) - Rolsten&Ditt mann (2009) - Sharma *et al.*(2009) - Webster (2005; 2007)		
		Supports significant numbers and diversity of native fish, including migratory species.				
	Cultural values**Error ! Bookmark not defined.**	Aesthetics, amenity		Yes – refer Cast et al. (2008)		-
		Cultural and spiritual significance for the Ngarrindjeripeopl e		Yes – refer Phillips & Muller (2006) Ecological Character Description (ECD)		This will require updating through consultation in order to ascertain the ongoing cultural and spiritual significance (and whether this is/has been affected by the changing condition of the Coorong and Lower Lakes).
		Educational and research site		Yes		Consultation with local schools and Universities (as well as MBBA and DEWNR) should confirm the ongoing importance of the Coorong and Lower Lakes as educational and research sites.

South Lagoon						
Wetland type located within unit (as described in Phillips & Muller (2006)	**Ecosystem service**	**Details of Ecosystem Service at Ramsar designation (1985)**	**Current status**	**Evidence?**	**Supporting processes**	**Knowledge Gaps**
• Rocky marine shores • Sand, shingle or pebble shores • Intertidal mud, sand or salt flats • Coastal brackish/saline lagoons • Permanent rivers/streams/creeks • Seasonal/intermittent saline/brackish/alkaline	Wetland Products	Drinking Water	Number of freshwater soaks around the South and North Lagoons has diminished and those remaining are becoming more saline (as opposed to brackish)	The Ngarrindjeri community have told of the freshwater soaks around South and North Lagoons having once been vital for freshwater for humans and animals	- Salinity - Turbidity and sedimentation patterns - Water levels - Water regime (particularly flow patterns) - Water quality	Consultation with local users and stakeholders should establish whether the freshwater soaks are still usable.

lakes and flats • Seasonal/intermittent saline/brackish/alkaline marshes/pools • Shrub-dominated wetlands • Freshwater, tree-dominated wetlands • Freshwater springs, oases		Commercial and recreational fisheries	The sector in the Lakes and Coorong is a multi-species fishery including Coorong mullet, mulloway, bony bream, callop, European carp and Goolwa cockle (Pipi). There is a small commercial fishery for mulloway, mostly restricted to the Coorong Lagoons where nets are used to take fish between about 46cm and 70cm in length.[11]	Yes - 36 fishing licences current in place[12] although only a small number are currently active Fishery Stock Status Report for the Southern Australian Lakes and Coorong Fishery (Ferguson 2012) provided current data on the status of the fishery and showed the greatest contributions to total catch in 2010-1011was yellow-eye mullet (with 47% of the fishery catch) and pipi with the second greatest (38%).	- Salinity - Turbidity and sedimentation patterns - Keystone aquatic plant species and assemblages - Water levels - Habitat availability (particularly temporal and spatial connectivity) - Water regime (particularly flow patterns)	Econsearch (2011) for PIRSA undertook an economic profile of the River Murray Region of SA (utilising 2006/07 data). Consultation should be undertaken with PIRSA/Econsearch to ascertain whether this report can be broken down further to provide economic data on the Coorong, Alexandrina Coastal, Alexandrina Strathalbyn District Council and Murray Bridge Regional Council Statistical Local Areas only. Request from SARDI / PIRSA whether a stock status assessment was carried out in 2011-2012 and update if applicable.

[11] http://www.pir.sa.gov.au/fisheries/recreational_fishing/target_species/mulloway

[12] http://www.environment.sa.gov.au/cllmm/pdfs/mhf-document.pdf

		Grazing	Dairy and beef farms in areas adjacent to South Lagoon. Grazing is managed around key wetland areas through partnership with the farmers and DEWNR.	Yes - Dairy and beef farms adjacent to South Lagoon	- Salinity - Water levels - Primary production - Vegetational productivity, pollination, regeneration processes, succession etc.	Consultation required with PIRSA on number of dairy and beef farmers remaining within industry and/or having transitioned to dryland farming
		Reeds and grasses for traditional crafts	Area significant for location of spiny flat-sedge and other reed species	Reduction in quantity and quality of reeds in recent years (Phillips and Muller 2006)	- Salinity - Water quality - Primary productivity - Vegetation productivity - Water levels - Farming (eg grazing pressures) - Competition with other reed species	Although reported through consultation undertaken by Philips and Muller (as part of the 2006 ECD), consultation should be undertaken with DAARD and local stakeholders in relation to use of the Coorong and Lower Lakes by traditional owners.

		Traditional Ngarrindjeri food species (eggs, birds,fish, yabbies)	Area locally important for items such as swan, duck, seagull and emu eggs, fish such as hardyhead and yabbies (Phillips and Muller 2006)	Yes – although there has been a loss, or severe decline of many of these species and their products, particularly in recent years	- Salinity - Turbidity and sedimentation patterns - Keystone aquatic plant species and assemblages - Water quality - Water levels - Habitat availability (particularly temporal and spatial connectivity) - Water regime (particularly flow patterns)	Although reported through consultation undertaken by Philips and Muller (as part of the 2006 ECD), consultation should be undertaken with DAARD and local stakeholders in relation to use of the Coorong and Lower Lakes by traditional owners.
	Maintenance of hydrological stability	Flood mitigation	-	South Lagoon is likely acting as flood mitigation on a localised level during elevates flows)-	- Water levels - Water regime (flow patterns and gradients) - Slope and bank stability - Connectivity between water bodies	Consultation could be undertaken with Alexandrina and Coorong Councils coastal engineer to ascertain their understanding of the role the Coorong and Lower Lakes play in local flood prevention. Was modelling carried out as part of the CLLAMMecology work as to the retention of each part of the system?

		Groundwater interactions	The number of freshwater soaks around South lagoon has diminished and those remaining are becoming more saline (as opposed to brackish)	Major processes such as groundwater recharge anddischarge, drylandsalinisation,irrigation and groundwater/surface water interaction identified within this region Barnett (1991),Barnett (1994), Cobb and Barnett (1994).	- Salinity - Water levels (particularly in the aquifers) - Water regime (particularly flow patterns and gradients) - Connectivity of surface water and groundwater	A number of boreholes exist within the Coorong and Lower Lakes catchment. In 2010 they were being monitored by the LAP for depth and salinity (as part of 200 BH's monitored). Current monitoring status and who currently undertaking should be identified DEWNR?). Also SA Obswell Network online has 33 BH's located within and directly adjacent to the Lower Lakes and Coorong. This data could be analysed for groundwater levels and salinity changes. Up-to-date irrigation details to be requested from PIRSA / MDBA.
	Water purification	Removal and dilution of wastewaters form irrigation areas, urban areas and septic tanks	-	Yes – South Lagoon receives catchment waters and sediments from the Upper South East Drainage Scheme via Salt Creek.	- Salinity - Turbidity and sedimentation patterns - Keystone aquatic plant species and assemblages - Water levels - Water regime (particularly flow patterns) - Water retention times of Lakes	-

	Coastal shoreline and bank stabilisation	Reduce impacts of wind and wave action and currents	-	Yes – the South and North lagoons play a key role in sheltering the habitats and communities behind them from wind and wave actions	- Keystone coastal plant species and assemblages - Dune and bank stability and slope gradients - Habitat availability (particularly temporal and spatial connectivity)	Refer previous comments within North Lagoon table
		Prevent erosion by holding sediments with plant roots	-	Yes - the coastal shoreline and vegetation plays a key role in prevention of wind erosion. This was particularly important during drought times when risk of ASS/PASS soils being exposed and mobilised through being blown around is higher	- pH and salinity - Keystone aquatic plant species and assemblages - Turbidity and sedimentation patterns - Water levels - Habitat availability (particularly temporal and spatial connectivity) Water regime (particularly flow patterns)	Refer previous comments within North Lagoon table

	Sediment and nutrient retention	Flood retardation and sediment and nutrient deposition	-	Yes - South Lagoon receives catchment waters and sediments from the Upper South East Drainage Scheme via Salt Creek.	- Soil, geology, substrates, soil type - Turbidity and sedimentation patterns - Keystone aquatic plant species and assemblages - Water levels - Water regime (particularly flow patterns)	-
	Local climate regulation	Local climate stabilisation, particularly in relation to rainfall and temperature	-	No direct evidence although highly likely that Lagoons will be acting as climate regulators on a local level by absorbing heat during the day and expelling heat during the nights.	- Area, boundary and dimensions of lake - Temporal and spatial connectivity of Lake in conjunction to other water bodies - Water regime (particularly flow patterns) - Water levels - Temperature and stratification	Further research required to provide evidence that lagoons are acting as climate regulators on a local scale.

	Climate change mitigation	Sequestering and cycling of carbon	-	Yes – Brookes *et al.*(2009) demonstrated the Lower Lakes as a nutrient (and likely carbon) source for the downstream Coorong and Murray Mouth	- Carbon cycling - Nutrient cycling	-
	Biological control of pest and diseases	Support of predators of agricultural pests		Yes – evidenced through support of bird populations (Patton *et al.*2009) and Rogers & Paton (2009)	- Salinity - Turbidity and sedimentation patterns - Keystone aquatic plant species and assemblages - Water levels - Habitat availability (particularly temporal and spatial connectivity) - Water regime (particularly flow patterns)	-

	Recreation and tourism	Boating and water skiing	Diminished in recent years (particularly during the drought) due to low water levels and flows	Yes – area historically has been a popular boating area.	- Access - Area, boundary and dimensions of Lakes - Temporal and spatial connectivity of Lakes in conjunction to other water bodies - Water regime (particularly flow patterns) - Water levels - Water quality - Visual aesthetics	Current recreation and tourism numbers should be sought (Tourism SA?) Also refer Econsearch (2011) comments previously in relation to possible breakdown of economic data into smaller spatial units.
		Fishing	Diminished in recent years due to water quality issues (particularly salinity) and falling fish stocks	Yes – recreational fishing historically been a popular pastime in the Lagoons and adjacent areas	- Salinity - Turbidity and sedimentation patterns - Keystone aquatic plant species and assemblages - Water levels - Habitat availability (particularly temporal and spatial connectivity) - Water regime (particularly flow patterns)	Consultation with SARFAC and local fishers should be undertaken for up-to-date numbers of rec fishers utilising the area.

		Bird watching and sightseeing	Current status of bird numbers and visits needed	Yes - Site internationally renowned for bird watching. Refer Oborne (2003), Patton *et al.*(2009) and Rogers & Paton (2009)	- Salinity - Turbidity and sedimentation patterns - Keystone aquatic plant species and assemblages - Water levels - Habitat availability (particularly temporal and spatial connectivity) - Water regime (particularly flow patterns)	Current status of bird numbers and visits needed – Consultation with Dave Paton and other experts as well as local bird groups needed
		Swimming, picnicking and camping		Yes - refer CSIRO report. Refer also Econsearch (2011)	- Access - Area, boundary and dimensions of Lakes - Temporal and spatial connectivity of Lakes in conjunction to other water bodies - Water regime (particularly flow patterns) - Water levels - Water quality - Visual aesthetics	Consultation should be undertaken with local tourism operators / caravan parks etc for current levels

	Food web support	Nutrient cycling		Yes – Brookes *et al.* (2009) demonstrated the Lower Lakes as a food source for the downstream Coorong and Murray Mouth. Also refer CLLAMMecology reports: Cook *et al.* (2008), Fernandes& Tanner (2009), Grigg*et al.* (2009), Haese*et al.* (2009), Krull*et al.* (2008; 2009)	- Water levels - Salinity - Turbidity and sedimentation patterns - Keystone aquatic detritivores - Water regime (particularly flow patterns)	-

		Primary ecosystem production	Submerged vegetation in the South Lagoon is characterised by extensive areas of *Ruppia tuberosa, Lepilaena and Lamprothamnion* (Oborne, 2003). However, these areas havegreatly declined in extent and quality. These submerged plants are a critical component of thehabitat as they provide a source of detritus for benthic communities and architecture for juvenile fish, invertebrate and biofilm habitat (Oborne, 2003). South Lagoon also traditionally supported a limited number of crustaceans thereby providing forage for water bird species, although, these have decreased in number with rising salinity levels.	Yes – refer CLLAMMecology reports - Aldridge *et al.*(2009) - Revill*et al.*(2009) - Cook *et al.*(2008) - Nayar& Loo (2009)	- Salinity - Turbidity and sedimentation patterns - Keystone aquatic plant species and assemblages - Water levels - Habitat availability (particularly temporal and spatial connectivity) - Water regime (particularly flow patterns) - Nutrient and organic cycling	-

	Ecological values	Representative of a unique ecosystem (globally, national and regionally) Supports a large variety of ecological communities Supports a number of globally and nationally threatened species and communities Supports a high diversity of species and assemblages important for conserving biodiversity at the bioregional scale Supports animal taxa at critical stages of their lifecycle and during drought Supports significant numbers and diversity of wetland-dependent birds including migratory species listed under the JAMBA and CAMBA agreements		Yes – As evidenced by inclusion within the Ramsar Site series. Refer Ramsar designation sheets. Also refer Phillips & Muller (2006) Ecological Character Description (ECD), Murray Darling Basin Plan (2013) and the following CLLAMMecology publications for data concerning underpinning processes: - Aldridge *et al.* (2009) - Deegan*et al.* (2009) - Ford (2007) - Gillanders& Munro (2009) - Lamontagn e*et al.*(2007) - Langley *et al.* (2009) - Lester *et al.* (2009) - Lester &Fairweathe	- Salinity - Turbidity and sedimentation patterns - Keystone aquatic plant species and assemblages - Water levels - Habitat availability (particularly temporal and spatial connectivity) - Water regime (particularly flow patterns) - Nutrient and organic cycling	A review of Ramsar status since designation should be undertaken. A focus could be made on bird numbers as a surrogate for overall ecological health. Will have to be in two parts: designation to drought and post drought

		Supports significant numbers and diversity of native fish, including migratory species.		r(2008, 2009) - Noelle*t al.* (2009) - Rogers & Paton (2009) - Rolsten&Dittmann (2009) - Sharma *et al.* (2009) - Webster (2005; 2007)		
	Cultural values	Aesthetics, amenity		Yes – refer Cast et al. (2008)		-
		Cultural and spiritual significance for the Ngarrindjeri people		Yes – refer Phillips & Muller (2006) Ecological Character Description (ECD)		This will require updating through consultation in order to ascertain the ongoing cultural and spiritual significance (and whether this is/has been affected by the changing condition of the Coorong and Lower Lakes).
		Educational and research site		Yes		Consultation with local schools and Universities (as well as MBBA and DEWNR) should confirm the ongoing importance of the Coorong and Lower Lakes as educational and research sites.